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Translation

HANDBOOK ON THE ENGINEERING DESIGN OF SHIPYARDS, SHIPBUILDING SHOPS AND SHEDS

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Leningrad SPRAVOCHNIK PO TEKHNOLOGICHESKOMU PROYEKTIROVANIYU SUDOSTROITEL'NYKH VERFEY I TSEKHOV in Russian (signed to press 28 Jan 80) pp 1-198

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CONTENTS

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ANNOTATION

[Text] A discussion is presented of materials on the methodology of developments in the engineering predesign and design of shipyards for building metal-hulled transport and factory ships. The basic initial data for designing shipyards, shipbuilding shops and sheds and information about the layout, content, volume and example sequence of execution of the engineering parts of the designs are presented.

This book is intended for engineering and technical workers in the design, consulting and process engineering organizations and enterprises of the shipbuilding industry. It can also be used by teachers and students of the shipbuilding schools for the study of the corresponding disciplines.

FOREWORD

The scientific and technical revolution in the industry of our country, including shipbuilding, the growth of production and expansion of international economic relations require systematic replacement of the fleet with ships that are improved in technical respects and that are economical to operate and maintain.

In the "Basic Directions of Development of the National Economy of the USSR for 1976-1980" approved by the 25th CPSU Congress, the instruction is given: "... replace the fleet with highly efficient dry-cargo ships, tankers and combined ships with an overall deadweight of about 5 million tons. Increase the proportion of the specialized dry-cargo fleet--lumber carriers, container ships, lighter carriers, trailer carriers, dry bulk cargo carriers, and so on." As a result of raising the technical level, increasing the power and capacity of the ships under construction, systematic reequipment is taking place, and new capacities of the shipbuilding industry are being created with complicated building slip and launching structures, covered slipways, hull platers shops, assembly and welding shops, assembly and fitting shops and makeup shops equipped with varied and, to a significant degree, unique equipment allowing the most advanced methods to be used in building the ships.

The technical progress of the rebuilt and new shipyards will find its fruition primarily in the designs. Design work must be based on maximum consideration of the latest achievements of science and engineering and the application of advanced production processes so that the shipyards being built or rebuilt will be technically advanced when put into operation and have high indices with respect to productivity of labor, cost and quality of production, and they will correspond to the modern requirements with respect to working conditions.

The developed plans for building new shipyards and rebuilding those in operation must provide for building present-day and future ships which will be significantly improved technically, structurally complex, saturated with the latest instruments, electrical equipment and machinery.

The design of the shipyards is a very difficult, creative process for a large collective of specialists who are called upon to solve a variety of technical problems. The most important of these problems is definition of the initial data when developing the engineering part of the design (that is, the methods and means of building ships, the basic production processes, volume, labor consumption and duration of the operations by phases, and also the determination and the calculation of the material resources and manpower required for production.

One of the primary problems of shipyard design is substantiation of the initial data and engineering solutions adopted in the plans, including safety engineering and environmental protection measures.

This book discusses these problems, giving consideration to the handbooks and standards presently in effect. When using the book, it is necessary to introduce the corresponding corrections in case of changes in the guidance materials and standards.

This handbook must not be taken as a reference with exhaustive data on the development of all aspects of shipyard design. It only discusses the reference data on the methodology of developments in the engineering predesign and design phases, calculations and substantiations of both shipyards as a whole and their individual shops and structures.

The book will familiarize the reader with types of shipbuilding enterprises, with predesign developments with respect to shipyards, including the master plans for the prospective development of existing shipyards and the engineering-economic substantiation of the design and construction or rebuilding of shipyards, design phases, the preparation, content and sequence of development of the engineering design, the methods and organization of shipbuilding, specialization and cooperation of shipyards. The determination of production volumes, labor consumption and time required for building ships is considered, general data are presented on planned shipyards and shops, and primary attention has been given to the problems of the procedure and practice of designing shipyard sheds, shops and structures and their storage areas. All of the problems of the engineering design of the shipyard shops are discussed in general form with reflection of the characteristic features by individual shops.

The design solutions by shops have been investigated as applied to the organization of the series construction of marine transport and factory ships. A distinguishing feature of such organization is division of the shops into two specialized groups:

the hull and assembly-fitting shops which are responsible for machining the hull steel, assembly and welding the subassembly units and sections, the assembly-fitting operations on the modules and on the ships, including the acceptance trials;

the makeup shops which turn over their production to the central makeup warehouse or the assembly-fitting shops and do not participate in installation operations on the ship itself.

Example design solutions are presented in the book as applied to the provisional classification of shipyards and also considering the provisional annual design programs and adopted example ships.

The individual design factors presented give only an approximate representation of the initial data and characteristics of the designed production facilities, and they permit better understanding of the design procedure. The equipment and planning of the shops and sheds are also considered only as examples. The shop planning basically reflects theoretical solutions, and in design practice it can be otherwise, depending on the adopted technology, the organization of production, equipment, mechanization means and systems.

Various technical specifications, standards, instructions and other guidance materials on developing designs and estimates for industrial construction and also published sources and data from shipbuilding periodicals were used when working on the book.

The discussed material corresponds quite fully to the instructions, design standards and other materials on engineering design of shipyards and shipbuilding sheds in effect at the present time.

The author expresses his sincere appreciation to all of his coworkers for valuable suggestions and advice aimed at supplementing, classification and more precise definition of the material presented in the book.

PART ONE. PREDESIGN AND GENERAL DESIGN DEVELOPMENTS WITH RESPECT TO SHIPYARDS, SHIPBUILDING SHEDS AND SHOPS

Chapter I. Basic Principles. Predesign Phase

§1. General Principles

The development of shipbuilding is determined by the long-range plans for the USSR national economy.

Increased production of ships is being promoted by the existing shipyards by more intense use of capacity and the introduction of advanced production technology and organization, the rebuilding and expansion of existing shipbuilding facilities, and the construction of new shipyards. The role of a new, rebuilt or expanded shipbuilding facility and its capacity is determined by specially developed technical-economic substantiation. The production capacity of the shipyard depends on the class of ships being built, their annual production volume and the layout of the shipyard itself.

The basic production means of the shipyard, including the buildings and production equipment, the building slips and launching facilities, the cranes and other materials-handling equipment are determined depending on the basic specifications of the ships, the design program and the planned process flowchart.

In socialist industry two basic principles guide the territorial organization of enterprises:

Location of industry as close as possible to the raw material and the areas where the product is to be used;

Location of new industrial sites considering the fastest rise of the economy in previously backward regions.

The all-around development of industrial branches, including shipbuilding, is an important principle. By all-around development of the shipbuilding industry we mean the creation of a set of enterprises which will provide the materials, machinery, equipment, fittings, castings, forgings, and so on needed for ship construction. The natural conditions of an area in which a shipbuilding facility is proposed for construction have no less significance. They must be suitable for erecting the primary structures of the shipyard, including the building slips, the launching facilities, outfitting quays, the water area, protective structures (jetties and seawalls) and waterways. It is also necessary to consider the manpower available in the area.

Capacity buildup is achieved by capital investments in the construction of new enterprises and facilities or the rebuilding of existing ones.

It is expedient to direct the capital investments at the construction of facilities that will accelerate scientific and technical progress and technical reequipment and rebuilding of existing enterprises.

Capital construction is the set of construction installation work which provides for putting new or reconstructed fixed capital into operation. It is achieved in the following basic steps: the conceptual, exploratory and scientific research work, development and approval of designs and estimates, preparatory operations on the site, including an auxiliary construction base and accesses, construction and installation operations, the introduction of new or rebuilt enterprises and facilities into operation.

Design is a component part of capital construction. A design is a set of technical documents with the basic technical solutions discussed in explanatory notes and materials and providing for the construction or rebuilding of enterprises and individual facilities. The cost estimate is an inseparable part of design.

The basic element of planning and design work is the creation of a plan for an industrial project which corresponds to the advanced level of Soviet and foreign technology.

In developing construction or reconstruction plans for shipbuilding enterprises, the engineering designers must know not only advanced production technology, but also means of further improvement of it and the direction of future developments in shipbuilding.

When developing the plans it is necessary to consider the basic areas of scientific and technical progress in shipbuilding:

the creation of qualitatively new tools of labor, new materials and improved processes, standardization of products, subassembly units and equipment;

acceleration of the rates of renewal and replacement of obsolescent equipment;

mechanization of labor-consuming operations considering the maximum possible replacement of manual labor with machines and also partial automation of the production processes;

broad introduction of automated control systems.

In order that the enterprises under construction and being rebuilt have high technical-economic indices and that they correspond to the modern requirements with respect to working conditions at the time they are put into operation, the following measures must find reflection in shipyard designs:

the application of advanced methods of building ships, including large-section and large-modular techniques with maximum saturation of the sections and modules, the installation of machinery and equipment in consolidated units, zonal modules, blocks, and so on, which will permit a significant amount of the work to be taken out of the building slips and performed under shop conditions, and it will create the necessary conditions to implement all-around mechanization;

the organization of flow-type mechanized production encompassing all of the basic operations with respect to the manufacture of certain parts, products and structural elements when building ships;

maximum use of mechanized floor systems as the primary transport means in the shops;

mechanization of the building slip and launching operations, including the application of highly efficient welding and other equipment, low-mechanization means, modern powerful cranes, transport-building and launching equipment;

the improvement of the organization of production with the introduction of modern technical means of production control.

The engineering part of the design must ensure the following basic technical-economic indices: effectiveness of capital investments expressed in return per ruble of expenditures, output per ruble of fixed capital, and the magnitude of specific capital investments; profitability reduced to the fixed productive capital; return time for the planned expenditures; level of productivity of labor reckoned in output (expressed in financial or natural terms) per participant in production.

One of the most important problems of the designers is to provide for the growth of productivity of labor which is achieved:

for production workers, by the introduction of advanced technological processes, high-output equipment, mechanization and automation of production processes and the technical level of production as a whole;

for auxiliary workers, by high organization of production, mechanization of the loading-unloading, materials-handling, warehousing and other operations;

for administrative labor, accounting and bookkeeping operations, by raising the level of mechanization and automation of these operations.

The technological process and the production equipment adopted in the plan must provide for both the appropriate quality of production output and high productivity of labor and the most complete use of the initial material, in particular, metal, which accounts for 65-70 percent of the mass of the structural elements of ships being built at the shipyards.

The primary goal of mechanization and automation of production is improvement of the productivity of labor and facilitation of it. The expediency of introducing one type of mechanization and automation or another must be confirmed by the corresponding calculations and substantiations.

When resolving the engineering parts of the design, in order to improve the effectiveness of capital investments it is necessary to apply the maximum possible standardized bay dimensions, column spacings, building heights, blocking of the buildings, reducing their overall perimeters and the covered area, and ensurance of the shortest path for intraplant movement of people and materials.

The plan for the shipyard (shop) must provide the workers with suitable working and living conditions both in the workplace and in domestic facilities, medical service and organization of feeding.

The layout and content, the order of development, the coordination and approval of the designs and the estimates by which new industrial enterprises, buildings and facilities will be built or existing ones will be expanded and rebuilt are defined by the State Committee of the USSR Council of Ministers on Construction by the corresponding instructions and construction norms and rules (planning and design norms).

The design organization producing the engineering part of the design, as a rule, is the general designer; if necessary the design organization calls in specialized design and research organizations for development of individual parts of the designs or research under contract.

In accordance with the rules approved by resolution of USSR Gosstroy [23], the general designer is responsible for all-around development of the plans and estimates and also the coordination of all parts of the design, including the parts developed by organizations called in under contract.

The general designer is obligated:

to participate, playing the leading role, in the development of the technical-economic substantiation for the construction of large-scale, complex enterprises and facilities, the writing of the planning and design assignments, the choice of the construction site, determination of the volumes, stages and cost of the design and research work;

by commission of the design client (by individual agreement) to prepare the initial data needed for the planning and design work, the materials from research and exploration that has been performed and measurements of the existing buildings, facilities and service lines;

to issue the initial requirements to the client for the development of specially made equipment, including nonstandard and nonstandardized equipment and also to obtain the initial planning and design data from him;

to define the volumes of construction-installation operations, the composition and amount of equipment, products and materials with compilation of parts lists and bills of materials for the latter;

compilation of an overall estimate and summary of expenditures on construction;

to ensure correspondence of the contract-detail (contract) designs to the planning and design assignment and correspondence of the detail drawings to the approved contract design, and also ensurance of patent purity of the design solutions;

complete assembly of the design by parts and transmittal of it to the client;

provision for creation of the technical forms and reports by the established time;

participation in acceptance of the construction projects and assimilation of the designed capacities, organization of the designer's supervision and, if necessary, also technical supervision of the construction.

The general designer has the right to request that the client reexamine obsolescent designs, establish a reduced volume of design plans, specifications and estimates by agreement with the contract construction organizations, shutdown of the construction installation work performed with inadmissible deviations from the plan and also in case of unsatisfactory work.

The chief design institute approved by the established procedure ensures that a united engineering policy is followed in planning and designing the enterprises, buildings and facilities of the branch [42].

Along with the development of designs of its own profile, the chief design institute is engaged in the following:

generalization, study and propagation of both Soviet and foreign advanced experience in the design and construction of projects of the shipbuilding industry;

the development of the basic technical areas of planning and designing enterprises and facilities of the branch considering the development of shipbuilding science and engineering;

the development of guidance and normative materials on planning and design, including the engineering design and the technical-economic indices of the shipyard shops of the shipbuilding enterprises;

development of standards for the explanatory notes on the designs, price lists, and other guidance and normative materials;

systematic monitoring of the correspondence of the effective standard designs to the technical level that has been achieved (also recommendations of economical individual designs for repeated execution);

the preparation of the annual and long-range budget plans (the creation and development of normative and guidance materials for planning and design);

the study and generalization of the experience in the application of prices and development norms for design and research work;

maintaining relations with the scientific research, planning and design organizations, the design organizations related by profile both in their own facility and branches and other branches of industry, construction organizations and industrial enterprises for the fastest introduction of the results of their work into the designs;

rendering of technical assistance to the design and research organizations of related profile attached to it by consultation, examination of individual designs, and so on;

provision of the above-mentioned organizations with normative, guidance and procedural instructions and information materials not getting into the book-trading network.

The chief design institute has the right to obtain and use needed design materials, planning and accounting information from the ministries, departments, enterprises, construction and design research organizations by the established procedure.

The technical council of the chief design institute periodically considers the technical areas of their activity with the participation of representatives of other planning organizations of corresponding profile.

The designs are developed on the basis of a planning and design assignment which is compiled in accordance with the technical-economic substantiation of the expediency of the mentioned construction (or reconstruction) of the enterprise. Both when compiling the planning and design assignments and when developing the designs themselves, special attention must be given to economical, efficient use of capital investments and social labor, ensurance of high quality and low cost of production, high productivity of labor and the best working conditions.

When developing plans for the construction and rebuilding of enterprises, the planning and design organizations are guided by the existing areas of improvement of the technical level, including requirements with respect to the scientific organization of labor and automated control systems and reduction of capital investments in the construction of the enterprises; effective normatives and instructions with respect to planning and design of the enterprises, buildings and structures; current equipment catalogs, standard industrial structural elements and products; approved estimate norms, price lists, rates and quotations for determining the estimated cost of construction.

The design organizations also make use of the results of developments of the corresponding scientific and adjacent planning organizations, generalized and analyzed data on the work of the advanced enterprises.

The types of industrial buildings and structures are selected in accordance with the approved standardized drawings of buildings and structures for the given branch of industry and also in accordance with the established requirements with respect to interbranch standardization of buildings and structures.

§2. Types and Classification of Shipbuilding Enterprises

With respect to organization of the building of ships, the shipbuilding enterprises are divided into the dockyards, shipyards, ship assembly yards and acceptance bases.

The dockyard is an enterprise which has both hull and fitting shops providing for the construction of ships and machinebuilding shops which make the principal and auxiliary machinery, boilers, ship's equipment and other makeup products.

The shipyard is an enterprise having production means providing for the manufacture of the parts and structural elements of the hull, hull fittings, lines, systems, insulation and finishing of the compartments and providing assembly-fitting operations when building the ships and acceptance trials. The shipyard does not have production means for manufacturing machinebuilding or instrumentmaking products, and all the mechanisms, equipment and instruments are obtained from other specialized enterprises.

The ship assembly yard is an enterprise which has production means only for assembly of the hull from parts, subassembly units and sections from other enterprises and also for the performance of assembly-fitting and finishing operations, and the acceptance trials. In contrast to the shipyard, the ship assembly yard does not have hull-platers, assembly-welding and makeup shops. The ship assembly yard is a very rarely encountered enterprise.

The acceptance base is an enterprise which only does sea trials and acceptance trials. The bases have equipped quays or piers for mooring ships, workshops for eliminating defects discovered during the trials, the required power equipment and warehouses. In individual cases the acceptance bases provide outfitting services and mooring trials.

The most efficient of the shipbuilding enterprises are the shipyard and a complex of marine machinebuilding plants; these enterprises are characterized by high specialization and better-developed cooperation than a broad-profile enterprise of the combined dockyard and machinebuilding plant. Many machinebuilding facilities built at the shipbuilding enterprises have been transferred to the corresponding branches of machinebuilding during the course of development of Soviet shipbuilding or they have been made into independent ship's machinebuilding enterprises.

All the shipbuilding enterprises can be broken down into the following categories:

by the hull materials of the ships built--metal, reinforced concrete, plastic, wood and composite shipbuilding enterprises;

by specialization--enterprises for building defined classes of ships, for example, tankers, dry-cargo vessels, trawlers, tugboats, and so on;

by the operational waters of the ships--marine, river and lake shipbuilding enterprises;

by ship production volume--individual and small-series shipbuilding enterprises, small-series and series, series and large-series;

by the predominant method of building ships--enterprises for sectional or large-section construction on inclined building slips and at docks, modular-sectional and modular construction with flow-position organization of production, sectional with flow-position or conveyor organization;

with respect to complexity of the ships, determining the composition of the basic means of production--enterprises for building especially complex ships, ships of medium complexity and simple ships.

In addition, the description of the ships (the principal dimensions and launching weight) determining the parameters of the shipyard facilities and also the number of workers required is an important index.

When designing shipbuilding enterprises primary consideration is given to their classification as a function of the complexity of production, launching weight of the ships built (maximum capacity of the launching facilities) and the number of workers (scale of production). All of the shipbuilding enterprises are divided into five classes in accordance with this classification: I, II, III, IV, V, where the primary classification index is the launching weight of the ships determining the capacity of the hydroengineering structures. The classification of shipyards by this index, the example ships adopted for further discussion and other initial data are presented in Table 1.

Table 1. Classification of Shipyards by the Primary Index--Launching Weight

	Classes of Shipyard				
	I	II	III	IV	V
	Launching Weight of Ship, tons				
Data and Indices	7,001 and Higher	3,501-7,000	1,001-3,500	251-1,000	To 250
Example ships and weight of their structural elements, Q_c, t	Tanker, $Q_c = 14,000$	Dry cargo, $Q_c = 6,200$	Trawler, $Q_c = 2,500$	Tugboat, $Q_c = 660$	Seiner, $Q_c = 90$
Annual production expressed in weight of the structural elements of the ship, t	140,000	136,400	87,500	39,600	9,000
Approximate maximum dimensions of the ships and products of the main shops and sheds of the shipyard:					
Breadth of the ship's hull, m	--	24.0	19.0	15.0	10.0
Hull height (in the vicinity of the superstructure, equipment loading), m	--	15.0	12.0	9.5	8.5
Overall height (from the base line to the top of the superstructure, wheelhouse or tower), m	--	28.0	22.0	17.0	12.0

Table 1 (continued)

Data and Indices	Classes of Shipyard: I Launching Weight of Ship, tons: 7,001 and Higher	II 3,501-7,000	III 1,001-3,500	IV 251-1,000	V To 250
Length of hull steel plate, m	16.0	16.0	10.0	8.0	6.0
Breadth of hull steel plate, m	4.5 and 3.2	4.5 and 3.2	2.4	2.0	1.6
Length of rolled section, m	16.0	16.0	10.0	8.0	6.0
Web height of rolled section	0.6	0.5	0.4	0.3	0.2
Length of hull sections, m	16.5	16.5	10.5	8.5	6.5
Breadth of hull sections, m	24.0	24.0	19.0	15.0	10.0
Length of system pipes and pipelines, m	9.0- 12.0	9.0	6.0	6.0	6.0
System pipe and pipeline diameter, m	400.0-850.0	325.0	300.0	220.0	190.0

Notes: 1. The dimensions of ships for Class I shipyards are not regulated in view of the fact that they have a large range, and the covered-in berths for building these ships are unique structures, the dimensions of which are determined for the specific design. 2. The width of 24-m sections for shipyards in Class I is taken considering splitting of them with respect to the diametral plane or by other longitudinal cross sections.

§3. Master Plan for Future Development of an Existing Shipyard and the Technical-Economic Substantiation of Planning, Design and Construction or Reconstruction of the Shipyards

Master Plan for Future Development of an Existing Shipyard. The master plan for the future development of existing shipyards has been developed for 10 or 15 years with organization of 5-year periods considering the requirements of the Instructions for the Development of Designs and Estimates for Industrial Construction [5], the Instructions for layout, Development Procedure and Approval of the Technical-Economic Substantiation (TEO) of the Planning, Design and Construction of Large-Scale and Complex Enterprises and Facilities approved by resolution of USSR Gosplan as of 9 January 1970, No 1 [47], and experience of the design organizations in the development of master plans for the development of enterprises and plans for the development and siting of the shipbuilding branch and also the directives of the ministry which strictly regulate the volumes of development and the composition of materials with respect to master plans for the development of the enterprises.

The master plan for the future development of a shipyard is a predesign document which is tied to the plans for the development and placement of the branch (subbranch) and tied to the future and long-range branch plans.

When developing a master plan, consideration must be given to the latest achievements of science and engineering, providing for high-quality production by the shipyard under the conditions of application of advanced technology and organization of production providing for high productivity of labor and other technical-economic indices when putting the capacity into operation.

Considering that the master plan is in the form of predesign material, on the basis of which the TEO will be developed in the future, its volume and content must be sufficient to define the approximate amount of capital investments considering the development priorities and the complexes being started up. The master plan must also define the basic technical-economic indices of the shipyard.

However, the presented documents must have the minimum required volume. The decisions made in the master plan can be more precisely defined in later planning and design work.

In the master plan for future development of an existing shipyard, the materials on the solutions that follow below are considered and presented as examples.

The initial principles are the basis for the development of the master plan, the purpose of the shipyard and the description of its role in the overall plan for development and location of the branch (subbranch), geographic-economic and demographic analysis of the region in which the shipyard is to be located, description of the condition of an existing shipyard, analysis and evaluation of activity, and the basic technical-economic indices.

The substantiation of the necessity of reconstruction (expansion) of an existing shipyard, multiple analysis of the possible versions of development of capacity constitute the production output budget in the future period, the calculated program of the shipyard and proposals with respect to specialization and cooperation (intrabranch and with the enterprises of other branches), and the analysis of possible versions of the schematic plans for development of the shipyard.

The basic design solutions are the schematic production process flowchart (by versions), the basic design solutions in accordance with the master plan and transportation of the shipyard (by versions); basic design solutions with respect to the development of production and auxiliary shops and facilities at the shipyard, the raw material requirement, the requirement for intermediate products and finished products, basic design solutions with respect to development of the shipyard storage facilities, the electric power and water supply requirement, the requirement for steam and other forms of energy, basic planning solutions with respect to the power plants of the shipyard and external power service lines, and basic structural solutions.

Other measures connected with the development of the shipyard include those with respect to environmental protection, provision of the shipyard with manpower, social-cultural measures and residential-civil construction, and so on.

Capital investments and fixed capital, the cost benefit of capital investments and the basic technical-economic indices include the consolidated calculation of capital investments by development versions, the basic technical-economic indices and comparison of them with the technical-economic indices of advanced Soviet and foreign enterprises.

The proposals with respect to construction phases and the complexes being started up include isolation of construction phases and complexes being started up, proposals with respect to organization of construction, capital investments by construction phases and complexes starting up with amounts of financing by years and the basic technical-economic indices.

Conclusions (Selection of the Version of Development of the Shipyard). The appendices include the master plan (by versions), the situation plan of the arrangement of the shipyard, the process flowchart with respect to basic production facilities, the construction plans with respect to general views, sections and facades of basic buildings and structures, and demonstration materials.

Technical-Economic Substantiation of the Design and Construction or Reconstruction of a Shipyard

The Effective Instructions for Development of the Plans and Estimates for Industrial Construction [5] provide that the planning and design of enterprises, buildings and structures must be realized on the basis of technical-economic substantiation (TEO) (or other predesign forms and reports replacing the TEO), confirming the economic expediency and necessity of planning, design, construction and developed in accordance with the instructions regarding layout, development procedure and approval of the technical-economic substantiations, the planning, design and construction of enterprises, buildings and structures. When developing the planning estimate documents for the construction of the enterprises, buildings and facilities, the technical-economic indices provided for in the approved TEO and the planning and design assignments must not be worse, and the estimated cost of construction must not exceed the construction cost defined in the TEO.

According to the instructions of USSR Gosplan [47], the TEO are a predesign document in which, beginning with the plans for the development and siting of the corresponding branches of the national economy and industry and the plans for the development and siting of productive forces by economic rayons and Union Republics, the siting of the enterprise to be designed and built, buildings and structures considering the rayon planning are more precisely defined, the productive capacity of the economy, production nomenclature, provision with raw material, intermediate products, manpower, fuel, electric power and water, transport communications, requirements on the other branches of the national economy and industry, cooperation with other prospective enterprises and the possibility of creating groups of enterprises with common facilities (industrial complexes) are substantiated, the basic process, planning and construction solutions, the construction site are defined, and the basic technical-economic indices and cost of construction (reconstruction) of the enterprise, building and facility are established.

When developing the TEO for the construction of new enterprises and projects, the expediency of this construction must be considered by comparison with the possibility of obtaining the equivalent production growth by expanding or rebuilding existing production facilities.

When developing the TEO it is necessary to consider the latest achievements of science and engineering so that the newly built, rebuilt and expanded enterprises, buildings and structures will be technically advanced at the time they are put into operation, they will have high indices with respect to productivity of labor and quality of production, they will provide high production efficiency and advanced industrial methods of construction, measures will be taken with respect to the efficient use of territory and environmental protection, and the best working conditions will be ensured.

As a rule, several versions of the design solutions are compiled to determine the economic expediency and technical possibility of construction (reconstruction) of the enterprise, building or facility, substantiation of the nomenclature and volume of production and also the theoretical process flowcharts. The choice of the construction site, the planning and other solutions must be tied to the master plans of the cities or other populated areas.

The TEO are developed for the complete designed capacity of the enterprise, building and facility. For large enterprises, buildings and facilities, the TEO substantiate the composition of the construction phases, and they isolate the first construction phase with the technical-economic indices and construction cost required for approval. The complexes being started up must be planned in the first phase of construction. The TEO are developed and confirmed for the subsequent phases by the established procedure.

The technical-economic substantiations have been developed with broad use of advanced experience with respect to analogous operating enterprises (facilities) and the most effective planning solutions.

The TEO are developed in accordance with the work plans for compiling the TEO approved by the corresponding agencies. The leading planning organization of the branch executes the TEO calling on the territorial planning organizations and, if necessary, the organization that compiles the plan for development and siting of the branch of industry, specialized planning research and design organizations, scientific research institutes and institutes of the city planning profile.

When compiling the TEO, the necessary research must be performed (or research data collected) in the area where the enterprise, building or structure is to be placed in the required volume for selection of the site and determining the cost of construction.

The technical-economic substantiations are formulated as an explanatory note with the application of the required calculation, tabulated and graphical data.

The TEO are agreed upon, considered and approved in the established procedure.

The volume and the degree to which the TEO materials have been worked out are more precisely determined by the branch standards as a function of complexity and national economic significance of the planned projects.

Below, considering the requirements of the Instructions for the Development of Plans and Estimates for Industrial Construction [5] and the Instructions on the Layout, Procedure for Development and Approval of the Technical-Economic Substantiation (TEO) of Planning, Design and Construction of Large and Complex Enterprises and Facilities [47], an example of the contents of the TEO for planning, design and construction or reconstruction of a shipyard is presented.

Initial Principles. The given section discusses what the substantiation for the development of technical-economic substantiations of construction or reconstruction of a shipyard is (the nomenclature, class and location are indicated), a description of the role of the given shipyard in the master plan for the development and siting of enterprises of the shipbuilding branch is given, and the factors of expediency of construction or reconstruction of a shipyard in the given geographical region are presented.

The TEO for reconstruction of a shipyard provide data as to when it will be funded and where it will be located, data on the area and the possibility of siting of new buildings and facilities on it, the indices of production output before reconstruction, the layout and a description of the state of the basic means of production, including data on the buildings and facilities, the basic process and materials-handling equipment, the number of workers and also materials on provision of the shipyard with raw material, intermediate products, finished products by cooperation, accounting data on the consumptions of all forms of energy and existing sources of power supply, water supply and sewage, primary data and indices on the previously approved plan, data on provision of the shipyard workers with housing and an overall analysis of the yard from the point of view of the conditions of future remodeling of it.

Substantiation of the Need for the Construction of a New Shipyard in a Given Region or Rebuilding of an Existing One. This section discusses the summary calculated data on the plan for prospective development of the shipbuilding branch by phases and types of construction of ships, for the production of which the necessity for building new or rebuilding existing shipyards is revealed. The demand for the construction of ships, support of it by the existing enterprises of the shipbuilding branch and the necessity for creating new capacity have been established. Beginning with the latter, the calculation program is defined for which the construction of a new shipyard or rebuilding of an existing one is needed.

The analysis of the ship production by the prospective plan and the shortage of ships is carried out beginning with the characteristics and technical level of the objects of production, specialization, series nature of production output and the possibilities, accordingly, of introducing advanced forms of organization of production and methods of shipbuilding, the volume and nomenclature of possible cooperation with respect to the basic and auxiliary production under the conditions of the given area, the prospective development of industry in the region, including for the needs of the shipbuilding branch.

By the defined design program for a new or rebuilt shipyard, along with the characteristics of the ships, an estimate is made of their quality, their place with regard to advanced design and efficiency as a result of analysis and comparison of the basic technical operating characteristics and technical-economic indices of the designed ships with the data and indices of analogous Soviet and foreign-built ships. Consideration is given to the introduction of mechanization and automation of the control of the machinery and the ship as a whole, the satisfaction of the requirements of the international conventions, the Rules of the USSR Registry and the Gosgortekhnadzor agencies, improvement of living conditions for the crew, and so on.

Provision of the Shipyard With Various Types of Power (Electric Power, Water, and so on), Raw Materials and Intermediate Products. In this section approximate data are presented on the proposed installed power of the current pickups and the annual electric power consumption, the demand for heat, and the steam consumption for process needs, the demand for compressed air, gas, fuel oil, acetylene, oxygen, carbon dioxide, argon, production process and general plant water supply, fuel and sewage. The demand for raw materials, intermediate products and finished products is defined by the basic nomenclature indicating the quantity, a brief characteristic and sources of supply or by cooperation. Approximate data on the demand for basic building materials and intermediate products are also presented by the basic nomenclature in the required quantity with indication of the place of obtaining them (open-pit mine, plant, and so on).

Substantiation of the Siting of the Shipyard. Master Plan and Transportation Network. The version of siting the shipyard is selected on the basis of the optimal technical-economic indices with complete observation of the laws of the USSR and Union Republics regarding the use of mineral, land, water, forest and other resources, environmental protection, restriction of the development of large cities and other directives.

The following information is presented in the comparative characteristics and technical-economic indices:

the siting of the shipyard;

basic areas of development of industrial enterprises in the region and possibilities of cooperation;

number of population;

provision with actual living space and the norm per person;

the presence of available manpower;

the presence of middle and higher specialized schools, professional-technical and other technical training institutions with the number of students;

nearest populated areas;

possible dimensions of the construction site;

correspondence of the siting of the shipyard with respect to the rayon plan or the future development of industry and the city (populated area);

conditions of transport communications with the railroads of the Ministry of Railways, public highways and waterways;

provision with water and power during construction and operation of the shipyard, conditions of obtaining them and length of the service lines;

length of the external sewage networks;

industrial waste and purification facilities;

the presence and capacity of local construction organizations and construction industry;

the presence of local building materials;

the distance to the primary sources of raw material and fuel;

the presence of creep and karstic phenomena in the region and underground workings [mines];

seismicity and climatic conditions of the region;

relief of the site (minimum and maximum altitudes);

brief soil characteristics (calculated loads and other data);

the body of water and its identity with the basin, protection and depth, channel and the possibility for the exit of ships;

aggressiveness of the water;

fluctuation of the water level, the highest wave action and drifting of the water area;

duration of the freeze-up and thickness of the ice;

amount of excavation required, including rock excavation, for shaping the site, the water area and approaches.

The site plan and the master plan for the shipyard with indication of the location of new and existing buildings and structures, transport routes, sites for possible expansion of the shipyard and construction phases, sanitary-protection zones, the basic indices with respect to the master plan are briefly described, and information is presented on the freight turnover and organization of transportation. The site and master plans and the data on the shipyard freight turnover are presented in the appendix.

Basic Process Solutions and layout of the Shipyard. In this section the recommended methods of shipbuilding and the production process of the shipyard are presented, considering the basic trends in designing enterprises of the shipbuilding branch, beginning with the most immediate prospects for development of science and engineering and substantiation of the expediency of their application; the composition of the shipyard and its basic shops; calculation and substantiation of the choice of the basic equipment considering the future planned output and also the specially built equipment and initial requirements on its construction; the required area and compositional layout of the main production buildings and facilities; calculation of the number of workers; requirements on the level of mechanization and automation of the production processes and the technical level of production; cooperation of the repair, auxiliary and preparation shops with the enterprises of the rayon.

When rebuilding a shipyard, the dependence of the organizational, process and other solutions on the existing means of production, the possible and expedient trends and the volume of reconstruction, the phasing of the implementation of the reconstruction measures (the production activity of the shipyard is not shut down), and other factors, in particular, the location of the shipyard in the given industrial rayon, the production and administrative ties to the rayon enterprises and possibilities for expanding them are reflected.

The calculations are made by the consolidated normative indices or by the materials of analogous approved plans.

Environmental Protection Measures. The flow rates and characteristics of wastewater and gas discharge are determined. A brief description is presented of the planned environmental protection measures connected with protecting the air, water and soil (with reclaiming of the land), production noise control measures, data on their effectiveness and substantiation of the dimensions of the sanitary-protection zone, and proposals for utilizing production waste.

Basic Structural Solutions. The theoretical floor plan and structural solutions with respect to the basic, largest and most complicated buildings and facilities (hull and makeup shop modules, covered slipways, docks, building slips, launching facilities, and so on) with the necessary diagrams and other data for determining the construction cost are discussed.

Basic Solutions With Respect to Organization of Construction and Construction Deadlines. The approximate volumes of basic construction and installation operations, and data on the presence of a construction base and the possibilities of utilizing it for the planned construction, the peculiarities of the organization of construction, times for starting construction and duration of construction are presented.

Housing and Civil Construction. The volumes of housing and civil construction are defined, and the site plan for it is presented.

Construction Cost. The cost of construction (reconstruction) of the shipyard, buildings and facilities is determined with the reliability required for correct planning and estimation of the cost benefit of capital investments, economic expediency and economic necessity for the design and construction of the shipyard, buildings and structures.

The cost of construction (reconstruction) is defined, as a rule, by the branch consolidated construction cost indices. Here price lists for the construction of buildings and facilities, estimates for the standard and repeated individual economic plans, the consolidated estimate norms, and other available data on the cost of construction of analogous projects with required coordination with local building conditions can be used.

In the summary costing for the TEO, reserve sums are provided in amounts established by resolution of the USSR Council of Ministers as of 28 July 1972, No 560, "Measures To Provide for Reducing the Estimated Cost of Construction." In the construction cost calculations if necessary consideration is given to the novelty of the technical solutions, technology and equipment; increased requirements on the environmental protection; degree of study of the geological, hydrological and seismic conditions of the shipyard site; improvement of working and living conditions at the production facility; the construction conditions in uninhabited parts of the country.

In cases where shipyard construction is planned in phases, two separate summary calculations are made--for the shipyard as a whole and for the approved phase.

Capital Investments in Fixed Capital, Construction and Production Economics. In this section the following are presented:

general data on the volume of capital investments, including the construction and installation operations with respect to industrial and housing construction considering the associated expenditures in adjacent branches of industry;

specific capital expenditures;

specific consumption of raw materials, intermediate products, fuel, electric power, and so on;

number of workers and sources of manpower, productivity of labor;

cost of basic forms of production (ships);

cost effectiveness of capital investments reckoned by the standard procedure in effect [43];

comparison of the technical level and most important technical-economic indices of the new or rebuilt shipyard with the level and indices of the existing advanced Soviet and foreign shipbuilding enterprises and also with the advanced approved technical-economic indices of the enterprises of the shipbuilding branch, previously developed and approved analogous TEO and plans.

The fixed capital of a rebuilt shipyard is presented in the TEO with subdivision into the existing fixed capital, incomplete construction, and new capital investments. The increase in fixed capital is indicated in percentages of the existing period.

Conclusions and Proposals. In the conclusions and proposals based on analysis of the data and the technical and economic indices with respect to the construction sites for a new shipyard (or with respect to versions of rebuilding an existing one) recommendations are made with respect to the optimal version of the design and construction (or version of reconstruction) of the shipyard. In the general estimate of the economic expediency and necessity for designing and building (rebuilding) a shipyard, we begin with the following basic factors:

optimalness of the given program, specialization of the shipyard for the given nomenclature of ships and their technical level; the advanced nature of the decisions made with respect to organization and production process and also the composition of the shipyard considering the maximum possible cooperation with respect to basic and auxiliary production facilities, provision with all forms of power during operation and during the construction (rebuilding) period; the advanced nature of the technical-economic indices from the point of view of minimum volume and duration of construction (reconstruction), the volume of capital investments and time required for repayment of them.

The requirements on other branches of industry arising in connection with the design and construction (reconstruction) of a given shipyard are discussed from the point of view of simplification and decreasing the cost of construction (for example, obtaining shipbuilding steel free of scale and rust and in primed form, a variety of machinery and equipment previously assembled into units, and so on).

A list of the required scientific research, planning design and experimental work and also the recommended phasing of the design are presented.

The site and master plans for the shipyard, the freight turnover (approximate data), the process flowchart with respect to the basic production facilities, the construction plans in general views, sections and facades with respect to the primary buildings and facilities, demonstration materials, agreements and planning assignments for the shipyard are proposed for technical-economic substantiation.

§4. Planning and Design Assignment. Initial Planning and Design Data

The shipyards, buildings and structures are planned on the basis of the planning and design assignment confirmed by the corresponding procedure [5].

The assignment to develop a detail-contract (contract) design is given by the customer and general designer in accordance with the plan for development and distribution of the branch, the plan for development and distribution of productive forces by economic rayons and Union Republics considering the basic engineering trends in the planning and design of the branch enterprises on the basis of the technical-economic substantiations approved in the established procedure, which must be a component part of the indicated assignment.

The basic technical-economic indices with respect to the first construction phase and for full development of the enterprise are established in accordance with the decision made on approval of the TEO. They must not become worse during future planning.

The participation of the design organization in the compilation of the planning and design assignment, just as in the choice of the construction site and the performance of the design research operations connected with it enters into the work of designing a shipyard, building or structure.

The assignment for designing a shipyard, building or structure is approved by the established procedure.

In the shipyard, building or structure design assignment, the following are indicated:

the name of the shipyard, building or structure;

justification for the design;

type of construction (new, expansion, remodeling), the substantiation for which is presented in the TEO;

the rayon, place and site for construction;

purpose of the shipyard, building, structure and brief description of production;

calculated annual program of the shipyard (project);

nomenclature and characteristic of production and capacity with respect to basic forms of it for complete development in the first phase of construction;

> Note. A change in capacity as opposed to that approved in the TEO is subject to agreement with the corresponding agencies.

for reconstruction and expansion of an existing enterprise, the degree of use of the existing production facilities;

operating conditions;

cooperation of the shipyard;

basic sources of supplying the shipyard during its operation and during the construction period with raw material, water, heat, gas, electric power, telephone and "radiofication" [development of a wire broadcast network];

requirements with respect to environmental protection and production waste recovery;

the necessity for the development of automated technological process and enterprise control systems;

basic specifications for planning and designing residential and cultural construction;

cooperation when building the shipyard as part of an industrial complex;

planned size of capital investments and basic technical-economic indices of the shipyard or structure, when building in phases—the first phase of construction in accordance with the approved TEO;

planned construction times, the procedure to be followed in realizing construction and introduction of capacity by phases and complexes being started up;

requirements with respect to development of versions of the design or parts of it for selection of optimal solutions;

phasing of the planning and design work;

nomenclature of the master plan organization;

nomenclature of the construction organization--the general contractor;

presence of agreement with territorial design organization;

additional instructions and requirements;

special conditions;

requirements on reclamation of the land.

If during the planning and design work the organization finds it necessary to introduce changes into the design assignment (including the necessity for developing an auxiliary version, not provided by the design assignment, but ensuring better technical solutions and technical-economic indices), it must be presented to the design client and the office that approves this assignment or proposals which must be considered by this office with the corresponding decisions to be made.

The supplements and revisions are introduced into the approved design assignment by permission of the office approving the design assignment.

> Note. The above-presented composition of the design assignment is more precisely defined by the standard (model) of the design assignment approved in the corresponding procedure.

In order to execute the design plans and specifications for building a new shipyard or rebuilding an existing one and also individual parts of them, the design client submits a body of initial data together with the design assignment to the design organization--the general contractor [5]. The client can commission the design organization--the general contractor--or a specialized design or research organization recommended by him to prepare the initial data required for planning and design work by separate contract.

Thus, when developing the engineering part of the detail-contract or contract design for building a new shipyard, the general designer receives the following data:

the shipyard design assignment approved by the corresponding procedure;

the design and engineering data on the ships for the design program;

topographic-geodetic, geological, hydrographic, hydrogeological and meteorological data in accordance with the existing research programs;

data on the place of holding the mooring, sea and acceptance trials;

reports on the scientific research work connected with creating new technological processes and equipment.

When developing the engineering part of the detail-contract or contract design for rebuilding an existing shipyard the client presents the following to the design organization in addition to the above-presented materials:

list of operating shops and structures (with indication of the areas of the production and general services facilities, the bulk of the building, year of construction, physical wear and arguments regarding further use);

the master plan of the shipyard with superposition of shops, facilities and structures, railways, roads and power supply network;

plan of the depths of the water area with indication of approaches to the shipyard from the water;

plans and sections of the shops and facilities of the shipyard with indication of the arrangement of equipment in them;

list of machine tools, welding equipment, materials-handling equipment, laboratory and other equipment, both installed and in the warehouses and ready for use, with indication of the basic engineering characteristics, the technical condition (percentage of wear), the cost of each unit and the place of installation of it in the shop;

the accounting data on the actual labor consumption and deadlines for building ships, data on the shift operation of the shipyard and the satisfaction of the work output norms;

accounting data and operating indices of the shipyard shops, including the annual production output in tons, labor consumption for the annual program and the ship, the composition and number of workers, the amount of process equipment, the shift index [total machine-shifts worked divided by the number of machines], level of mechanization and automation of production processes, the technical level of production, and so on;

the data on the production output, including output expressed naturally and in terms of money and cost;

the number of industrial production personnel (for the shipyard as a whole and by shops).

For preparing the detail drawings for the construction of a new shipyard both in the detail-contract design and in the two-phase planning and design (contract design and detail drawings), the design organization receives the following: for two-phase design the decision of the approving offices with respect to the contract design and the design office materials and materials of other organizations with respect to ships (if new materials which must be taken into account in the design work have been published at the time of developing the detail drawings); the technical data, outline drawings and installation drawings of the ordered equipment which include the following:

complete technical specifications corresponding to the certificate for the machine tool, unit or piece of equipment;

the outline and installation drawings of the equipment received from the suppliers;

he drawings for siting equipment with all auxiliary equipment;

"coupling" dimensions between the individual units of the assembly;

operating instructions and manufacturers' specifications with respect to the ordered equipment.

For development of detail drawings to rebuild the facilities of an existing shipyard it is necessary to have (in the case of two-phase design, confirmation of the data obtained when developing the contract design or new, more precisely defined data):

the master plan with all of the underground service lines and altitude marks superimposed on it;

topographic-geodetic, hydrographic, geological and hydrogeological materials;

a description of the production process of the rebuilt facility, the technical and physical condition of the equipment and buildings;

plans for the intrashop power networks of the rebuilt facility with indication of diameters or cross sections and physical condition of them with coupling to the intershop (operating) networks in the vertical and horizontal directions;

drawings of buildings and facilities to be rebuilt: the plans and sections of the shops and facilities with production, transport, power and other equipment superposed on them and also plans for the structural elements and devices connected with the equipment (foundations, work areas, leads of all forms of power to the workplaces, regulating and starting mechanisms, monitoring and measuring equipment), with the specifications of equipment and devices (with coupling); technical specifications and more precisely defined dimensions of the machine tools, welding equipment, cranes, power and other equipment ordered, installed in the shops or located in the warehouses (subject to relocation in the rebuilt facilities).

Chapter II. Design Phases. Preparation and Procedure for Developing the Engineering Part of the Design

§5. Content of the Contract-Detail and Contract Designs and Detailed Drawings

The design phases and content are defined in accordance with the Instructions for the Development of Designs and Estimates for Industrial Construction approved by USSR Gosstroy [5].

In accordance with these instructions, as a rule, when constructing industrial enterprises, buildings and structures it is necessary to develop contract-detail (single-phase) designs; for projects which are to be built by standard designs and repeatedly used economical individual designs and also for technically simple projects, only the contract-detail designs need be developed.

Two-phase design--contract design and detailed drawings--is permitted for large-scale, complicated industrial complexes and when using new, unassimilated production processes, pilot models of complicated production equipment, complex architectural-construction solutions and under especially complicated building conditions.

A decision regarding the phasing of the design of industrial enterprises, buildings and structures is made by the office approving the technical-economic substantiations (TEO).

In the contract-detail design for building a shipyard, shop, building or structure (or the phases of their construction) the following problems must be considered and solved:

the layouts of the transport flows of materials, equipment, structural components, modules and the ships as a whole;

specialization of production and cooperative production, methods and practice of shipbuilding and production;

the economics and organization of the production facility;

the application of automated shipyard control systems;

supplying the facility with personnel;

efficient use of the land chosen as the construction site and selection of the optimal version of the master plan;

floor space planning, architectural and structural design of the buildings and structures;

the creation of conditions for scientific organization of labor and general services for the employees;

provision for housing and general services for the shipyard (shop) employees and for the construction site;

organization of the construction and implementation of it on schedule;

protection of water areas, soil and air from pollution by wastewater and industrial waste;

re overy (reclamation) of fouled land and conservation of mineral resources;

stimated cost of construction;

technical-economic indices;

quality of the planned product, evaluation of the progressiveness and effectiveness of it in the national economy;

mastery of the designed capacities of the shipyard, shop, phase, or complex being started up in accordance with the existing norms.

The above-indicated design estimate data are presented for approval with the primary detailed drawings appended if necessary.

Simultaneously with the design estimate reports and specifications required for approval of the contract-detail design, the detailed drawings and estimate reports and specifications are developed for the buildings and structures which are to be built by individual designs, and the standard and repeatedly used economical designs for projects planned to be built in the first year are coordinated.

In the contract-detail design of shipyards, buildings and structures, the construction time of which does not exceed 2 years according to the norms, it is recommended that the detailed drawings be developed for the entire amount of construction and installation work provided for by the design, and the standard and repeatedly used economical designs can be coordinated with respect to all of the projects planned for construction if necessary.

In the corresponding parts of the contract-detail design, specifications are presented for the placement of orders for process, power engineering, materials-handling, pump-compressor, special and other equipment, for the manufacture of which a long period of time is needed and also for equipment by which the design organizations obtain the initial data for development of the detailed drawings from the manufacturing plants; lists compiled by the consolidated nomenclature, for the remaining equipment, including the general shipyard equipment, imported and non-standardized equipment, instruments, fittings, cables and other mass and series produced products.

The contract-detail designs for rebuilding small and simple operating shipyards, shops and structures are developed in reduced volume with inclusion of the materials and data, for example, the technical-economic part, the civilian housing construction in the overall explanatory note, the materials and data for the master plan and transportation, organizational construction, in the construction part, and the technical reequipment of the operating shipyard, shop and structures must be developed in the minimum required volume.

In the design-estimate reports and forms of the contract-detail design presented for approval only the materials and drawings required to substantiate the design solutions and the technical-economic indices of the design and the estimated cost of construction need be presented.

In the detailed design of the shipyard (structures) or phases of it, in addition to solving the problems discussed with respect to the contract-detail design, the following decisions made in the TEO are also considered and more precisely defined:

by the recommended methods of shipbuilding and the production process, the selected equipment and the planning, construction and other solutions connected with them;

by the production requirement for materials, intermediate products, equipment and other deliveries by cooperative effort, power, water, fuel and other resources;

by the composition of the designed construction phases;

by the master plan for the shipyard, with respect to structures and its complete development;

by the technical-economic indices and cost of all construction (by the consolidated indices).

When developing the detailed design in the necessary cases other problems can also be considered which were assumed in the TEO, for example, the decisions regarding the expediency and the effectiveness of new construction of individual production facilities, installations, shops and structures instead of controlling the production capacity of the existing industrial enterprises and structures, the initial data are more precisely defined which are required for preparing the technical specifications for connecting a shipyard (structure) to the water, electric power, heating, gas and other resources.

In the cases where it is necessary to perform scientific research and experimental work to realize construction by the detailed plan, a list of these operations with a brief description and substantiation of the requirement for execution of them are presented.

The contract design materials for the shipyard (structure) or its phases consist of the same parts as the materials of the contract-detail design.

The technical documents for equipment in the contract design were developed in accordance with the requirements discussed for the contract-detail design.

For production facilities, buildings and structures to be built by individual plans, the schematic drawings of the plan views and sections of the main buildings and structures are presented with a brief description of them and indication of the dimensions of the buildings and structures, the type of construction and type of materials.

The detailed drawings are developed in accordance with the adopted phases of designing the projects: in the single-phase contract-detail design or in the double-phase design after approval of the contract design in accordance with the decisions made in it.

In exceptional cases, simultaneously with the development of the contract design in the presence of the corresponding solution, detailed drawings can be compiled for the projects and the operations of the first year of construction.

The detailed drawings are developed in the layout and in the volume required for executing the construction and installation operations by industrial methods according to them. They are developed for the project or type of operations as a whole or by phases of operations determined in the established procedure and providing for the possibility of settlements between the client and the contracting construction organization for the completed project.

The detailed drawings of an industrial project include the following:

the detailed construction drawings, including the drawings of metal structural components;

the detailed drawings of standard and repeatedly used individual economical plans for buildings and structures tied to the construction section;

drawings (plan views and sections) of the installation of the production, transport and power engineering equipment and the service lines, structural components, devices and process pipelines connected with this equipment;

the drawings of the structures and devices connected with environmental protection, protection of labor and safety engineering;

the drawings including plan views, sections, and profiles of the routes, networks and structures for electric power and electric lighting, automation of the production processes, communications and signal system, radiofication and other networks and structures;

drawings of the heating networks and structures, ventilation, heat, gas and water supply and sewage;

the drawings of general types of nonstandard (atypical) production and power engineering structures, elements, subassemblies and structural components and also nonstandardized equipment (in addition to the nonstandardized machinery and equipment to be manufactured by individual special order) in the volume required to compile the technical assignment for development of the indicated production facility;

the lists of applied standards, standard designs and drawings of standard structural components, elements and subassemblies compiled for each basic set of drawings (the standards, standard designs and drawings of standard structural components, elements and subassemblies used in the design and also the standard designs of temporary structures indicated in the list are not distributed by the design organization);

the lists showing the amount of construction and installation operations;

corrected lists showing the requirement for structural components, products and materials for construction;

the certificate for the building and structure designs.

On the basis of the developed detailed drawings, the design organizations compile order specifications for each projects for all types of equipment delivered to the client, including nonstandardized equipment, instruments, fittings, means of monitoring, automation and communications, cable and other products.

The detailed drawings with respect to all basic parts of the design are executed by the assignments of the engineering designers and must be executed by agreement with them.

The engineering part of the detailed drawings are produced last after the final decisions are made with respect to all basic parts of the design.

The standard designs are coordinated when developing the contract-detail design in accordance with the instructions discussed above and when developing the contract design, after approval of this design, in the detailed drawings.

When coordinating the standard designs of buildings and structures, the design organizations proceed as follows:

they determine the coordinates and the levels of the parts of the buildings and structures, dimensions and depth of foundations, if necessary they change the structural solutions for the foundations and underground facilities, they develop additional structural measures required by the hydrogeological conditions of the construction site;

they correct the solutions for the foundation or basement levels of the buildings and also the junctions for fitting adjacent tunnels, corridors, galleries and other similar structures considering the relief of the building site;

they develop junctions for tying onto the water supply, sewage, district heating, power and communications networks and also transportation units and service lines;

they determine the thicknesses of the outside walls and the insulating layer of the enclosing structures, and they also more precisely define the number and type of heating and ventilation units in accordance with the climatic conditions of the construction zone;

the types of structural components corresponding to snow and wind loads in the construction zone are selected;

they introduce the required changes into the detailed drawings of standard designs when individual types of equipment are taken out of the facility at the beginning of construction, and they also alter the drawings of the standard structural components, the construction norms and rules and other normative documents in accordance with the engineering and construction design;

they eliminate errors detected in the standard designs and report them to the organization disseminating the design and the organization developing it.

The design organizations bear responsibility for the quality of the reports and forms developed with the application of standard designs, and they can, by permission of the ministries and departments of the USSR and the councils of ministers of the Union Republics, introduce changes into the standard designs in connection with the application of more advanced production processes, space-planning and construction solutions (using standard, unitized structural components and by agreement with the contract construction organization), improving the technical-economic indices and lowering the building costs of the project.

In the materials for coordinating the standard design it is necessary to substantiate the introduced alterations and also provide data on a comparison of the technical-economic indices of the approved and corrected design.

§6. Preparation of the Engineering Design

After obtaining the assignment for the design approved by the corresponding office and agreed on by the established procedure, and signing the contract to develop the design and obtain the initial data for the design, the chief design engineer develops and distributes the "basic instructions (rules) for development of the design" to the departments. This document develops and more precisely defines a number of the items in the design assignment. It is approved by the manager of the design organization (the general designer).

In individual cases of the most complicated projects the "basic instructions" can be considered by the engineering council of the design organization with the participation of representatives of the client and the office approving the design assignment.

It is expedient to agree with the client on the "basic instructions" for rebuilt shipyards.

In the "basic instructions for development of the design," along with other data, the following data are presented for development of the engineering design:

the complete production program of the designed shipyard (with respect to ships and other products);

nomenclature of example ships to which the remaining ships will lead (in the case of designing a shipyard by a presented program);

instructions for production cooperation of the designed shipyard with other enterprises with respect to obtaining both contract deliveries and deliveries by interplant cooperation;

the planned layout of the shipyard and its buildings (siting of shops and individual production of facilities with respect to the buildings) for production and auxiliary purposes and also the storage areas and other facilities;

the phasing of the design and volume (depth) of development of the engineering design of individual shops, buildings or types of production facilities;

the direction with respect to the introduction of the latest production processes, the application of new techniques and equipment, Soviet or imported equipment, the possibility of using international currency and also the introduction of means of mechanization and automation of production processes and automated production control systems;

the instructions with respect to the application of standard and repeated designs.

The layout of the shipyard and the blocking of the buildings planned in the "basic instructions" before beginning the design work can be corrected and more precisely defined during the process of preparing the design and when developing the design.

Along with the development of general "basic instructions for design development" and distribution of them to the departments of the design organization for the engineering departments, the assignment for the engineering design is developed and distributed to them.

The development procedure and the content of this assignment are established as a function of the organizational structure of the design organization. For example, in the assignment to develop the engineering contract-detail or contract design of a shipyard the following basic data are presented with indication of their archive (stock) numbers and locations in the design organization:

the approved assignment for the design or another document upon the basis of which the design work must be done;

a list of resolutions, orders and instructions which must be considered when developing the design;

the predesign developments (technical-economic substantiations, arguments, and so on);

the design materials by objects of production (ships and other products);

the production materials with respect to the ships and other products in the calculated program;

the recommended design and published materials which must be used when developing the design;

proposals and arguments with respect to the basic areas of development of the design, the necessity for developing versions and their basic content, the layout of the shipyard, the design layout, and so on.

In the assignment for development of the engineering contract-detail or contract design to rebuild a shipyard (facility), in addition to the above-presented data, information is given on the presence and the location of the following materials:

the effective design materials for the shipyard (facility) which must be used when developing the design;

the plan views and sections of the shops and structures of the shipyard with siting of the equipment and the workplaces in them;

data on the machine tool, welding, materials-handling and other equipment, both installed and in the storage areas and suitable for use with indication of the technical data, the wear (percentage wear) and cost of each unit;

the accounting data and the operating indices of the shops, including the annual production output, the labor consumption for the annual program, the composition of employees, the amount of production and materials-handling equipment, the areas, the shift index of the workers, the level of mechanization and automation of the production processes and the technical level of production.

When developing the contract-detail design the client presents the initial data considering the requirements for the development of the detailed drawings discussed below.

In the case of absence of the engineering materials with respect to their production facilities, including data on the methods, practice, volumes, labor consumption and duration of construction of ships with respect to the basic phases, the necessity for developing them by the design organization engineers is indicated in the assignment.

When the client does not have the initial data available on the shipyard to be rebuilt, the necessity for inspecting the shipyard to gather and process materials for compiling the engineering design is indicated in the assignment.

The design organization performs this work by a special contract with the client during the predesign period.

In the case of two-phase design (the contract design and the detailed drawings) the following data and materials are discussed in the assignment for executing the detailed drawings of the engineering design with indication of their archive (stock) numbers and location:

the previously executed contract design;

the decision of the superior office with respect to approval of the contract design;

the resolutions, orders and other directive instructions of the superior agencies (the CPSU Central Committee, the USSR Council of Ministers, USSR Gosstroy, the ministry) adopted after approval of the contract design which must be considered when executing the detailed drawings;

new materials of the design, scientific research and other organizations with respect to the objects of production (ships) which are to be considered when executing the detailed drawings;

a list of remarks and proposals of the expert organizations which must be considered and taken into account when executing the detailed drawings;

recommendations of the chief design engineer with respect to execution of the detailed drawings.

When executing the detailed drawings for rebuilding the shipyard (project) both as part of the contract-detail design and in two-phase design, instructions are presented on the following available materials (or the necessity for obtaining them from the design client):

plan views and sections of the shops and facilities with superimposition of the production, power engineering, warehousing and other equipment on them and also the structural components and structures connected with the equipment (foundations, work areas, feeds of all types of power to the workplaces, the adjusting and starting mechanisms, monitoring and control equipment) with specifications for the equipment and structures coordinated in the drawings;

the technical data, including the general type drawings, the layout and installation drawings of the ordered equipment, the equipment installed in the shops and at the warehouses (subject to location and installation in the rebuilt facilities), machine tool, welding, crane, power engineering and other equipment.

In individual cases instructions are given on the rendering of technical assistance to the client in the preparation of these materials which is spelled out in a special contract.

§7. Brief Content and Sequence of Execution of the Engineering Design

The engineering design of shipyards and shops is a complicated process connected with a significant number of adjacent design subdivisions, with external enterprises and organizations.

A brief content and sequence of execution of it are presented in the example of developing the contract design and detailed drawings.

When developing the contract design, the engineering design can be broken down approximately into the following basic phases:

i. obtaining the materials and the assignment for development of the contract design for construction or rebuilding of a shipyard (shop). Study of the materials and the initial data for the design work. Substantiation of the methods and development of the theoretical production process with determination of the volumes and labor consumption with respect to basic forms of operations and also the shipbuilding time with respect to the basic steps.

ii. determination of the required production equipment, of the composition of the employees and work areas. The development of the basic design solutions and agreement on them with the client and other organizations.

iii. the development and distribution of assignments for the construction design, including noise control measures and the design of hydroengineering structures.

iv. calculations and substantiations. The preliminary agreement when obtaining solutions with respect to the construction and hydroengineering parts of the design.

v. development and distribution of assignments for execution of designs of the means of mechanizing materials-handling operations and the master plan and internal transportation system of the shipyard.

vi. continuation of the calculations and substantiations, agreement on and obtaining of the design solutions with respect to mechanization of materials-handling operations, construction and hydroengineering parts of the design.

vii. development of coordinated shop plans with mutual coordination of the location of the production and materials-handling equipment and mechanization means. Consultations with respect to the design planning solutions with specialists from the Gossaninspektsiya [State Sanitation Inspectorate] and the fire safety agencies.

viii. the development and distribution of assignments for designing the power supply, production control hardware, communications and signal system, the process monitoring devices, automation, heating and ventilation, air conditioning, water lines and sewage, environmental protection measures, and so on.

ix. the development and distribution of the assignments for special construction operations;

x. agreement on solutions with respect to the shop and section plans with adjacent design subdivisions.

xi. completion of execution of the detailed drawings and explanatory notes to them, signing and acceptance for formulation.

xii. waiting, checking out the filled out design forms and reports and acceptance of them for final formulation, signing of the filled out design and acceptance of it in the archives.

An example sequence of execution of the engineering detailed drawings of shipyard shops by basic steps and their interrelation to the adjacent design subdivisions, external enterprises and organizations is presented in Figure 2.

Key to Figures 1 and 2:

1. Chief design engineer
2. Design client and specialized enterprises and organizations
3. Architectural-construction design, including noise control measures
4. Hydroengineering structure design
5. Development of designs for the means of mechanizing materials-handling operations
6. Master plan and internal transportation for the shipyard
7. External enterprises and organizations
8. Gossaninspektsiya and fire safety
9. Pneumatic, gas, process steam and oil supplies
10. Electrical equipment and electric power supply, trolley lines, electric drives, electrical equipment of the test stations
11. Automated systems and production control hardware, communications and signal system, production control, automation of the units and sections
12. Heating and ventilation, air conditioning
13. Internal and external water lines and sewage
14. Environmental protection measures
15. Compiling estimates for the production equipment and mechanization means
16. Compilation of the production cost, consolidated data on the equipment and cranes, on the shipyard as a whole, calculation of the cost of unused equipment
17. Execution of demonstration materials
18. Filling out design forms and reports
19. Technical archive
20. Reviewers and approving office or agency
21. Heating and ventilation, air conditioning, atmospheric protection
22. Internal and external water lines and sewage, water protection

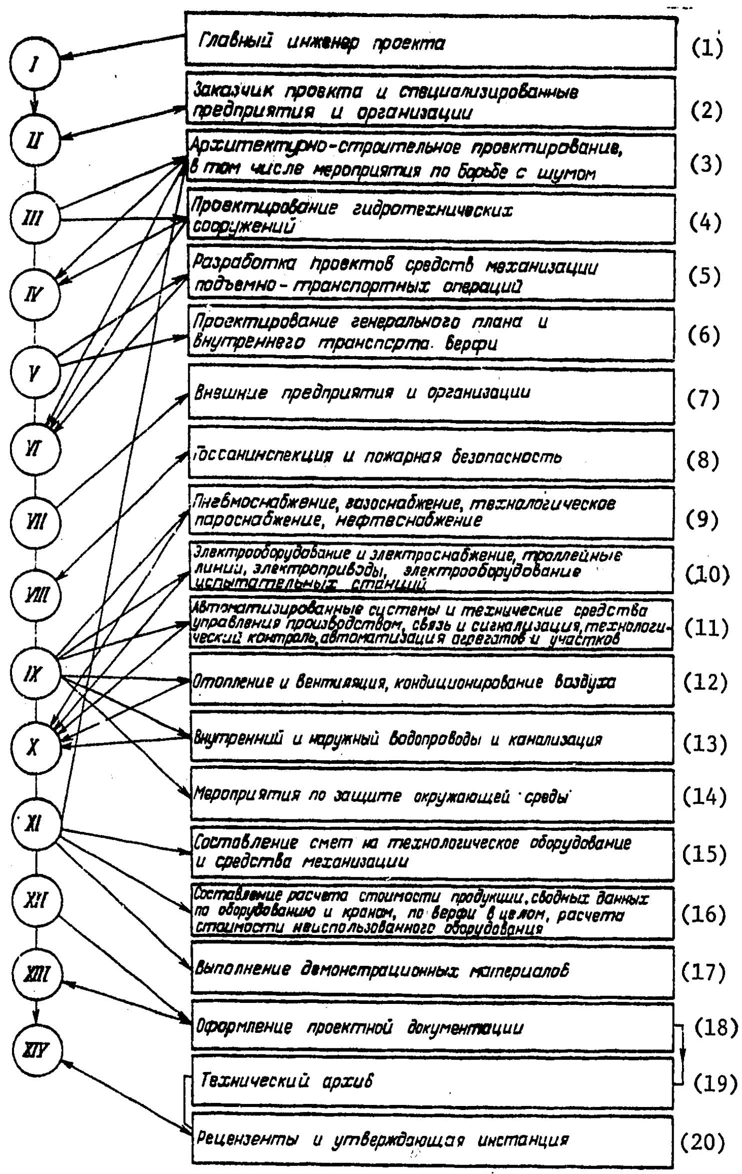

Figure 1. Example sequence of execution of the engineering design of shipyard shops by basic phases and interrelation of it to the adjacent design subdivisions, external enterprises and organizations. I-XIV--basic steps in developing the engineering design of shipyard shops.

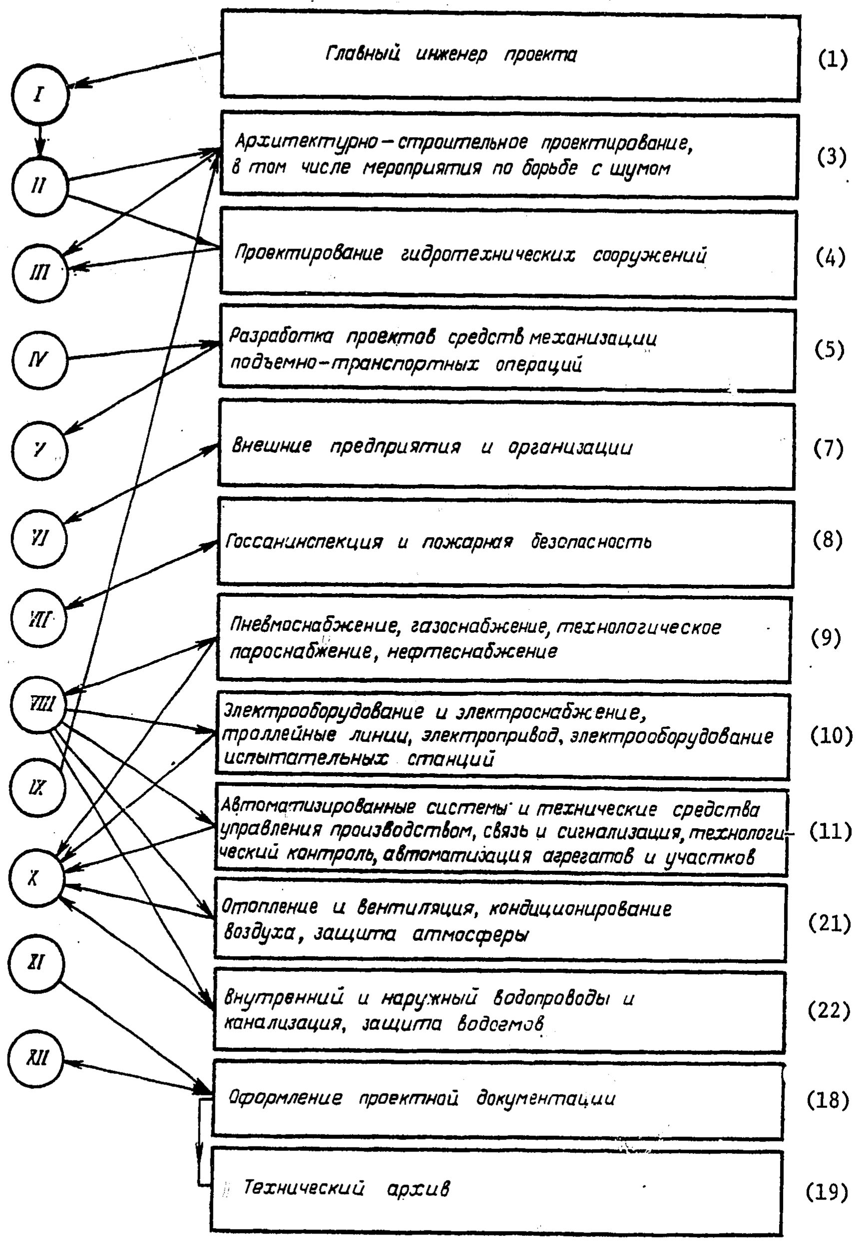

Figure 2. Approximate sequence of execution of the engineering part of the detailed drawings of shipyard shops by basic steps and their interrelation to the adjacent design subdivisions, external enterprises and organizations. I-XII--basic steps in developing the engineering part of the detailed drawings of the shipyard shops.

Chapter III. Methods and Organization of the Building of Ships Used When Developing the Designs for Building and Rebuilding Shipyards

When developing the complex contract-detail or contract designs for building new shipyards or expanding and rebuilding the existing ones, before proceeding with the design developments by individual shops and structures it is necessary to develop the general principles of the methods and organization of the building of ships considering advanced experience in Soviet and foreign shipbuilding.

When expanding and rebuilding shipyards it is also necessary to consider the effective use of the existing production means, in particular, such expensive items as the shipbuilding ways and launching facilities.

§8. Methods of Building Ships

The method of building ships when developing designs for building or rebuilding shipyards is selected considering specific conditions of their location (the site, the water area, climate, and so on) and, above all, beginning with a comparison of the capital investments and the cost benefit of building the ships.

When designing shipyards the following basic methods of building ships on the shipbuilding ways are considered and analyzed: sectional, in which the ship is formed from previously assembled and welded subassemblies and sections; modular, in which the ship is formed from previously assembled modules (zones) of the ship installed in a specialized shop or section; modular-sectional, in which the ship is formed from previously assembled and installed modules (zones of the ship most saturated with machinery, equipment, systems, and so on) and sections in the hold or tank areas.

In the sectional method, the hull of the ship is formed by the pyramidal or island method on the shipbuilding ways.

The pyramidal method of assembly and welding can be used when building both large, medium and small ships. The ship's hull is broken down into "pyramids," consisting of planar and volumetric sections, considering that provision will be made for fast forming of the hull in the transverse cross section, maximum completion of the hull compartments in each pyramid and simplification of the assembly-welding operations. A deficiency of this method is the limited operations front and the impossibility of conducting the assembly-welding operations simultaneously in more than two zones from midships to the extremities, which increases the building time of the ship, in particular, when building long hulls.

The island method of assembly and welding is expedient when building large ships. The hull is broken down into several building zones--"islands," the formation of which is by the pyramidal method. By comparison with the pyramidal method, the island method provides for expansion of the front of the assembly-welding operations on the shipbuilding ways and reduces the overall building time of the ship.

The modular-sectional method is expedient when building transport ships having a broad cargo hold or tank zone which by comparison with the other zones of the ship requires significantly less expenditure of time for erection. This method can be used both in newly designed shipbuilding enterprises and those being expanded or rebuilt with different types of shipbuilding ways and launching structures. It is also expedient in cases where the shipyards have shipbuilding ways, the length of which permits an entire ship to be placed on them simultaneously with the module-zone of another ship requiring significantly more time for erection than other zones. Here, on inclined ways, the module is fitted to its location in the overall ship on slides, at the same time as on horizontal shipbuilding ways the module is brought to its position in the ship in the majority of cases on the ship-cradle trolleys.

For more intense use of the shipbuilding ways and launching facilities, other procedures for building the ships can also be used.

The modular-sectional method has recently become widespread at foreign, primarily Japanese, shipyards under the name of the "tandem" method of building large tankers in drydocks [40], in which the entire hull of one ship and the stern of another are formed simultaneously on a dock (or docks).

In the modular method of building, the ship on the ways is formed from modules assembled and erected in a specialized shop designed for this purpose. The forming begins with the base module which is selected depending on the type of ship, the overall process of building it and the nature of the shipbuilding ways, beginning with the conditions of accelerating the installation work. The modular method can be used to build small and medium ships, and in individual cases, also large ships of various classes. This is the most advanced method of building, for minimum welding deformations of the hull are obtained, and in addition, it permits organization of the most efficient flow-position building of the ships with movement of them from one position to the next.

The building of ships by the flow-position modular method permits the following: breakdown of the operations with respect to individual positions; significant expansion of the work front on each ship being built; improvement of the organization of material and technical supply as a result of specialization of the shipbuilding positions; the reinforcement of specialized production accessories and fitting brigades for each position; broader introduction of unitized and large subassembly methods of installation; reduction of not only the time spent on the shipbuilding ways, but also the entire building cycle of the ships; intensification of the use of the shipbuilding ways and launching structures and, at the same time, a sharp reduction in capital investments for the creation of these expensive structures.

The possibility of organizing the modular method of building ships at some of the existing shipyards depends to a significant degree on the specific conditions, especially the master plan of the enterprise.

The improvement of the methods of building the ships has as its goal increased carrying capacity of the expensive shipbuilding ways and launching facilities as a result of transfer of a significant volume of the operations from the shipbuilding ways to the assembly-welding shops, the module-building and unitization shops and uncovered areas; it proceeds along the path of forming the ships from large unitized sections and modules with complete fitting of them, which could be used for forming the hull of ships of analogous designs. The latter has, for example, found reflection in the modular method of building ships, the essence of which consists in the fact that the hull of the ship is formed at the construction location from the standard modules for the midships section (a cylindrical insert), the bow and stern and superstructures. The modules are like (standard) modules having complete or almost complete outfitting and assembled from unitized sections. The modular method can also be used when building individual hull components, superstructures, living, service and general services facilities, and so on.

The modular method gives the greatest benefit when building ships in large series. For defined specific climatic conditions the hull-building method used at the "Gotawerken" Shipyard in Arendal (Sweden) is of interest [41]. At this shipyard the head of the dock runs approximately 30 meters into the covered building of the assembly-welding shop where sections and modules weighing up to 300 tons are assembled. The shop bay is equipped with two 150-ton bridge cranes and two 15-ton cranes, the tracks of which are at different elevations, as a result of which the cranes can operate simultaneously without interfering with each other.

The assembly of the ship's hull begins with the stern zone at the head of the dock which runs into the covered shop building (see Figure 3). Simultaneously the machinery, piping and other equipment are installed in the module. The assembled stern module is moved out of the shop to the outside part of the dock, and the next module is built on the part of the dock inside the shop. Special attention is given to precision of fitting the joint elements in the joined sections. Each completed module is joined to the previously prepared part of the hull and advanced together with it on special cradles through the shop entrance to the outside part of the dock.

The dock is equipped with seven lines of concrete shipbuilding ways along which the cradles are moved with the finished part of the hull a distance of up to 14.5 meters at a speed of about 1 cm/min by using 700-ton hydraulic jacks. Between the cradles and the ways there is a layer of plastic with very low coefficient of friction which excludes lubrication. The primary machinery and superstructures are installed on the part of the hull that extends outside. The superstructures are first assembled in large sections in the shop and are fed to the dock cranes on trailer trolleys.

The inside outfitting operations are conducted during assembly of the hull; after completion of assembly and welding of the bow section of the ship it is considered ready for floating, and after a short time interval, ready for sea trials.

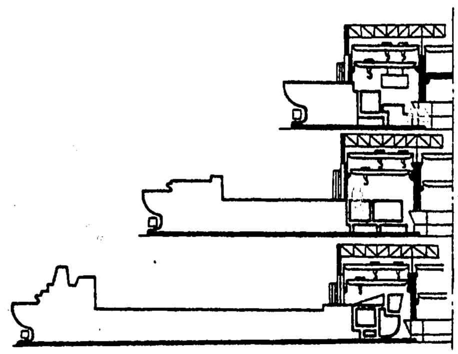

Figure 3. Diagram of the formation of a hull in the hull assembly shop of the "Gotawerken" Shipyard in Arendal.

Initially there was insufficient length for building large ships on the shipbuilding ways, and then in order to reduce the building time and save capital investments in creating the shipbuilding ways and launching facilities, the method of forming the ships from two parts with subsequent joining of them after launching or leaving the dock became widespread. The joining of the individually built halves of the ship can be accomplished in a dock of the corresponding dimensions or afloat with the application of special devices.

Building ships with the formation of them from two parts sometimes can be expedient also at a dock which permits complete construction of the ship. This pertains to ships, for the construction of which the greatest labor and time are spent on forming the stern of the ship in which the machine room and deck superstructures are located.

In this case first the stern parts of two ships are built at the dock, and they are moved to the outfitting quay where the installation, outfitting operations and mooring trials take place. After removal of the stern parts, the bow parts of the ships are built in the dock, and then they are joined with the sterns in the same dock.

For formation of the hull of a ship from parts afloat, several procedures and devices have been developed [20, 39, 40]. As an example, it is possible to present two types of caisson structures, a system for connecting them with application of a special rubber strip and hinged seal for joining the parts of a ship afloat.

The first caisson is a U-tube (see Figure 4) encompassing the underwater part of the joint from side to side under the bottom of the ship. The tube consists of two halves welded to the hull of the ship and joined by bolts. Divers go underwater to join them, and these divers simultaneously install a watertight gasket along the weld. Then the water is pumped out, and welding operations are conducted inside the caisson.

The two parts of the ship are trimmed by ballast, and winches with an electric drive are installed on the deck to pull one part of the hull up to the other. In order to avoid vertical relative displacement of the parts of the ship as a result of wave action, or for other reasons, wedge clamps and bolted clamps are temporarily installed at defined distances in the underwater part of the joint. These are removed after the welding operations are completed. Then the welding of the joint is completed, the painting operations are completed, and the caisson is dismantled.

The second structural design of a caisson (see Figure 5) for joining the parts of a hull afloat consists of three sections: the horizontal bottom and two side parts with bilge sections.

The bottom 1 of the caisson and its walls 2 form the inside cavity of the caisson, the dimensions of which are sufficient for the welders to work in it. Inside this cavity the walls 7 enclose ballast compartments 3. The caisson box is reinforced by a longitudinal stiffening rib 13 and transverse ribs 14. The flanges 4 of the vertical walls 2 are equipped with stops 6 adjacent to the bottom of the ship 10 and seals 5.

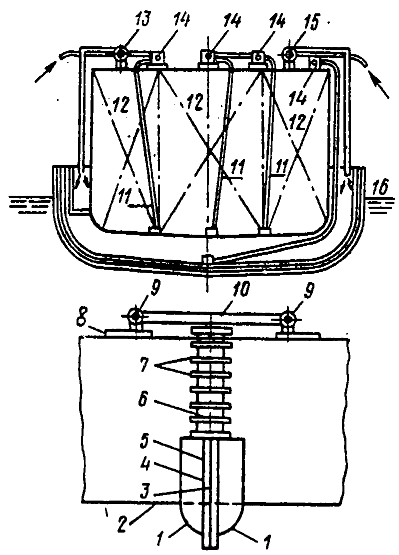

Figure 4. Caisson structure for welding two parts of a ship afloat. 1--parts of the caisson installed on the hull and bow sections of the ship; 2--bottom of the ship; 3--rubber gaskets; 4--connecting flange of the caisson; 5--clamping bolts; 6--clamps with bolts; 7--temporary wedge clamps; 8--upper deck; 9--electric winches; 10--cables for drawing up the parts of the ship; 11--drainage lines; 12--ballast tanks; 13--delivery fan; 14--pump; 15--exhaust fan; 16--water level.

For initial pickup of the caisson, the couplings 11 and 12 are used which are joined by cables to the crossarm supported by the crane.

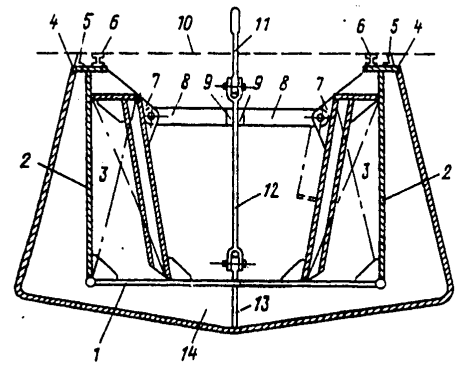

Figure 5. Caisson for joining parts of a hull afloat (section of the bottom part of the caisson parallel to the DP of the joined parts of the ship).

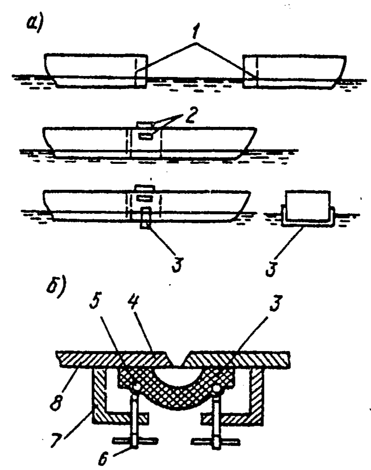

Figure 6. Diagram of joining two parts of a ship afloat with the application of a special rubber strip: a--general view; b--cross section of the joint in the diametral plane of the ship. 1--watertight bulkheads; 2--temporary connections; 3--rubber strips; 4--air space; 5--steel bar; 6--clamping screw; 7--angle; 8--bottom of the ship.

In the working position the couplings 12 are connected by bolts to the flanges 9 of the supporting stops 8. After pumping the water out of the compartments 3 of the caisson it is clamped to the hull of the ship, the water is pumped out of its inside cavity, the couplings 11 and 12 are laid on the bottom 1, the stops 8 on the walls 7. The bottom section of the caisson is joined to its side sections using sections of smaller transverse cross section entering into the lateral sections of the caisson with seals along their perimeter.

For the version of joining individual parts of the ship afloat with the application of a special rubber strip (see Figure 6), also after separate building and launching of the stern and bow parts of the ship, their heel and trim are eliminated by the corresponding ballasting, the parts of the ship are joined, and their position is fixed by temporary connections. Then a rubber strip is installed along the joint, the edges of which are tightly clamped against the plating of the ship using screws, steel bars and angles. The angles are tack welded to the plating with an interval of 1.5-2.0 meters. Then the water is pumped out of the compartment, and one-sided welding is done inside the ship.

The hinged seal (see Figure 7) is a relatively rigid floating collar of hollow design made of two hinged halves having a moving flexible tube seal along the inside supporting contour and stationary rubber gasket seal in the upper part of the joint in the diametral plane. In the upper part of the hinged seal between the sealing junctions there is a working chamber for transporting the attachments by winches during the welding process with reverse forming of the weld, gamma-ray inspection, cleaning and painting of the shell plating adjacent to the installation joint.

The possibility of the structure slipping within the limits of 20-100 mm sideways permits free positioning of it against the hull of the ship. Each half of the structure is divided into three tanks: two bottom and one side. The tanks have constantly open bottom sea valves for admitting and removing ballast (water). The tanks are blown out with air from the shipyard air main. The method of forming the hull of the ship from two parts afloat has a unique application. Without further improvement or technical-economic substantiation it can still be recommended for broad application in building and rebuilding shipyards.

When building small ships, which, as a rule, are built in large sections, the overall dimensions and weight of the sections and modules in practice are not limited in any way for the existing possibilities of creating modern transport means. There is a trend toward building ships from the maximum consolidated elements by the so-called monomodular method [40].

One of the versions of this method is building the ships from two halves formed by dividing the ship along the diametral plane. The indicated parts of the ship, including all of the elements of half of the hull can be assembled and welded in any area of the shipyard without expensive jigs and other accessories. The finished parts of the hull can be moved to the point of final assembly by any materials-handling means, including powerful caterpillar-tracked cranes.

Another version of the monomodular method of building small ships is the process in which the midsection of the ship's hull in the first position is assembled keel up in the form of a monomodule with simultaneous installation of various fittings.

The stern and bow sections are assembled separately. At the second position, the monomodule is tipped over using a special manipulator. At the third position the bow and stern sections are joined, and the greater part of the machinery is installed. At the fourth position the superstructure modules are installed. At the fifth (outfitting) position, the final outfitting and launching take place. As soon as the hull of the ship is moved to the second position, the next ship is set up, and the entire cycle repeats.

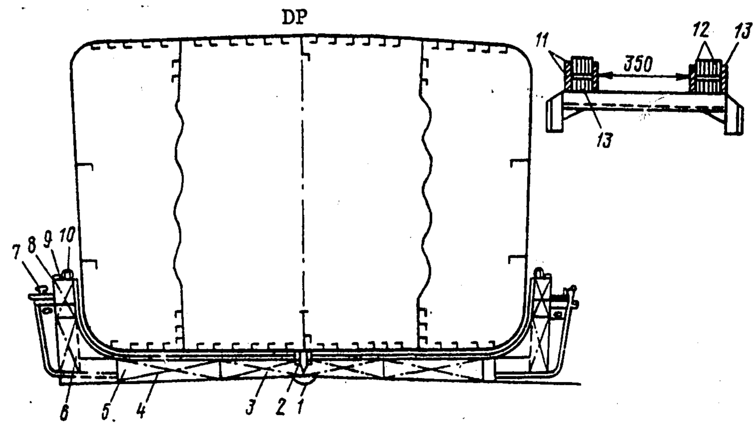

Figure 7. Diagram of a hinged seal. 1--hinge; 2--hinged seal breakdown lock; 3, 4, 6--central, middle, side tanks of the hinged seal; 5--bilge wells; 7--pumps of the system for draining the working chamber of the hinged seal; 8--air buoyancy tanks of the hinged seal; 9--lugs; 10--manual winches; 11--contact rubber; 12--seal collar; 13--seal tubing.

The final decision with respect to selecting the optimal method of building ships is made after analyzing the technical-economic indices and the conditions of building or rebuilding the shipyard. For example, when developing the designs for expansion and rebuilding of shipyards this choice is determined by the following arguments:

if the shipyard program is enlarged and for execution of it by the sectional method it is necessary to build new shipbuilding ways or to apply more advanced methods (let us assume, modular or mixed), and the cost of construction of the shipbuilding ways providing for building ships only by the sectional method is higher than the cost of introducing the new method, then it is expedient to introduce the new method of building ships in this case;

if the shipyard program is also enlarged to execute it by the sectional method, it is necessary to build new shipbuilding ways for which the cost of the ways turns out to be lower than the total cost of rebuilding providing for the introduction of the modular method, the expediency of using the modular method is determined by additional calculations and arguments;

if the length of the shipbuilding ways, in addition to building of one ship, permits simultaneous assembly and installation of the zone of the module most saturated with fittings with subsequent movement of it to the ship-forming location, then it is expedient to use the modular-sectional method of building ships, and so on.

Along with the optimal method of building ships, in the shipyard designs provision is made for the most improved methods of parallel performance of operations on the hull as a whole, fittings, and, primarily, transfer of the maximum possible volume of mechanical installation work from the shipbuilding ways to the shops. Here unitization of the main power plants, the main and auxiliary machinery, systems and pipelines in a shop has special significance, and when building dry cargo vessels, it is significant to assemble the hatch coamings and install the hatch covers in the deck sections in a shop.

Note. All of the data and indices are presented as applied to the provisionally adopted methods of building ships: at Class I shipyards, the sectional method, at Class II, III and IV shipyards, the modular method, and at Class V shipyards, the sectional method on container flowlines.

§9. Flow-Position and Flow-Brigade Methods of Organizing the Building of Ships

In the designs of shipyards at the present time primarily provision is made for two methods of organizing the building of ships: flow-position and flow-brigade.

In the case of a flow-position method, the building is done on flowlines having specialized locations--positions--at which defined types and volumes of operation ("process steps") take place, after which the module or the ship is moved to the next position. The specialized brigades are attached to the corresponding positions, that is, they have permanent workplaces.

The flow-position organization of the building of the ships at the present time has come to be widely used when building both small and medium ships and large tankers. As an example, some diagrams of position-flow construction of large tankers in the drydocks of the new Japanese shipyards at Koyagi of the "Mitsubishi" Company, in Ariak of the "Hitati" Company and in Tita of the "Isikavadzima-Kharima Heavy Industries" Company are presented [40].

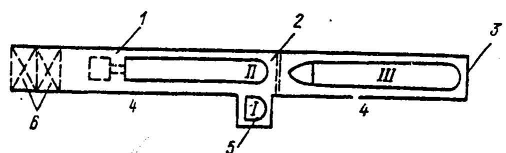

Figure 8. Diagram of the flow-position construction of large ships in the dock at the shipyard of the "Mitsibushi" Company in Koyagi. I-III--building positions of large ships in the dock; 1--dock; 2--intermediate lock; 3--caisson gate; 4--area for forming the module-sections and modules; 5--side docking basin for forming the stern section of the ship; 6--draw curtain to protect the workplaces from atmospheric precipitation.

On the dock of the shipyard at Koyagi (Figure 8) the first position for forming the hull section of the ship is located in a special side basin of the midsection of the dock. The next two positions are in the main dock.

The finished stern section of the ship is moved along rails in the transverse direction to the second position which is located on the main dock, where the midsection of the ship formed from module-sections is joined to it. The stern and midsection of the ship formed together are moved to the third position (to the caisson gate) where the bow is attached to them, and the outfitting-installation operations are performed.

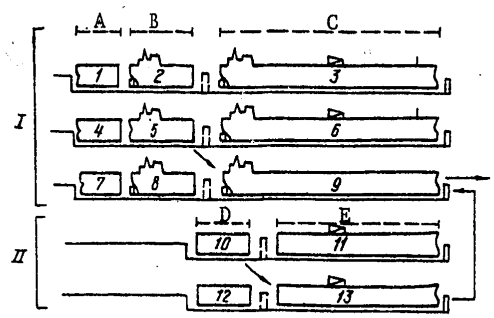

Figure 9. Diagram of the flow-position building of ships in docks Nos 1 and 2 at the shipyard in Ariak of the "Hitati" Company. I--dock No 2; II--dock No 1; A, B and C--positions of forming the hulls of ships in dock No 2; D, E--positions of forming the hulls of the bow sections of the ships in dock No 1; 1--module of the stern section of the ship No 3; 2--stern section of the ship No 2; 3--ship No 1; 4--module of the stern section of the ship No 4; 5--stern section of the ship No 3; 6--ship No 2; 7--module of the stern section of the ship No 5; 8--stern section of ship No 4; 9--ship No 3; 10--bow section module of ship No 3; 11--bow section of ship No 2; 12--bow section module of ship No 4; 13--bow section of ship No 3.

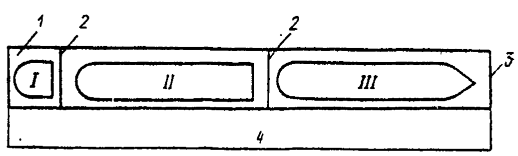

Figure 10. Diagram of the flow-position construction of ships in the dock at the shipyard at Tita of the "Isikavadzima-Kharima Heavy Industries" Company. I-III--positions of building large ships; 1--dock; 2--intermediate lock; 3--caisson gate; 4--area for forming the module-sections and the modules.

At the shipyard in Ariak, the flow-position construction of large tankers has been provided for with simultaneous use of two drydocks (Figure 9).

On the large dock No 2 (620 x 85 x 14 meters) divided into two basins, the stern sections of the ships of more complex configuration are assembled, and the hulls of the finished ships are finally formed. In the smaller dock No 1 (380 x 85 x 14 meters) which also can be divided into two basins, the bow sections of the hull are assembled, which make up up to 75 percent of the total length of the ship. The stern sections of the hulls weighing more than 20,000 tons from position A to positions B and C are shifted without floating them using a special tra sporter. At position C the bow section of the hull built in dock No 1 is joined to the stern section assembled in dock No 2. The adopted method permits simultaneous construction of 2.5 ships.

On completion of the first ship, the degree of completion of the second ship is 70 percent, and the third 30 percent.

On the dock at the shipyard in Tita of the "Isikavadzima-Kharima Heavy Industries" Company, a three-position shipbuilding procedure has been adopted (see Figure 10), for which it is divided into three basins 80, 350 and 380 meters long. In the first (small) basin, the stern section of the ship is assembled, which is then moved by winches to the second basin where the hull of the ship is completely formed without the bow. This hull is then floated to the third basin where the bow is installed, and the outfitting operations are completed with respect to all parts of the ship. The ship is moved from the dock ready for sea trials. The completion of the ship in the dock to the indicated technical readiness is the result of the act that the peninsula of Tita on which the shipyard is located is subject to frequent typhoons.

The flow-position building of the ships can be organized by the system depicted in Figure 11 for which the operations of assembly and installation of the modules, joining of them and forming of the entire ship on the shipbuilding ways and also outfitting afloat and the trials are performed successively at specialized positions.

As is obvious from the diagram, the assembly and installation of the modules are done at four positions; the shipbuilding operations at two, the outfitting afloat and trials, also at two.

This system provides for completing the ship before launching it off the shipbuilding ways approximately 92-93 percent with respect to labor consumption of operations in the shipyard shops and 95-96 percent with respect to empty weight of the ship. With this degree of completion of the ships, an insignificant volume of outfitting operations are performed afloat, and then the mooring and acceptance trials are held.

The flow-position method of building ships can also be organized with the arrangement of a number of positions afloat, for example, in cases where the ship is launched off the shipbuilding waves about 70-percent complete, and the remaining operations are performed afloat.

The indicated system is also used when for expansion and rebuilding of the shipyard launching from the available shipbuilding ways is expedient with a low degree of completion of the ship because significant capital investments and time are required in the rebuilding measures to provide for launching of the ship with a higher degree of completion. The same system can also be used in cases where it is necessary for the creation of uncovered shipbuilding ways to spend significantly more capital investments and time than on building berths on the outfitting quay.

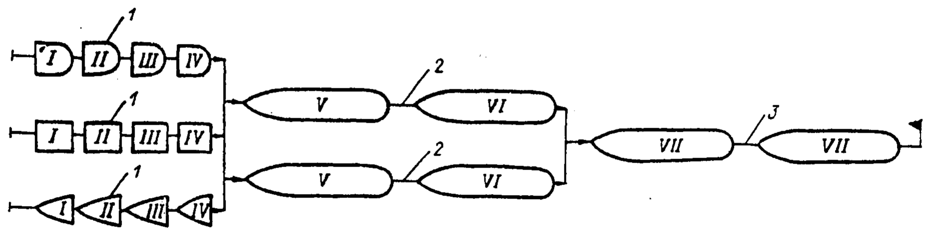

Figure 11. The diagram of the flow-position building of ships by the modular method. 1--positions for assembly and installation of modules; 2--positions for building ships on the shipbuilding ways; 3--positions for outfitting the ships afloat and trials. I-VII--position numbers.

The final decision regarding the adoption of one system of flow-position building of ships or another when developing the design is made after analyzing a set of factors, including the problems of the organization and practice, and also the technical-economic indices of building the ships. The flow-position method is more advanced, but it requires careful planning of the operations and uninterrupted material-technical support of the building of the ships.

For the flow-brigade method, all of the operations at the building location are divided into the production steps performed by specialized complex brigades. Here the ships remain stationary at the building berth, and the brigades move from one ship to another, successively performing the operations by production steps.

A characteristic example of the application of the flow-brigade method of building large tankers at modern shipyards is the organization of the building of them in drydocks with two-way exit equipped with intermediate movable gates, which ensures the best intensification of use of the docks (Figure 12). This method is used when the movement of the ships or modules from position to position is realized complexly, for example, when building the ship on an inclined building slip.

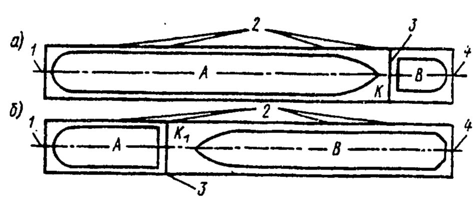

Figure 12. Schematic diagram of the building of large ships in a dock with two-way exit of them: a--location of the ships in the dock at the time of forming the stern section of the ship B and completion of the ship A; the intermediate gate is in position K; b--location of the ships in the dock at the time of forming the stern section of the ship A and the ship B completely; the intermediate gate is in position K_1. 1--caisson gate No 1; 2--locations for installing the intermediate gates; 3--movable gate; 4--caisson gate No 2.

The deficiencies of the flow-brigade method must include some complexity of the clear delimitation between the completion of operations of one brigade and the beginning of operations of another, the absence of permanent workplaces for the brigades, and so on.

§10. Specialization and Cooperation

The specialization of production in any branch of industry is planned specialization of the production facility which produces the defined product (or part of the finished product) and is characterized by special technological processes.

The expansion and the deepening of the specialization of production is one of the most important conditions of rapid development of shipbuilding, the basis for which must be maximum standardization and unitization of parts, subassemblies and products for building ships.

The specialization of a newly designed, expanded or rebuilt shipyard or individual production facilities of it is determined by the design assignment.

Three basic types of specialization are used in the shipbuilding industry:

subject, realized by attachment of the construction of defined classes of vessels to each shipbuilding enterprise;

parts, used at the enterprises manufacturing individual parts and subassemblies for shipbuilding, for example, the ship's fixtures, hull fittings, electrical equipment parts, and so on;

phases occurring on separation and specialization of the individual phases building the ship and organization of independent enterprises for this purpose, for example, the installation of the electrical equipment on the ships. In addition, broad interbranch and intrabranch cooperation are realized in the shipbuilding industry.

Interbranch cooperation has as its purpose the provision of the ships under construction with equipment, machinery and fixtures manufactured by other branches of industry (for example, the principal machinery, electrical equipment, communications and observation equipment).

The intrabranch (interplant) cooperation has as its purpose provision of the individual shipbuilding enterprises with products made at the plants of the shipbuilding industry (for example, castings, forgings, ship's fixtures, auxiliary machinery, and so on).

Both forms of cooperation are realized considering the location of the shipbuilding enterprises in order to avoid excessive expenditures on transporting the products and intermediate products.

Along with the deliveries of marine equipment by cooperation, when building ships it is also efficient to cooperate in the performance of various installation operations. At the present time the specialized enterprises perform operations with respect to the installation of electrical equipment, communications and observation equipment, thermal monitoring instruments, insulation for systems, pipes and compartments, and so on.

The preparation and preliminary assembly operations with respect to electric wiring, the installation of communications and observation equipment are performed by specialized enterprises located outside the shipyard; in a number of cases the suppliers of marine equipment direct the installation of the equipment delivered by them directly on the ships.

The cooperation of the enterprises when building ships can be expanded significantly, for example, with the help of the following specialized installation enterprises: electrical equipment, communications and observation equipment; heat monitoring instruments; marine units; marine systems and pipelines; main engines with service machinery; ventilation, air conditioning and heating systems and refrigeration units; equipment and furnishings for the compartments and wooden products; insulation, paint.

The basic production facilities must provide their specialized installation enterprises with the required products for performance of the installation operations on the ships to supplement that obtained in the established procedure by the interplant and interbranch cooperation; in addition, they must have the necessary personnel with the corresponding qualifications at their disposal.

Clear-cut specialization and broad cooperation are economically the most advantageous forms of production organization.

The effectiveness of specialization is ensured by the following:

the achievement of the highest series nature of production;

improvement of the technical level of production under the condition of optimal production output and utilization of production capacity;

a high degree of mechanization and automation of the production processes and the materials-handling operations and also the production control hardware, economically justified and reducing the number of employees;

the highest degree of organization of production and technical guidance of the enterprise characteristic of specialized production;

more careful development of the structural design for the parts, subassemblies and products from the point of view of their technological nature, economicalness and reliability;

the performance of operations with respect to further unitization and standardization of the produced parts and subassemblies and reduction of the number of types and sizes.

In accordance with the nomenclature of external deliveries established by the design assignment, when determining the volumes of operations of the shipyard shops in weight of products, the volume of deliveries is also expressed in the weight of the machinery, equipment, and so on.

Chapter IV. Volume, Labor Consumption and Duration of Ship Construction

§11. Volume of Shipbuilding Operations in Terms of Weight of Parts and Products

In the assignment to design a new shipyard or expand and rebuild an existing one, usually the annual calculated program is presented with respect to the number of ships of a defined class and design to be produced and the nomenclature of the deliveries by cooperative efforts from other enterprises. On the basis of this overall calculated program the annual calculated program (load) of the individual shops is defined when developing the shipyard design.

The most exact method is the method of determining the load of individual shops measured in natural terms--the length and thickness of the machined edges of the parts, the length and cross section of welds, the length and thickness of joined edges, the length and diameter of the pipelines, and so on. The discovery of these meters requires the development of detailed flowcharts for the manufacture of all parts and products and also all assembly and installation operations with respect to building the ship, for which, in turn, it is necessary to have the production forms and records with respect to the designed ship, including instructions for the performance of all operations. The development of the indicated flow diagrams requires significant means and work time on the part of a large collective of engineering designers; therefore this work can be justified only for individual parts and products made in large series requiring unique, expensive equipment.

Considering what has been discussed and also the provisional nature of the designed ships of the program, in design practice the volumes of operations as a whole with respect to the shipyard and with respect to its individual shops are defined in terms of the mass of structural components, parts, subassemblies and products considering cooperative deliveries. First the volumes of operations expressed in mass with respect to the basic forms of operations on one ship are found by the weight load items of the ship, and then the annual volume of operations for the entire shipyard as a whole and each of its shops is calculated in accordance with the calculated program.

Considering the prospectiveness of the introduction of aluminum-magnesium alloys and synthetic materials into shipbuilding, when determining the volumes of operations with respect to building the ships sometimes provision is made for the possibility of replacing the metal structural elements and products by structural elements and products made of the indicated materials. For example, for elimination of the total volume of operations with respect to machining the parts and assembling structural components made of aluminum-magnesium alloys provision is made for the possibility of manufacturing the plating and framing of the superstructures of the ship also from aluminum-magnesium alloys.

When determining the volumes of operations with respect to machining the parts and assembling the structural components from synthetic materials it is also possible provisionally to assume that when building the ships, synthetic materials (sheets, plates, pipes, spreaders, glue components, and so on) and intermediate products (panels for light bulkheads and enclosures) arriving in finished form from specialized enterprises will be used.

The weight load of the ship with respect to basic forms of shipyard shop operations are distributed in the form of tabulated lists (see Table 2) in which data are presented on the weight load of the ship by items with indication of the total mass and the masses of outside deliveries, deliveries from the machinebuilding part of the plant or shipyard and also the consumption of materials by the set of shipyard shops, separately. With respect to each basic type of shipyard shop operation, data are indicated, from which the production output of the shop is developed, expressed in weight (the outside deliveries plus the deliveries of other shops, plus the consumption of materials). All of the mass data are presented in accordance with the weight load of the ship developed by the design office, without considering waste.

The weight loads, for example, of transport and factory ships are distributed with respect to the following basic forms of operations:

preliminary dressing, cleaning and priming of the steel;

the machining of the hull parts;

assembly and welding of the subassemblies and panels;

painting and drying the subassemblies and panels;

machining and assembly of structural elements made of aluminum-magnesium alloys;

the same, made of synthetic materials;

hull-fitting preparation operations;

pipe fabrication and preparation operations;

woodworking preparation operations;

painting preparation operations (preparation of paint materials, mastics, spackling and adhesives);

rigging preparation operations;

sail preparation operations;

work on electrical equipment, communications and control (operations of the specialized electrical wiring enterprise);

operations with respect to insulation;

operations with respect to heat control instruments;

manufacture of units and zonal modules;

assembly and installation of modules (with the modular method of construction);

building slip operations;

outfitting afloat and trials.

Table 2. Distribution of the Ship's Weight Load With Respect to Basic Types of Operations

Weight Loan Items	Weight, tons											
	Total load per ship	Outside deliveries	Deliveries of the machinebuilding section	Materials consumption by shops	Basic types of operations: Preliminary straightening, cleaning and priming of steel				Machining the hull parts			Total
					outside deliveries	deliveries from other shops	material consumption	total	outside deliveries	deliveries from other shops	material consumption	
Metal hull												
Shell plating with framing and second bottom decking												
decks, platforms, and so on												
foundations and fastenings												
hull fixtures												
equipment of the living and service compartments, and so on.												

Note: Only two types of operations are indicated here. For distribution of the weight load of a ship with respect to the remaining types of operations the table must be continued correspondingly.

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When determining the volume of operations, special attention must be given to the distribution of them among the building slip operations and the operations of outfitting afloat. Here it is necessary to consider primarily the comparative cost of the designed slipways or existing ones and the outfitting quay.

When carrying out the preliminary design developments (and sometimes the contract-detail and contract designs) the volumes of shipbuilding expressed in terms of mass with respect to basic forms of operations are taken with respect to the percentage ratio of these volumes designed for the previously built analogous ships (Table 3). In Table 3 when determining the volumes of operations, the degree of technical completion of the ships with respect to mass of installed structural elements is taken for assembly and installation of modules at the Class II, III and IV shipyards to 85 percent of the total mass of the structural components of the ships, and in the slipways of the shipyards of all classes, to 95 percent.

Table 3. Approximate Volume of Basic Operations (expressed in mass) When Building Ships

Types of Operations	In Percentages of Total Mass of Structural Elements of Slip				
	Tanker, Q_c = 14,000 t	Dry Cargo, Q_c = 6,200 t	Trawler, Q_c = 2,500 t	Tugboat, Q_c = 660 t	Seiner, Q_c = 90 t
Operations in the Shipyard Shops and Sheds					
Mold loft operations	--	--	--	--	--
Preliminary dressing, cleaning and priming of the steel	82.0	68.0	47.0	49.0	44.0
Machining the hull parts	70.0	60.0	42.0	43.0	38.0
Manufacture of subassemblies and sections of the hull	72.0	61.0	43.0	44.0	35.5
Manufacture of structural elements made of aluminum-magnesium alloys	3.0	3.0	2.0	2.0	0.95
Painting and drying of the sections	72.0	61.0	43.0	44.0	35.5
Manufacture of structural components made of synthetic materials	2.00	2.25	3.60	1.50	1.40
Manufacture of assemblies and zonal modules	10.0	11.0	12.8	12.8	12.6
Assembly and installation of the ship's modules	--	85.0	85.0	85.0	--
Assembly and installation operations in the building slip	95.0	95.0	95.0	95.0	95.0
Outfitting afloat, trials and acceptance	100.0	100.0	100.0	100.0	100.0
Manufacture of hull fittings and products	3.2	2.5	3.0	1.8	5.8

Table 3 (continued)

Types of Operations	Tanker, Qc = 14,000 t	Dry Cargo, Qc = 6,200 t	Trawler, Qc = 2,500 t	Tugboat, Qc = 660 t	Seiner, Qc = 90 t
	In Percentages of Total Mass of Structural Elements of Slip				
Manufacture of pipeline parts and subassemblies	3.4	2.7	3.6	2.8	3.5
Chemical cleaning, hot galvanizing and priming of the pipe	3.4	2.2	3.6	2.8	3.5
Machining and manufacture of parts and products from wood	2.2	3.1	4.5	6.0	10.4
Galvanizing	5.8	6.1	10.8	1.5	--
Preparation of paints, mastics, spackling and adhesives	1.00	1.10	1.40	1.66	1.32
Rigging and sail preparation work	0.25	0.21	0.16	0.57	0.30
Outside Enterprise Operations					
Electric wiring	1.1	1.1	2.6	3.0	1.3
Installation of heat-control instruments and automation	--	--	--	--	--
Insulation work:					
Manufacture of parts and subassemblies in the shop	0.94	1.20	3.30	--	--
Installation on the ships	1.4	1.8	4.1	--	--

§12. Labor Consumption of the Building of Ships

When designing a shipyard, the most exact method is the method of determining the labor consumption of the building of ships as part of a calculated program by the circulating flow diagrams for the manufacture and installation of all parts and products of the ship. The development of these flow diagrams requires the participation of a large number of process specialists and also expenditures of significant time and means.

Inasmuch as when designing a shipyard, the calculated program, as a rule, is provisional, permitting determination of only the nature and volume of production, the type and sizes of structures required for building ships of the given dimensions and characteristics, the labor consumption of the operations are determined by consolidated indices in the circulating flowcharts for the manufacture or installation of the most characteristic parts or products of a given process group with subsequent extension of the obtained specific indices to the entire group.

The process group includes parts and products for the manufacture of which uniform process operations are needed which have identical process circulation and also identical indices with respect to material, shape, overall dimensions and mass. Summing up the labor consumption of the manufacture (or installation) of the parts or products of different process groups, the labor consumption is established with respect to basic forms of operations, and summing up the labor consumption with respect to basic forms of operations, the total labor consumption of the shipyard operations for the ship as a whole are calculated.

When designing the shipyards with calculated programs close to the plans previously executed, it is possible to define the labor consumption of the ship construction by the obtained indices per unit of natural measure (ton of weight of products, meter of weld, square meter of surface, and so on) both with respect to individual forms of operations and with respect to the entire construction of the ship.

The correctness of determining the labor consumption of the construction of ships at a future shipyard is estimated by comparing it with the best indices already achieved by the shipbuilding enterprises when building analogous ships and also the data from the design and process developments of specialized planning and engineering organizations with design normatives in effect in the branch. Here it is proposed that the planned labor consumption will be reached with complete assimilation of all of the production means and the process methods and organization of the construction of the ships are adopted in the design.

The primary factors influencing the variation of the labor consumption are specialization of the enterprise and the series nature of ship production, the level of organization, mechanization and automation of the production processes and the technical level of production.

The most acceptable for analysis of the overall labor consumption of the construction of ships at a given shipyard are the indices of labor consumption per ton of weight of the ship's structural components:

$$I_{des} = I_s K_{1.s} K_{m.p} K_{c.sh},$$

where I_{des} is the labor consumption per ton of weight of the structural elements for a ship of the series adopted in the design as the calculated ship, man-hours/ton; I_s is the labor consumption per ton of weight of the structural components of a ship of the series by other sources, man-hour/ton; $K_{1.s}$ is the coefficient taking into account the expenditure of labor as a function of the number of the ship in the series; $K_{m.p}$ is the coefficient taking into account the variation of the labor consumption when building a ship as a function of the level of mechanization and automation of the production processes and the technical level of production at the shipyard; $K_{c.sh}$ is the coefficient taking into account the variation of the labor consumption of the building of the ship as a function of its structural elements considering the type of material.

At the new shipyards, along with the mastery of the production capacity, as a rule, the construction of new series ships is also mastered. During the process of mastery of a new series, a significant reduction in labor consumption of building of each ship by comparison with the first one is observed approximately to outfitting the 12th or 14th ship (see Figure 13).

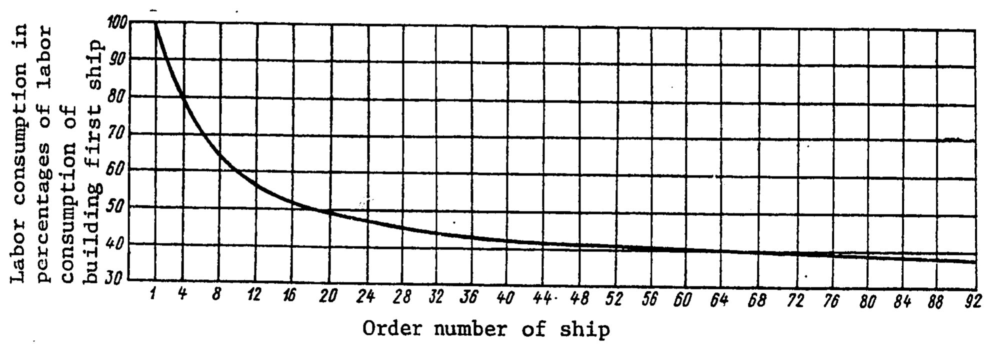


Figure 13. Reduction in labor consumption of building ships as the series is mastered.

When developing the designs of shipyards for series construction of ships usually the ship with order number corresponding with respect to value to two annual calculated programs of the shipyard with respect to ship production is taken as the calculated ship in the series.

When performing the design work, the coefficient $K_{1.s}$ is defined by the graph of the reduction in labor consumption of building of ships as the series is mastered (see Figure 13). Beginning with the graph, the coefficient $K_{1.s}$ can be found by the formula

$$K_{1.s} = I_{d.p}/I_{s.p},$$

where $I_{d.p}$ is the labor consumption per ton of structural components of the series ship taken in the design as the calculated one, percentage; $I_{s.p}$ is the same by other sources, percentage.

For determination of the coefficient $K_{m.p}$ it is possible to use the following approximate values of the variation of the labor consumption of building the ships as a function of the technical level of production of the shipyard:

Technical level of shipyard production	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
Variation of the labor consumption of building the ships	1.65	1.48	1.36	1.26	1.16	1.06	1.00	0.94	0.88

Beginning with these values, the coefficient $K_{m.p}$ is calculated by the formula

$$K_{m.p} = K_{des}/K_s,$$

where K_{des} is the labor consumption per ton of structural components of the ship corresponding to the designed technical level of production of the shipyard; K_s is the labor consumption per ton of structural components of the ship corresponding to the technical level of the shipyard production by another source.

For example, for $K_{des} = 1.0$ and $K_s = 1.48$, the coefficient

$K_{m.p} = 1.0/1.48 = 0.67$.

The coefficient taking into account the variation in labor consumption of the building of the ship as a function of its structural design can be expressed as a function both of the mass of the ship components (of one class and type) and their complexity (different with respect to class and type).

The approximate indices of these values as a function of the mass of the structural components of the ship are presented in Table 4, and depending on the complexity of the structural components of some different ships, in Table 6.

Beginning with the data presented in Tables 4 and 5, the coefficient $K_{c.sh}$ can be defined by the formula

$K_{c.sh} = K_{d.1}/K_{s.1}$,

here $K_{d.1}$ is the labor consumption per ton of structural components of the ship corresponding to the ship of design; $K_{s.1}$ is the labor consumption per ton of structural components of the ship corresponding to the ship according to another source.

A comparison of the labor consumption used in the design and the labor consumption by other sources is made in tabular form (see Table 5). If the application of large-scale metal plates for the hulls of the designed ships is considered in the shipyard design, it is also necessary to consider variation of labor consumption as a function of size and volume of the metal plates used.

Thus, when using sheet metal 16,000 x 4,500 mm in the amount of 20 percent and sheet metal 16,000 x 3,200 mm in the amount of 30 percent of the total mass of metal per ship instead of sheet metal 12,000 x 3,000 mm at the Class I shipyards, the labor consumption of building the ship with respect to shipyard shop operations is reduced by about 2.6-2.9 percent, and at Class II shipyards, with the application of 16,000 x 4,500 mm sheets in the amount of 10 percent and 16,000 x 3,200 mm sheets in the amount of 20 percent the indicated labor consumption is decreased by 1.5-1.7 percent.

When comparing the designed labor consumption of construction of the ships with foreign data it is necessary to pay special attention to the reduction of it to the identical conditions and, in particular, to consider that the published data on labor consumption of building ships at the foreign shipyards pertains to their shipyard operations without considering the labor consumption of operations performed by contract enterprises, which at some shipyards reaches 40 to 50 percent of the total labor involved in building the ship.

It is also expedient to check how the designed labor consumption of building the ships provides for planned future growth of productivity of labor.

Beginning with the designed labor consumption of building a ship, the productivity of labor is defined by the formula

$$P = C_{sh}F_{av}K_{pr}/A_{sh},$$

where P* is the annual production output per IPP worker, rubles/man; C^{*}_{sh} is the cost of a ship, rubles; F_{av} is the average annual available time per worker, hours; A_{sh} is the designed labor consumption of building a ship, man-hours; K_{pr} is a coefficient which takes into account the ratio of the number of production workers to the number of industrial production personnel (IPP) of the shipyard.

Table 4. Approximate Values of the Variation of Labor Consumption of Building 1 Ton of Structural Components of a Ship as a Function of Their Weight for One Ship

Танкеры (1)		Сухогрузные суда (2)		Траулеры (3)		Морские буксиры (4)		Сейнеры (5)	
Q_c	Значение изменения трудоемкости (6)	Q_c	Значение изменения трудоемкости (6)	Q_c	Значение изменения трудоемкости (6)	Q_c	Значение изменения трудоемкости (6)	Q_c	Значение изменения трудоемкости (6)
5 000	1,45	2 000	1,42	500	1,62	300	1,12	90	1,00
10 000	1,18	3 000	1,25	1000	1,36	350	1,09	100	0,98
15 000	1,00	4 000	1,15	1500	1,22	400	1,07	110	0,96
20 000	0,90	5 000	1,06	2000	1,10	450	1,05	120	0,94
25 000	0,83	6 000	1,00	2500	1,00	500	1,03	130	0,92
30 000	0,80	7 000	0,94	3000	0,97	550	1,02	140	0,90
35 000	0,78	8 000	0,90	3500	0,93	600	1,01	150	0,89
40 000	0,77	9 000	0,88	4000	0,91	650	1,00	160	0,88
45 000	0,76	10 000	0,86	4500	0,90	700	0,99	170	0,87

Key:
1. Tankers
2. Dry cargo vessels
3. Trawlers
4. Seagoing tugs
5. Seiners
6. Variation of labor consumption

The approximate specific values of the labor consumption of the basic operations in the shipyard shops in percentages of the total labor consumption of building the ships are presented in Table 7. Here when determining the labor consumption of the operations with respect to the assembly and installation of the modules and the assembly-installation operations in the building slip, we began with the condition of the performance of these operations in enclosed buildings and also advancement and completion of the ships in accordance with Table 8.

§13. Construction Time of Ships. Graphs

One of the important operating indices of a future shipyard is the time it takes to build a ship in it. Therefore when designing shipyards the shipbuilding time is established as a function of the designed program, the methods, organization, process and volume of operations and also the series nature of the ship production.

* When determining the productivity of labor by the net normative production P is the annual net normative production per IPP worker, rubles/man; C is the cost of net normative production of the shipyard for a ship, rubles.

Table 5. Comparison of the Designed Labor Consumption Per Ton of Mass of the Structural Components of a Ship With the Labor Consumption Obtained by Other Sources

Sources	Initial Data and Indices					Reduction of Indices to Designed Conditions			
	Тип судна	Масса конструкций судна, т	Порядковый номер судна в серии	Технический уровень производства	Значение $И_н$, чел.ч/т	$K_{1.s}$	$K_{m.p}$	$K_{c.sh}$	$И_п = И_н K_{с.т} \times K_{м.п} K_{к.с}$, чел.-ч/т
(7) По настоящему проекту	(1)	(2)	(3)	(4)	(5)				(6)
(8) Материалы технологической организации									
(9) Утвержденный проект судна									
(10) Утвержденный проект верфи									
(11) Отчетные данные верфи									

Key:
1. Class of vessel
2. Mass of structural components of the ship, tons
3. Order number of the ship in the series
4. Technical level of production
5. Value of I_s, man-hour/ton
6. $I_{des} = I_s K_{1.s} K_{m.p} K_{c.sh}$, man-hours/ton
7. By the design itself
8. Engineering organization materials
9. Approved ship design
10. Approved shipyard design
11. Shipyard accounting data

Table 6. Approximate Values of the Variation of the Labor Consumption of Construction Per Ton of weight of the Structural Components of a Ship as a Function of Their Complexity for Different Ships

Class of Shipyard	Type and Weight of Structural Elements of Ship, Q_c	Variation of Labor Consumption
I	Tanker, Q_c = 14,000 tons	0.76
II	Dry-cargo vessel, Q_c = 6,200 tons	1.00
III	Trawler, Q_c = 2,500 tons	1.60
IV	Seagoing tug, Q_c = 660 tons	1.90
V	Seiner, Q_c = 90 tons	3.30

Table 7. Approximate Specific Values of the Labor Consumption of the Basic Operations in the Shipyard Shops in Percentages of the Total Labor Consumption of Building a Ship

	Percentage of Total Labor Consumption of Building Ship — Class of Shipyard and Example of Ship				
	I	II	III	IV	V
Basic Forms of Operations	Tanker, Q_c = 14,000 t	Dry Cargo, Q_c = 6,200 t	Trawler, Q_c = 2,500 t	Tugboat, Q_c = 660 t	Seiner, Q_c = 90 t
Shipyard Shop Operations					
Mold loft operations	0.20	0.18	0.23	0.40	0.60
Preliminary dressing, cleaning and priming of the steel	0.37	0.30	0.24	0.40	0.40
Machining the hull parts	4.20	4.10	2.62	4.00	3.00
Manufacture of subassemblies and panels from steel	10.7	11.6	7.4	8.8	10.0
Manufacture of structural elements made of aluminum-magnesium alloys	2.70	2.80	1.85	2.35	0.90
Painting and drying of the panels	1.10	1.10	0.81	1.12	0.80
Manufacture of structural components made of synthetic materials	1.70	2.00	3.10	1.25	0.80
Manufacture of assemblies and zonal modules	7.5	7.5	8.0	8.0	8.0
Assembly and installation of the modules	--	19.5	20.2	21.0	--
Assembly and installation operations in the building slip	37.60	19.00	18.80	20.55	42.10
Outfitting afloat, trials and acceptance	9.00	9.00	6.15	4.40	4.40
Manufacture of hull fittings and products	6.0	4.9	5.7	3.4	7.2
Manufacture of pipeline parts and subassemblies	5.50	4.80	5.60	4.35	3.60
Chemical cleaning, hot galvanizing and priming of the pipe	0.80	0.60	1.00	0.75	0.60
Machining and manufacture of parts and products from wood	2.10	2.95	4.40	5.80	6.50
Galvanizing	0.40	0.38	0.60	0.13	0.70
Preparation of paints, mastics and spackling	0.40	0.39	0.40	0.75	0.60
Rigging and sail fabrication work	0.13	0.10	0.15	0.85	0.30

Table 7 (continued)

	I	II	III	IV	V
Total	90.40	91.20	87.25	88.30	90.50
Operations by Outside Enterprises					
Electric wiring	4.25	4.05	8.00	9.55	5.00
Installation of heat-control instruments and automation	1.05	1.02	0.55	0.65	0.65
Insulation work:	4.30	3.73	4.20	1.50	3.85
Manufacture of parts and subassemblies in the shop	0.95	0.90	1.60	0.37	0.93
Installation on the ships	3.35	2.83	2.60	1.13	2.92
Total	100.00	100.00	100.00	100.00	100.00

Table 8. Advancement and Completion of Ships When Assembling and Installing Modules and the Assembly-Installation Operations at the Building Slip (without the operations of outside enterprises)

		Percentage of Total Labor Consumption of Operations at Shipyard			
		Assembly and Installation of Modules		Assembly and Installation Operations at Building Slip	
Class of Shipyard	Class of Vessel	Advancement	Completion	Advancement	Completion
I	Tanker, Q_c = 14,000 t	--	--	42	90
II	Dry-cargo vessel, Q_c = 6,200 t	21.2	69.3	20.7	90.0
III	Trawler, Q_c = 2,500 t	22.5	71.5	21.5	93.0
IV	Tugboat, Q_c = 660 t	23.5	72.0	23.0	95.0
V	Seiner, Q_c = 90 t	--	--	48	95

The shipbuilding time with respect to the basic process steps is determined most precisely by the developed process chart.

In order to make more effective use of the expensive locations (shops) for building modules, the covered slipways and launching facilities when developing the process charts for construction of ships (or for determining the shipbuilding time by other methods) it is necessary to consider that the reduction in the time required to build the modules and the ship as a whole in the building berth is achieved as a function of the following basic factors:

the maximum possible transfer of operations from the module-building shop and the building berths to the assembly-welding shop (here the capacity of the crane equipment in the shop is fully used, including paired operation of the cranes); an increase in volume of automatic and semiautomatic welding in the module construction shop and in the building berths; expansion of the installation of machinery and equipment by subassemblies, zonal modules and block modules, and the system pipelines--large units and panels; ensurance of a broad work front for the shipriggers and loading and installation of the units and individual mechanisms and machinery and also the systems and lines in the compartments fitted with them in the initial phase of construction of the modules or the slipway period (with the sectional method of building the ships), making the ship compartments available for installation work or part of them available by organizing purposeful work of the hull specialists; earliest possible preparation of the modules or the ship for the beginning of the electrical wiring operations, including laying the main cable, primarily in the most roomy electrical wiring areas (the control stations, engineroom, and so on);

priority presentation of the compartments of the ship in which the cycle of operations has the longest process time for insulation and "building-in" operations; specialization of the worker brigades by types of operations.

In design practice, consolidated indices are used to determine the shipbuilding time, beginning with the volume of operations and the number of workers required to perform the operations in one process phase or another with subsequent analysis of the results obtained.

The shipbuilding time by basic phases can be defined in consolidated manner by the formula

$$t_{ph} = A_{ph}/F_{day}p_{mean},$$

where t_{ph} is the duration of the phase, workdays; A_{ph} is the labor consumption of the operations in the given phase, man-hours; F_{day} is the average duration of the working day, hours/working day; p_{mean} is the mean diurnal number of workers working on the ship, men.

The calculation of the shipbuilding time by the basic phases is presented in Table 9. The calculation of the assembly time and installation time for the modules is shown by the average data. For ships in which the volume of operations with respect to installation and assembly of individual modules is different, the installation and assembly times are calculated for each module separately.

As an example, in Figures 14 and 15 we see the graphs of the construction of ships by modular and modular-sectional methods.

Just as when determining the labor consumption, the planned building time for series ships is taken for the series ship with order number corresponding with respect to its value to twice the calculated program of the shipyard with respect to ship production. A comparison of the time required to build the ships found by calculation (see Table 9) with the best indices achieved by shipyards when building analogous ships and also with the normative data, the design and process developments can be expressed by the formula

$$t_{des} = t_{o.s}K_{c.s}K_{m.l}K_{sh},$$

where t_{des} is the designed time for building the ship or the time reduced to the design levels, working days or months; $t_{o.s}$ is the time required to build the ship according to another source, working days or months; $K_{c.s}$ is the coefficient which takes into account the variation in the time required to build the ship as a function of its number in the series; $K_{m.l}$ is the coefficient taking into account the variation of the time required to build the ships as a function of the level of mechanization and automation of the production processes and the technical level of production; K_{sh} is the coefficient taking into account the shift index of the workers with respect to building the ships.

Here $K_{c.s} = t_1/t_2$, where t_1 is the time required to build a ship in this series, which is taken in the design as the calculated ship (Figure 13 is used); t_2 is the time required for building the ship of the series by the chart with respect to other sources; $K_{m.l}$ is found analogously to the determination of $K_{m.p}$;

$$K_{sh} = K_1/K_2,$$

where K_1 is the shift index of the workers according to another source; K_2 is the designed shift index of the workers.

When comparing the time required to build ships having significant structural differences, it is also necessary to use the coefficient which takes into account the variation in the shipbuilding time as a function of the structural design, the technical means and mechanization of the ship $K_{c.m}$.

A comparison of the designed construction time of ships with given construction time by other sources is made in table form (see Table 10).

Table 9. Calculation of the Construction Time of Ships by the Basic Phases of Operations

Basic Phases of Operations	Labor Consumption, man-hours	Average Number of Daily Workers, men	Daily Available Time of Workers	Construction Time: By Calculation, working days	Construction Time: Taken in Design, months
Sectional Method					
Building slip operations					
Outfitting afloat and trials					
Total					
Modular Method					
Assembly and installation of modules					
Building slip operations					
Outfitting afloat and trials					
Total					

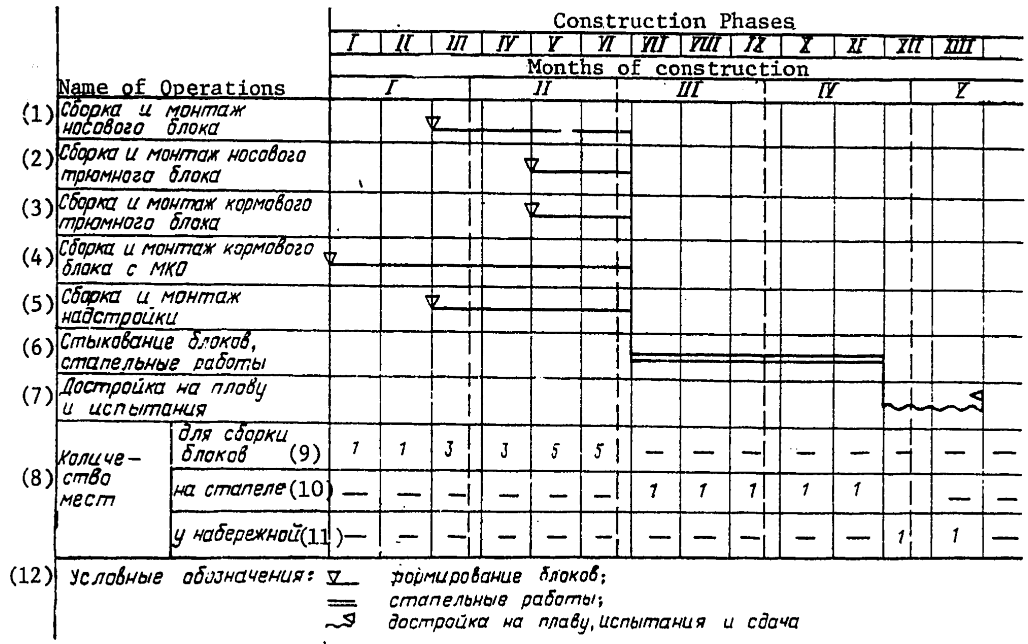


Figure 14. Construction chart for a dry-cargo vessel by the modular method.

Key:
1. Assembly and installation of the bow module
2. Assembly and installation of the forward hold module
3. Assembly and installation of the aft hold module
4. Assembly and installation of the aft module with MKO
5. Assembly and installation of superstructure
6. Joining of modules, building slip operations
7. Outfitting afloat and trials
8. Number of places
9. For assembly of modules
10. In the building slip
11. At the quay
12. Provisional notation: shaping of modules; building slip operations; outfitting afloat, trials and acceptance

In the above-presented formula and Table 10 comparison of the shipbuilding time is demonstrated under the condition of identical volume of operations performed after putting up the modules or ships on the building slips.

In the cases where comparison of the ship construction time is made with a significant difference in volume of unitization of the machinery and equipment performed in sections or shops especially created for this purpose, this must be considered with the corresponding coefficient K_{unit}.

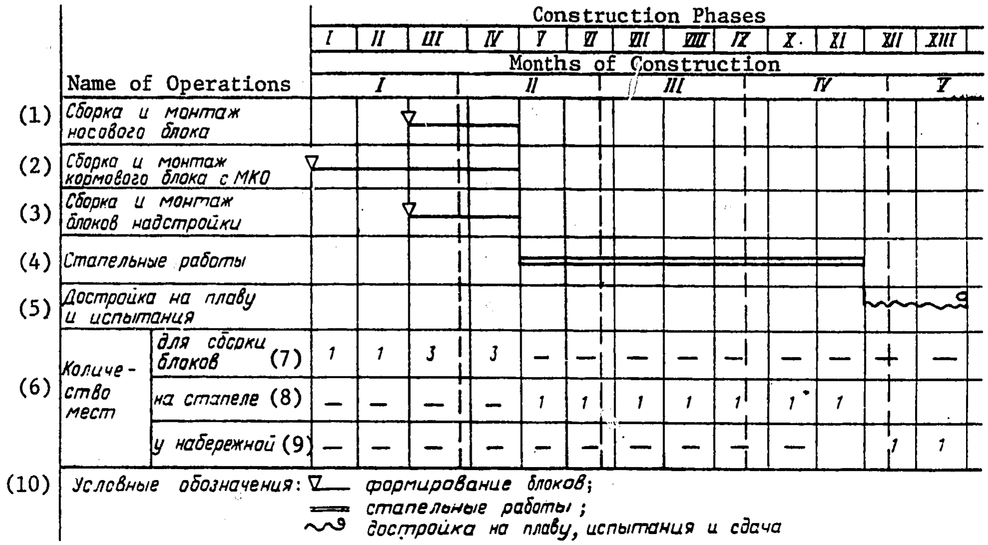


Figure 15. Construction chart for a dry-cargo vessel by the modular-sectional method.

Key:
1. Assembly and installation of the bow module
2. Assembly and installation of the stern module with MKO
3. Assembly and installation of superstructure module
4. Building slip operations
5. Outfitting afloat and trials
6. Number of places
7. For assembly of modules
8. In the building slip
9. At the quay
10. Provisional notation: shaping of modules; building slip operations; outfitting afloat, trials and acceptance

In this case the formula for comparison of the shipbuilding time has the form

$$t_{des} = t_{o.s}K_{c.s}K_{m.l}K_{sh}K_{unit}.$$

The coefficient taking into account the variation of the shipbuilding time as a function of the volume of unitization of the machinery and equipment (K_{unit}) can be defined by the formula

$$K_{unit} = I_{s.a}/I_{m.a},$$

where $I_{s.a}$ is the labor consumption of building the ship after setting up the modules or the ship as a whole on the building slip before acceptance as a function of the total labor consumption of the shipyard operations for building the ship by plan, percent; $I_{m.a}$ is the labor consumption of building the ship after setting up the modules or the ship as a whole on the building slip before acceptance as a function of the total labor consumption of the shipyard operations with respect to building the ship by another source, percent.

Table 10. Comparison of the Planned Building Time of Ships With the Data on the Building Time From Other Sources

	Sources	Initial Data and Indices						Reduction of Indices to Designed Conditions				
		Тип судна	Масса конструкций судна, т	Порядковый номер судна в серии	Технический уровень производства	Коэффициент сменности рабочих	Значение $t_{дн}$, мес	$K_{c.s}$	$K_{m.1}$	K_{sh}	$K_{c.m}$	$t_п = t_{дн} K_{п.с} \times K_{м.у} K_{см} K_{к.м}$, мес
		(1)	(2)	(3)	(4)	(5)	(6)					(7)
(8)	По настоящему проекту											
(9)	Материалы технологической организации											
(10)	Отчетные данные верфи А											
(11)	То же, верфи Б											
(12)	Утвержденный проект верфи В											

Key: 1. Class of vessel
2. Mass of structural components of the ship, tons
3. Order number of the ship in the series
4. Technical level of production
5. Shift index of workers
6. Value of t_{day}, months
7. $t_{des} = t_{day} K_{c.s} K_{m.1} K_{sh} K_{c.m}$, months
8. By the actual design
9. Process organization materials
10. Accounting data for shipyard A
11. The same, shipyard B
12. Approved design of shipyard C

When comparing the designed shipbuilding time with foreign data it is necessary to reduce the initial data to identical conditions, and in individual cases also to consider such peculiarities as the length of the workweek, and so on.

Beginning with a calculated program, the adopted method of construction and defined building time for the ships with respect to basic phases, an example building slip chart is put together for building the ships in the designed shipyard.

Figure 16 shows an approximate building slip chart for construction of dry-cargo vessels by the modular method when producing 26 ships per year on 2 building slip lines for climatic conditions with an ice period of 4.8 months. The ships are launched from the building slip lines the year around.

The chart shows that the trials and acceptance of the ships depend on the climatic conditions of the region in which the shipyard is located. Under southern conditions where there is no ice period, the trials and acceptance of the ships can be accomplished throughout the year. Under climatic conditions with an ice period, rhythmic trials and acceptance of ships during the entire year is highly complicated, and by the beginning of navigation many ships have accumulated at the outfitting quay. For example, in regions with an ice period of 4.8 months, up to 50 percent of the ships of the designed program accumulated, and in northern regions, if no special measures are taken, up to 60-65 percent.

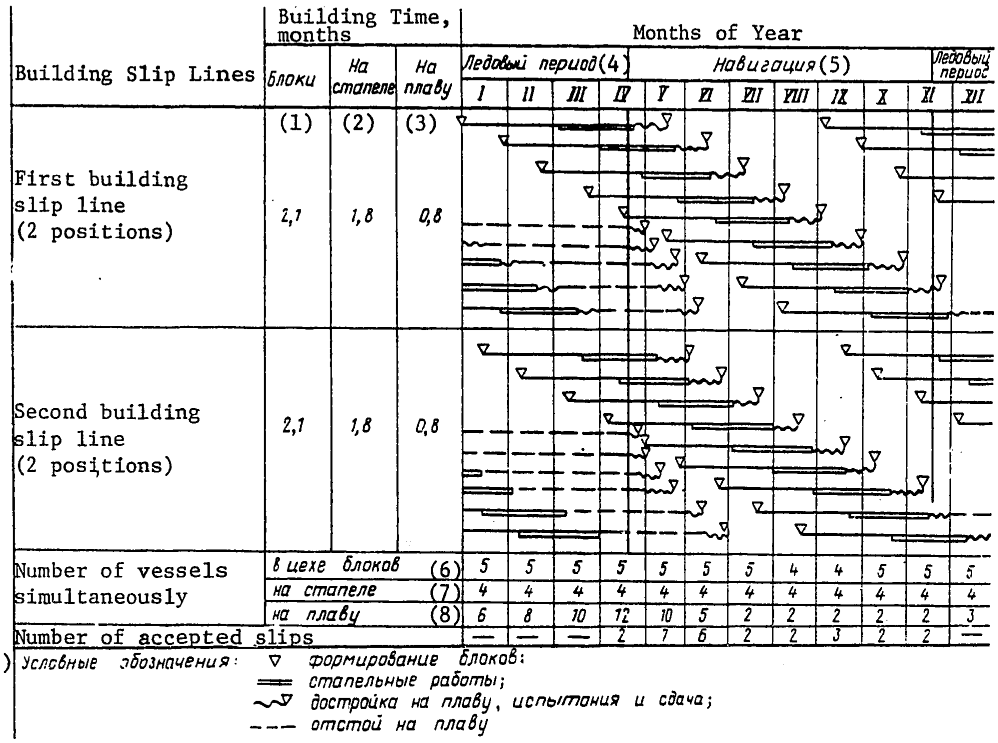


Figure 16. Example building slip chart for building dry-cargo vessels (26 ships built per year) under climatic conditions with 4.8 months of ice.

Key:
1. Blocks
2. In building slip
3. Afloat
4. Ice period
5. Navigation
6. In the module shop
7. In the building slip
8. Afloat
9. Provisional notation: shaping of modules; building slip operations; outfitting afloat, trials and acceptance; delay afloat

It is especially necessary to emphasize that the accumulation of a large number of ships at the outfitting quay during the ice period leads to the fact that at the beginning of navigation it is necessary to increase the number of acceptance instructions, that is, sharply to violate the rhythmic operation of the shipyard. Therefore it is expedient on the building slip charts for the construction of ships at these shipyards to provide for the distribution of sea trials and acceptance of ships over at least the first months of navigation. In addition, under such conditions it is very important to create devices at the shipyard which permit simulation of sea trials at the outfitting quay, and the presence of a nonfreezing body of water also has significance.

Chapter V. Capacity, Production Output, Production Program, Organization and Control of a Shipyard

§14. Capacity, Production Output, Production Program and Characteristics of Shipyard Production Projects, Evaluation of Quality, Progressiveness and Substantiation of Efficiency

The production capacity of a shipyard (shop) is the maximum possible production output in the established nomenclature and quantitative respects which can be realized by the shipyard (shop) in a defined time period for established operating conditions, with mastery of the production equipment by the personnel, complete use of equipment, areas and other production means, the application of advanced technology and the most modern organization of labor and production, the achievement of the advanced technical production and labor consumption norms established for the given period and also elimination of production bottlenecks [24].

The shipyard production as a whole is basically ships, and the product of its individual shops is the hull parts, panels, sections, ship modules, and so on.

The designed capacity is the production capacity established in the design for building or rebuilding the shipyard (shop). It can be achieved under the condition of provision with the production means, personnel and organization of production set forth in the design. If it is discovered during the design process that the production output program established for the shipyard (shop) design defining its designed capacity does not make sufficiently complete use of the shipbuilding ways, equipment and areas as a result of nonoptimalness of nomenclature and quantitative relation of the ships (products) or amount of output, the design organization must introduce proposals to change the given program to bring the designed capacity to that amount which will ensure complete use of the planned production means.

The optimal capacity of the shipyard is the capacity for which the greatest effectiveness of capital investments, the best use of production means in operation and the lowest production (ship) cost are achieved considering a number of other factors such as the construction time and the time required to assimilate the production process, the conditions of siting the new shipyard, the amount of simultaneous capital investments, the times for beginning of production output and the return time on the expenditures on construction.

Although with an increase in shipyard capacity conditions are created to improve the production efficiency, the influence of the remaining factors on the production volume restricts unlimited increases. The optimalness of the program for a shipyard under construction must be determined considering all of the influencing factors.

Depending on the degree of readiness, shipyard production is divided into the following types: finished ships, intermediate products, incomplete production.

The finished ships are the ships that have gone through all of the established phases of the technological process of construction and testing, completely outfitted, accepted by the technical control section of the shipyard and the client.

The intermediate products are the production completed with respect to work to be done in one shop of the shipyard or another, but subject to further work or assembly in other shops.

Incomplete production includes the objects of labor which are in the process of being completed in the workplaces or awaiting processing in the workplaces.

The production program is the list and the number of products (ships) which must be made (built) by the shipyard (shop) in the established period (year, quarter, month).

The calculated program of the designed or rebuilt shipyard is determined by the planning assignment, and it is presented in it, as a rule, in units of annual production of ships of each class with indication of displacement or carrying capacity or the design number. Sometimes this program is given for calculation of the total production volume of the shipyard.

When determining individual types of equipment of the shops, the shipbuilding ways, the launching facilities, outfitting quays, the water areas and the waterways, provision is made for the probability of building future ships considering the development of shipbuilding, the requirements of the national economy with respect to prospective plans, actual possibilities and economic expediency of building these ships at the designed shipyard and also the conditions of delivering the ships to the operating zones.

In the developed shipyard plan, on the basis of the designed materials of the ships or their prototypes in the absence of designs, basic measurements and characteristics of the ships are presented which are required for making technical decisions and adopting the technical parameters of the designed objects of production (Table 11). In addition, the type of steel in the main hull, the maximum sizes of plates, the type of rolled section with indication of maximum length and maximum web height are presented.

The possibility of manufacturing the outer skin and frame of the superstructure from aluminum-magnesium alloys and the possibility of applying synthetic materials (sheets, plates, pipes, and so on) and intermediate products (the panels of light bulkheads, enclosures, and so on) which arrive in finished form from specialized enterprises for making secondary bulkheads, enclosures, window frames, guard rails, small fixtures and parts, and the insulation and finishing subassemblies for the compartments, soft furniture and the products to equip the facilities, pipe and water system and ventilation components, vacuum and speaking tubes, decking, landings and ladders is also determined.

Table 11. Basic Characteristics of the Ships in the Calculated Program

Basic Specifications	Numbers of Ship Designs			
Overall length, m				
Extreme beam, m				
Midship hull height, m				
Overall height, m				
Light displacement, t				
Light draft, m				
Weight of metal hull, t				
Basic hull material (type of steel)				
Main engine type				
Main engine power, HP				

In the presence of several ship designs in the shipyard program in individual cases it can be replaced by a reduced program. Here, the basic ships are taken as examples, by which we mean the ships having the greatest proportion of the output program and the means planned for building them. Here provision is made for building all other ships of the calculated program.

The recalculation of the calculated annual program for one type (design) of the basic ships is done by the reduction coefficient by dividing the total labor consumption for the annual calculated program with respect to labor consumption of building the basic example ship.

In accordance with the instructions for the development of plans and estimates for industrial construction [5], along with the characteristics of the production output (ships) in the design it is necessary to give an estimate of its quality, progressiveness and effectiveness.

The estimation of the quality, progressiveness and effectiveness of the ships in the calculated program can be made, for example, by comparing the basic technical-operating characteristics and the technical-economic indices of the designed ships with the analogous data for ships of Soviet and foreign construction.

The indicated comparison is made in tabular form (see Table 12, for transport ships).

It is also necessary to consider the introduction of the systems for mechanization and automation of control of the machinery and the ship as a whole, satisfaction of the requirements of the international conventions, the USSR Registry Rules, the agencies of the Gosgortekhnadzor, improvement of the living conditions of the crew, and so on (level of mechanization of all forms of operations on the ship, measures to decrease the contamination of the wastewater, reliability of the fire safety systems, application of air conditioning, reduction of noise level, precision of the instruments and equipment, and so on).

Table 12. Comparison of the Basic Technical-Operating Characteristics and Technical-Economic Indices of the Designed Ship With the Specifications for Analogous Ships

Characteristics and Indices	Designed Ship	Analogous Ships		
Technical-Operating Characteristics				
Overall length, m				
Extreme beam, m				
Midship hull height, m				
Maximum displacement, t				
Full draft, m				
Tonnage, t				
Rated power, HP				
Cruising speed, knots				
Technical-Economic Indices				
Construction cost, thousands of rubles				
Carrying capacity, thousands of tons				
Time to pay for itself, years				
Effectiveness of capital investments, %				

When developing the contract-detail or contract design for rebuilding a shipyard or individual shops and structures, their effective capacity and condition are indicated, and the basic characteristics are presented.

The characteristics of the following basic hydroengineering structures are given in more detail:

building berths with indication of their size and admissible specific loads (the possibility of building ships with maximum launching weight are indicated);

transporters for transporting the modules and entire ships with indication of size and weight of the modules and ships;

ship-pulling rails and special transport equipment for moving the ships and modules;

launching facilities with indication of size and load capacity;

outfitting quay with indication of its length, the bottom level at the cordon, equipment with cranes, and so on;

the water area and access routes with indication of size and depth;

the locations for mooring trials of the ships, and so on.

A brief characteristic of the basic shops and structures of a shipyard (span dimensions, crane equipment, area) is presented in tabular form.

The data on the production output volume, the labor consumption of the operations in the annual program, the composition of the workers, the equipment and the technical-economic operating indices of the existing shops are indicated in the explanatory notes on these shops along with the basic data and technical-economic indices and equipment specifications.

§15. Organization of Shipyard Production

The system (method) of organizing production at a designed shipyard is selected as a function of the calculated program, the series nature and methods of constructing the ships.

When developing the plan for a shop complex of a future shipyard design , for example, for an annual output of 15-20 dry-cargo (or other) vessels with a deadweight of 10,000 to 20,000 tons, the following principles with respect to production organization are recommended.

The production shops of the shipyard can be divided into two groups: hull and assembly-installation shops; packaged unit shops.

The hull and assembly-installation shops and sections include the hull platers and assembly-welding shops, the shop for making aluminum-magnesium structures, the shop for making structural components from synthetic materials, the section for painting and drying panels and sections of the ship, the section for manufacturing unitized units and zonal modules, the module-building shops, shipbuilding sheds and outfitting acceptance shop, the electric wiring shop (contractor) and contractors for installing remote-control devices, automation and insulation.

Along with the assembly-installation operations on the ships in the shop itself, the assembly-installation shops do fitting and finishing work as required during the installation process.

The makeup shops include the hull-fitting, pipe preparation, woodworking shops, the galvanizing shop, the paint preparation shop, the rigging and sail workshop.

The makeup shops turn over their production basically to the central makeup warehouse, and they do not perform assembly and installation operations on the ships under construction.

In addition to the production shops, the shipyard includes a central makeup warehouse designed to accept incoming parts and products from the makeup shops, store and package the parts and products into process installation packages and ship them to the assembly and installation shops.

An example composition and diagram of the production links of the basic shipyard shops when building one class of series ships are illustrated in Figure 17.

In cases where the calculated program provides for single or small-series production of ships, in particular, if this is a mixed program encompassing shipbuilding and ship repairs, when developing the design for the shipyard, somewhat different composition of the shops and a different diagram of production links are used in which there is no clear separation of the shops into hull, assembly-installation and makeup shops, for all of the shops perform both intrashop operations and installation operations on the ships. This type of shipyard has the corresponding sections in the basic shops instead of specialized shops for assembly of modules, shipbuilding and outfitting-acceptance shops.

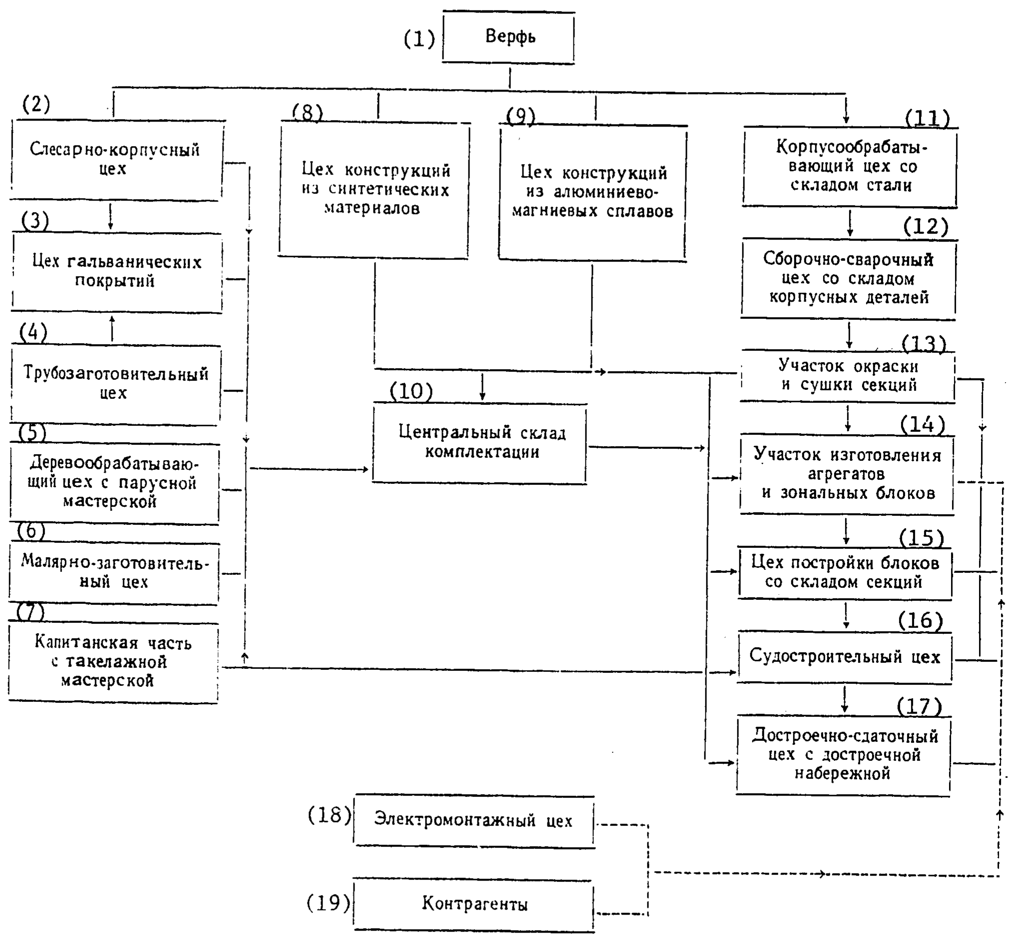


Figure 17. Diagram of the production links of the basic shipyard shops when building one class of series ship.

Key:
1. Shipyard
2. Hull-fitting shop
3. Galvanizing shop
4. Pipe preparation shop
5. Woodworking shop with sail workshop
6. Paint preparation shop

Key to Figure 17 (continued)

7. Captain's section and rigging workshop
8. Shop for building structural components from synthetic materials
9. Shop for making aluminum-magnesium alloy structural elements
10. Central packaged unit warehouse
11. Hull-platers shop with steel storage area
12. Assembly-welding shop with storage of hull parts
13. Section for painting and drying panels and sections of the ship
14. Section for making unitized units and zonal modules
15. Shop for building modules with section and panel storage area
16. Shipbuilding shed
17. Outfitting-acceptance shop with outfitting quay
18. Electric wiring shop
19. Contractors

§16. Example Diagram and Technical Means of Shipyard Control

The structure of shipyard control must correspond to the selected optimum size of the shipyard and its shops, the type of construction of the shops and the production sections and a proper relation between the basic and auxiliary shops and sections.

In the case of design resolution of the problems of shipyard control it is necessary to consider that the degree of use of the production resources and, above all, the effectiveness indices of their use depend to a significant degree on the technical-organizational level of production.

The application of engineering has a defined influence on the effectiveness and efficiency of the entire control system, in particular, the process of executing individual operations and the organization of administrative labor.

In the shipyard control system, as a rule, it is provided that all the departments and services are combined into groups that are related with respect to their purpose. These groups include the departments of technical training and technical servicing of production, control and planning, technical-economic planning and economics, the departments of supply, transportation, management problems, and personnel. Each group of departments is headed by a deputy or assistant director.

In cases where the assignment for designing the shipyard provides for the necessity of developing a plan for the automated production control system (ASUP), the organizational structure of the shipyard administration must consider the peculiarities of administration using the indicated system.

Before making the decision to use the ASUP in the shipyard design, a technical-economic substantiation of the expediency of its application must be produced.

The automated shipyard control system is a set of organizational-economic methods and hardware which provide for gathering, storing and processing information for regular solution of the basic problems of controlling the production activity of the shipyard.

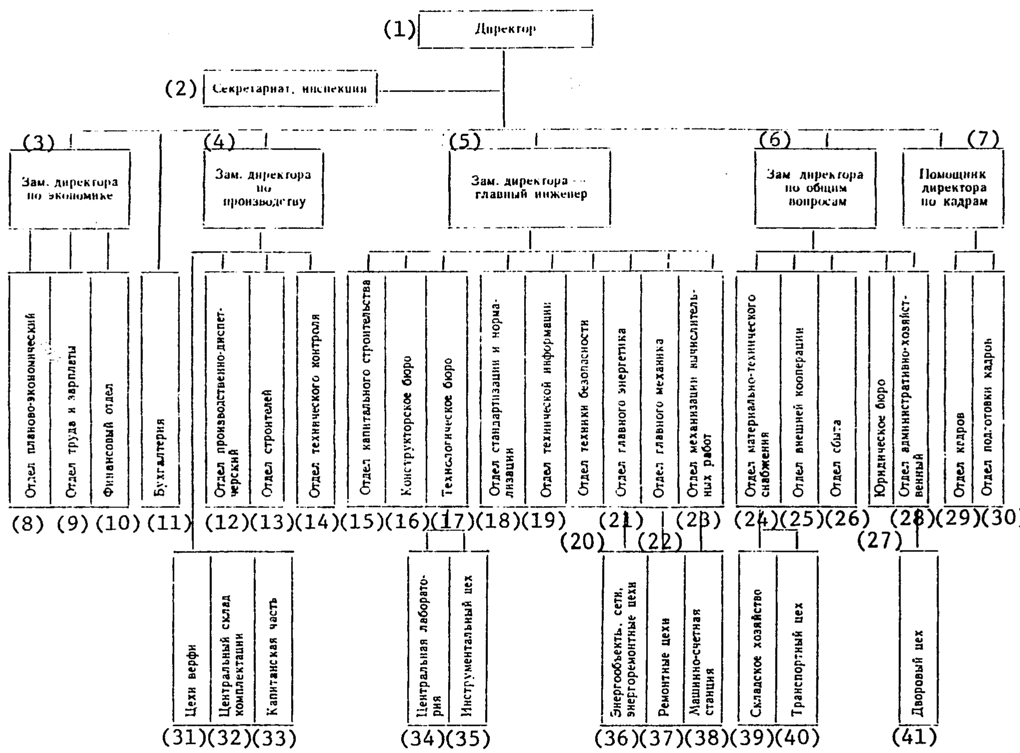


Figure 18. Shipyard control system.

Key:
1. Director
2. Secretariat, inspection
3. Deputy director for economics
4. Deputy director for production
5. Deputy director--chief engineer
6. Deputy director for general problems
7. Assistant personnel director
8. Economic planning department
9. Labor and wages department
10. Finance department
11. Bookkeeping
12. Production dispatch department
13. Builders' department
14. Technical control department
15. Capital construction department
16. Design office
17. Process office

Key to Figure 18 (continued)

18. Department of standardization and normalization
19. Technical information department
20. Safety engineering department
21. Department of the chief power engineer
22. Department of the chief mechanical engineer
23. Department of mechanization of computational operations
24. Department of material and technical supply
25. External cooperation department
26. Marketing department
27. Legal office
28. Administrative department
29. Personnel department
30. Personnel training department
31. Shipyard shops
32. Central makeup storage area
33. Captain's section
34. Central laboratory
35. Tool shop
36. Power facilities, networks, power repair shops
37. Repair shops
38. Machine accounting station
39. Warehouse management
40. Transport shop
41. Building and grounds shop

Key to Figure 19:

1. Director
2. Central dispatch service
3. Secretariat, inspection
4. Deputy director for capital construction
5. Department of capital construction
6. Chief shipbuilder
7. Department of builders
8. Deputy director for production--PDO chief
9. PDO deputy chief for production
10. Shipyard shops
11. Central makeup storage area
12. PDO deputy chief for material and technical supply
13. Department of material and technical supply
14. External cooperation department
15. Transport shop
16. Storage area
17. Deputy chief designer of the ASUP
18. Department of ASUP
19. Department of servicing the digital program control machine tools
20. Deputy director--chief engineer
21. Deputy chief engineer for funds
22. Central laboratory

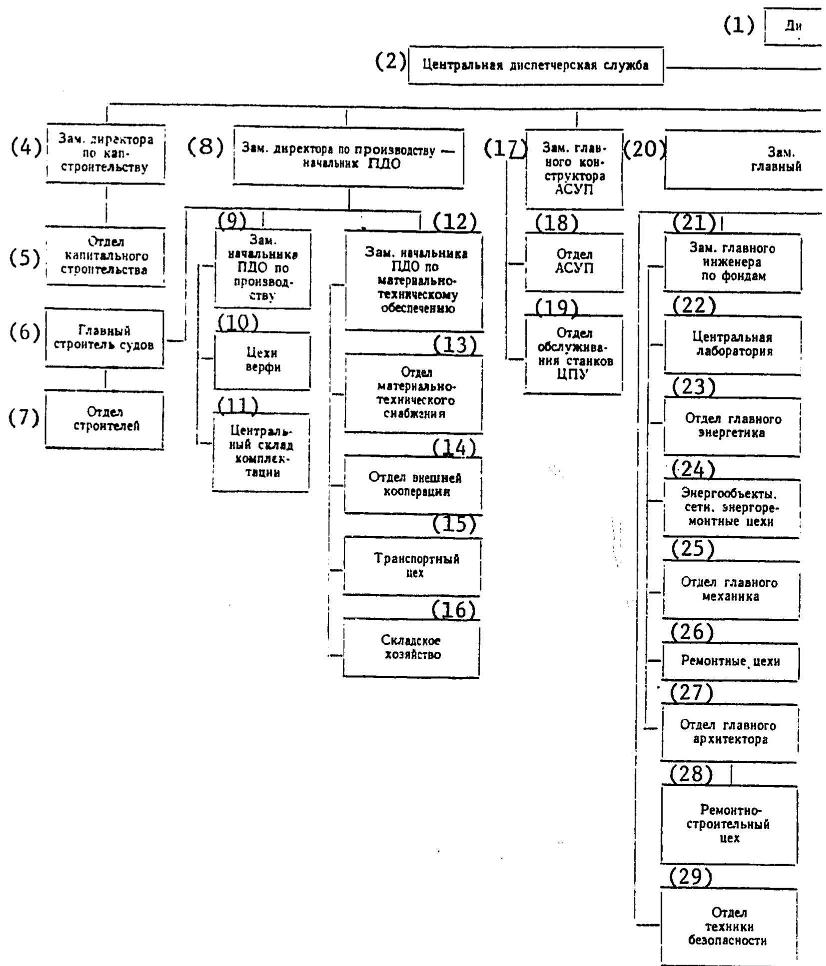


Figure 19. Shipyard control system under ASUP conditions.

Key to Figure 19 (continued)

23. Department of chief power engineer
24. Power facilities, networks, power repair shops
25. Department of chief engineer
26. Repair shops
27. Department of chief architect
28. Building and repair shop
29. Department of safety engineering
30. Deputy chief engineer for improvement of production
31. Technological process department
32. Design office
33. Department of tool management
34. Tool shop
35. Chief welder's department
36. Department of standardization and normalization

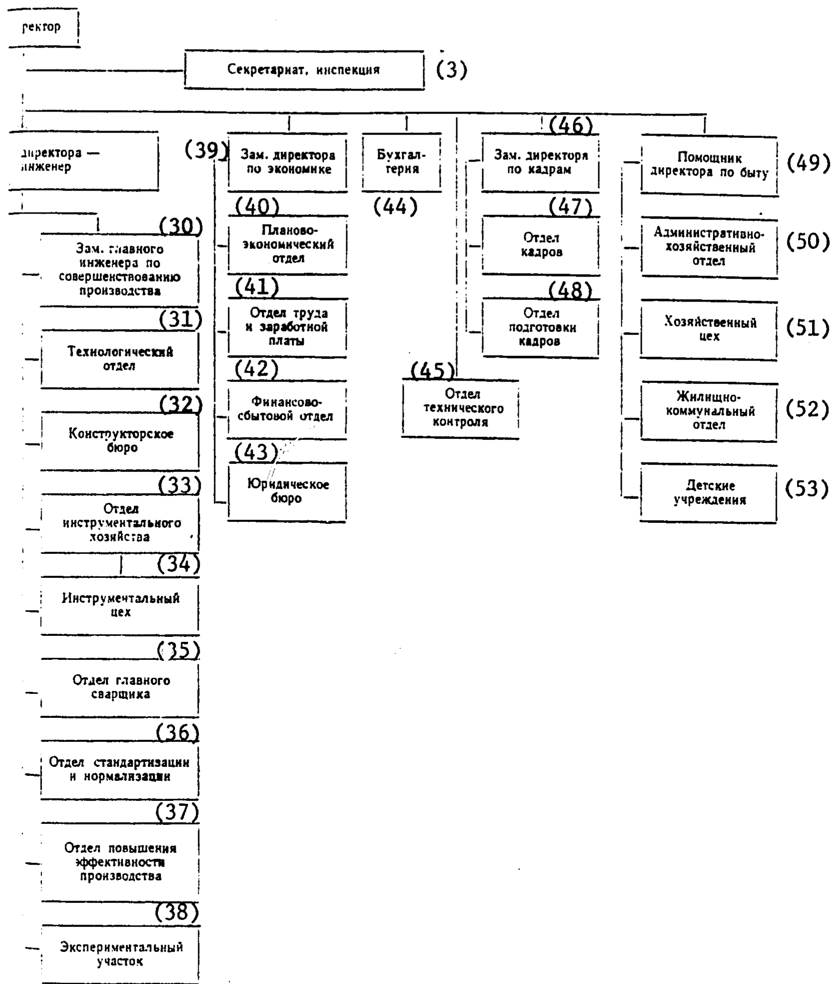


Figure 19 (continued)

Key to Figure 19 (continued)

37. Department for improvement of production efficiency
38. Experimental section
39. Deputy director for economics
40. Economic planning department
41. Department of labor and wages
42. Finance and sales department
43. Legal office
44. Bookkeeping
45. Department of technical control
46. Deputy director for personnel
47. Personnel department
48. Personnel training department
49. Assistant director for sales
50. Administrative department
51. Housekeeping department
52. Housing and communal services department
53. Children's institutions

In this control system the following basic parts are isolated: the organizational-economic, including the automated control structure, its place in the control system, functional relations, and so on; software, including production and control models formalizing the data processing processes, the programming languages and systems, and so on; hardware, including the control hardware, integration of it into the system and methods of using it; the administrative personnel, the system for their interaction with the automated control system and the structural subdivisions of the shipyard.

The application of computer engineering providing for functioning of all of the ASUP subsystems permits serious improvement of shipyard control, in particular:

the creation of a control system based on the all-around use of the latest computer engineering and communications equipment, better coordination of the work of the production and administrative subdivisions, and it offers the possibility for the management operative to follow the state of affairs in each subdivision;

operative gathering of the necessary information from the points of its production to the information computer center (IVTs), operative computer processing of the data and output of the processing results to the corresponding subdivisions of the shipyard;

it relieves the qualified specialists from office duties and permits them to engage in more creative activities;

it creates conditions for objective scientific substantiation of administrative decisions;

it reduces the number of administrative steps and allows redistribution of a number of the administrative functions;

the creation of conditions for organization of a branch dispatch service, the functions of which are significantly altered, and basically consist in control of all types of production-administrative activity of the shipyard.

When using the ASUP, changes are noted, for example, with respect to the following administrative functions: operative control of basic production; process and design preparation for production; technical-economic planning; organization of labor and wages; bookkeeping, accounting and financial activity; material and technical supply; cooperation and marketing of production; improvement of the organization of production, labor and control.

An example shipyard control system constructed on the basis of analogous systems at existing shipbuilding enterprises is shown in Figure 18, and the example shipyard control system under ASUP conditions is presented in Figure 19.

For the automated production control system in the organizational structure of the shipyard, an important role is given to the dispatch service of the shipyard. The central dispatch service of the shipyard created on the basis of clear separation by functions with direct subordination of all functional dispatch services of the shops to the corresponding dispatchers under ASUP conditions provides for operative monitoring of the production activity of the shipyard in order to prevent possible deviations from the production plans and schedules, it takes operative measures for correction of them for the purpose of unconditional execution of the indicated production plans and schedules.

For realization of operative control, the central dispatch service receives data on the production activity, on the basis of these data it prepares the information in the required quantity and form for decisionmaking by the line administration of the shipyard.

Under the conditions of ASUP operation, the information is basically gathered by two procedures: by interrogating the computer memory and receiving reports on established forms, by having the dispatchers in the central dispatch service contact the subdivision workers through the dispatch communications to obtain oral reports.

The central dispatch service is directly subordinate to the shipyard director, but in the operative work it gathers and prepares information for all of the deputy directors of the shipyard and commissions them.

The central dispatch service and the dispatch services of the shops are equipped with subscriber stations of the remote data processing system based on the united computer system which permits the information capacity of the information computer center (IVTs) to be used and it makes it possible to organize gathering, preliminary processing, output of data to the ASUP and receiving of data from the ASUP in real time based on the organization of man-machine dialog.

The information computer center can be located both at the shipyard itself and in the area servicing the enterprises of a defined territorial region.

The united computer system and the remote data processing devices include the computers of the united system; the peripheral equipment based on the remote data processing system; the equipment providing for data transmission over communication channels; the equipment for coupling the communication channels to the computer.

The united computer system is a set of stationary third-generation computers, and it is characterized by the following basic peculiarities, a wide range of output capacities, which makes it possible to solve problems of different complexity and nature; program compatibility of all models of the complex from bottom to top; broad use of integrated circuits; expanded nomenclature of the peripheral devices; a powerful software system.

Along with the presented hardware at the shipyard provision is made for the following basic communications hardware used for production control:

director's communications--director's switchboards are installed for the director, the chief engineer and the deputy director for production and the chief dispatcher of the shipyard for direct communications with the shop, department and service chiefs;

dispatch communications--for operative management, a dispatch switchboard is installed for the chief dispatcher of the shipyard. This switchboard is connected with the production shop dispatchers and some of the shop services; the communications are set up over a two-stage system: chief dispatcher of the shipyard and shop dispatchers;

the administrative-search signals: in the engineering building and auxiliary services, this is a sound signal; in the production shops it is a light signal. The shop search communication systems are used to find the required personnel in the shipyard control service shops;

production-dispatch signaling--for monitoring the course of production, dispatch panels are installed for the deputy director for production and the chief dispatcher. These panels reflect the execution of the plans, for example, in 1 day or 1 week for the shop as a whole and with respect to individual basic ships. The information is transmitted from the computer center.

In the shops and in the different shipyard sections provision is made for establishment of an information signal which fixes deviations from the schedules or the plan for intershop deliveries;

phototelegraphic communications--for transmission of different types of changes in the drawings and the process forms and records, a phototelegraphic communication system is used between the design and process divisions with the production shops and the computer centers; this system is also used to transmit different production records from one shop to another (they are used in individual cases);

teletype communications--for transmission of various types of orders, service forms and records throughout the entire shipyard and for communication of individual subdivisions with each other (they are used in individual cases);

television for visual dispatch monitoring of the building of the ships. The industrial television system includes a video monitor (for the chief dispatcher of the shipyard, the director and deputy director for production) and transceivers (in the leading shops of the shipyard).

A detailed description of the communications technology between the ASUP hardware complex and the dispatch complex is presented in a separate section of the design.

§17. Production Output Quality Control Measures

The high quality of production output (ships) of shipyard shops is ensured both by the corresponding quality of work and by the quality control measures used for the ships in all phases.

The quality of work is a very broad concept; it is made up of many production and economic factors and it encompasses a broad class of ethical problems. The work quality criterion is its correspondence to the system of requirements following from the modern level of engineering, technology and organization of production with respect to building ships, production relations, moral standards and attitude toward labor.

High quality of work presupposes primarily high qualifications of the workers, and in the production process itself, a strict labor process regime, unremitting observation of the technological process, economy and creative attitude toward the use of work time, material values and equipment. An inseparable part of high work quality is a creative discipline, mutual responsibility and mutual aid.

The discussed principles of improving the quality of production output by the shipyard shops are provided for by the equipment, advanced technology, introduction of standardization and unitization of parts and products, the strictest observation of the effective technical specifications, norms, standards and technological processes, modern high-output equipment, the corresponding accessories and attachments, mechanization and automation of the production processes and technical level of production, the training of highly qualified personnel, the transfer of the maximum possible volume of work from uncovered slips to enclosed buildings, measures to reduce the manual labor, the introduction of scientific organization of labor and rest, safety engineering, labor protection and environmental measures.

When constructing ships the operation-by-operation monitoring of the quality of the performance of the operations providing for their design, technical-operational characteristics and technical-economic indices basically is carried out by the corresponding instruments, equipment and devices. Thus, the indicated instruments, equipment and devices are used during the process of building the ships as follows:

before machining and during machining, fast visual and quantitative analysis of all of the most widespread types of alloy steels, nondestructive quality control of surface layers and sorting by types of materials, the discovery of breaks in the surface layers of the investigated materials and approximate measurement of the depths of surface cracks;

checking the thicknesses of the metal of the manufactured subassemblies, sections and panels, pipes and other metal structures, including determination of the wall thicknesses of the main pipelines with one-sided access to them without changing the technological process;

monitoring of the geometric dimensions of the hull structures and monitoring the set of test operations when building hulls from sections of modules and ships on the shipbuilding ways, measurement of the horizontal and vertical angles, superposition of the breaking bases of the ship's hull, measurement of the magnitude of the deviations of the distances between frames (spacing) from the theoretical value, measurement of the amount of initial camber of the plating with respect to the frames in the form of dents and bulges and also the breaks and different wall thicknesses of the plating along the joints, measurement of deviations of the frames from the vertical plane, determination of the actual position of the devices relative to the base planes, measurement and control of the distances when installing foundations and fittings;

monitoring the rectilinearity of the guides of the foundation beds, coaxialness of the bearings of different structures and openings, rectilinearity of the longitudinal straps of the foundation frames of the diesel engines when assembling and installing them, coaxialness of the shafting on the ships;

monitoring the preparation of edges for welding and correspondence of the dimensions of the welds to the drawing specifications, determination of the clearance between edges of the parts welded together, monitoring of the welds of the hull structural elements and other products and also monitoring with the help of equipment with gamma radiation of radioactive isotopes, radiographic and ultrasonic control;

control of the bend in the tubes on tube-bending machines by the process diagrams, determination of the coordinates of the theoretical axis of tubes of any configuration directly on the ship, discovery of defects in the inside surface of the pipe;

monitoring the testing of the structural elements of the ships for seal and detection of loss of seal in them, discovery of leaks at significant distances and in places that are difficult of access in closed spaces;

monitoring the operation of the devices and mechanisms during the boring trials, including measurement of the maximum gas pressure in the internal combustion engine cylinders during adjustment, measurement and recording of mechanical vibrations, rattling and various forms of movement of oscillatory bodies, measurement and recording of vibrations and rattling of the machines, structures, foundations, instrument panels, various devices, and so on, exact determination of the noise level for any dependence on time, measurement of the tensile forces during static testing of the machinery and ship's structural elements, testing of lines, cranes, and so on;

adjustment and determination of corrections to the pitometer log during the mooring trials of the ship without resorting to the measured mile, continuous recording of changes in water level at the outfitting quay, and so on.

Chapter VI. Arrangement of Shops and Master Plans. Construction Phases and Complexes About To Be Started Up. Shipyard Construction Time and Mastering Designed Capacities

§18. Basic Principles of Laying Out Shops and Buildings (Modules)

The layout of a building (module) with indication of the arrangement of the shops, divisions, sections and auxiliary facilities included in it is a part of the contract-detail (contract) design. The layout is executed considering the planned process and organization of production for coordinating the arrangement of the shops, divisions and sections in the building, the choice of the optimal direction of the production process and intrashop transportation, analysis of the flow of goods and people through the module and also determination of the best arrangement of auxiliary and domestic facilities.

First of all the expediency of the placement of certain shops or divisions of the shipyard in indicated buildings is analyzed in accordance with the process of building the ship.

The areas intended for the basic shipyard shops, depending on the technological characteristics of the production process can be broken down into four basic groups:

the area for the hull platers and assembly-welding shop complex;

the areas for the shops to assemble modules and the shipbuilding sheds (covered slipways);

the outfitting and acceptance shop areas;

the areas for the makeup shops.

Each group has its own specific nature arising from the characteristics of the technological process of building the ship, the equipment used, safety engineering, firefighting conditions, and so on.

When laying out the shipyard buildings (modules) the following basic structural design principles are taken into account: maximum modularization of the production buildings and structures with uniform technological processes; unitization of the structural components and elements of them (columns, beams, panels, floor and ceiling slabs of industrial buildings, and so on); the creation of simple, beautiful production facilities which correspond to the requirements of industrial esthetics and ensure high production culture; economy of materials when selecting the optimal standardized column grids for the industrial buildings.

In accordance with the area specifications calculated by individual shops and the solution regarding arrangement of them in the building (module) at the shipyard, the overall dimensions of the building are determined, and then, considering the technological process requirements, the boundaries of the shops, passages and services common to the building are planned, the areas for placement of transformer and generator substations, ventilation chambers and other structures are determined. The arrangement of the production shops and auxiliary services permits graphical expression of the technical siting solutions and determination of the direction and nature of the flows of goods.

An industrial building (module) is characterized by the technological process characteristics, area, quantity and size of bays (length and spacing of columns, width, height to the upper edge of the crane tracks or to the lower flanges of the bearing beams), crane equipment, heating, lighting, ventilation and sewage conditions.

On the functional diagram of a building (module) the overall dimensions of the building, walls, major outside and inside partitions, the bay column dimensions and the grid, the boundaries between shops and sections, auxiliary services, facilities, structures, cranes and their capacity and height from the floor to the crane rail level are indicated.

Some individual example layouts of shipyard shops are presented in Figures 20-24.

§19. Master Plan Flow Diagrams

The master plan of a shipyard is the plan which shows the arrangement of all buildings, shipbuilding ways, launching facilities, the outfitting quays, transport lines, power engineering facilities and service lines and possible open areas for various purposes in the territory of the shipyard.

The master plan is determined by the production profile and class of the shipyard and also the geological, hydrological and meteorological conditions, the topography of the land and the hydrography of the water area.

One of the most important problems when developing a master plan is the choice of the optimal flow diagram for the production process under the specific geographic conditions which must provide for building ships by the most advanced and economical methods, the best use of territory with the highest built-up factor.

The arrangement of the shops and structures in which the materials, parts, sections, modules, unitized units and equipment are arranged along the shortest and most convenient paths without counterflows is considered to be the most successful. It is also necessary to consider the flows of people and, primarily, the movement of workers during the production process from the shops to the ships under construction on the ways and the outfitting quays.

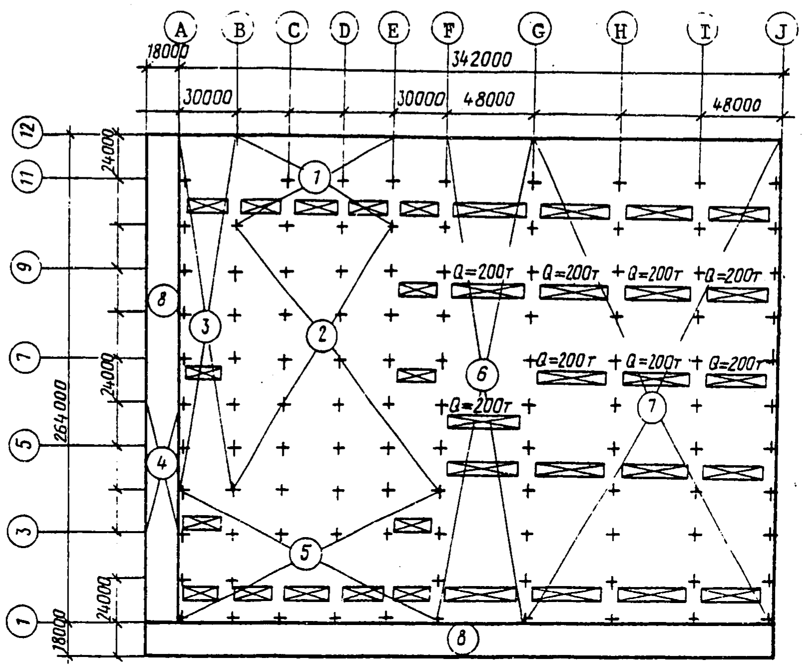


Figure 20. Layout of a module of the hull shops of a Class I shipyard. 1--section for straightening, cleaning and priming steel; 2--hull platers shop; 3--hull platers section of the shop for making structural components from aluminum-magnesium alloys; 4--anodic oxidation section of the aluminum-magnesium alloy structural components shop; 5--hull parts storage area; 6--assembly-welding section of the shop for making structural components from aluminum-magnesium alloys; 7--assembly-welding shop; 8--auxiliary and general services facilities (multistory annex). Electric bridge crane in the A-B bay has a capacity Q = 15 tons; in the remaining bays Q = 30 tons. In the bays A-B, B-C, C-D, D-E and E-F, the height from the floor to the crane rail level H = 11.45 meters; in the remaining bays H = 22.5 meters. In the given figure and also others the numbers and letters in the circles outside the buildings denote the coordinates of the bay columns.

Beginning with the data on the distribution of the weight load of the ship with respect to basic types of operations (see Table 2) and the annual program, the process flows (freight turnover) between the main shops of the shipyard are calculated (Table 13).

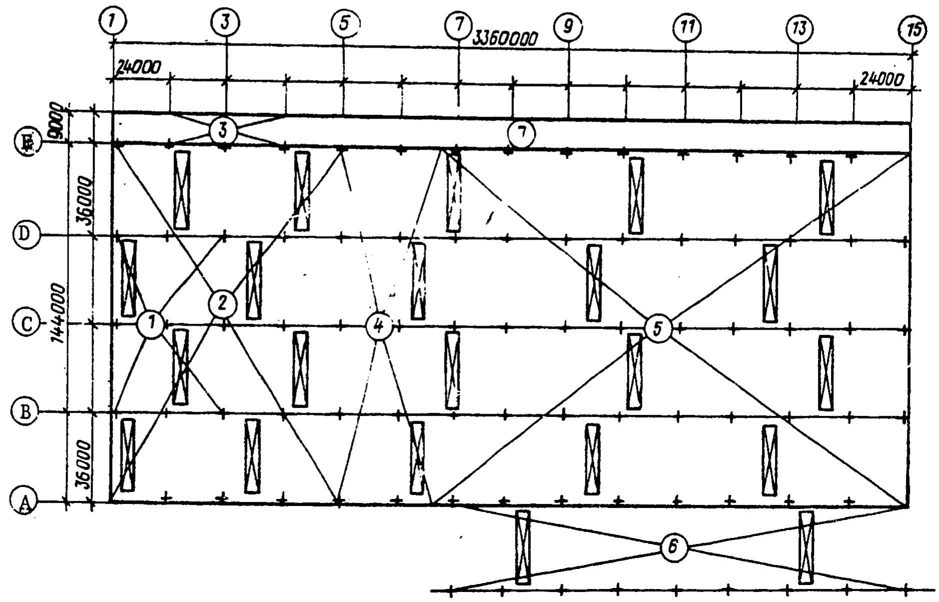


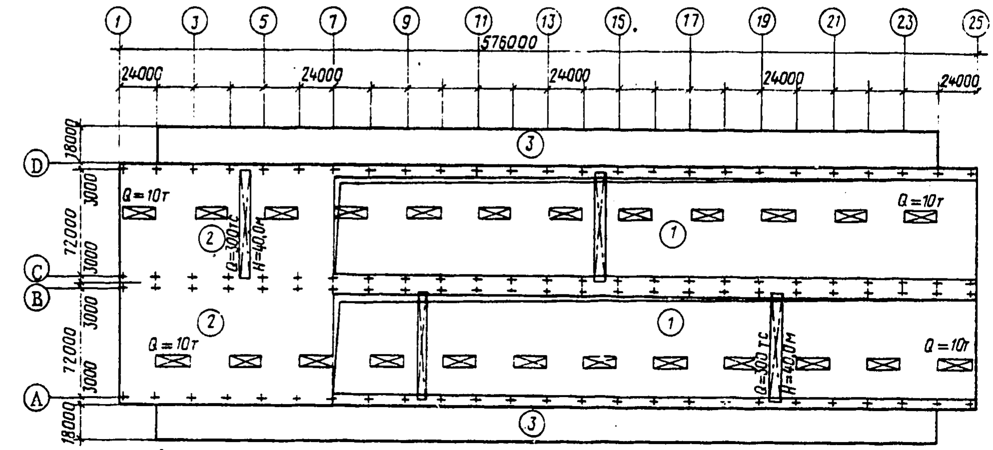
Figure 21. Layout of a module of the hull shops of a Class III shipyard. 1--section for straightening, cleaning and priming steel; 2--hull platers shop; 3--anodic oxidation section for parts and products made of aluminum-magnesium alloys; 4--hull parts storage area; 5--assembly-welding shop; 6--storage area for sections of the ship; 7--auxiliary and general service facilities (multistory annex). In sections 1, 2, 4 the electric bridge cranes have Q = 10 tons, H = 8, 15 meters; in the hull parts storage area for H = 24.9 meters, Q = 10 tons; in the assembly-welding shop 5 and the section storage area 6--Q = 50/10 tons, H = 24.9 meters.

When developing the master plan flow diagram, special attention must be given to the process flows between the hull, assembly-installation and outfitting shops. The corresponding attention must also be paid to the location of the group of makeup shops and the central makeup storage area which ensures rhythmic operation of the assembly-installation and outfitting shops.

The minimum density of building the shipyard sites is 52 percent [32].

Figures 25-28 illustrate approximate site plans for the basic facilities at the shipyards, in each of which one possible version is presented. Other arrangements compiled, for example, in accordance with the conditions of the shipyard sites can also be considered.

The layouts of the new Japanese shipyards in Oppama of the Sumitomo Shipbuilding and Machinery Company and in Tita, the Isikavadzima-Kharima Heavy Industries Company [40] are presented in Figures 29 and 30.



igure 22. Layout of covered slipway of a Class I shipyard. 1--drydock; 2--pre-dock platform; 3--installation and outfitting sections of the shops, auxiliary and general services facilities (multistory annex).

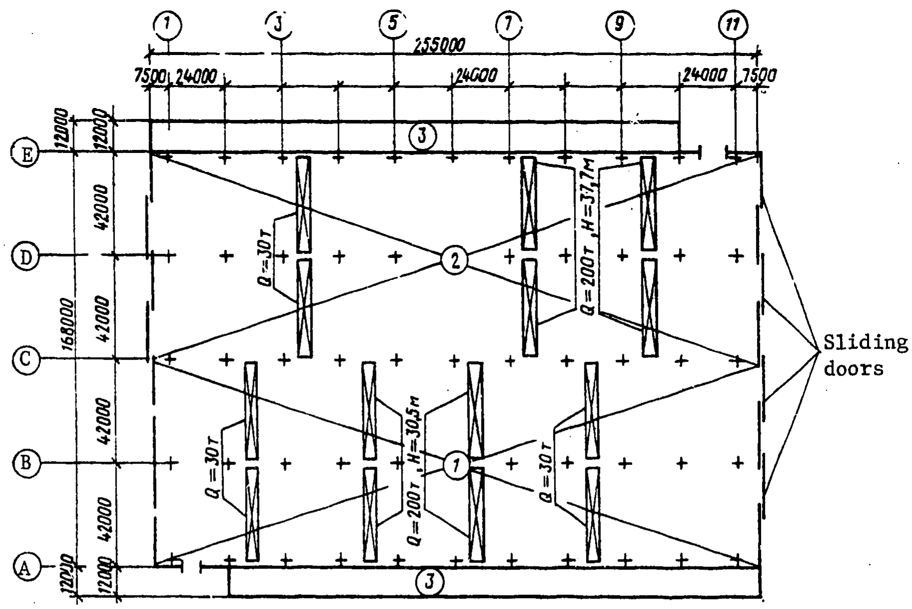


Figure 23. Layout of shipbuilding sheds of Class II shipyards. 1--module construction shops; 2--shipbuilding shed; 3--installation and outfitting sections of the shops, auxiliary and general services facilities (multistory annex).

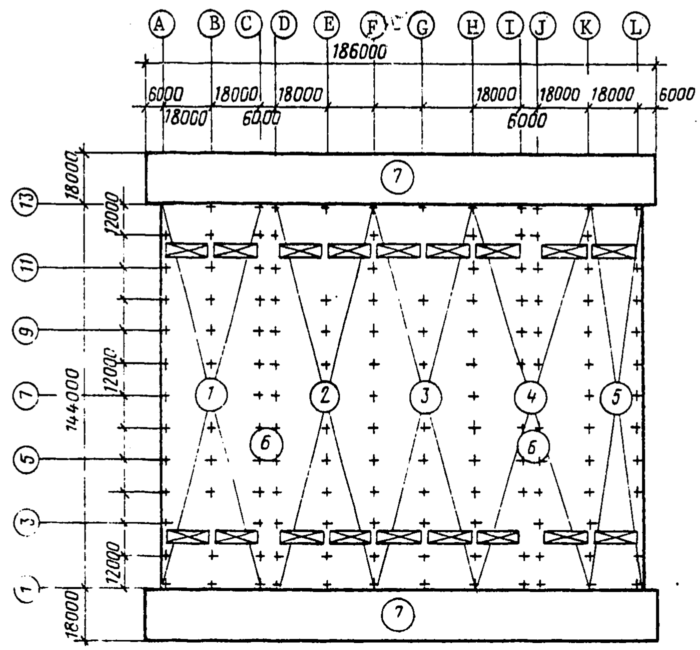


Figure 24. Layout of a module of the makeup shops of a Class II shipyard. 1--shop for structural elements made of synthetic materials and paint preparation shop; 2--hull fittings shop; 3--makeup storage area; 4--pipe fabrication shop; 5--galvanizing shop; 6--engineering corridor; 7--auxiliary and general services facilities (multistory annex); electric overhead cranes in bays A-B and K-L have Q = 3 tons; in the remaining bays Q = 5 tons. Height from floor to bottom of the ceiling of all bays is 8.4 meters.

Key to Table 13:

1. Production output shops and subdivisions
2. Production-receiving shops and subsections
3. Hull-platers shop with steel storage area
4. Assembly-welding shop
5. Module construction shop
6. Shipbuilding shed
7. Outfitting-acceptance shop and outfitting quay
8. Shop for making structural components from aluminum-magnesium alloys
9. Shop for making structural components from synthetic materials
10. Hull fittings shop
11. Pipe preparation shop
12. Galvanizing shop
13. Woodworking shop
14. Paint preparation shop

Table 13. Process Flows (turnover of goods) Among the Main Shipyard Shops

Цехи и подразделения, выдающие продукцию (1)	(2) Цехи и подразделения, получающие продукцию: Корпусообрабатывающий цех со складом стали	Сборочно-сварочный цех	Цех постройки блоков	Судостроительный цех	Достроечно-сдаточный цех и достроечная набережная	Цех конструкций из алюминиево-магниевых сплавов	Цех конструкций из синтетических материалов	Слесарно-корпусный цех	Трубозаготовительный цех	Цех гальванических покрытий	Деревообрабатывающий цех	Малярно-заготовительный цех	Капитанская часть с такелажной мастерской	Центральный склад комплектации	Склады	Внешние заказчики и поставщики	Итого	Выпускаемая продукция (20)
(3) Корпусообрабатывающий цех со складом стали		+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	+	Детали корпуса максимальными размерами ...—... мм, массой до ... г (21)
(4) Сборочно-сварочный цех	−		+	+	−	−	−	−	−	−	−	−	−	−	−	−	+	Секции максимальными размерами ...—... мм, массой до ... т (22)
(5) Цех постройки блоков	−	−		+	−	−	−	−	−	−	−	−	−	−	−	−	+	Блоки с максимальными размерами ...—... мм, массой до ... т (23)
(6) Судостроительный цех	−	−	−		+	−	−	−	−	−	−	−	−	−	−	−	+	Суда со спусковым весом до ... т (24)
(7) Достроечно сдаточный цех и достроечная набережная	−	−	−	−		−	−	−	−	−	−	−	−	−	−	+	+	Суда массой ... т (25)
(8) Цех конструкций из алюминиево-магниевых сплавов	−	−	+	+	−		−	−	−	−	−	−	−	−	−	−	+	Детали и конструкции (26)
(9) Цехи конструкций из синтетических материалов	−		+	+	−	−			−		−		−	+	−	−	+	Детали и конструкции
(10) Слесарно-корпусный цех	−	−	−	−	−	−	−		−	+			−	+	−	−	+	Детали и узлы максимальными размерами ...—... мм, массой до ... т (27)
(11) Трубозаготовительный цех	−	−		−	−		−	−		+	−	−		+	−	−	+	Детали и узлы трубопроводов с максимальным диаметром труб до .. мм (28)
(12) Цех гальванических покрытий		−	−	−	−	−	−	−	−		−	−	−	+			+	Детали, узлы, изделия (29)
(13) Деревообрабатывающий цех				−	−	−	−	−	−	−		−		+	−		+	Детали, узлы, изделия
(14) Малярно-заготовительный цех	−	−	−	−	−	−	−	−	−	−	−		−	+	−		+	Краски, шпаклевки, мастики (30)
(15) Капитанская часть с такелажной мастерской	−	−			−	−	−	−	−	−	−			+	−		+	Такелажные детали и изделия (31)
(16) Центральный склад комплектации		+	+	+	+	−	−	+	+				+				+	Детали, узлы, изделия
(17) Склады			+	+	+	+	+	+	+	+	+	+	+	−		−	+	Оборудование, механизмы, приборы, различные материалы и т. д. (32)
(18) Внешние заказчики и поставщики	+		−	−	−	−	−	−	−				−	+	+		+	
(19) Итого	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		

Примечание. + цехи и подразделения, получающие продукцию от смежных цехов, материалы, оборудование и другие изделия из складов (33)

Key to Table 13 (continued)

15. Captain's section with rigging workshop
16. Central makeup storage area
17. Storage areas
18. Outside clients and suppliers
19. Total
20. Production output
21. Hull parts with maximum sizes of ..., weight to ...
22. Sections with maximum dimensions of ..., weight to ...
23. Modules with maximum dimensions of ..., weight to ...
24. Ships with launching weight to ...
25. Ships weighing ...
26. Parts and structural components
27. Parts and subassemblies with maximum dimensions of ..., weight to ...
28. Pipe parts and subassemblies with maximum pipe diameter to ...
29. Parts, subassemblies, products
30. Paints, spackling, mastics
31. Rigging parts and products

Key to Table 13 (continued)

32. Equipment, machinery, instruments, various materials, and so on
33. Note: + - shops and subdivisions receiving products from adjacent shops, materials, equipment and other products from the storage areas.

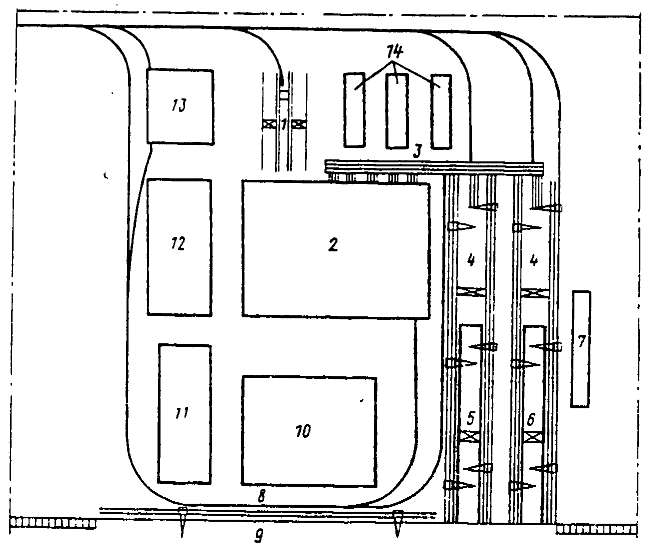


Figure 25. Master plan layout of the main facilities of a Class I shipyard. 1--steel storage area; 2--hull shop module (hull platers, assembly-welding, shop for making structural components from aluminum-magnesium alloys, section for preparation and unitization of machinery, auxiliary and general services facilities of dock No 1); 3--transporter; 4--section storage and predock platforms; 5--drydock No 1; 6--drydock No 2; 7--auxiliary and general services facilities of dock No 2; 8--outfitting quays; 9--water area; 10--outfitting shop module (outfitting-acceptance, electrical wiring, contractors, central makeup storage); 11-- makeup shop module (hull fitting, pipe preparation, galvanizing, structural components made of synthetic materials); 12--module of mechanical and auxiliary shops and storage areas; 13--woodworking shop with storage areas, dryers and impregnating units; 14--power engineering facilities.

§20. Construction Phases and Complexes About To Be Started Up. Construction Time and Mastery of Designed Capacities

The construction phase is part of the shipyard (enterprise) which must provide for putting the production capacities for building ships into operation in the volume established for the given phase. The construction phase of the shipyard can consist of one or several complexes about to start up.

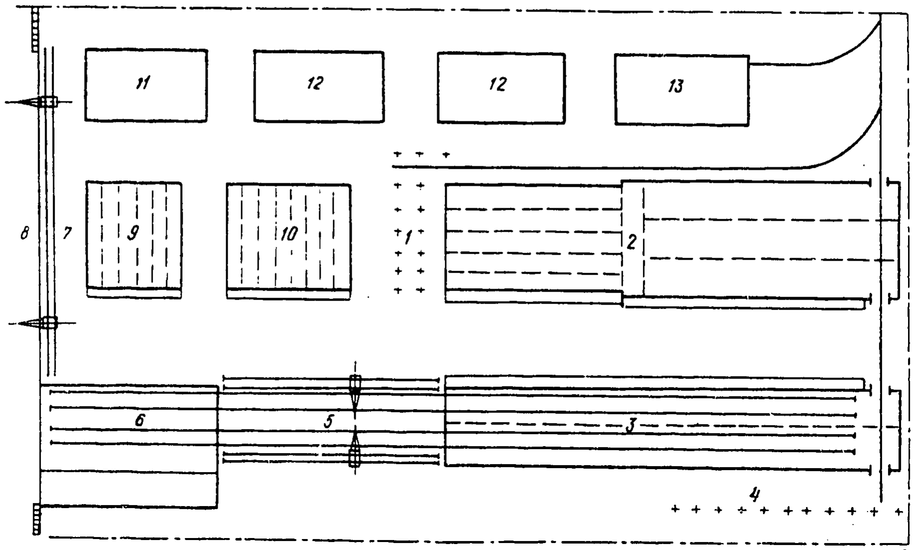


Figure 26. Master plan layout of the main facilities of a Class II shipyard with horizontal building berths. 1--steel storage area; 2--hull shop module (hull platers, assembly-welding, structural elements made of aluminum-magnesium alloys); 3--covered slipway (shop for assembly of modules and shipbuilding shed); 4--section storage; 5--uncovered shipbuilding ways; 6--wet dock; 7--outfitting quay; 8--water area; 9--outfitting shop module (outfitting-acceptance and electrical wiring shops, contractors, electrical equipment storage, shop for structural elements made of synthetic materials); 10-- makeup shop module (hull fitting, pipe preparation, galvanizing; central makeup storage); 11--woodworking shop with storage areas, dryers and impregnating unit; 12--mechanical and auxiliary shop module; 13--storage area module.

The complex to be started up is made up of basic production, auxiliary and service facilities, electrical, transport and warehousing units, communications, service lines, purification structures, amenities and other facilities, the capacities of which provide for the production of the output (ships) by the complex to be started up as provided in its design and normal working conditions for the service personnel.

The primary facilities of complexes about to start up also include the buildings and the facilities for general services, public eating, public health and other facilities which can be used during the construction period.

The construction time of a shipyard (enterprise), buildings and structures is established by the norms.

The construction time includes the time from beginning of the operations in the intrasite preparation period to putting the capacities of the shipyards into operation (their phases, complexes to be started up, production shops, devices) or to the acceptance of the production facilities for operation with complete performance of the jobs provided for by the designs. The construction time of the shipyards (shops) includes the time for all-around testing of the process equipment and testing of the hydroengineering structures with production output [18].

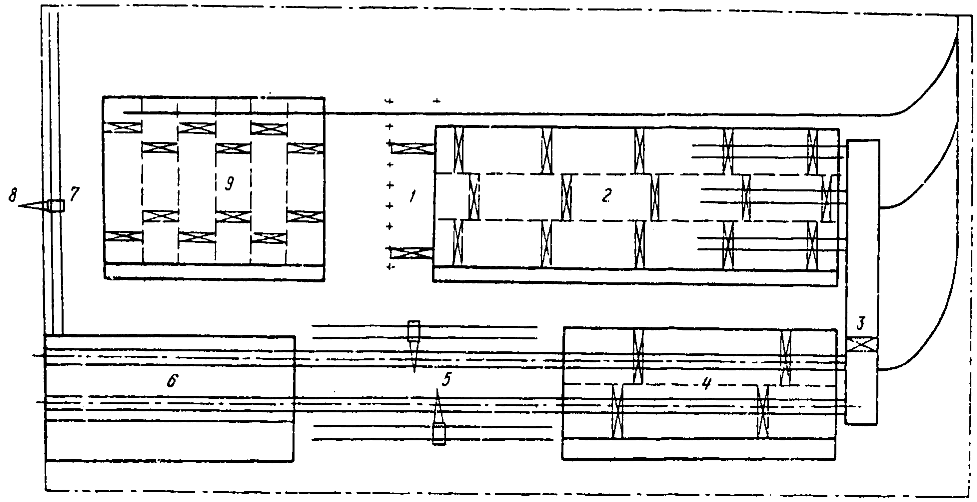


Figure 27. Master plan layout of the main facilities of a Class III shipyard. 1--steel storage area; 2--hull shop module (hull platers, assembly-welding, assembly of modules); 3--conveyor; 4--covered slipway (shipbuilding shed); 5--uncovered shipbuilding ways; 6--wet dock; 7--outfitting quay; 8--water; 9--makeup and outfitting shop module.

The duration of the preparatory period determines the time from its beginning to the beginning of the performance of the basic operations.

The mastery of the designed capacity is characterized by the mastery norm (the mastery time), the level of mastery of the designed capacity, the volume of production output during the mastery period, the achievement of the designed cost levels, productivity of labor and profitableness [19].

By the norm for the time required to master the designed capacity of a shipyard or section of it (phases, a complex about to start up, shop, section) is taken as the time from the time of signing the acceptance papers in accordance with the construction norms and rules (SNiP, Part III) to stable production output in the volume corresponding to the capacity provided for by the design (calculated as the mean monthly capacity).

The duration of stable production output is determined by the production cycle, and at the shipyards with a short production cycle, it is 1 month. The norms for the time required to master the designed capacity are established considering the size and complexity of the shipyards, the level of specialization, the degree of cooperation and combination of production and nature of production.

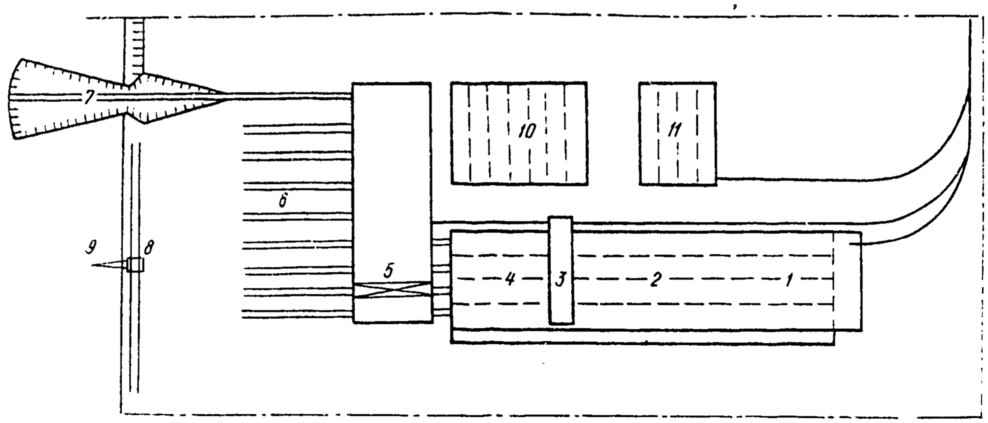


Figure 28. Master plan layout of the main facilities of a Class IV shipyard. 1, 2, 4--shop module (steel storage; shops: hull platers, assembly-welding, assembly of modules and shipbuilding shed); 3--small conveyor; 5--large conveyor; 6--area for winter storage of ships; 7--longitudinal slip; 8--outfitting quay; 9--water; 10-- makeup and machine shop module; 11--storage area module.

The norm for the time required to master the designed capacity does not include the time providing for preparation of the production facility for production output at the facility put into operation (supplying it with personnel, provision with materials, power resources, the creation of the corresponding stockpile of parts, and so on), the complex testing of equipment and startup and adjustment operations. The indicated operations must be performed before signing the document.

When putting the shipyards into operation by phases (complexes being started up) the norms for the time required to master the designed capacities are established for each phase (complex being started up) beginning with the norms approved for the shipyards as a whole.

The norm for the time required to master the designed capacity for a rebuilt shipyard is defined by the difference between the designed capacity and the actual production output at the time it is put into operation.

The level of mastery of the designed capacity is the stable percentage of mastery achieved on the defined date, which can be calculated by the ratio of the production output in the defined period (month, year) to the corresponding designed capacity.

The coefficient of mastery of designed capacity (the use factor of the capacity put into operation) indicates the mastery for the period, and along with the designed capacity it is the base for determining the production volume.

When estimating the work of the shipyard with respect to mastery of designed capacity, the level of mastery of designed capacity and production output for the year are taken into account beginning with the established coefficient of mastery of the annual designed capacity. A complete year of operation reckoned from the date of putting a shipyard (shop) into operation is considered to be the normative operating year of the facility.

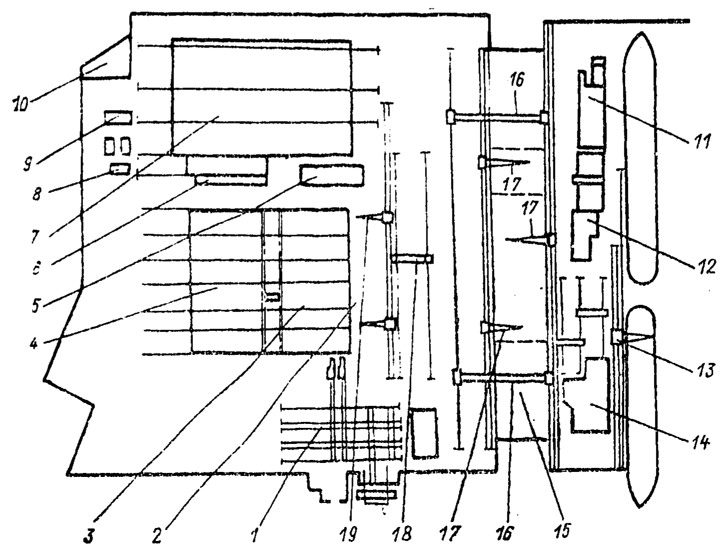


Figure 29. Master plan of a shipyard in Oppama of the Sumitomo Shipbuilding and Machinery Company. 1--steel storage; 2--module storage section; 3--metalworking shop; 4--shop for small and medium assembly of sections; 5--shipyard office; 6--service building; 7--main section assembly shop; 8--main corridor of the shipyard; 9--electrode shop; 10--gas plant; 11--pipe shop; 12--shop for assembly of unitized units; 13--15-ton portal crane; 14--packaged unit and main engine shop; 15--building dock (with exit from both ends); 16--300-ton gantry crane; 17--30-ton portal crane; 18--10-ton crane; 19--200-ton portal crane.

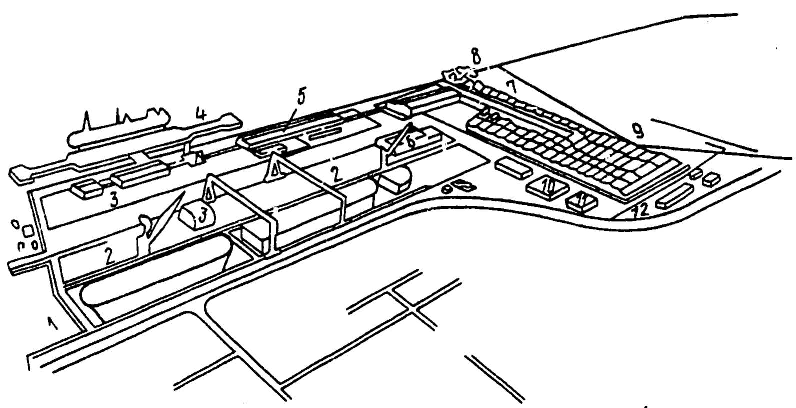


Figure 30. Master plan of shipyard in Tita of the Isikavadzima-Kharima Heavy Industries Company. 1--building docks; 2--module storage area; 3--outfitting and installation shops; 4--outfitting quay; 5--paint shop; 6--assembly-welding shop (assembly of modules); 7--assembly-welding shop (assembly of the mid-section of the hull); 8--steel storage; 9--hull platers shop; 10--pipe fabrication shop; 11--electromechanical shop; 12--main administrative building.

Chapter VII. Operating Conditions and Times Available. The Layout and Brief Composition of the Process Part of the Contract-Detail (Contract) Design of a Shop, Shop Module and Shop Complex of a Shipyard

§21. Operating Conditions and Operating Time Available of Equipment and Workers

The operating conditions of a shipyard (enterprise) are characterized by the following basic factors [14, 24]: discontinuous or continuous production, the number of working days in a week, the length of the working week (in hours), the number of holidays per year, the number of operating shifts per day, the length of a shift (in hours), the adopted work schedule. The shipyards are considered to be discontinuous production facilities.

Independently of a 6-day or 5-day working week with 1 or 2 days off, respectively, the average work time in a week must be 41 hours (36 hours for jobs with harmful working conditions).

In the design calculations eight holidays a year are assumed (1 January, 8 March, 1, 2 and 9 May, 7 October, 7 and 8 November), in contrast to the actual number of holidays in each specific year, which depends on their coincidence with weekends or regular days off. As a rule, shipyards and shops are designed calculating two-shift operation (the working conditions of the shipyard or shop are established by the design assignment). Three-shift operation can be used only for unique equipment: 1,000-ton or larger hydraulic presses, guillotine shears for sheets 25 mm or more thick, sheet-straightening machines for sheets 15 mm or more thick, roll bending machines for sheets 15 mm or more thick.

For the 5-day workweek the work is done by schedules approved by the shipyard (enterprise) administration by agreement with the shipyard trade union committee.

Independently of which work schedule is adopted, the work time per week and the total number of working hours of the equipment in a year are kept the same for an identical number of shifts.

The rated and actual calculated annual work time available of the workers and equipment are presented in Tables 14-16.

The rated time available is the number of hours per year in accordance with the operating conditions without considering losses.

Table 14. Rated Annual Time Available of Workers and Operating Time of Equipment

Nature of Production	No of Shifts Worked	Rated Annual Time Available, hrs	Remarks
With continuous technological process and normal operating conditions			
Workers	--	2,070	41-hour workweek
Equipment	1	2,070	
	2	4,140	
	3	6,210	
With discontinuous technological process and harmful working conditions			
Workers	--	1,830	36-hour workweek
Equipment	1	1,830	
	2	3,660	
	3	5,490	
With continuous technological processes			
Equipment	3	8,760	Continuous year-round operation (365 days)
	3	8,570	Continuous year-round operation except the 8 holidays (357 days)
	3	6,490	Continuous year-round operation except weekends (271 days)

Table 15. Actual (Calculated) Time Available of Workers

	Length of Workweek, hrs			
	41	41	41	36
Main vacation, days	15	18	24	24
Rated annual time available, hours	2,070	2,070	2,070	1,830
Percentage losses from rated time available	10	11	12	12
Actual annual time available, hours	1,860	1,840	1,820	1,610
For the Far North and areas equivalent to the Far North, with additional vacation, hours				
12 days	1,780	1,760	1,740	1,530
18 days	1,740	1,720	1,700	1,490
24 days	1,700	1,680	1,660	1,450
30 days	1,660	1,640	1,620	1,410

The actual calculated time available is the rated time available after subtracting unavoidable losses.

The lost work time is the lost time connected with the routine holidays, additional holidays for continuous operation, training days off, sick leave, pregnancy leave, births, breast feeding of children, and losses connected with a shortened workday for youths from 16 to 18 years old and also the performance of state obligations. The lost work time for equipment is determined beginning with equipment idle time in planned preventive repairs.

§22. Brief Composition of the Process Part of the Contract-Detail (Contract) Design of a Shop, Shop Module or Shipyard Shop Complex

As a rule, the engineering parts of the contract-detail (contract) designs of shipyards and their individual shops are performed in accordance with the existing standards (models) of the contract-detail (contract) designs of shipbuilding enterprises developed on the basis of the experience of the design organizations of the shipbuilding industry and the operating instructions with respect to development of the plans and estimates for industrial construction [5].

The materials of the standards for the engineering part of the contract-detail (contract) design consist of the explanatory notes for the designs with example discussion text, forms of tables and lists, and instructions for development of the design.

In the text and table materials of the standard, the required list of questions is established to which the design must provide answers and technical-economic solutions, and the example content of these answers and solutions is discussed.

The standard materials offer the possibility of individual variations as applied to the specific design conditions. In the standard the volume of design materials is defined beginning with the necessity for solving the basic engineering and economic problems in the design.

The engineering part of the contract-detail (contract) design of the shipyard, as a rule, is developed as part of the designs for individual shops, shop modules and shipyard shop complex.

The engineering part of the contract-detail (contract) designs of individual shipyard shops has the following general basic subdivisions:

purpose and calculated program;

operating conditions and time available;

basic principles with respect to organization of production and scientific organization of labor;

basic principles of production technology;

labor consumption of operations, calculation of equipment, workplaces and number of workers;

designs of bays, materials-handling equipment and platforms;

mechanization, automation and technical level of production;

production control hardware;

safety engineering and labor protection;

freight turnover;

power engineering;

the basic specifications and technical-economic indices.

Table 16. Actual Calculated Annual Time Available for Operation of the Basic Equipment With a 41-Hour Workweek and 8 Holidays a Year

Оборудование (1)	(2) При одной смене			(3) При двух сменах			(4) При трех сменах		
	(5) Номинальный годовой фонд времени, ч	(6) Процент потерь от номинального фонда времени	(7) Действительный годовой фонд времени, ч	Номинальный годовой фонд времени, ч	Процент потерь от номинального фонда времени	Действительный годовой фонд времени, ч	Номинальный годовой фонд времени, ч	Процент потерь от номинального фонда времени	Действительный годовой фонд времени, ч
(8) Электросварочное и газорезательное автоматическое и полуавтоматическое	2070	3	2010	4140	5	3935	6210	7	5775
(9) Металлорежущее и деревообрабатывающее	2070	2	2030	4140	3	4015	6210	4	5960
(10) Металлорежущее уникальное	—	—	—	4140	6	3890	6210	10	5590
(11) Автоматические линии	—	—	—	4140	10	3725	6210	12	5465
(12) Трубогибочные станки	2070	2	2030	4140	3	4015	6210	4	5960
(13) Заготовительное (ножницы, вальцы и т. д.)	2070	2	2030	4140	3	4015	6210	4	5960
(14) Прессы усилием, тс:									
(15) до 315	—	—	—	4140	3	4015	6210	4	5960
(16) до 800	—	—	—	4140	6	3890	6210	9	5650
свыше 800	—	—	—	4140	10	3725	6210	12	5465
(17) Печи термические электрические	—	—	—	4140	5	3935	6210	8	5715
(18) Печи сушильные немеханизированные (камерные)	2070	3	2010	4140	4	3975	6210	6	5840
(19) Оборудование неавтоматизированное	2070	2	2030	4140	3	4015	6210	4	5960
(20) Оборудование автоматизированное	—	—	—	4140	8	3810	6210	10	5590
(21) Крановое и прочее подъемно-транспортное оборудование	2070	3	2010	4140	6	3890	6490	10	5840
(22) Рабочие места (без оборудования)	2070	—	2070	4140	—	4140	6210	—	6210

Key:
1. Equipment
2. For one shift
3. For two shifts
4. For three shifts
5. Rated annual time available, hrs
6. Percentage losses out of the rated time available
7. Actual annual time available, hrs
8. Automatic and semiautomatic electric and gas welding

Key to Table 16 (continued)

9. Metal cutting and woodworking
10. Metal cutting, unique
11. Automatic lines
12. Pipe-bending machines
13. Billeting (shears, rolls, and so on)
14. Presses with a force, tons
15. To ...
16. More than 800
17. Thermal electric furnaces
18. Unmechanized (chamber) drying furnaces
19. Nonautomated equipment
20. Automated equipment
21. Cranes and other materials-handling equipment
22. Workplaces (without equipment)

Appendices: 1) authorized list of auxiliary workers, engineering-technical workers, office workers and junior service personnel;

2) the composition of the workers by groups of production professions as a function of the sanitary characteristics of the production process according to the construction norms and rules (SNiP II-M.3-68);

3) the production category and class of facilities with respect to explosion and fire hazard according to the construction norms and rules (SNiP II-M.2-72) and the electrical installation rules (PUE, 1966);

4) the list for the production equipment, the process accessories and attachments and the production and organizational equipment;

5) the order specifications for the designated production equipment and equipment requiring a longer manufacturing cycle;

6) the tables for calculating the level of mechanization and automation of production processes;

7) table for determining the technical level of production;

8) initial requirements on the development of nonstandard (atypical) and nonstandardized equipment;

9) drawings: in the contract-detail design, the detail drawing of the shop plan (with sections)--and in the contract design, the functional diagram of the shop (with sections);

10) reference materials (stored only in the design organization copy), including an equipment list not used for reconstruction design; the initial data for calculating the noise level from the process equipment; the process requirements on other parts of the design.

Depending on the peculiarities of one shop or another, the above-enumerated subdivisions and indices can be supplemented or more precisely defined.

The "Operating Conditions and Time Available" subdivision is presented only for the contract-detail (contract) design of an individual shop.

In the engineering part of the contract-detail (contract) design of the shop module (building) the following basic data are discussed:

the composition of the shop module (unit);

the operating conditions and time available;

building and layout of the shop module (unit);

power engineering of the shop module;

summary data on the shop module (unit), including the total area of the shops in the module, the employ payroll (production workers, auxiliary workers, engineering technical workers, office workers, young service personnel), and the amount of process equipment.

After discussion of the general data on the module, explanatory notes and drawings are presented by shops located in the module.

The engineering part of the contract-detail (contract) design of the complex of shipyard consists of the following basic subdivisions:

the production program, the characteristics of the production subjects (ships), estimation of their quality and progressiveness and substantiation of the effectiveness;

cooperation of the basic and auxiliary production;

operating conditions and time available;

composition of the complex of shipyard shops and production flow diagrams;

method of building ships and characteristics of the basic technological processes;

production output quality control measures;

volume of operations, labor consumption and shipbuilding time;

siting of the basic structures and shops of the shipyard (basic hydroengineering structures and shops of the shipyard);

basic data and technical-economic indices (annual production output or carrying capacity per year; labor consumption for the annual program; employee payroll, including production workers, auxiliary workers, engineering-technical workers, office workers and junior service personnel; the amount of process equipment, including machine tools, cranes, means of mechanization, and so on; total area; extent to which the operations are electrified; annual production output per worker, per employee and per square meter of total area; labor consumption per ton of production output; level of mechanization and automation of production processes; technical level of production; degree to which one worker is aided by electric power and for the largest shift).

The basic data and the technical-economic indices are presented both with respect to the complex and with respect to individual shipyard shops.

At the beginning of the engineering part of the contract-detail (contract) design of an individual shop or shop module or complex of shipyard shops, information is presented on the patent information research in which the examined patent and technical reports and forms, sources of information with respect to the adopted technical solutions and also a list of claims for inventions entering into the design, information about the patentability and the patent purity of the production processes, the equipment, instruments, structural components, materials and products used for the first time or developed in the design are presented.

At the end of the reference material, conclusions are presented on the patentability and patent purity of the subject.

PART 2. PLANNING AND DESIGN OF SHIPYARD SHOPS AND STRUCTURES

CHAPTER VIII. PURPOSE, DESIGNED PROGRAM, BASIC PRINCIPLES OF THE PRODUCTION PROCESS AND ORGANIZATION, LABOR-CONSUMPTION AND PERSONNEL

§23. Purpose and Designed Program of the Shops

The problems of designing shipyard shops are discussed as applied to their organizational structure providing for division of the production shops of the shipyard into groups:

Hull and assembly-installation shops;

The makeup shops which basically turn over their production to the central makeup warehouse and do not participate in the assembly-installation operations of the ships being built.

According to this organizational structure, a brief description of the purpose of the shipyard shops and sections is presented below.

Mold Loft Operations Office. With mechanized production of the hull components, the mold loft operations office is responsible for the following:

The mold loft calculations (analytical coordination of the hull lines, calculation of the position of the seams, the joints of the shell plating and longitudinal joining lines, and the shell-plate development on the hull surface, determination of the sizes of the structural elements and the scaled lofting linework of the hull);

Programming of the technological processes (determination of the dimensions of the hull parts, mechanical line drawings of the parts, programming of the thermal cutting, layout, marking and other operations of machining the parts and also programming the tracing of the prints);

The servicing of the computer and the drawing units (repair and preventive maintenance of the equipment, insurance that it operates in the established mode);

The solution of the process engineering problems (implementation of the process of machining the parts and assembly of the structural elements of the hull provided for in the design plans and specifications, production forms and records, considering all of the current changes);

The manufacture and storage of bending templates and gauges, frames and mockups.

Preliminary Dressing, Finishing and Priming of Steel. This section is an intermediate process link between the steel warehouse and the hull platers shop. It provides for preliminary dressing of the steel, finishing and priming.

Hull Platers Shop. This shop makes the parts of the hull from sheet metal and rolled section.

Assembly and Welding Shop. This shop is used to assemble and weld the hull assemblies and sections of metal ships made of parts obtained from an intermediate warehouse. Fittings and fixtures are also installed in the hull assemblies and panels, that is, the portlights, covers, and scuttles, the compartment equipment fastenings, bitts and chocks, service tank, platforms and ladders, piping systems, marine gear, and so on. The "saturation" products make up 5-7% of the total weight of the assemblies and panels produced by the shop (for example, for dry-cargo vessels and trawlers).

Section for Painting and Drying the Panels. The creation of special sections at the shipyard for painting and drying the hull panels of the ship arises from the necessity for preserving the panels from corrosion during their storage in the warehouse and then building the ship in the building slip and also inadmissibility of painting and drying directly in the assembly and welding shops with respect to safety engineering requirements.

Aluminum-Magnesium Alloy Structural Shop. This shop makes the parts, assemblies and panels of the ships the hull or part of the hull components of which (superstructure, smokestacks, and so on) are made of light aluminum-magnesium alloys. In this book a study is made of the planning and design of shops for making assemblies and panels of superstructures, smokestacks and other analogous structural elements from these alloys.

Synthetic Materials Structural Shop. This shop is intended for machining, assembly, welding and bonding of products made from synthetic materials and intermediate products and also the preparation of synthetic mastics and adhesives, the materials for which come to the shipyard by cooperative efforts. Primarily laminated plastics, fiberglass, textovynite, rigid and flexible foam plastics, polyvinylchloride, polyethylene, capron, textolite, and so on are used for parts and structural elements.

The synthetic materials structural shop makes the internal bulkheads and enclosures of the ships; ladders, guard rails and small fixtures; insulating parts and assemblies; nonstandard furniture, shelves, lockers and other products for equipping the compartments; water system pipes and fittings, air pipes and speaking tubes; engine room decking; and linoleum and mastics are made for covering the floors and decks.

Section for Making unitized units and Zonal Modules. This section performs assembly operations and installs the machinery, equipment and systems in the unitized units and the zonal modules, and it also performs necessary checks and bench tests under shop conditions to reduce the amount of work directly when building the modules and on the ship as a whole. It can also be an independent shop.

Module Building Shop. The shop for building modules is designed for the assembly and welding of the hull and superstructure modules by the flow-position method from assemblies and panels previously made in the assembly-welding shop and also for installing machinery, systems and lines, electrical equipment, the compartment equipment, and so on in these modules. The hull and superstructural modules are built, as a rule, during the series construction of the ships at the class II, III and IV shipyards.

Shipbuilding Shed. The shipbuilding shed is designed for performing the operations of building the ships in the shipbuilding ways, that is, the operations connected with hull assembly, installation of the machinery, systems, pipelines, and devices; equipment of the compartments, painting and so on. Thus, this shed performs all of the building slip operations of the shipyard, with the exception of the electrical wiring operations and the operations with respect to installing heat control instruments and insulation which are performed by the corresponding specialized enterprises. (The composition of the specialized enterprises can be expanded.) As a rule, the shipbuilding shed is an assembly and installation shop, and it does not perform intermediate operations, except for a small amount of fabrication required during installation.

Electrical Installation and Wiring Shop. At the shipyard the electrical installation and wiring shop installs, tests and accepts electrical equipment, the external communications and observation means when building the ships. As a rule, this shop is considered to be a specialized contractor with the existing cooperation.

Outfitting and Acceptance Shop. This shop is designed for outfitting the ships after launching, preparation and holding of the mooring trials at the outfitting quay of the shipyard, plant and acceptance sea trials and acceptance of the ships by the customer.

Hull Fitting Shop. This shop makes parts, assemblies and structural elements for the hull fitting of the ships: light bulkheads and enclosures, light foundations and supports, marine ventilation units, built-in metal furniture, nonstandardized hull fittings, fasteners for the systems and devices.

Pipe Fabrication and Preparation Shop. The pipe shop makes pipe from materials of various types and the assemblies for the marine systems and pipelines, and it also does copper work for making nonstandard products from sheet and intricately shaped rolled copper: connecting lines and elbows with flanges, bulkhead sockets, speaking tube parts, and so on.

Section for Chemical Cleaning, Hot Galvanizing and Priming of Pipe. The water system pipe of the ship from the pipe fabrication shop is subjected to hot galvanizing in this shop with subsequent heat treatment of the coating, and the pipes of other systems are subject to nonmetallic coating (phosphate coating and priming). At the present time a new method of coating the pipe systems by enameling is being checked out (instead of hot galvanizing with subsequent heat treatment).

Woodworking Shop. At the shipyard this shop is designed to manufacture wood parts and products constituting part of the ship's hull and also insulating parts, the compartment equipment and stores, loader, fixtures, anchor and boat-handling gear.

Insulation Fabrication Section. In this section the insulating parts and assemblies are fabricated for the compartments, pipelines, systems and machines. Independent insulation fabrication sections basically are provided in the designs of class I, II and III shipyards, and in the class IV and V shipyard plans, the insulation fabrication operations are, as a rule, performed in the woodworking, painting and other shops.

Galvanizing Shop. The parts and products are coated in the galvanizing shop to protect them against corrosion (and also to protect places not subject to case-hardening). The parts are given a decorative finish, and individual defects permitted when machining the parts are corrected.

The basic forms of operations in this shop are galvanizing, chemical coating and anodizing of parts and products.

Paint Preparation Shop. In the shipyard this shop is needed to prepare paints, mastics, spackling and adhesives. In the practice of designing these shops, as a rule, we begin with the fact that the shipyard receives paints and varnishes through cooperative effort. They are basically stored in the commercial chemicals warehouse, and the paint preparation shop prepares them; the finished paints and other materials are sent from the shop to the warehouse or through it to the corresponding user-shops.

When discussing the purpose of the shipyard shops, the nature of their production is noted: series, small-series, individual.

The calculated annual program of the designed shipyard shops, as a rule, is defined in terms of the mass production output in accordance with the distribution of the weight load of the ships with respect to basic forms of operations during construction (see Table 2) and by the given annual production of ships in units:

$$B_{\text{ц}}^{(1)} = (Q_1 + Q_2 + \cdots + Q_n)\, n_c,$$

Key: 1. sh

where B_{sh} is the calculated annual shop program, tons; Q_1, Q_2, ..., Q_n are the weights of parts or products determined by the weight load of the ship for the specific type of operations in the shop, tons; n_c is the calculated annual program of the shipyard with respect to production of ships, units.

When ships of several classes are present in the shipyard program, the calculated annual program for the shop is determined for each class of ship individually, and then these data are summed.

In design practice the data on the calculated shop program expressed in mass of parts or products are presented in tabular form (see Table 17).

Table 17

Calculated Annual Shop Program

(a) Статьи весовой нагрузки	(b) Масса изделий, т, на одно судно типа			(c) Общая масса изделий на годовую программу, т
	A	B	C	
(d) 1. Металлический корпус				
(e) 2. Фундаменты и подкрепления				
3.				
4.				
(f) и т. д.				
(g) Итого				

Key:
a. Weight load items
b. Mass of products, tons, per ship of class
c. Total mass of products for the annual program, tons
d. Metal hull
e. Foundations and supports
f. and so on
g. Total

Sometimes with a large variety of products in the shop program (for example, products for several ship designs) the program is replaced by a program reduced to the products for one example ship design.

The recalculation of the annual calculated program of a shop for one type of product (for one basic example ship) is carried out by the formula

$$B_{red.sh} = \frac{A_{pr}}{I_{ex.s}},$$

where $B_{red.sh}$ is the reduced calculated annual program of the shop, tons; A_{pr} is the labor consumption of the shop operations for the annual program, man-hours; $I_{ex.s}$ is the labor consumption per ton of production output of the shop with respect to an example ship, man-hours/ton.

Ships, the products for which have the greatest specific weight in the shop program are taken as the example ships. The means provided for the production of these products also provide for the production of the products for all other ships of the calculated shop program.

The calculated annual program of the galvanizing shops is defined by the types of coating (for example, galvanizing, parkerizing, acid copper plating, nickel plating, chrome plating, chemical oxidation, and so on), and it is presented both with respect to area (m^2) and mass (tons) of coated parts and products.

For proper selection of the designed production means, characteristics of the parts and products made by the shop are presented. For example, when describing the calculated program of the hull platers shop, the characteristics of the metal to be machined (the basic type of steel, maximum and average sizes of the sheets and rolled section, the average and maximum mass of the individual sheets and rolled section) are discussed. Data are also presented on the steels of other types if machining them limits the equipment characteristics.

In the assembly and welding shops, among the basic data characterizing the structural elements produced by the shop are maximum and mean dimensions of the mass of the panel, maximum and mean thickness of the welded parts, types of steels used in the hulls.

In the module construction shops the basic data characterizing their production output are the dimensions and mass of the modules (Table 18).

Table 18

Example Data on Ship Modules by Classes of Shipyards

Shipyard class	Maximum module sizes, meters			Maximum weight, tons
	Length	Width	Height (without superstructure)	
II	30.0	24.0	15.0	1500
III	25.0	19.0	12.0	750
IV	15.0	15.0	9.5	200

§24. Basic Principles of the Organization of Production and Scientific Organization of Labor

When developing the shop plans, the basic principles with respect to organization of production are discussed, including the composition of the sections, their purpose and interrelations, organization of the production processes considering the series nature of ship construction and also with respect to organization of the auxiliary services, including warehousing with description of the purpose of the stores (warehouses) and their relations to the general shipyard warehouses, the repair facilities with indication of the types of repairs performed by the shop repair service, the tool management with description of the purpose of the stores and relations to the general shipyard tool service.

Thus, the module construction shops and the shipbuilding sheds have approximately the following specialized sections[1]:

The hull building section which assembles and welds the ships' hulls;

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[1]The list of sections is presented under the assumption that the electrical installation and wiring operations, the installation of the heat control and automation instruments and also the insulation operations on the ships are performed by contractors.

The hull fitting section which installs hull fittings, fixtures, devices, metal compartment equipment and other hull fitting products;

The mechanical installation section which installs the machinery and equipment;

The pipe installation section which installs pipelines and systems;

The wood installation section which performs all operations connected with installing the wooden parts of the hull and compartments;

The paint section which performs spackling, painting and other analogous operations.

The organization of shop control must correspond to the adopted optimal volume of production, the type of construction of the production sections and their relations to the auxiliary services.

The application of technical means has defined influence on the efficiency of the shop control system and, primarily, the process of executing individual operations and organization of administrative labor. This influence is particularly significant when using the ASUP [automated enterprise control system] for the shipyard, including individual shops.

An example diagram of shop control based on analogous diagrams for existing shops of the shipyard is presented in Figure 31, and an example diagram of shop control under ASUP conditions, in Figure 32.

Under the conditions of using the ASUP, the planning and distribution office of the shop is changed significantly as a result of the fact that the functions of establishing assignments for the sections are primarily eliminated, for the shop receives an operative production plan by section profile directly from the computer center.

In addition, the significance of the function of monitoring the fulfillment of the planned assignments both by sections and by the shop as a whole increases. Therefore, the organizational structure of the shop provides for a dispatch planning office (PDB), which is directly subordinate to the shop chief.

The shop PDB includes a branch dispatch service which provides for operative functioning of the ASUP and also monitoring of the support of basic production and the course of production directly. This service is set up beginning with the principle of specialization of dispatchers with respect to types of operations and control functions, which permits operative monitoring of the condition of all of the production subdivisions of the shop and processing of the information received both for the shop administrative services and for the central dispatch service and also transmittal of the required information to the ASUP to support its operative functioning.

For successful direction of the personnel administration function, the organizational structure of shop control provides for a specialized control link -- the job of assistant shop chief for personnel.

The function of bookkeeping accounting at the shipyard is completely centralized, and therefore bookkeeping as an administrative link in the shop control structure is no longer necessary.

The fundamentals of advanced organization of labor insuring highest productivity of labor are set down in the engineering design. The problems of the organization of labor are considered when selecting and substantiating the technological processes, the process equipment and mechanization means. When developing the requirements on the technical means of production control, solutions are found to such problems of the organization of labor and the operating conditions and available time of the workers and equipment, the sharing and cooperation of labor in production operations, organization of the work places, the number of personnel by categories, measures with respect to protection of labor and safety engineering.

Primary attention is given to providing for the requirements of scientific organization of labor in the shipyard plans as a whole and the plans for individual shops when selecting and substantiating the technological processes for the building of ships and, in particular:

Observation of the rectilinearity of the process flows through the shipyard, individual shops and sections;

The application of highly efficient modern equipment;

Mechanization and automation of the technological processes in all production links;

Mechanization and automation of the transport and the loading and unloading operations with reduction of manual labor to the minimum, and so on.

The requirements of scientific organization of labor must also be considered when developing the equipment designs. They also include the initial requirements for the development of nonstandard and nonstandardized equipment and the creation of new equipment which must provide:

A decrease in the expenditures of physical labor and maintenance of high activity of the worker over the entire ship;

The possibility of quick mastery of the equipment, simplicity and convenience of operation, control and servicing;

Application of efficient work procedures and methods and also process-organizational attachments;

Improvement of the interest in labor, growth of qualifications and development of intellectual functions of the workers;

Favorable sanitary-hygienic conditions in labor and safety engineering requirements.

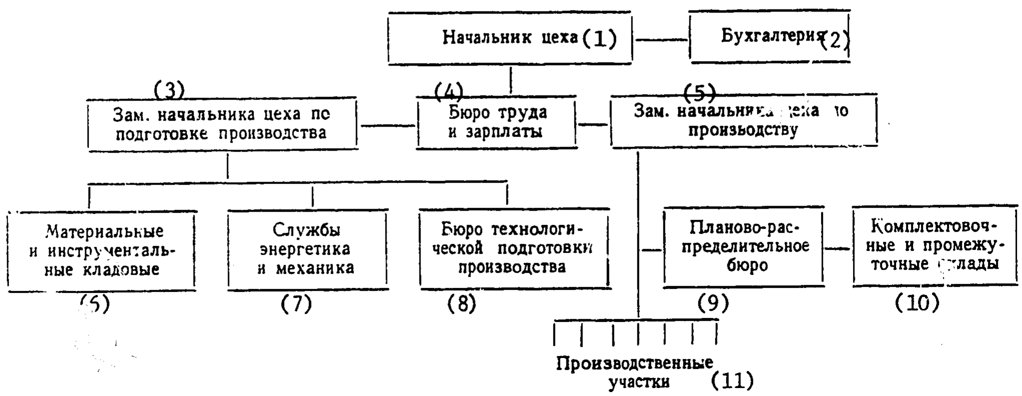

Figure 31. Example diagram of shop control on the basis of analogous diagrams of existing shipyard shops

Key:
1. Shop chief
2. Bookkeeping
3. Deputy shop chief for production preparation
4. Office of labor and wages
5. Deputy shop chief for production
6. Materials and tool stores
7. Power engineering and mechanical services
8. Office of engineering preparation of production
9. Planning and distribution office
10. Makeup and intermediate warehouses
11. Production section

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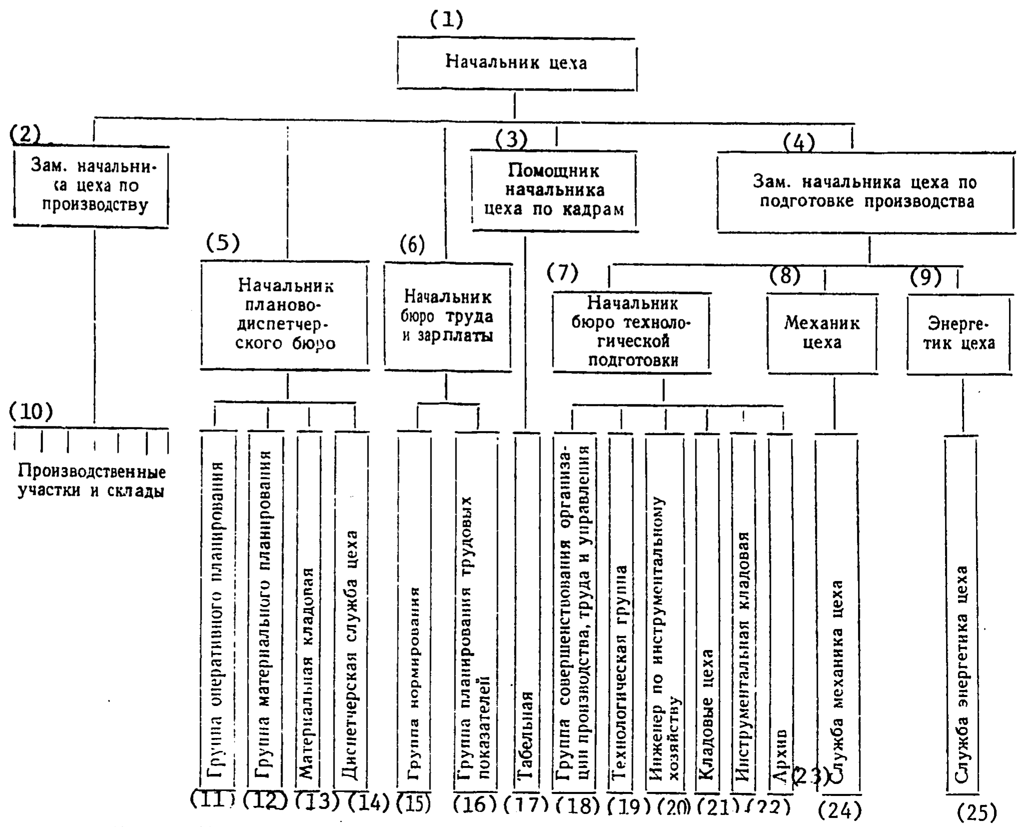

Figure 32. Example diagram of shop control under ASUP conditions

Key:
1. Shop chief
2. Deputy shop chief for production
3. Assistant shop chief for personnel
4. Deputy shop chief for preparation of production
5. Chief of planning and dispatch office
6. Chief of office of labor and wages
7. Chief of process preparation office
8. Shop mechanical engineer
9. Shop power engineer
10. Production sections and warehouses
11. Operative planning group
12. Material planning group
13. Material storage
14. Dispatch service of the shop
15. Normalization group
16. Labor index planning group
17. Timekeeping
18. Group for improvement of the organization of production, labor and management
19. Process group
20. Tool service engineer
21. Shop storage
22. Tool storage
23. Archive
24. Shop mechanical engineering service
25. Shop power engineering service

§25. Basic Principles of the Shop Production Processing

The shop designs are developed fully in accordance with the basic processing principles and production organization adopted and discussed in the design.

An example of discussion of the technological processes with respect to basic forms of operations (as a rule, corresponding to the lines of the shops) when constructing series transport and factory ships is presented below in abbreviated form.

Mold Loft Operations. These operations are performed with the application of analytical methods and means of computer engineering providing for the following:

Analytical determination of the ship's lines, the shapes and dimensions of the parts and structural elements of the hull;

Mechanical drawing of scaled loftings, the outlines of the parts and layout drawings for the machine tools with program control;

The programming of the processes of manufacturing parts, subassemblies and panels and other products; obtaining calculated mold loft data for all phases of construction of the ship.

Preliminary Dressing of the Steel. Dressing is carried out on leveling rolls or stretching machines, where both the sheet and tolled section are dressed on the stretching machines; part of the sheets (more than 40 mm thick) are not subjected to preliminary straightening.

The scale and rust are removed from the steel mechanically and chemically. The mechanical means include shot-blasting (the stationary chamber with dust formation and dustless portable units and guns) and a cleaning by pneumatic metal brushes and needle cutters.

The chemical method includes chemical cleaning of the steel by pickling in solutions of hydrochloric or sulfuric acid. The pickling is done in steel baths lined with acid-resistant material and equipped with exhaust fans.

After cleaning, the metal is coated with the corresponding primers for temporary protection against atmospheric corrosion.

In the majority of cases shot-blasting is used to clean the steel for a ship's hull. This method allows sheets from 3 mm up in thickness to be cleaned.

The preliminary dressing of the steel, cleaning and priming are provided for on the flow lines that connect the steel warehouse to the hull platers shop. For example, in the sections of class I and II shipyards, a flow line is provided for preliminary dressing, cleaning and priming of sheet steel from 16 mm up in thickness; the same, for sheet steel from 3 to 16 mm thick, and a flow line for cleaning and priming sectionsteel.

Sometimes the intricately shaped rolled products are subjected to preliminary dressing directly at the steel warehouse in order to improve transportation by roller conveyors, storage units and other devices and prepare the steel for machining.

Machining Hull Components. The machining is done on specialized flow lines.

The sheet components are measured and marked on the flow lines using measuring and marking machines with program control. Sometimes the hull components are marked manually by special marking pencils at individual positions. The gas cutting of the sheets and also finishing of the edges by welding are done on gas cutting machines with program control having three-head modules. The gas electric cutting of the plates is done on analogous machines having additional fittings for this purpose (a gas-electric cutting head and electric arc feed). The mechanical cutting of the plates up to 8-10 mm thick is done on guillotine shears equipped with all-purpose mechanized attachments. The cut parts are sorted by electromagnetic or vacuum sorters with program control. The sheet parts are straightened on sheet-straightening rollers and presses. The cutting, cutout and marking of intricately shaped rolled products are done, as a rule, on special presses with automatic stamping machines. The shaped rolled products are also cut on the gas-cutting machines with programmed control.

The sheet components of simple curvature (cylindrical and conical shape) are bent on bending rolls equipped with manipulators and a tracking system permitting bending without templates; parts of complex curvature are bent on hydraulic presses; individual small and medium parts are bent on flanging machines. Intricately shaped rolled products with constant radius of curvature are bent on horizontal bending machines, and with variable radius and wall height to 450 mm, on a machine with programmed control and heating by high-frequency currents.

The finished parts are transported to the packaged product sections, where they are put into groups (by sections), and then in specialized containers or packages sent to the hull components warehouse.

The manufacture of the components of a ship's hull is broken down into classes and groups by the following attributes: the initial material (sheet and intricately shaped rolled products), the dimensions of the components, the presence of bends of all types, the shape of the edges of the parts, the presence of internal notches and finishing of the edges with molding, uniformity of operations and the process circulation and also the possibility of using computers to determine the outlines and dimensions of the parts, for programming of the processes of planning and accounting for the manufacture of the hull component.

In the classification of hull components (Table 19) all parts of the ship's hull are broken down into five classes, and each class, into eight groups. The classes and groups have a two-digit code: the first digit indicates the class the part belongs to, and the second, each group it enters into.

In accordance with the presented classification for each group of parts, the circulation flow charts (Tables 20 and 21) are compiled, in which the number of parts and their weight per ship with respect to each group, the labor consumption of manufacture, recalculated for 1 ton of parts and the ship as a whole, and the sequence of the process operations and operation-by-operation labor consumption are presented.

The flow lines for machining the hull components in the hull platers shops at class I and II shipyards can be organized, for example, as follows:

	Class and group code of parts made on the flow lines
Lines for making parts from sheets up to 4500 mm wide	11, 12, 13, 15, 16, 22, 23, 25, 26
Lines for making parts from sheets up to 3200 mm wide	11, 12, 15, 17, 21, 22, 23, 25, 26, 31, 32, 35, 41
Lines for making parts from rolled section	51, 52, 53, 54, 55, 57

The lines for making parts from sheets, in turn, can be broken down into gas-cutting lines and machine tool cutting. For example, for the hull platers shops at class III, IV and V shipyards, the flow lines for machining the hull components can be organized as follows:

	Class and group code of parts made on flow lines
Lines for manufacturing parts from sheets using automatic gas-cutting	11, 12, 13, 15, 16, 18, 21, 22, 23, 25, 27, 28, 32, 35, 41
Lines for making parts from sheets using machine tool cutting	11, 12, 13, 14, 15, 18, 21, 24, 31, 32, 35, 41
Lines for making parts from rolled section	51, 52, 53, 54, 55, 57

In the designed assembly and welding shops, the flow method with direct support of all lines with parts, assemblies and fittings is provided for for the series construction of ships as the basic method of manufacturing the assemblies and panels.

The process flow of assembly and welding of panels begins with the hull components warehouse, in which the parts are packaged by assemblies and panels, after which the finished sets are sent to the corresponding flow or process lines. Here on the flow lines the manufactured assemblies and panels are shifted according to special positions, and on the process lines, the assemblies and panels are made at stationary work places.

The framing is assembled and welded separately. The rectilinear T-beams are assembled and welded on a specialized, mechanized MIB-700A type unit, and the curvilinear and rectilinear beams, on the SKT12-1 type unit. The measuring and testing operations are performed using data prepared by the computers and also using optical and laser instruments. On the mechanized, all-purpose jigs for assembly of the panels with curvilinear lines, the height of the uprights or the lines of the templates are set, and the dimensions and shape of the panels are checked by data also obtained by using computers.

Table 19

Classification of Hull Components

(a) Классы				
1. Крупногабаритные с прямолинейными кромками	2. Крупногабаритные с криволинейными кромками	3. Мелкие с прямолинейными кромками	4. Мелкие с криволинейными кромками	5. Детали из профильного проката
(b) Группы				
1.1. Плоские без вырезов и разделки кромок	2.1. Плоские без вырезов и разделки кромок	3.1. Плоские без вырезов и разделки кромок	4.1. Плоские без вырезов и разделки кромок	5.1. Прямые без вырезов и разделки кромок
1.2. Плоские с вырезами без разделки кромок	2.2. Плоские с вырезами без разделки кромок	3.2. Плоские с вырезами без разделки кромок	4.2. Плоские с вырезами без разделки кромок	5.2. Прямые с вырезами без разделки кромок
1.3. Плоские без вырезов с разделкой кромок	2.3. Плоские без вырезов с разделкой кромок	3.3. Плоские без вырезов с разделкой кромок	4.3. Плоские без вырезов с разделкой кромок	5.3. Прямые без вырезов с разделкой кромок
1.4. Плоские с вырезами и разделкой кромок	2.4. Плоские с вырезами и разделкой кромок	3.4. Плоские с вырезами и разделкой кромок	4.4. Плоские с вырезами и разделкой кромок	5.4. Прямые с вырезами и разделкой кромок
1.5. Гнутые с простой кривизной без разделки кромок	2.5. Гнутые с простой кривизной без разделки кромок	3.5. С отогнутыми фланцами без вырезов и разделки кромок	4.5. С отогнутыми фланцами без вырезов и разделки кромок	5.5. Гнутые без вырезов и разделки кромок
1.6. Гнутые с простой кривизной и разделкой кромок	2.6. Гнутые с простой кривизной и разделкой кромок	3.6. С отогнутыми фланцами без вырезов с разделкой кромок	4.6. С отогнутыми фланцами без вырезов с разделкой кромок	5.6. Гнутые без вырезов с разделкой кромок
1.7. Гнутые с углами слома, со сложной кривизной без разделки кромок	2.7. Гнутые с углами слома, со сложной кривизной без разделки кромок	3.7. С отогнутыми фланцами с вырезами без разделки кромок	4.7. С отогнутыми фланцами с вырезами без разделки кромок	5.7. Гнутые с вырезами без разделки кромок
1.8. Гнутые с углами слома, со сложной кривизной и разделкой кромок	2.8. Гнутые с углами слома, со сложной кривизной и разделкой кромох	3.8. С отогнутыми фланцами с вырезами и разделкой кромок	4.8. С отогнутыми фланцами с вырезами и разделкой кромок	5.8. Гнутые с вырезами и разделкой кромок

Key:
a. Classes
1. Large-scale with rectilinear edges
2. Large-scale with curvilinear edges
3. Small with rectilinear edges
4. Small with curvilinear edges
5. Parts made of section
b. Groups
1.1. Flat without notches and finishing of the edges
2.1. Flat without notches and finishing of the edges
3.1. Flat without notches and finishing of the edges
4.1. Flat without notches and finishing of the edges
5.1. Straight without notches and finishing of the edges
1.2. Flat with notches without finishing of the edges
2.2. Flat with notches without finishing of the edges
3.2. Flat with notches without finishing of the edges
4.2. Flat with notches without finishing of the edges
5.2. Straight with notches without finishing of the edges
1.3. Flat without notches with finishing of the edges
2.3. Flat without notches with finishing of the edges
[continued]

[Key to Table 19, continued]

3.3. Flat without notches with finishing of the edges
4.3. Flat without notches with finishing of the edges
5.3. Straight without notches with finishing of the edges
1.4. Flat with notches and finishing of the edges
2.4. The same as 1.4
3.4. The same as 1.4
4.4. The same as 1.4
5.4. Straight with notches and finishing of the edges
1.5. Bent with simple curvature without finishing of the edges
2.5. The same as 1.5
3.5. With bent flanges without notches and finishing of the edges
4.5. The same as 3.5
5.5. Bent without notches and finishing of the edges
1.6. Bent with simple curvature and finishing of the edges
2.6. The same as 1.6
3.6. With bent flanges without notches with finishing of the edges
4.6. The same as 3.6
5.6. Bent without notches with finishing of the edges
1.7. Bent with breaking angles, with complex curvature without finishing of the edges
2.7. Bent with breaking angles, with complex curvature without finishing of the edges
3.7. With bent flanges with notches without finishing of the edges
4.7. The same as 3.7
5.7. Bent with notches without finishing of the edges
1.8. Bent with breaking angles, with complex curvature and finishing of the edges
2.8. The same as 1.8
3.8. With bent flanges with notches and finishing of the edges
4.8. With bent flanges with notches and finishing of the edges
5.8. Bent with notches and finishing of the edges

During assembly, the mechanisms and devices are used which permit fixing of the mutual position of the structural elements so as to sharply reduce (and in individual cases even exclude) the assembly electric tack welding. In addition, these mechanisms and devices provide for increased tolerances on the welding gaps (considering that the welding will be done on mechanized jigs, with flexible flux channels) permitting a significant reduction in the volume of fitting and adjustment operations. Automatic and semiautomatic welding are widely used (within the limits of 80 to 85% of the total volume of welding by mass of the built-up metal), including gas-shielded welding, one-sided automatic welding of panels with two-sided shaping of the weld, including one-sided mechanical welding on ceramic liners, slant electrowelding, group welding of the frames by multiarc devices, welding of individual structural elements (cast-welded stems, brackets, cast-forged-welded rudder stocks, and so on) by automatic electroslag welding machines. It is also necessary to consider the further development of welding processes and the creation of new, advanced welding equipment, including optimization of the geometric and engineering parameters of welded joints in the direction of decreasing the volume of built-up metal, the process for slit gap welding, the development

Table 20

Circulation Flow Charts for the Manufacture of Hull Components from Sheet Steel

							Последовательность технологических операций (8)									
							Трудоемкость на одно судно, чел.-ч (9)									
Классы деталей (1)	Группы деталей (2)	Шифр класса и группы деталей (3)	Количество деталей на одно судно, ед. (4)	Масса деталей на одно судно, т (5)	Трудоемкость на 1 т массы деталей, чел.-ч/т (6)	Трудоемкость на одно судно, чел.-ч (7)	разметка и маркировка (10)	газовая автоматическая резка (11)	газоэлектрическая автоматическая резка (12)	станочная резка (13)	снятие фасок на газорезательных машинах (14)	правка деталей в вальцах (15)	правка деталей на прессах (16)	гибка в вальцах (17)	гибка на прессах (18)	сверловка и зенкование (19)
Крупногабаритные с прямолинейными кромками (20)	Плоские без вырезов и разделки кромок (21)															
	Плоские с вырезами без разделки кромок (22)															
Крупногабаритные с криволинейными кромками (23)	Плоские с вырезами без разделки кромок (24)															
	Гнутые, с углами слома, со сложной кривизной, без разделки кромок и т. д. (25)															

Key:
1. Classes of parts
2. Groups of parts
3. Class and group code of parts
4. No of parts per ship, units
5. Weight of parts per ship, tons
6. Labor-consumption per ton of parts, man-hours/ton
7. Labor consumption per ship, man-hours
8. Sequence of process operations
9. Labor consumption per ship, man-hours
10. Measurement and marking
11. Automated gas cutting
12. Automated gas electric cutting
13. Machine tool cutting
14. Removal of facets on the gas-cutting machines
15. Straightening parts in rolls
16. Straightening parts in presses
17. Bending in rolls
18. Bending on presses
19. Drilling and countersinking
20. Large-scale with rectilinear edges
21. Flat without notches with finishing of the edges
22. Flat with notches without finishing of the edges
23. Large-scale with curvilinear edges
24. Flat with notches without finishing of the edges
25. Bent, with breaking angles, with complex curvature, without finishing of the edges, and so on

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Table 21

Circulating Flow Charts of the Manufacture of Hull Components
from Intricately Shaped Steel

Классы деталей (1)	Группы деталей (2)		(3) Шифр класса и группы деталей	(4) Количество деталей на одно судно, ед.	(5) Масса деталей на одно судно, т	(6) Трудоемкость на 1 т массы деталей, чел.-ч/т	(7) Трудоемкость на одно судно, чел.-ч	Последовательность технологических операций (8) Трудоемкость на одно судно, чел.-ч (9)				
								маркировка (10)	рубка профиля и вырубка отверстий (11)	гибка на кольцегибочном станке (12)	гибка на прессе (13)	сверловка и зенкование (14)
Детали из профильного проката (15)	Прямые (16)	Без вырезов и разделки кромок (18)										
		С вырезами без разделки кромок (19)										
	Гнутые (17)	Без вырезов и разделки кромок (20)										
		С вырезами без разделки кромок и т. д. (21)										

Key:
1. Class of parts
2. Groups of parts
3. Parts class and group code
4. No of parts per ship, units
5. Weight of parts per ship, tons
6. Labor consumption per ton of parts, man-hours/ton
7. Labor consumption per ship, man-hours
8. Sequence of process operations
9. Labor consumption per ship, man-hours
10. Marking
11. Cutting the profile and cutting out holes
12. Bending on annular bending machine tool
13. Bending on a press
14. Drilling and countersinking
15. Parts made of intricately shaped rolled products
16. Straight
17. Bent
18. Without notches and finishing of the edges
19. With notches without finishing of the edges
20. Without notches and finishing of the edges
21. With notches without finishing of the edges, and so on

of gas-shielded welding, the welding of hull structures with the application of sealed flux-cored, small-diameter electrode wire, the creation of new automatic welding machines and power supplies, and so on.

The assemblies and panels of series ships are made with minimum tolerances, which offers the possibility of significantly reducing the fitting and adjustment operations when assembling the modules and constructing the ships in the building slip ways.

Quality control of the welded joints is provided for with the application of optoelectronic instruments (feeding an image of the check section to a television set), ultrasonic defectoscopes and radioactive cobalt (for sample and random monitoring of the welded seams of individual structural elements).

The flow and process lines are created in accordance with the classification with respect to standard process groups of assemblies and panels (Table 22) and also in accordance with the data from the circulating flow charts for assembling and welding of the assemblies and panels by standard process groups (see Table 23).

Table 22

Classification by Standard Process Groups of Assemblies and Panels (as Applied to Dry Cargo Vessels and Trawlers)

Standard process groups	No of panels per ship, unit	Total weight of panels per ship, tons	Dimensions (ℓ×b×h) (maximum/ minimum), meters	Weight of one panel (maximum/ minimum), tons
Bottom panels				
Fore and aft panels				
Side panels				
Bulwark, decorative enclosure and other enclosure panels				
Upper deck and forecastle deck panels				
Lower deck, platform and bulkhead panels				
Corrugated enclosures				
Hatch covers				
Volumetric panels of the forecastle, aftercastle, forepeak and superstructures (tiers)				
Masts, booms and funnel casing				
Foundations and supports				
Panels				
T-framing				

Table 23

Circulating Flow Charts for the Assembly and Welding of Hull Sections (Applied to Dry Cargo Vessels)

Наименование типовых технологических групп (1)	Наибольшие габариты, м (2)	Количество секций на одно судно (3)	Масса на судно, т (4)	Максимальная масса секции, т (5)	Трудоемкость на 1 т секций, чел.-ч (6)	Трудоемкость на одно судно, чел.-ч (7)	Технологические операции и трудоемкость на судно, чел.-ч (8)
Днищевые секции (9)							Наладка оснастки (10) Сборка наружной обшивки (11) Сварка наружной обшивки (12) Разметка (13) Зачистка (14) Установка набора главного направления (15) Сварка набора главного направления (16) Установка перекрестного набора (17) Сварка перекрестного набора (18) Разметка мест установки насыщения (19) Установка и приварка насыщения (20) Контуровка набора под настил второго дна (21) Установка настила второго дна (22) Установка и приварка насыщения на втором дне (23) Кантовка (24) Сварка настила второго дна с набором и подварка наружной обшивки (25) Правка (26) Проверка и контуровка секций (27) Испытание и сдача (28)
Бортовые секции (29)							Наладка оснастки (30) Сборка наружной обшивки (31) Сварка наружной обшивки (32) Разметка (33) Зачистка (34) Установка набора главного направления (35) Сварка набора главного направления (36) Установка перекрестного набора (37) Сварка перекрестного набора (38) Установка и приварка насыщения (39) Кантовка (40) Подварка (41) Установка и приварка насыщения (42) Правка (43) Проверка и контуровка секций (44) Испытание и сдача (45)

Key:

1. Name of standard process groups
2. Greatest overall dimensions, meters
3. No of panels per ship
4. Weight per ship, tons
5. Maximum panel weight, tons
6. Labor consumption per ton of panels, man-hours
7. Labor consumption per ship, man-hours
8. Process operations and labor consumption per ship, man-hours
9. Bottom panels
10. Adjustment of attachments
11. Assembly of shell plating
12. Welding of shell plating
13. Measurement
14. Stripping

[Key to Table 23, contd]

15. Installation of principal-direction framing
16. Welding of principal-direction framing
17. Installation of cross framing
18. Welding of cross framing
19. Measuring the places of installation of fittings
20. Installation and welding of fittings
21. Contouring of framing under the inner bottom decking
22. Installation of inner bottom decking
23. Installation and tacking of fittings to the inner bottom
24. Canting
25. Welding the inner bottom decking to the framing and welding on the shell plating
26. Dressing
27. Checking and shaping sections
28. Trials and acceptance
29. Side sections
30. Adjustment of attachments
31. Assembly of shell plating
32. Welding of shell plating
33. Measurement
34. Stripping
35. Installation of principal-direction framing
36. Welding of principal-direction framing
37. Installation of cross framing
38. Welding of cross framing
39. Installation and welding of fittings
40. Canting
41. Welding
42. Installation and welding of fittings
43. Dressing
44. Testing and contouring the sections
45. Testing and acceptance

The sections are painted and dried in sections especially equipped for this purpose.

The rust is cleaned off using dustless shot-blasting equipment and pneumatic brushes, and at points that are difficult of access, manual methods are used. White spirit is used to wipe areas contaminated with oil. When determining the methods and volume of operations of cleaning sections it is considered that the metal was cleaned of scale and rust before machining, and it was coated with the corresponding primer. The panels are painted by the airless spraying method, and in locations difficult of access, the paint was brushed on by hand.

The painted panels are dried in special chambers at a temperature to +80°C.

All of the operations are basically performed on platforms; if necessary (for working in high places), special elevators are used.

When manufacturing structural elements from aluminum-magnesium alloys, the following basic forms of operations are performed: machining of the parts, anodic oxidation of parts and products, assembly and welding of the units and panels.

Before machining the metal, it is cleaned to remove the mothballing compounds in special units. Provision is made for machining on two specialized flow lines: machining of sheet metal and machining of section.

The sheet metal is first dressed and straightened on the roll-straightening machines or stretching machines, it is measured and marked on the measuring and marking machines. The cutting, cutouts and marking of parts from the strips, angle and bulbar strip profile are done on a special press with automatic marker; the mechanical cutting of the sheets is done on guillotine shears and a band saw equipped with all-purpose mechanical attachments; gas-electric cutting is done on the gas-electric cutting machines.

The edges of the sheet parts are machined on edge planing and copying milling machines, the parts are dressed after mechanical and gas-electric cutting on the roll straightening machines. The sheet parts are bent on the sheet bending and edging machines and presses; the intricately shaped parts are dressed and bent on the bending and straightening machine tool equipped with a special attachment.

The machined and completed parts (and sometimes parts assembled into small structural elements) made of aluminum-magnesium alloys are oxidized in special baths in sulfuric and chromic acid solutions, they are primed and dried in the corresponding chambers at a temperature of 70-80°C for 30-40 minutes.

The panels, flat sections and enclosures are made on flow lines, and the corrugated enclosures, foundations, panels with variable radius of curvature and level of superstructures, on the process lines; the funnel casings are assembled and welded on a special bench.

Manufacture of Structural Components from Synthetic Materials. Sheet materials are marked on special marking benches before machining; the billets are cut on circle saws; the edges of the billets are prepared for assembly and bonding on jointing machines and surface gauges; the parts with complex configuration are cut out on band saws and milling machines; the plastic-lined pipe is bent on ordinary pipe bending machines, and thermoplastic pipe is bent on special attachments with preliminary heating in baths in which hot glycerine and air are used as the heat-transfer agent; the pipes are welded on special welders using hot air or nitrogen torches, and the foam plastics are welded on special machines.

Roll gluing machines are used to apply adhesive to the surface of foam plastics. The plastic structural elements and products are assembled in special attachments on assembly benches lined with laminated plastic; they are basically bonded using adhesives based on thermosetting polymers. The mastic and adhesive are prepared in a separate facility using special equipment. Then they are poured in closed containers which are transported to the gluing section where the adhesives are poured into an enamel container and polyethylene dispensers which are distributed to the work places.

The enamel container and tools are washed three times at the end of the shift: with hot 40% calcined soda solution (40-45°C), hot water (40°C), warm water (25°C).

Sealed washing machines in facilities specially provided for these purposes are used to wash container and tools after working with mastics and adhesives. The equipment is washed to remove the remainder of the adhesive at the end of the shift. The polyethylene dispensers are washed if unpolymerized parts of the adhesives remain on the walls which cannot be removed mechanically.

Before the machinery and equipment are installed in the modules and on the ships, as a rule, they are unitized. The assembled units receive the necessary checkout and go through partial functional testing under shop conditions.

It is especially necessary to note that along with reducing the labor consumption of installing the machinery and equipment the primary goal of unitization is reducing the construction time of the ships in the expensive berths and building slips by maximum possible expansion of the mechanical installation operations front and parallel execution of these operations with the hull assembly operations.

It is primarily necessary to relegate some volume of mechanical installation, hull fitting and other operations to the unitization sections (shops) which will permit the time required to build the modules and the ship as a whole in the building slips to be reduced and at the same time to intensify the use of the expensive module and ship building slips and berths.

The following classification of assembly units is used:

The block module -- an independent structural unit including part of the hull of the ship with all of the machinery, electrical equipment and other fittings;

Zonal module -- large assembly unit with dimensions of an entire or part of a compartment of the ship. (It contains almost all of the compartment equipment, pipelines and local cable. The zonal modules are assembled on the supporting hull structure from installation modules, units and installation subassemblies.);

The installation module is a large assembly unit with dimensions equal to the dimensions of part of a ship's compartment with installation of a significant amount of equipment, pipelines and local cable in it. (The installation modules are assembled on the supporting structures made up of unitized units and installation subassemblies.);

The unitized unit is an assembly unit entering into the composition of the zonal and installation modules or installed directly on the ship. (It contains individual functional mechanisms or installations with pipelines and auxiliary devices. The unitized units are assembled on supporting frames made up of the installation subassemblies.);

The installation subassembly is an assembly unit which enters into the composition of the unitized units, installation and zonal modules and the block-modules, also installed directly on the ship. (It contains pipes, machine building products, electrical equipment and local cable.)

The installation units and unitized units are assembled at the shipyard from equipment, foundation frames, subassemblies and parts from the corresponding shops or central packaged unit warehouse.

The machinery and equipment coming in individual subassemblies is assembled to the maximum admissible sizes and weight, and then it is checked out and adjusted, using all of the possibilities of the available test equipment and power engineering of the section. The remothballing of the machinery is done by applying fireproof solvents such as OP-7 and OP-10 types and guns with electric air heating. Kerosene, gasoline and other fire-hazardous solvents must not be used.

Assembly and Installation Operations When Building the Hulls of the Modules. These operations are realized by the flow-position method: autonomous assembly-installation lines. Each line consists of a calculated number of positions which constitute the work places with a mastered nomenclature of operations performed within the rhythm limits. For assembly of the module hulls, mechanized devices and attachments are used, and for welding, automatic and semiautomatic machines (vertical gas-shielded welding of the installation joints is also used with solid and flux-filled electrodes). The quality of the welds is checked by ultrasonic defectoscopes and radioactive cobalt equipment (primarily for sample monitoring of the welds of individual structural elements).

The installation operations in the modules are performed by the series-parallel method with the application of portable machine tools and attachments permitting the times for execution of the operations to be reduced. For this purpose and also to insure appropriate quality of the installation work in the specialized sections the machinery is prepared and unitized before installation on the ship.

The modules are moved from one position to the other and sent to the shipbuilding shed by mechanized means, as a rule, on special cradles. The transverse displacement of the modules when moving them from the module assembly shop to the shipbuilding shed (covered slip ways) is in the majority of cases accomplished by transporters.

The technology and nature of the assembly and installation operations in the shipbuilding shed are determined in accordance with the planned method of building the ships.

Thus, with the series method of construction at a class I shipyard the design can call for the following basic organizational-process principles:

The hull is assembled with the application of light jacks with mechanical drive and other modern accessories. The checkout operations when installing the panels, measuring the deformations of the ship, measuring the principal dimensions and checking the lines are performed by optical and laser instruments;

The metal structural components of the hull are welded by automatic and semi-automatic welders, and the vertical welds of the main hull are welded primarily by automatic electroslag welders (the aluminum-magnesium alloy components are welded by special semiautomated machines and manual argon-shielded welders);

When building high-tonnage vessels in docks, the hull building operations are performed using unitized portable machines such as combines that move along the dock;

The hull is tested for impermeability by flooding with water under pressure, flooding with water without pressure, spraying with water under pressure, blowing with air, blowing jets of compressed air and wetting with kerosene in accordance with the methods and norms for testing hulls, compartments and individual structural components of ships under construction as provided for in the designs;

The places where the fasteners and fittings are to be installed in the ship's compartments are laid out using a photoprojector;

The machinery is installed on a ship in zonal and installation modules, unitized units and installation units, previously assembled and prepared in a specialized fashion;

The axial line of shafting is punched through using optical and laser instruments, and the shafting is installed with respect to the loads on the bearings; the installation of the stern tubes on the ships, as a rule, takes place without reaming operations, by filling the annular installation clearances between the hull components and the stern tubes or boss bushings with plastic or adhesive compound after installation of them along the line of shafting and sealing at the ends. The propeller is connected to the shaft by a hydraulic press. The installation of the machinery is accomplished with the help of low-shrinkage plastic. The installation of the pipes and systems on the ships is done from subassemblies which were assembled and tested in advance in the ship;

The operations on the ships are performed with the application of parts and subassemblies built in advance under shop conditions to insulate the compartments, the pipelines, systems and machinery. When performing these operations and equipping the compartments, provision is made for broad application of the modular system by which, for example, the bulkheads between cabins made of asbestos Siliter, furniture of triple laminated construction, the plastic cabin doors and portlights, fiberglass heads, and so on are installed;

During the outfitting operations, pneumatic and electric tools are used; an airless sprayer, ejector sprayers, roller type brushes, and so on are used for painting.

Various products are installed on the ship with the application of special devices and accessories: namely, dollies for installing the shafting in inconvenient places, dollies for installing the rudder and propeller, loading shackles for delivering loads to inaccessible parts of the ship's compartments, telescopic portable towers for finishing operations outside the hull, portable elevators, and so on.

When designing the electric wiring shops, an effort is made to see that the shop can perform the maximum volume of electric wiring operations, process packaging of the electrical equipment and cables can be accomplished, nonstandard wired products and individual distribution stations will be manufactured, random damage to the electrical equipment will be eliminated, the external communication observation equipment will be checked out and preadjusted, there will be a precheck on the high and low current electrical equipment, minor repairs will be performed, and batteries will be charged.

The following process principles are also considered:

In the overall flow chart for building of a ship, the installation of the electrical equipment and cable networks is isolated as an independent process step;

All the insulating and fitting operations connected with electric wiring must be completed by the beginning of electric wiring operations on the ships;

The cables of the various systems are made up in accordance with their "territorial nature," that is, the cables beginning and ending at common locations are combined into a single bunch;

The basic standardized parts, subassemblies and products must be delivered by specialized enterprises.

In addition, it is necessary to consider the specialization of the brigades and finishing workers with respect to defined types of operations.

The volume and the process of the outfitting and testing of the ships afloat depend on in what degree of completion the ship is launched from the building slip or from the dock.

When launching a ship from horizontal open building slips using an independent launching facility, the completion of the ship with respect to labor consumption is within the limits of 80 to 90%. In this case, the work of installing the devices, fittings, pipes, finishing the compartments is done at the outfitting quay, the shafting alignment is checked, the inventory, equipment, portable furniture and spare parts are put in place and secured.

A significant part of the mooring trials of the machinery and equipment, instruments and devices are performed in parallel with the outfitting operations. The outfitting operations are performed using mechanical, pneumatic and electrical tools, painting is done by airless spraying, atomizers and other units. In order to reduce the operations performed during sea trials, use is made of devices and methods that will provide for testing and acceptance of the steering and anchor-handling gear and also the main engines at the outfitting quay of the shipyard.

After performing the mooring trials on the ship at the outfitting quay, the sea trials and acceptance trials are run in the corresponding parts of the water basin.

When designing the hull fitting shops, the following basic principles are applied. The shop turns over its production to the central package unit warehouse and does not participate in the installation and outfitting operations on board the ships. The sheet metal and intricately shaped rolled products more than 3 mm thick, as a rule, go to the shop straight and cleaned of scale and rust from the section for preliminary dressing, straightening, cleaning and priming of the steel in the hull platers shop, and metal less than 3 mm thick goes from the main shipyard warehouse.

The mechanical cutting equipment is designed considering machining of parts made of sheet metal and intricately shaped rolled products needed for the ships of the calculated program. For example, at class I and II shipyards the equipment must provide for mechanical cutting of sheet metal from 0.5 to 6 mm thick (in individual cases, to 10 mm) and rolled section with web on flange thickness to 10 mm.

Flow and process lines are created for the manufacture of the parts, on which the basic process operations are performed with the application of the following equipment.

The sheet parts are measured and marked on machines with program control; the parts are cut out of the sheet metal mechanically on guillotine shears equipped with all-purpose mechanized accessories, upcut and downcut shears, and the gas cutting is done on gas cutting machines. The section is measured and marked on the automatic stamping and marking machine, cutting and blanking, on the combined press-shears.

The sheet parts are bent on roll bending machines, hydraulic presses and edging machines; the dressing and bending of the intricately shaped parts are done on the LTS-2 type bending machine and hydraulic press.

The sheet parts are dressed on the roll straightening machines and on presses; the edges of the parts are rounded on a special machine tool and in the tumbler; parts are stamped on crank, hydraulic and eccentric presses; the parts are machined on screw-cutting lathes, universal milling machines, upright drilling machines and radial drilling machines.

The products are assembled and welded on specialized process lines or sections organized with respect to the closed object cycle and equipped with stands, jigs, slabs, work benches and various accessories; mechanical tools are widely used in the assembly sections. The subassemblies and structural components are welded by automatic and semiautomatic carbon dioxide-shielded welders and by manual electric arc welding. When manufacturing thin-sheet components, seam resistance welding and spot welding are used, and in individual cases, manual gas welding.

The structural elements and products are tested on specialized test stands equipped with pumps and presses; the subassemblies and products are cleaned, primed, heated and dried in special chambers and baths.

The parts and billets are transported along the flow lines of the preparation section by conveyors, roller conveyors, telphers and cranes; for transportation of the finished parts, packaged on containers and pallets to the assembly-welding sections, cranes are used.

In the assembly sections, telphers, cranes and transport dollies are used to transport the products, and motor transportation is used to move the finished products from the shop to the central packaged unit warehouse.

When designing the hull fitting shop with the flow method of production, the parts, subassemblies and products, just as in the hull platers and assembly-welding shops, are divided into classes and groups with respect to structural and process attributes;

Table 24

Classification of Pipes by Standard Process Groups

(8) Материал труб	(9) Шифр групп	(7) Типы путевых соединений	(1) Шифр подгрупп 1, (2) Диаметр труб, мм: (3) до 14, (5) Прямые	1, до 14, (6) Гнутые	2, 15—32, (5) Прямые	2, 15—32, (6) Гнутые	3, 33—75, (5) Прямые	3, 33—75, (6) Гнутые	4, 76—150, (5) Прямые	4, 76—150, (6) Гнутые	5, 151—219, (5) Прямые	5, 151—219, (6) Гнутые	6, (4) более 220, (5) Прямые	6, более 220, (6) Гнутые
(10) Стальные	01	(11) Штуцерное соединение	011П (17)	011Г (18)	012П (17)	012Г (18)	013П (17)	013Г (18)	014П (17)	014Г (18)	015П (17)	015Г (18)	016П (17)	016Г (18)
	02	12 Свободный фланец на приварном кольце	021П	021Г	022П	022Г	023П	023Г	024П	024Г	025П	025Г	026П	026Г
	03	13 Свободный фланец на отбортованной трубе	031П	031Г	032П	032Г	033П	033Г	034П	034Г	035П	035Г	036П	036Г
	04	14 Приварной фланец	041П	041Г	042П	042Г	043П	043Г	044П	044Г	045П	045Г	046П	046Г
	05	15 Фитинговое соединение	051П	051Г	052П	052Г	053П	053Г	054П	054Г	055П	055Г	056П	056Г
	06	16 Дюритовое соединение	061П (17)	061Г (18)	062П (17)	062Г (18)	063П (17)	063Г (18)	064П (17)	064Г (18)	065П (17)	065Г (18)	066П (17)	066Г (18)
(19) Медные	07	(11) Штуцерное соединение	071П	071Г	072П	072Г	073П	073Г	074П	074Г	075П	075Г	076П	076Г
	08	12 Свободный фланец на приварном кольце	081П	081Г	082П	082Г	083П	083Г	084П	084Г	085П	085Г	086П	086Г
	09	13 Свободный фланец на отбортованной трубе	091П	091Г	092П	092Г	093П	093Г	094П	094Г	095П	095Г	096П	096Г
	10	14 Приварной фланец	101П	101Г	102П	102Г	103П	103Г	104П	104Г	105П	105Г	106П	106Г
(20) Медно-никелевые	11	11 Штуцерное соединение	111П	111Г	112П	112Г	113П	113Г	114П	114Г	115П	115Г	116П	116Г
	12	12 Свободный фланец на приварном кольце	121П	121Г	122П	122Г	123П	123Г	124П	124Г	125П	125Г	126П	126Г
	13	13 Свободный фланец на отбортованной трубе	131П	131Г	132П	132Г	133П	133Г	134П	134Г	135П	135Г	136П	136Г
	14	14 Приварной фланец	141П	141Г	142П	142Г	143П	143Г	144П	144Г	145П	145Г	146П	146Г

Key:
1. Subgroup code
2. Pipe diameter, mm
3. to 14
4. >220
5. Straight
6. Bent
7. Types of joints
8. Pipe material
9. Group code
10. Steel
11. Nipple joint
12. Loose flange on welded ring
13. Loose flange on flanged pipe
14. Welded flange
15. Fitting connection
16. Durite connection
17. P
18. G
19. Copper
20. Copper-nickel

Table 25

Functional Flow Sheets for the Manufacture of Pipe

Шифр группы труб (1)	Средняя масса одной трубы, кг	Средняя длина трубы, м	Общая масса труб, т	Общая длина труб, м	Количество труб, ед.	Масса путевых соединений и арматуры, т	Трудоемкость на 1 т, (чел.-ч)/т	Трудоемкость, чел.-ч		(10) Технологические операции												
										Отрезка заготовок	Отбортовка	Разметка отверстий на трубах	Вскрытие отверстий	Обработка отростков	Подготовка труб под сварку	Сборка	Электроприхватка	Сварка электродуговая	Зачистка после сварки	Маркировка	Гидравлические испытания	—
011П и 012П (23)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	Последовательность операций (24)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	
									Трудоемкость, чел.-ч (25)													
011Г и 012Г (26)										Отрезка заготовок	Гибка станочная	Резка после гибки	Отбортовка	Разметка отверстий на трубах	Вскрытие отверстий	Обработка отростков	Подготовка труб под сварку	Электроприхватка	Сварка электродуговая	Зачистка после сварки	Маркировка	Гидравлические испытания
									Последовательность операций (40)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)
									Трудоемкость, чел.-ч (41)													

Key:

1. Pipe group code
2. Average weight of one pipe, kg
3. Average pipe length, meters
4. Total weight of pipe, tons
5. Total length of pipe, meters
6. No of pipes, units
7. Weight of connections and fittings, tons
8. Labor consumption per ton, (man-hours)/ton
9. Labor consumption, man-hours
10. Process operations
11. Cutting the skelps
12. Flanging
13. Marking holes on the pipe
14. Making the holes
15. Machine taps
16. Preparing the pipe for welding
17. Assembly
18. Electric tack welding
19. Electric arc welding
20. Trimming after welding
21. Marking
22. Hydraulic testing
23. 011P and 012P
24. Sequence of operations
25. Labor consumption, man-hours
26. 011G and 012G
27. Cutting the skelps
28. Machine tool bending
29. Cutting after bending
30. Flanging
31. Marking holes on pipes
32. Making the holes
33. Machining taps
34. Preparation of pipe for welding
35. Electric tack welding
36. Electric arc welding
37. Trimming after welding
38. Marking
39. Hydraulic testing
40. Sequence of operations
41. Labor consumption, man-hours

Table 26

Process Routing Sheets for the Manufacture of Pipes

Route numbers	Standard process subgroups en route
I	011P, 071P, 111P, 011G, 061G, 071G, 111G
II	012P, 013P, 022P, 023P, 033P, 042P, 043P, 052P, 053P, 072P, 082P, 083P, 102P, 103P, 112P, 122P, 123P, 142P, 143P
III	012G, 022G, 042G, 052G, 062G, 072G, 082G, 102G, 112G, 122G, 142G
IV	013G, 023G, 033G, 043G, 053G, 063G, 073G, 083G, 093G, 103G, 113G, 123G, 133G, 143G
V	042G, 044G, 054G, 081G, 094G, 104G, 124G, 144G
VI	042P, 044P, 054P, 084P, 104P, 124P, 144P, 025P, 026P, 045P
VII	025G, 045G, 085G, 105G, 125G, 145G
VIII	026G, 046G, 126G, 146G

for the most characteristic representatives of these groups, detailed routing sheets are developed, after which the results of the developments are expanded to the entire group; the groups are combined into flows and make up the flow diagrams of the processes.

When designing the pipe fabrication shops for series shipbuilding, we begin with the following basic principles: the shop turns its production over to the central package unit warehouse, and it does not participate in the installation of the pipe on the ships; with the exception of driven pipe, the pipe is subjected to cleaning, priming and whenever possible, insulation in the shop; the preliminary assembly of individual subassemblies and components from the pipes with fittings is realized by drawings and dimensional diagrams in the shop.

The pipes are made on flow lines with performance of the machining operations and assembly of the pipe into subassemblies in specialized sections.

For this purpose all of the pipe intended for specific ships is first classified by standard process groups. Then out of the total number of 168 groups indicated in the classification (see Table 24), defined groups are selected (as a result of absence of certain types and sizes of pipe for different joints), as a result of which the number of groups is reduced and, for example, is 59 for a dry-cargo vessel weighing 6200 tons (for this vessel the missing groups in the presented classification are printed in boldfaced type). Defining the nomenclature and the number of standard process groups, the functional flow sheets for the manufacture of pipe are developed (see Table 25).

The entire process of manufacturing pipe in the shop can be reduced to several standard process routes, for example, for the indicated ship it reduces to eight routes (see Table 26). When machining the pipe some of it is subjected to all operations included in the given flow chart, and the rest, only some of them.

When designing the pipe fabrication shops, we begin with the conditions of improving the use coefficient of the equipment, the placement and composition of the equipment and sections. As a rule, two process flows are adopted for the manufacture of pipe. These operate in parallel:

The manufacture of pipe from material of all types with outside diameter to 75 mm (process routes I, II, III and IV);

The manufacture of pipe from material of all types with outside diameter of more than 75 mm (process routes V, VI, VII and VIII).

In the designs of the pipe fabrication shops at class I and II shipyards, the following methods of performing individual operations of manufacturing pipe and copper smithing are provided for:

Cold bending of pipe up to 220 mm in diameter is realized on pipe bending machines equipped with devices that mechanize the auxiliary operations; bending of pipe more than 220 mm in diameter takes place on a machine tool with high-frequency current heating, and, as an exception, pipe having complex and close bends is bent on a slab with heating of the pipe in an electric furnace; the pipe is cut before and after bending on machine tools with a grinding disc, by gas electric cutting and on cutting-off lathes using an ordinary cutting tool; flanging, reduction, spreading and machining the ends of the pipe for welding take place on all-purpose machine tools; the threads are cut on the pipe for fittings on thread-cutting machines; holes are cut in the pipe for taps and branch fittings on a machine tool for gas cutting of pipe and on special machine tools for making holes by milling; the parts of the pipe and tap joints are fitted on layout stands with the application of all-purpose positioners.

Welding of the pipe is provided for with the application of rotating benches with a supporting device providing for the necessary rotation of the pipe during welding; the welding of the flanges, the rings, the branch fittings and taps to steel pipe is done by semiautomatic welding and manually, and to copper and copper-nickel pipe, by semiautomatic argon-shielded welding and manual argon-shielded welding; the flanges and thrust rings are broached after welding on the SP-200 and FP-450 type machine tools; the pipe is hydraulically tested on an all-purpose hydraulic unit; the layout of the insulating material and insulation of the pipe is done by special equipment; the finished pipe is sent to the central package unit warehouse of the shipyard in special containers.

During the process of manufacture of the pipe, it is moved along the process route and successively goes through specialized sections where it is subjected to the required machining operations. In each section the pipe is machined by an independent specialized brigade.

The completed water system pipe is subjected in a special section to hot galvanizing with subsequent heat treatment of the coating, and the pipes of other systems, to nonmetallic coatings (parkerizing and priming). At the present time a new method of coating pipe systems by enameling them has been developed and is being introduced instead of hot galvanizing with subsequent heat treatment.

The surfaces of the pipes are cleaned chemically and by shot-blasting. During chemical cleaning, the pipe mounted on suspensions is subjected to degreasing in a hot alkali solution and flushed in hot and cold water; then the steel pipe is subjected to pickling in an aqueous solution of hydrochloric acid (150 g/liter with PB-5 or PB-8 additive), and the copper pipe is pickled in a mixture of nitric acid and hydrochloric acid. After pickling, the pipe is washed in cold and hot water and dried by compressed or heated air in a drier.

The pipe to be primed and hot galvanized is subjected, after pickling, to parkerizing, fluxing, respectively, and subsequent drying in the drier.

The cleaned phosphate-coated pipe is sent for priming, and the fluxed pipe is sent for hot galvanizing, and then part of it, for priming.

Along with chemical cleaning, the pipe subjected to hot galvanizing and also rejected pipe after low-quality priming is shot-blasted.

The pipe which has been chemically cleaned in advance is subjected to priming. Priming is done by spraying, and in individual cases, by brush.

The water systems of the ships must be protected against corrosion by hot galvanizing of the surface of the pipe with subsequent heat treatment of the coating to decrease its porosity and increase the diffusion into the body of the pipe material. The pipe subjected to hot galvanizing is first degreased in hot alkali solution and washed. Then it is subjected to pickling in acid, it is washed in cold and hot water and dried. After chemical cleaning the pipe is shot-blasted and fluxed for 7-8 minutes, it is submerged in an aqueous solution containing 8-14% ammonium chloride and 6-8% zinc chloride heated to 70-80°C with subsequent drying at a temperature of 105°C for 1 hour. Being convinced of the good quality of fluxing, the pipe is hot galvanized by submersion for 3 to 5 minutes in molten zinc with a melt temperature of 460°C. The pipe is submerged in the bath in such a way that it will be within the layer of molten zinc and not come within 150-200 mm of the bottom of the bath.

The iron-zinc alloy (garzinc) formed during the hot galvanizing process and having higher specific weight than the molten zinc precipitates on the lead cushion of the bath; as it accumulates it is removed by a scoop.

The bent pipe is submerged in the galvanizing bath so that the pipe will be completely filled with the molten zinc; straight pipe must be at an angle of 5-10°C to the bottom of the bath. The pipe is put into the bath and removed from it by hoists with special attachments.

In order to obtain a smooth zinc coating and remove beads of alloy and flux, the pipe are blown out inside with steam and outside with air. After hot galvanizing the pipe is heat treated at a temperature of 480-530°C for 10 minutes.

Lumber is dried in special chambers with steam heating at a temperature to 100°C.

The wooden parts and billets are worked on ordinary machine tools; the furniture and ship's equipment are assembled and glued using mechanized tools and assembly attachments, and the finished products are painted by sprayers in a special room with subsequent drying in a drying chamber.

Usually the sawdust and shavings are pneumatically transported with aspiration system in a bin, with later briquetting of the shavings in a special device. The wooden insulation parts and nonstandard furniture parts are subjected to impregnation by special solutions.

When constructing transport and factory ships, the following basic materials are used as insulation:

For compartments, FS-7 slabs, expansite, foam glass, staple fiber, asbestos fabric, asbestos, asbestos cardboard, asbestos cement, felt, fabrics, crushed cork, fiberglass, pergamyn, and so on;

For pipelines, systems and machinery, cork and sovelite slabs, hulls and segments of roasted vermiculite, novel in powder form, VT-40 heat insulating material, asbestos fabric, asbestos cement, asbestos down, aluminum foil, asbestos cardboard, asbestos, wool felt, liquid glass, capron fiber, crushed cork, calico, duck, sailcloth, steel and brass wire, pergamyn spackling, adhesives, varnishes, primers, and so on are used.

Insulating materials are basically worked on with working machines. The slab materials (foam plastic, expansite, and so on) are laid out on a band or circle saw by a stop; the curvilinear parts are cut on a band saw by a mark. The slab material for insulating rounded sides and pipe of circular cross section is cut on a circle saw or milling machine. The segments are cut out on the circle saw: from slabs, depending on the length of the slab; from tubes, depending on the bends in the tubes striving to obtain the minimum number of joints.

The mattresses are assembled and sewn together on special tables in a defined sequence using accessories and attachments. Simple mattresses are made of pouring width and thickness, about 8-10 meters long, and they are rolled up. Faced mattresses are made from drawings or patterns using insulated products.

For insulation of pipe at a temperature of no more than 100°C, half-cylinder sleeves are used which are molded from staple fiberglass with phenolformaldehyde resin sizing on special standard patterns. The outside surface of these sleeves is covered with fiberglass or cotton fabric. Sleeve lengths are 500 mm, wall thicknesses 20-50 mm; the inside diameter must correspond to the outside diameter of the pipe.

All of the billets for the insulation packages having defects and large depressions are filled in with celalite spackling using a spatula, after which the packages are covered with calico on special tables with a stretching device. Then the packages are marked and, if necessary, faced.

When preparing the surface of the parts for the application of galvanized coatings the products are degreased chemically or electrochemically in hot alkaline electrolytes with subsequent pickling in acids. The coatings are applied by two methods: electrodeposition with galvanizing and decorative coatings, treating the products by immersing them in the corresponding electrolytes with parkerizing and chemical coatings. Then the products or parts with decorative coatings are polished: the galvanized products and parts are passivated, and the parkerized ones are treated with potassium bichromate.

The fasteners and small parts are nickel-plated in mechanical baths of the bell or drum types.

The materials handling operations in the shop are realized, as a rule, by power trucks, electric bridge cranes and telphers.

The technological processes of galvanizing include automatic control of the current density and reversing of the current, temperature, thickness of the coatings, and the measurement and adjustment of the acidity of the bath electrolyte.

The dilution of the finished paints coming from the outside, preparation of spackling, mastic and adhesives are realized on the corresponding equipment in the painting preparation shop specially provided for this purpose.

§26. Labor Consumption of the Shop Operations

When developing the complex contract-detail or contract design for a shipyard, the labor consumption of the shop operations is taken in accordance with the labor consumption with respect to the basic types of operations obtained when determining the labor consumption with respect to the ship as a whole (see §12) and the given annual calculated program for ship production.

When developing the designs of individual shops, the labor consumption of the operations in these shops is determined either on a consolidated basis or by its individual indexes.

In the first case the labor consumption is calculated by the formula

$$A_1 = \frac{(I_1+I_2+ \dots +I_n)Q_g}{Q_p}$$

where A_1 is the labor consumption of the manufacture or installation of a group of parts or products, man-hours; I_1, I_2, ..., I_n are the normative labor consumption with respect to individual operations of the manufacture or installation of a part or product, man-hours; Q_p is the weight of the part or product, tons; Q_g is the weight of the group of parts or products, tons. The labor consumption of the manufacture or installation of subsequent groups of parts or products are defined analogously: A_2, A_3, ..., A_n.

Then $A=A_1+A_2+A_3+\ldots+A_n$,

where A is the labor consumption of all of the shop operations on one ship, man-hours.

The labor consumption (man-hours) of the shop operations for the annual program will be

$$A_{pr} = An_c,$$

where n_c is the number of ships in the annual calculated program of the shop.

If the construction of several classes of ships is planned in the shipyard program, then the labor consumption of the shop operations is determined for each class of ship, and the obtained results are summed.

In the second case the labor consumption is calculated by the normatives or analogous previously executed designs

$$A_{pr} = B_{sh}I_\ell,$$

where B_{sh} is the calculated annual program of the shop, tons; I_ℓ is the labor consumption per ton of production output of the shop (man-hours)/ton.

The overall calculated annual shop program and labor consumption operations by shop sections, flow lines and operations is distributed by the indexes obtained in the previously executed designs considering new solutions with respect to mechanization and automation.

In individual shops (for example, the galvanizing shops), the labor consumption of the operations for the annual program can be defined as the sum of the labor consumption with respect to individual operations

$$A_{pr} = S_{01}I_{01} + S_{02}I_{02} + \ldots + S_{0n}I_{0n},$$

where A_{pr} is the labor consumption of the shop operations for the annual program, man-hours; S_{01}, $S_{02}, \ldots,$ S_{0n} is the area of machined surface of the parts and products for the annual plan by operations, m^2; I_{01}, I_{02}, ..., I_{0n} is the labor consumption per square meter of machined surface of the parts and products by operations, (man-hours)/m^2.

Sometimes the labor consumption of the shop operations for the annual program is calculated by the equipment service norms or the distribution of the production workers with respect to work places

$$A_{pr} = n_{equip}K_{serv}\Phi_w,$$

where n_{equip} is the amount of production equipment in the shop, units; K_{serv} is the coefficient defining the equipment service norm by the production workers; Φ_w is the annual calculated available time of the worker, hours.

Table 27

Approximate Labor Consumption per Ton of Production of the Basic Shipyard Shops

Shops and sections	Labor consumption per ton of production, (man-hours)/ton				
	Class of shipyard				
	I	II	III	IV	V
Section for preliminary dressing, cleaning and priming of steel	0.28	0.33	0.5	0.8	1.5
Hull platers sections	3.5	4.6	5.5	8.6	12.6
Assembly-welding shops	8.5	13.0	16.5	20.5	36.0
Section for painting and drying the panels	1.0	1.3	1.8	2.6	3.5
Shop for structural elements made of aluminum-magnesium alloys	50.0	70.0	90.0	120.0	155.0
Shop for synthetic structural elements	48.0	65.0	80.0	85.0	90.0
Section for making unitized units and zonal modules	42.0	51.0	58.0	64.0	92.0
Module building shop	–	17.0	23.0	26.0	–
Shipbuilding shed	22.0	15.0	19.0	22.0	71.0
Electric wiring shop	220	270	290	340	720
Outfitting and acceptance shop	5.0	6.7	5.8	4.55	7.0
Hull fitting shop	105	145	180	190	200
Pipe fabrication shop (pipe fabrication sections)	90	130	150	160	170
Woodworking shop	53	70	95	100	105
Galvanizing shop	4.0	4.5	5.2	8.5	–
Paint preparation shop	24.0	25.0	26.0	47.0	70.0

Note. The annual output and labor consumption per ton of production are presented with respect to the electric wiring shop from the condition of installation of equipment weighing up to 15 kg and cables of all types on the ships, and with respect to the outfitting and acceptance shop, the entire weight of the ships outfitted and tested afloat is considered.

The labor consumption per ton of production output of the shop in the last case can be determined by dividing the labor consumption of the shop for the annual program defined by the presented formula by the annual production output program of the shop in tons.

The approximate labor consumption per ton of production of the basic shipyard shops (corresponding to the annual production output of the shipyards indicated in Table 1) is presented in Table 27.

The approximate distribution of the labor consumption of the operations of the basic shipyard shops by operations when building dry cargo ships (Q_c=6200 tons) and trawlers (Q_c=2500 tons), %, is presented below:

	Dry cargo	Trawler
Hull Platers Shop (Hull Platers Sections)		
I. Line for making parts from sheets up to 2400 mm wide (84% of the total volume of operations expressed in weight of the parts)		
Measuring and marking	-	14.3
Automated gas cutting	-	22.1
Automated gas-electric cutting	-	10.4
Machine tool cutting	-	6.5
Trimming of the edges	-	1.7
Dressing of the parts:		
on roll machines	-	5.0
on presses	-	2.4
Bending of the parts:		
on roll machines	-	6.4
on presses	-	11.6
Drilling and countersinking	-	1.4
Total	-	81.8
II. Line for making parts from sheets up to 3200 mm wide (64% of the total volume of operations expressed in weight of the parts)		
Measuring and marking	9.0	-
Automated gas cutting	16.5	-
Automated gas-electric cutting	8.0	-
Machine tool cutting	2.5	-
Trimming of the edges	0.5	-
Dressing of the parts:		
on roll machines	4.0	-
on presses	2.1	-
Bending of the parts:		
on roll machines	3.0	-
on presses	22.7	-
Drilling and countersinking	1.9	-
Total	70.2	-
III. Line for making parts from sheets up to 4500 mm wide (20% of the total volume of operations expressed in weight of the parts)		
Measuring and marking	1.8	-
Automated gas cutting	4.7	-
Trimming of the edges	1.2	-
Dressing of the parts:		
on roll machines	0.8	-
on presses	0.3	-
Bending of parts:		
on roll machines	5.5	-
on presses	0.5	-
Total	14.8	-

	Dry cargo	Trawler
IV. Line for making parts from intricately shaped rolled products (16% of the total volume of operations expressed in weight of the parts)		
Marking	4.1	4.4
Cutting of the profile and cutting out the holes	4.1	6.1
Bending of parts:		
on ring bending machines	2.1	2.4
on a press	4.0	4.6
Drilling and countersinking	0.7	0.7
Total	15.0	18.2

Assembly-Welding Shop

	Dry cargo	Trawler
Marking, assembly, dressing, canting, testing and outlining	48.0	46.0
Manual welding and tack welding	12.0	14.0
Semiautomatic welding:		
submerged arc	4.0	4.0
carbon dioxide shielded	16.0	15.0
Automatic welding	10.0	9.0
Trimming and cutting	5.0	6.0
Gas cutting	2.0	2.5
Electric air gouging	1.0	1.5
Monitoring and testing	2.0	2.0

Shop for Making Structural Components from Aluminum-Magnesium Alloys

	Dry cargo	Trawler
I. Hull platers section		
1. Sheet metal machining line		
Demothballing	1.0	1.02
Preliminary straightening	1.05	1.02
Measuring and marking	2.95	3.30
Cutting on guillotine shears	1.34	1.51
Cutting on a band saw	0.80	0.83
Milling	0.75	0.78
Planing	0.78	0.78
Roll bending	2.00	2.45
Dressing and bending on presses	1.96	2.15
Straightening in roll machines	0.98	1.09
Gas electric cutting	2.8	3.14
Drilling	1.42	1.58
2. Shaped metal machining line		
Demothballing	0.62	0.59
Marking	1.30	1.45
Machining on a press with automatic stamping and marking machine	2.06	2.30
Bending and straightening	0.85	0.92
Drilling	0.74	0.78
Total	23.4	25.7

	Dry cargo	Trawler
II. Anodic oxidation section		
Oxidation, priming and drying	5.2	5.0
III. Assembly-welding section		
Measuring and checking	6.30	5.90
Assembly and dressing	30.0	29.40
Electric tack welding	3.34	3.32
Electric welding:		
semiautomatic	12.70	12.34
manual	10.27	9.90
automatic	4.18	4.12
Trimming and cutting	4.08	3.82
Gas-electric cutting	0.53	0.5
Total	71.40	69.30
IV. Section for preparing unitized units and zonal modules		
Measuring and checking	2.5	2.4
Assembly and testing	16.0	15.0
Gas cutting and gas gouging	2.7	2.5
Electric arc tacking and manual welding	11.0	10.5
Semiautomatic welding	2.8	2.6
Pneumatic operations (cutting, drilling, and so on)	4.0	3.6
Hull fitting operations	7.0	7.1
Mechanical installation operations	30.0	31.4
Pipe fitting operations	24.0	24.9
Total	100.0	100.0
Module Construction Shop		
Measuring and checking	2.3	2.25
Assembly and testing	21.0	19.6
Gas cutting and gas gouging	2.5	2.4
Electric arc tack welding	2.8	2.3
Welding:		
manual electric arc	11.2	10.2
semiautomatic	3.6	3.2
automatic	0.85	0.6
Pneumatic operations (cutting, drilling, and so on)	3.6	3.0
Hull fitting	12.5	14.0
Mechanical installation	21.5	21.4
Pipe fitting	7.2	8.8
Carpentry	6.2	6.0
Painting	4.5	6.0
Rigging and sails	0.25	0.25
Total	100.0	100.0

	Dry cargo	Trawler
Shipbuilding Shed		
Measuring and checking	1.4	1.3
Assembly and testing for impermeability	8.0	6.4
Gas cutting and gas gouging	1.0	1.0
Electric arc tack welding	0.9	0.95
Welding:		
manual electric arc	4.0	3.6
semiautomatic	1.9	1.9
automatic	0.2	0.2
Pneumatic operations (cutting, drilling, and so on)	1.3	1.2
Hull fitting operations	16.2	16.4
Mechanical installation	30.0	30.0
Pipe fitting	9.0	9.2
Carpentry	7.8	9.5
Painting	17.4	17.4
Sails and rigging	0.9	0.95
Total	100.0	100.0
Hull Fitting Shop		
I. Billeting section		
1. Flow line for machining shaped parts		
Measuring and marking	0.61	0.62
Cutting on press shears	0.40	0.36
Cutting by circular saw with abrasive disc	0.17	0.18
Manual gas cutting	0.09	0.06
Trimming	0.10	0.11
Bending on the GS-2 machine	0.15	0.14
Drilling	0.13	0.12
Bench work	0.20	0.18
Total	1.85	1.75
2. Line for machining sheets more than 2.5 mm thick		
Measuring and marking	1.30	1.90
Cutting on guillotine shears	2.25	2.35
Trimming	0.55	0.6
Straightening of sheets:		
on presses	0.18	0.25
on roll machines	0.72	0.7
Bending on an edging machine	0.1	0.14
Drilling	0.38	0.65
Bench work	0.12	0.16
Total	5.60	6.75

		Dry cargo	Trawler
3.	Line for machining sheets up to 2.5 mm thick		
	Measuring and marking	0.82	0.81
	Cutting on guillotine shears	1.54	1.78
	Cuttong on upcut shears	0.82	0.63
	Trimming	0.26	0.28
	Rounding of the edges	0.06	0.06
	Straightening of sheets:		
	on roll machines	0.18	0.24
	on presses	0.40	0.41
	Bending on the edging machine	0.10	0.11
	Drilling	0.32	0.34
	Total	4.50	4.65
4.	Gas cutting line		
	Measuring and marking	0.37	0.37
	Gas cutting:		
	mechanical	0.38	0.38
	manual	0.15	0.15
	Trimming	0.52	0.52
	Straightening on roll machines	0.58	0.58
	Total	2.0	2.0
5.	Mechanized stamping line		
	Stamping, trimming, bench work	2.25	2.6
6.	Semiautomatic line for making fasteners for the electric wiring		
	Making electric wire parts	0.45	0.55
7.	Process equipment located outside the flow lines		
	Bending:		
	on roll machines	0.16	0.26
	on presses	0.67	0.75
	Turning	0.13	0.10
	Milling	0.03	0.04
	Drilling	0.24	0.40
	Bead forming machine work	0.12	0.15
	Total	1.35	1.70
	Total for section	18.0	20.0
II.	Section for making complexly shaped and tubular structural elements		
	Assembly in attachments	2.35	2.67
	Assembly on a slab	1.20	1.24
	Pneumatic operations	0.48	0.54
	Electric welding:		
	semiautomatic	0.20	0.26
	manual	1.5	1.58
	Dressing	0.57	0.61
	Bench work	2.5	2.6
	Total	8.8	9.5

	Dry cargo	Trawler
8. Line for making small fasteners		
Assembly in attachments	2.38	2.6
Assembly on a slab	0.75	1.3
Pneumatic operations	0.23	0.35
Manual electric welding	1.22	1.55
Gas welding and cutting	0.07	0.07
Dressing	0.48	0.58
Bench work	1.87	2.25
Total	7.0	8.7
Total for section	15.80	18.20
III. Section for making large-scale products		
9. Line for assembly and welding of planar structural elements		
Assembly in attachments	0.48	0.13
Assembly on a slab	2.08	1.70
Pneumatic operations	0.35	0.24
Electric welding:		
automatic	0.27	0.25
semiautomatic	0.60	0.42
manual	0.72	0.48
Dressing	0.38	0.28
Bench work	0.72	0.20
Total	5.60	3.70
10. Line for assembly and welding of three-dimensional structural elements		
Assembly in attachments	3.30	3.80
Assembly on a slab	1.74	2.10
Pneumatic operations	0.68	0.82
Electric welding:		
semiautomatic	1.16	1.38
manual	1.20	1.40
Gas welding and soldering	0.82	0.57
Dressing	0.80	0.93
Bench work	3.50	4.10
Total	13.20	15.10
Total for section	18.80	18.80
IV. Furniture and ventilation section		
11. Line for making ventilation components		
Assembly in attachments	4.15	3.55
Assembly on a slab	8.20	7.20
Pneumatic operations	0.90	0.78
Semiautomatic electric welding	1.60	1.38
Gas welding	0.70	0.60
Dressing	1.75	1.52
Tinsmithing	2.80	2.42
Total	20.1	17.45

	Dry cargo	Trawler
12. Line for making metal furniture		
Assembly in attachments	5.30	5.20
Assembly on a slab	1.50	1.26
Pneumatic operations	0.90	0.82
Gas welding	0.60	0.45
Electric welding:		
semiautomatic	0.38	0.32
manual	0.12	0.20
Dressing	1.10	1.00
Bench work	4.95	4.40
Tinsmithing	0.50	0.35
Total	15.35	14.00
Total for section	35.45	31.45
V. Resistance welding section		
Spot welding	3.55	3.25
Seam welding	1.45	1.30
Total for section	5.00	4.55
VI. Section for testing structural elements and products		
Air testing	0.22	0.22
Water testing	0.33	0.38
Total for section	0.55	0.60
VII. Painting section		
13. Flow line for painting large products		
Cleaning, priming, painting, drying	3.00	2.68
14. Flow line for painting medium size products		
Cleaning, priming, painting, drying	2.50	2.64
15. Flow line for painting small products and parts		
Cleaning, priming, painting, drying	0.90	1.08
Total for section	6.40	6.40
Total for Sections II-VIII	82.00	80.00
Total for shop	100.0	100.0

Pipe Fabrication Shop

	Dry cargo	Trawler
1. Flow line for making pipe more than 75 mm in diameter		
Bending pipe, mm:		
76-159	3.6 }	8.2
more than 160	4.3	
Cutting after bending	0.82	0.6
Blocking off holes on the pipe	0.52	1.05
Making the holes for taps and branch fittings	0.74	1.6
Machining the ends of pipe and preparation for welding	0.67	1.0
Welding with electric tacking	21.5	17.85
Carbon dioxide-shielded semiautomatic welding of steel pipe	3.72	2.9
Manual welding of steel pipe	0.93	0.75

	D cargo	Trawler
Semiautomatic argon-shielded welding	0.2	0.60
Manual argon-shielded welding	0.05	0.05
Turning flanges	1.66	1.8
Trimming pipe	0.55	0.5
Hydraulic testing	1.39	2.3
Marking	0.37	0.40
Total	41.02	39.6
II. Flow line for making pipe up to 75 mm in diameter		
Bending of pipe with diameter, mm:		
up to 14	0.57	
15-38	1.21 }	6.75
39-75	4.45	
Cutting after bending	1.32	1.5
Thread cutting	2.25	0.55
Marking off holes in the pipe	0.76	1.1
Making the holes	0.74	1.3
Machining the ends of the pipe for welding	2.5	2.7
Welding with electric tacking	10.6	16.0
Semiautomatic carbon dioxide shielded welding of steel pipe	4.9	6.5
Manual argon-shielded welding	0.36	0.65
Gas welding of pipe up to 14 mm in diameter	0.86	0.15
Turning of flanges	1.75	1.5
Trimming of pipe	1.1	1.5
Hydraulic testing	2.7	3.35
Marking	1.74	1.85
Total	37.81	45.4
III. Common operations for both flow lines		
Cutting skelps	2.7	2.25
Annealing the pipe	0.45	0.25
Packing the pipe with sand	0.07	0.07
Hot bending	0.71	0.2
Tapping	1.44	1.2
Unitized assembly of pipe	4.4	3.5
Pipe insulation	3.6	1.83
Blind flanging of pipe	1.62	1.9
Copper bench work	2.88	2.15
Manufacture of standards	3.30	1.65
Total	21.17	15.0
Woodworking Shop		
I. Machine tool operations		
Circle saw	4.6	5.7
Band saw	2.0	2.2
Jointing machine	3.4	4.2
Surface gauging	3.4	2.2
Milling	4.5	3.6

	Dry cargo	Trawler
Planing	2.2	1.6
Tenoning and chain-type slotting operations	1.4	2.2
Drilling	1.7	1.9
Grinding	2.2	2.9
Polishing	1.1	1.3
Universal	0.5	1.0
Lathe turning	1.0	2.2
Pressing and squeezing	0.5	1.0
Total	28.5	32.0
II. Assembly operations		
Carpentry assembly	59.5	48.8
Sail fitting	4.9	6.4
Varnishing and polishing	4.2	3.7
Pattern	1.7	5.7
Layout	1.2	3.4
Total	71.5	68.0

Note. The distribution of labor consumption by operations for the shops that build modules and the shipbuilding sheds is presented considering the performance of the operations with respect to manufacturing unitized units and zonal modules and the volumes of operations determined for them (see Tables 3 and 8).

§27. Composition and Calculation of Number of Personnel

The shop personnel include production workers, auxiliary workers, engineering-technical workers (ITR), office workers and junior service personnel (MOP). The production workers are the workers in the production shops directly performing the operations of manufacturing the product.

The number of production workers is calculated as a function of labor consumption of the operations in man-hours and the time available per worker in hours.

Here

$$n_w = A_{pr}/\Phi_w,$$

where n_w is the number of production workers required to perform each operation in the shop, men; A_{pr} is the labor consumption of performing the annual shop program by operations or by labor specialties, man-hours; Φ_w is the actual (calculated) annual available time of the workers, hours.

In individual cases the number of production workers is determined by the amount of equipment adopted and the number of work places

$$n_w = n_o \Phi_o P_{ave} K_{rated}/\Phi_w,$$

where n_o is the amount of process equipment and the number of work places; Φ_o is the actual calculated annual time available of the equipment or work places;

P_{ave} is the average composition of a brigade, men; K_{rated} is the normative load coefficient of the equipment or the work places; Φ_w is the actual (calculated) annual time available for the workers, hours.

In the flow lines the number of workers can be determined by their distribution with respect to work places in accordance with the principles of synchronizing all of the operations on the line by the formula

$$n_{w.\ell} = n_w \Phi_{rated} / \Phi_w,$$

where n_w is the number of workers with respect to the distribution at the work places in the line (by plan); Φ_{rated} is the rated annual time available of the work place (4140 hours for two-shift operation); Φ_w is the actual annual time available of one worker, hours.

The number of production workers on the automatic lines (operators, adjusters) is calculated by the norms for servicing these lines (the normative time, including the time for technical and organizational servicing of the automatic line, for rest and personal necessities).

The number of production workers is also determined by the service norms and the distribution by work places in some shops (for example, the galvanizing shop).

The total number of bench work places is found by summing the data obtained by individual operations or specialties.

Then the number of production workers by specialties (operations) obtained is distributed by shifts.

The auxiliary workers in the basic production shops are the workers that do not participate directly in the performance of operations of manufacturing the basic product made by the shop, but employed in servicing the production process. In the production shops the auxiliary workers include the workers that adjust and repair the equipment, accessories and industrial distribution networks; with respect to current servicing of equipment, accessories and industrial distribution networks by the duty personnel of the shop; the warehousing operations in the shop; the materials handling operations; the cleaning of the production facilities and waste removal; production quality control.

In design practice the operators of the automatic devices and unitized units, the adjusters that work on the automatic lines on which the shop production takes place, the required coatings are applied, and so on are considered to be production workers.

The number of auxiliary workers in the shops and in the individual sections is determined by their distribution with respect to work places or by calculation with respect to the equipment service and repair group depending on the amount of installed equipment, the complexity of its repair and the work shift index; by the warehousing group (materials, tools and other stores), depending on the adopted process, the number of production workers per warehouse worker per shift, the number of warehouses, and so on. The indicated calculation is performed on the basis of the existing guidance and normative materials. For example, these include the following: a united planned preventive repair system, efficient operation of the process equipment of the machine building enterprises; the normatives for the number of personnel and service norms for the auxiliary workers of the shipyard shops of the shipbuilding enterprises, the process design norms for the mechanical repair shops and the shop repair bases of the shipbuilding enterprises.

The number of auxiliary workers in the basic professions can be determined by the following formulas [13]:

The repairmen, including fitters for the repair and servicing of the process and materials handling equipment, pipelines, ventilation systems and other forms of thermally powered equipment,

$$n_{rep} = \frac{\Sigma PEK_{sh.e}}{H_{bet}};$$

the adjusters

$$n_{adj} = \frac{n_o K_{sh.e}}{H_{bet}};$$

crane operators servicing the bridge, portal and gantry cranes,

$$n_{cr} = \frac{n_{cr} K_{sh.c} \Phi_{cr}}{\Phi_w n_{sh.e}};$$

sling operators (riggers)

$$n_{s\ell} = \frac{n_{cr} n_{s\ell} K_{sh.c} \Phi_{cr} K_{\ell.cr}}{\Phi_w n_{sh.c}};$$

the product, billet and tool unitizers

$$n_{unit} = n_w / H_{unit} K_{c.u};$$

the warehousemen of the tool, materials and other warehouses

$$n_{wh} = n_{code} K_{sh.w} / H_{wh}.$$

The following notation was adopted in the formulas:

ΣPE is the sum of the repair unit of the serviced equipment, repair unit;

$K_{sh.e}$ is the shift index of the equipment operation;

H_{bet} is the normative servicing between repairs per worker per shift, repair or physical unit;

n_o is the total amount of equipment used in the calculation, unit;

n_{cr} is the number of cranes, units;

$K_{sh.c}$ is the shift index of the operation of the cranes;

Φ_{cr} is the actual (calculated) annual time available of a crane, hours;

Φ_{w} is the actual (calculated) time available of the workers, hours;

$n_{sh.e}$ is the number of shifts the equipment is operated, unit;

$n_{s\ell}$ is the number of sling operators servicing one crane, men;

$K_{\ell.c}$ is the load coefficient of the crane per shift;

$n_{sh.c}$ is the number of shifts of crane operations, unit;

n_{w} is the total number of production workers of the shop, men;

H_{unit} is the service norm by one production worker unitizer, hours;

$K_{c.u}$ is the coefficient of complexity of unitization;

n_{code} is the number of tool and accessory codes of equipment stored in the warehouse, unit;

$K_{sh.w}$ is the shift index of the production workers;

H_{wh} is the production worker service norm per warehouseman per shift, men.

The approximate initial data for calculating the auxiliary workers of the basic shops of the class II shipyard are presented in Table 28.

The number of auxiliary workers of other professions are determined by the distribution by work places or analogous calculations in accordance with the effective guidance and normative materials.

For the consolidated calculations the number of auxiliary workers can be determined in percentages of the production workers by the effective normatives of the technical-economic indexes of the shipyard shops of the shipbuilding enterprises.

The engineering and technical workers are workers that perform duties connected with the technical direction of the production processes and organization of production or who have jobs for which the qualification of engineer or technician is required. In the shops the engineering-technical workers include the shop chiefs, their deputies and assistants, the chiefs and workers in the shop offices, the senior superintendents, foremen and shift engineers.

The office workers are workers that perform administrative, economic and commercial functions including finances, equipment, marketing, accounting and reporting, statistics, personnel, social-general services and similar problems and also lawyers, translators and so on. The office workers of the shops include, for example, bookkeepers, accountants, business correspondents, timekeepers, tallymen, archive custodians, secretaries and typists.

Table 28

Approximate Initial Data for Calculating the Number of Auxiliary Workers of Basic Shops of Class II Shipyards

Initial data	Hull platers shop	Assembly-welding shop	Module construction shop	Shipbuilding shop	Pipe fabrication shop
Average repair complexity of equipment, PE:					
fitter repairmen	11	11	12	10	10
electrician repairmen	11	11	12	10	10
pipe fitters and sanitary engineers	11	11	12	10	10
Normative for the servicing between repairs per worker per shift, PE:					
repair fitters	300	200	200	200	200
electrician repairmen	650	300	500	500	350
pipe fitters and sanitary engineers	750	600	450	450	450
Servicing norm per adjuster, units of equipment	10	15	15	15	10
Servicing norm for one production worker unitizer, men	20	35	35	35	100
Coefficient of complexity of the unitization	0.8	1.0	1.0	1.0	1.0
Service norm for one production worker loader, men	110	200	110	110	110
Number of tool and accessory codes for equipment stored in the tool warehouse, units	7000	12000	30000	50000	20000
Tool service norm for one warehouseman per shift, number of codes	7000	5000	8000	8000	9500
Service norm of production workers for one warehouseman in the materials warehouse per shift, men	200	200	200	200	140

The junior service personnel include yardmen, messengers, couriers, still operators, watchmen, guards, coat closet attendants, yard and office janitors, shop office and shop domestic facilities janitors, and office stokers.

Note. A separate group is made up of the shipyard security forces (military, armed guard, professional firemen and watchmen): watchmen, firemen, guards and other workers and also their administrative and command personnel.

The number of engineering and technical workers, office workers and junior service personnel is determined by the employment lists which are made up when designing the shop or in percentages of the number of production workers with respect to the process design norms and technical-economic indices.

For the consolidated calculations, the number of auxiliary workers, engineering-technical workers, office workers and junior service personnel can be taken by the approximate ratio of them to the production workers (Table 29).

In the case of two-shift operation of the shipyard, the shift index of the workers in the hull and unitizing shops is taken equal to 1.7 and in the assembly-installation shops, the employees working on the ships under construction, 1.6; the number of engineering-technical workers 1.3-1.4, office and junior service personnel 1.2-1.25.

Table 29

Approximate Ratio of Auxiliary Workers, Engineering-Technical Workers, Office and Junior Service Personnel to the Production Workers in the Basic Shipyard Shops

Shops	No of production workers	Auxiliary workers	Engineering-technical workers	Office workers	Junior service personnel
		Percentage of number of production workers			
Hull platers shop	300-150	35	10-12	4.0-5.0	2.5-3.0
Assembly-welding shop	600-200	30	10-12	4.0-5.0	2.0-2.5
Aluminum-magnesium alloy structural elements	150-50	30	11-13	4.5-5.0	3.0-3.5
Structural elements made of synthetic materials	150-30	25	11-13	4.5-5.0	3.0-3.5
Module construction	1200-500	25	10-12	4.0-5.0	2.0-2.5
Shipbuilding shed	1700-350	25	10-12	4.0-5.0	2.0-2.5
Electrical wiring	400-200	20	12-14	3.5-4.5	2.0-2.5
Outfitting-acceptance	500-100	20	10-12	3.5-4.5	2.0-2.5
Hull fitting	270-75	25	10-12	3.5-4.5	2.0-2.5
Pipe fabrication	300-100	20	10-12	3.5-4.5	2.0-2.5
Woodworking	200-100	20	10-12	3.5-4.5	2.5-3.0
Galvanizing	40-20	35	14-15	4.0-5.0	4.5-5.0
Paint preparation	30-20	20	10-12	4.0-5.0	4.0-4.5

CHAPTER IX. EQUIPMENT AND WORK PLACES

§28. Equipment and Its Use

With respect to purpose, the equipment is divided into the following groups: production, auxiliary, materials handling, and power engineering.

The production equipment is all of the operating machines, machine tools and equipment directly engaged in the process operations of manufacturing the parts, subassemblies and unitized units and also assembly, installation, finishing and testing of the ships produced by the shipyard. With respect to nature of operation performed, basic and other production equipment are distinguished.

The basic equipment is considered to be the production equipment directly involved with the process operations. The other production equipment includes the equipment which during performance of production operations has secondary significance (grindstones, manual presses, and so on).

The auxiliary equipment is the equipment not participating directly in the manufacture of the production output, but by means of which the operations of servicing the needs of the basic shipyard production are performed.

The basic production shops include the equipment for repairing tools and different attachments.

The equipment provided for in the plans is also divided into the equipment series produced industrially (standard equipment); not standardized and nonstandard.

The nonstandardized and nonstandard equipment are distinguished by the following basic attributes [6]:

Nonstandardized equipment is the equipment made on an individual basis by the industrial enterprises or the construction and installation organizations with respect to order specifications and drawings of the design organizations, both nonrepeating, not having branch classification with respect to manufacture and used only on the basis of special engineering designs;

Nonstandard equipment is the equipment which is atypical, having branch classification, with deviation from the normalized types and sizes produced by Soviet industry with respect to coordinated technical specifications.

When developing the designs for nonstandardized and nonstandard equipment in accordance with All-Union State Standard "Development and Delivery of Products to the Production Facility" [5], the initial specifications are set up in which the following must be indicated:

The purpose and area of application of the new equipment;

The technical and economic substantiation of the manufacture of the new equipment (analogous equipment and products produced abroad, type, form, parameters, information source);

The equipment parameters and characteristics;

The conditions of application of equipment (operating conditions, organization of work, distribution of manpower, the technological process complex in which the equipment will be used, and so on);

Other requirements (conditions of control, repair, transportation, storage, and so on);

The permitted levels of vibration and noise loads, thermal effect, the effect of the electric current, dust, gases in accordance with the existing standard and sanitary norms;

Maximum price and its substantiation.

The work place is the production section designed for the performance of individual process operations, equipped for this purpose with the corresponding means and serviced by one or several workers.

At the existing enterprise in industrial statistics the shift index of the operation of the equipment is defined as the ratio of the number of machine tool shifts worked on all shifts to the number of machine tools working on the largest shift.

The shift index for operation of the equipment reckoned by the indicated method does not indicate the actual use of equipment due to the fact that not all 100% of the equipment can operate on the largest shift, and the operating equipment could be underloaded by shifts. For determining the degree of use of the shop work places, the shift index of the workers is used, which is defined as the ratio of the total number of shop workers to the number of workers employed on the largest shift.

This definition does not give a correct idea of the degree of use of the work places, for the composition of the workers at the work places is different for individual shifts.

More exact data on the degree of the use of equipment and work places is provided by their load factor which is also predominantly used in shop design practice.

The load coefficient of the equipment and work places is the ratio of calculated (theoretically required) number of equipment units and work places to the number of units of this equipment and work places used in the design (designed for installation).

It is necessary to emphasize that the mean load coefficient of the shop equipment is insufficient for representation of the existing reserves which can be used to increase the production output. It is necessary to define the equipment load coefficients by limiting types of equipment and sections which are bottlenecks to the operation of the shop.

When developing the designs for rebuilding the shipyards (shops) it is necessary to consider that a serious factor in improving the degree of use of the operating equipment is this modernization in order to increase output capacity, operating precision and wear resistance and also mechanization and automation of the production processes and facilitation of the conditions of labor of the workers.

The approximate mean load coefficients of the equipment and work places of the main shipyard shops are presented in Table 30.

Table 30. Approximate Mean Load Factors of Equipment and Work Places of the Basic Shipyard Shops

Shops and sections	Shipyard class	Mean load factor of the equipment and work places
Hull platers shop		
Section for preliminary dressing, cleaning and priming of steel	I	0.82-0.85
	II	0.65-0.70
	III	0.60-0.65
	IV	0.50-0.60
	V	0.50-0.55
Hull platers sections	I-II	0.82-0.85
	III	0.80-0.83
	IV-V	0.80
Welding-assembly shop		
Subassembly and panel assembly and welding sections	I-V	0.9
Panel priming and drying section	I-V	0.9
Aluminum-magnesium alloy structural component shop	I-II	0.80-0.85
	III	
Shop for structural elements made of synthetic materials	I-III	0.80-0.85
Module construction shop	II-IV	0.90-0.95

[Table 30, continued]

Shops and sections	Shipyard class	Mean load factor of the equipment and work places
Shipbuilding shed	I-V	0.90-0.95
Hull fitting shop	I-II	0.82-0.85
	III	0.80-0.83
	IV-V	0.78-0.80
Pipe fabrication shop	I-III	0.82-0.85
	IV	0.80-0.82
	V	0.78-0.80
Woodworking shop	I-II	0.82-0.85
	III	0.80-0.83
	IV	0.78-0.80
	V	0.75

§29. Calculation of the Amount and Selection of the Process Equipment and Work Places

The required amount of process equipment and number of work places are determined beginning with the labor consumption of the shop operation in the volume of the annual program for each operation and the types and sizes of equipment, the effective calculated annual operating time available of the equipment or work places and the average makeup of the brigade.

Here

$$n_{equip} = A_{pr.equip}/\Phi_{equip}P_{ave},$$

where n_{equip} is the amount of required process equipment or number of work places for each organization; $A_{pr.equip}$ is the labor consumption of the shop operations in the volume of the annual program of operations and types and sizes of equipment, man-hours; Φ_{equip} is the actual calculated annual time available of the equipment or work places, hours; P_{ave} is the average makeup of the brigade, men.

If the calculated amount of equipment or number of work places is found to be fractional, then it is rounded to a whole number, and it is taken considering the normative loading coefficient; then this amount is called the adopted amount of equipment or number of work places.

During the design work, the indicated calculations of process equipment and work places are made in table form. Depending on the assumed production organization the calculation is performed as a whole with respect to a shop or by individual sections and flow lines.

A calculation of process equipment for the flow lines for manufacturing hull parts (Table 31) and the calculation of the number of work places (positions) for assembly and welding of the subassemblies and panels (Table 32) are presented below as an example.

Table 31

Calculation of Process Equipment for the Flow Lines to Build Hull Parts

Операции (1)	Трудоемкость на годовую программу, чел.-ч (2)	Средний состав бригады, чел. (3)	Трудоемкость на годовую программу, станко-ч (4)	Расчетный годовой фонд времени оборудования, ч (5)	(6) Количество оборудования, ед		Коэффициент загрузки оборудования (9)
					расчетное (7)	принятое (8)	
(10) I. Линия изготовления деталей из листов шириной до 3200 мм							
Разметка и маркировка (11)							
Газовая автоматическая резка (12)							
Газоэлектрическая автоматическая резка (13)							
Станочная резка (14)							
Снятие фаски на газорезательных машинах (15)							
Правка деталей в вальцах (16)							
Правка деталей на прессе (17)							
Гибка в вальцах (18)							
Гибка на прессах (19)							
Сверловка и зенкование (20)							
(21) Итого							
(22) II. Линия изготовления деталей из листов шириной до 4500 мм							
(23) Разметка и маркировка							
(24) и т. д.							
(25) III. Линия изготовления деталей из профильного проката							
(26) Маркировка							
(24) и т. д.							

Key:
1. Operations
2. Labor consumption in the annual plan, man-hours
3. Average makeup of a brigade, men
4. Labor consumption for the annual plan, machine tool-hours
5. Calculated annual time available of the equipment, hours
6. Amount of equipment, units
7. Calculated
8. Assumed
9. Equipment load factor
10. I. Line for manufacturing parts from sheets up to 3200 mm wide
11. Layout and marking
12. Gas automatic cutting
13. Gas-electric automatic cutting
14. Machine tool cutting
15. Faceting on gas cutting machines
16. Dressing the parts in roll straightening machines
17. Dressing the parts on a press
18. Bending in rolls
19. Bending on presses
20. Drilling and countersinking
21. Total
22. II. Line for manufacturing parts from sheets up to 4500 mm wide
23. Layout and marking
24. and so on
25. III. Line for making parts from intricately shaped rolled products
26. Marking

Table 32

Calculation of the Number of Work Places (Positions) for Assembly and Welding of Subassemblies and Panels

Расчет количества рабочих мест (позиций) для сборки и сварки узлов и секций

Технологические и поточные линии (1)	(2) Трудоемкость на годовую программу, чел.-ч	(3) Средний состав бригады, чел.	(4) Трудоемкость на годовую программу, бригадо-ч	(5) Расчетный годовой фонд времени рабочих мест, ч	(6) Количество рабочих мест: расчетное (7)	принятое (8)	Коэффициент загрузки рабочих мест (9)
(10) А. Участок узловой сборки							
(11) Поточная линия сборки и сварки полотнищ							
(12) Технологическая линия сборки и сварки фундаментов							
(13) и т. д.							
(14) Б. Участок сборки плоскостных и полуобъемных секций							
(15) Поточная линия сборки и сварки плоскостных секций							
(16) Поточная линия сборки и сварки околобортовых палубных секций							
(13) и т. д.							
(17) В. Участок объемных секций							
(18) Поточная линия сборки и сварки днищевых секций							
(19) Технологическая линия сборки и сварки секций оконечностей							
(13) и т. д.							

Key:
1. Process and flow lines
2. Labor consumption for the annual program, man-hours
3. Average makeup of a brigade, men
4. Labor consumption for the annual program, brigade-hours
5. Calculated annual time available of work places, hours
6. Number of work places
7. Calculated
8. Adopted
9. Work place load factor
10. A. Subassembly section
11. Flow line for assembly and welding of panels
12. Process line for the assembly and welding of foundations
13. and so on
14. B. Section for assembly of planar and semivolumetric panels
15. Flow line for assembly and welding of flat panels
16. Flow line for assembly and welding of deck panels near the sides
17. C. Section for volumetric modules
18. Flow line for assembly and welding of bottom sections
19. Process line for the assembly and welding of end sections

Sometimes the number of positions of the mechanized flow and automated lines are calculated by the formula

$$n_{pos} = A_{n\ prod} / (T_\ell - t_{tr} - t_m) P_{ave} ,$$

where $A_{n\ prod}$ is the labor consumption of the operations of manufacturing the product performed on the given line, hours or minutes; T_ℓ is the line cycle or the operating time at the position, hours or minutes; t_{tr} is the nonoverlapping time of operation of the transport unit, hours or minutes; t_m is the product manipulation time, hours or minutes; P_{ave} is the average makeup of a brigade, men.

The output cycle is the time interval determining the output of products following each other in the flow (independently of the number of lines in a flow)

$$T_\ell = \Phi_{eff}/n_e;$$

for continuous flow lines

$$T_\ell = \Phi_{eff}K_{use}/n_e,$$

where Φ_{eff} is the effective annual time available of the equipment for the work places, hours or minutes; n_e is the annual output program, units; K_{use} is the use factor of the effective annual time available of a line as a result of random failures of the equipment (0.80-0.90).

For approximate calculations, the amount of process equipment can be determined by the technological-economic indices which can be represented, for example, as the parts production per unit of equipment.

The calculated formula for determining the amount of equipment has the form

$$n_{equip} = B_{sh}/\rho_{equip},$$

where B_{sh} is the calculated annual shop program, tons or pieces; ρ_{equip} is the annual output of finished shop production per unit of equipment, tons or pieces.

In individual cases the amount of process equipment and in particular large-scale or unique equipment, is determined by its carrying capacity.

For example, the amount of equipment can be found as follows:

Roll straightening machines for preliminary dressing of the sheet steel by the formula

$$n_{roll} = n_s t_s/\Phi_{roll}K_{roll},$$

where n_s is the number of sheets subject to dressing in the annual program, unit; t_s is the dressing time for one average sheet, hours; Φ_{roll} is the calculated time available of the rolls; K_{roll} is the average load factor of the rolls;

Devices for cleaning and priming the steel by the formula

$$n_{dev} = (\ell_s n_s + (\ell_p n_p/n_{lot}))/\Phi_{dev}K_{dev},$$

where ℓ_s is the average sheet length, meters; n_s is the number of sheets for the annual program, unit; ℓ_p is the average profile length, meters; n_p is the number of profiles in the annual program, unit; n_{lot} is the number of simultaneously cleaned profiles, unit; Φ_{dev} is the calculated annual time available of a device for cleaning and priming steel, hours; K_{dev} is the average load factor of the device;

Gas cutting machines by the formula

$$n_{g.m} = n_s \ell_{ave} V_{calc} / \Phi_{g.m} K_{g.m},$$

where n_s is the number of sheets for the annual program cut on gas cutting machines, units; ℓ_{ave} is the average length of cut per sheet, meters; V_{calc} is the calculated annual time available of the gas cutting machines, hours; $K_{g.m}$ is the average load factor of the gas cutting machines.

In design practice the calculation of the equipment for different welding operations is made in table form (Table 33).

The welding equipment of the basic shipyard shops (assembly-welding, module construction and shipbuilding shed) can be calculated consolidated and beginning with the consumption of rolling materials provided for in the ship's design.

In this case the number of manual welding arcs is determined by the formula

$$n_{m.arc} = p_{el} c n_{sh} K_n / K_{el} g_{m.arc} K_{shift} \Phi_w,$$

where p_{el} is the weight of electrodes for manual welding and tack welding per ship, kg; c is the specific value of manual welding and tack welding in the shop (by the weight of the builtup metal) as a function of the total volume of manual welding and tack welding per ship; n_{sh} is the number of ships in the calculated program, unit; K_n is the load nonuniformity factor; K_{el} is the coefficient taking into account the electrode waste; $g_{m.arc}$ is the weight of metal built up on the average by one manual welding arc, kg/hour; K_{shift} is the work shift factor of the welders; Φ_w is the annual time available of a welder, hours.

The number of automatic welding arcs is defined by the formula

$$n_{a.arc} = p_{el.w} c_1 c_2 n_{sh} K_n / K_{el.w} g_{m.c} K_{shift} \Phi_w,$$

where p_{el} is the weight of the welding electrode per ship, kg; c_1 is the specific value of automatic welding in the total volume of automatic and semiautomatic welding per ship; c_2 is the specific value of automatic and semiautomatic welding in the shop in the total volume of these forms of welding per ship; K_{el} is the coefficient taking into account the electrode waste during automatic welding; $g_{m.a}$ is the weight of metal built up on the average by one automatic welding arc, kg/hour.

The number of welding arcs in semiautomatic welding can be determined by an analogous formula.

The coefficient K_{el} considering the electrode waste is 1.75; the coefficient $K_{el.w}$ considering the welding electrode wire waste is -1.1.

Table 33

Calculation of Equipment for Different Shop Welding Operations

Статьи расчета (1)	(2) Операции				
	(3) Прихватка	(4) Ручная электродуговая сварка	(5) Полуавтоматическая сварка		(8) Автоматическая сварка
			под флюсом (6)	в среде CO_2 (7)	
(9) Наибольшее количество сварщиков в смену, чел.					
(10) Коэффициент неравномерности загрузки					
(11) Принятое количество сварочных дуг, ед.					
(12) Средняя сила тока на одну сварочную дугу, А					
(13) Принятое количество сварочного оборудования, ед.:					
(14) однопостового					
(15) многопостового					
(16) (на ... постов)					

Key:
1. Calculation item
2. Operation
3. Tack welding
4. Manual electric arc welding
5. Semiautomatic welding
6. Submerged arc
7. CO_2 shielded
8. Automatic welding
9. Largest number of welders per shift, men
10. Load nonuniformity factor
11. Adopted number of welding arcs, units
12. Average current strength per welding arc, amps
13. Adopted quantity of welding equipment, units:
14. Single-station
15. Multistation
16. (for ... stations)

The proportion of manual welding c when manufacturing subassemblies and panels in the assembly-welding shop in the total volume of manual welding when building a ship is 0.15 to 0.20.

The proportion of automatic welding c_1 in the total volume of automatic and semiautomatic welding when building a ship is 0.35 to 0.40. The proportion of automatic and semiautomatic welding c_2 when manufacturing subassemblies and panels in the assembly-welding shop in the total volume of these types of welding when building the ship is 0.80-0.85.

Table 34

Approximate Electrode and Electrode Wire Consumption per Welding Arc, kg/hr

Welding methods	Welding materials: Electrodes	Electrode wire
Tack welding	0.2	-
Manual welding	1.0–1.3	-
Submerged arc welding:		
semiautomatic	-	2.0–2.5
automatic	-	5.0–6.0
CO_2 shielded:		
semiautomatic	-	1.5–2.0
automatic	-	3.5–4.0

The approximate consumption of electrodes and electrode wire per welding arc is presented in Table 34.

When designing the module building shops and the shipbuilding sheds, the number of welding units is primarily determined by calculation. The stationary welding and other equipment of the installation and erection sections of these shops, as a rule, are taken in the form of process complexes beginning with the nature and the volume of the finishing operations occurring during the welding and installation work on the modules and ships.

The auxiliary equipment of the basic shops of the shipyard and also the basic process and auxiliary equipment of the electric wiring and the outfitting-acceptance shops are also taken by process complexes beginning with the nomenclature and nature of operations for the performance of which they are designed.

In contrast to the above-presented methods, another method is used when calculating the amount of basic equipment and number of basic work places in the anodic oxidation section of the shop for making aluminum-magnesium alloy structural components, the number of basic process baths, the grinding and polishing machines in the galvanizing shops.

The amount of basic equipment and number of work places in the anodic oxidation section and the galvanizing shop are determined by the formula

$$n_{e.w} = S_{pr} t_{op} / S_{ave.m.p} \Phi_{equip},$$

where $n_{e.w}$ is the amount of required equipment or number of work places, units; S_{pr} is the annual program for machining or coating the surfaces of parts and products, m^2; t_{op} is the duration of one operation, hours; $S_{ave.m.p}$ is the average surface of parts machined simultaneously, m^2; Φ_{equip} is the calculated annual time available of the equipment.

The calculation of the number of grinders and polishers is made beginning with the annual program for machining the surfaces of the products and the annual output capacity of the machine tool.

The number of basic process baths, grinding and polishing machines of the galvanizing shop and the design is calculated in tabular form (see Tables 35, 36).

In accordance with the calculation and equipment in the adopted amount, the equipment is selected beginning with the specific conditions of its purpose.

Thus, the choice of equipment is made considering the following conditions of the corresponding shops:

The hull platers shop -- types of machine steel and its characteristics, dimensions of the machined sheet and section steel (length, width, thickness of the sheets, number and type of section), and the construction of the finished parts;

Assembly-welding shop -- types and thicknesses of welded metal, type and seams of welded connections, possibilities of making the welds in the spatial situation and the required welding speed;

The shop for fabricating structural elements from synthetic materials -- characteristics and thickness of the machined synthetic sheet material and also the diameter of plastic pipe;

Pipe fabrication shop -- types of metal and sizes of machined pipe, and so on.

In the hull fitting shop the machine tool and ordinary welding equipment are selected analogously to the conditions for selecting the equipment of the hull platers and the assembly-welding shops, the resistance machines for spot welding, beginning with the thickness of the lap welded metal, the painting section line, considering the maximum overall dimensions of the painted parts.

For selection of the number and power of the motor generators or dc retifiers in the oxidation section and galvanizing shop designs the required current strength is calcula.ed (see Table 37).

At the existing shipbuilding enterprises all of the existing basic process equipment is divided into the following groups with respect to age:

1st group	to 10 years
2d group	11-20 years
3d group	more than 20 years

When doing the design work for the rebuilding and expansion of shipyards and shops, as a rule, the existing equipment up to 10 years old (the first group) is used in the design, considering the fact that the time from the beginning of the design work to the assimilation of the designed capacity of the project will be 5 to 10 years. During this time the greater part of the equipment in the second group, which it is inexpedient to keep in the new design, will become third group equipment. The obsolescence of the existing equipment used in the design is considered.

Table 35

Calculation of the Number of Process Baths

Оборудование (1)	(2) Внутренние размеры ванн, м	(3) Годовая программа покрытия поверхностей деталей, м²	(4) Средняя площадь поверхностей деталей при одной загрузке их в ванну, м²	(5) Количество ванно-загрузок в год	(6) Продолжительность одной операции, ч	(7) Загрузка на годовую программу, ванно-ч	(8) Расчетный годовой фонд времени работы единицы оборудования, ч	(9) Количество ванн, ед. (10) расчетное	(11) принятое	(12) Коэффициент загрузки
(13) Ванна гальванического цинкования труб										
(14) Ванна фосфатирования										
(15) Ванна кислотного меднения										
(16) То же										
(17) Ванна никелирования										
(16) То же										
(18) Ванна хромирования										
(16) То же										
(19) Ванна химического оксидирования										
(20) Ванна лужения										
(21) Итого										

Key:

1. Equipment
2. Inside dimensions of the baths, m
3. Annual program for coating the surfaces of parts, m^2
4. Average surface area of the parts for one submersion in the bath, m^2
5. Number of bath-loads per year
6. Duration of one operation, hours
7. Load for the annual program, bath-hours
8. Calculated annual operating time available of an equipment unit, hours
9. No of baths, units
10. Calculated
11. Assumed
12. Load factor
13. Pipe galvanizing bath
14. Parkerizing bath
15. Acid copper plating bath
16. The same
17. Nickel plating bath
18. Chrome-plating bath
19. Chemical oxidation bath
20. Tinning bath
21. Total

Table 36

Calculation of a Number of Grinding and Polishing Machines

(1) Виды обработки поверхности изделий	(2) Годовая программа, м²	(3) Годовая производительность одного станка, м²	(4) Количество станков		(7) Коэффициент загрузки
			(5) расчетное	(6) принятое	
Шлифовка (8)					
Полировка (9)					

Key:
1. Types of surface machining of products
2. Annual program, m^2
3. Annual output capacity of one machine tool, m^2
4. Number of machine tools
5. Calculated
6. Assumed
7. Load factor
8. Grinding
9. Polishing

Table 37

Calculation of Current Strength for Selection of Power Supplies

Оборудование и краткая его характеристика (1)	Максимальная поверхность одной загрузки, дм² (2)	Принятая плотность тока, А/дм² (3)	Сила тока на одну ванну, А (4)	Напряжение на клеммах ванны, В (5)
(6) Ванна				
(6) Ванна				
(6) Ванна				

Key:
1. Equipment and brief characterization of it
2. Maximum surface of one load, dm2
3. Assumed current density, amps/dm^2
4. Current strength per bath, amps
5. Voltage on the bath terminals, volts
6. Bath

In calculating the work places, during the design work special significance is attached to determining the work places (positions) for assembly and installation of the modules in the module building shops and building slips (positions) in the shipbuilding sheds.

The number of work places (positions) for assembly and installation of modules is calculated beginning with the labor consumption of the operations of manufacturing individual modules, the average density of the operations in the work places (the number of production workers per day) and the annual calculated time available of the work place. This calculation can be made also by the formula

$$n_{w.p} = t_{mod} n_{mod} / \Phi_{w.p},$$

where $n_{w.p}$ is the number of work places for module manufacture, units; t_{mod} is the time for assembly and installation of the module, working days or months; n_{mod} is the number of individual modules in the annual program, units; $\Phi_{w.p}$ is the calculated annual time available of the work places, working days or months.

The number of building slips is determined by the formula beginning with the assumed slipway period of building the ships, the annual calculated program for ship production and the annual time available of the building slips: namely,

$$n_{sl} = t_{sh} n_{sh} / \Phi_{sl},$$

where t_{sh} is the slipway period of construction of a ship, months; n_{sh} is the annual calculated program with respect to ship production, units; Φ_{sl} is the effective calculated annual time available of the slipways, months.

§30. Approximate Composition and Engineering Characteristics of the Basic Process Equipment of the Shipyard Shops

The equipment composition of the shipyard shops and, in particular, the engineering characteristics of this equipment has very great variety, reflecting the specific nature of performance of the building operations of ships of different classes and different purposes.

The approximate composition and engineering characteristics of the basic equipment of the primary shops of class I and II shipyards are presented below (see Table 38).

It is especially necessary to emphasize that the composition and engineering characteristics of the equipment presented in the table are approximate, and they are more precisely defined for a specific design as a function of the design requirements, new developments and the production of the equipment and also the possibility of obtaining equipment from abroad.

Table 38

Approximate Composition and Engineering Characteristics of the Basic Equipment of the Primary Shops of Class I and II Shipyards

Equipment and material	Type, trademark, model	Engineering characteristics	Installed capacity of a unit of equipment, kw	Dimensions (ℓ×b×h), mm	Weight of an equipment unit, kg
1	2	3	4	5	6
		Hull Platers Shop			
		Mold Loft Operations Office			
		Mold loft layout, drawing and computaticn operations			
Drawing machine	"Start-2"	Drawing scales 1:10, 1:20, 1:50. Drawing speed 1200 mm/min	1.9	3000×2000×1000	2620
The same	"Vega-2"	Overall dimensions of the drawing 375×1200 mm. Drawing speed 960 mm/min	0.28	880×1604×1020	460
Keyboard desk-top keyboard computer	"Iskra-122"	Electronic. Operation execution time no more than 0.3 sec	0.05	405×385×127	15
Telegraph for printing punch tapes	STA-M67	Telegraph speed 45 and 50 baud	0.08	530×470×325	35
Coordinator	-	Maximum size of scaled drawing 1000×300 mm. Read time of one coordinate point 10-13 seconds	1.9	-	1000
Horizontal photographic unit	STSh-451	Scales of photographing the drawings 1:5 and 1:10	2.0	6000×1200×1700	750

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[Table 38, contd]

1	2	3	4	5	6
Pneumatic copy frame for contact copying	FKR-115	Largest size of copied plates 1150×1400 mm	0.6	2050×1215×1560	430
		Standards Workshop and Warehouse			
Photoprojector for projecting negative images	EDI-457	With RF-102 objective. Largest image size 10000×2000 mm with a height of 6800 mm	2.5	1000×1550×1650	1200
Jointing machine	SF-4	Greatest planing width 400 mm	2.8	2065×1000×1200	700
Band saw	LS-80-01	Greatest sawing height 400 mm. Greatest sawing width 780 mm	4.5	2075×1100×2415	1400
Universal circular saw with manual feed for longitudinal and transverse sawing	Ts-6-2	Greatest width of worked material 400 mm, thickness 130 mm	4.0	1520×1545×1235	815
Single-spindle medium milling machine	FS	Greatest thickness of machined parts, 100 mm	4.1	1085×1075×1255	790
Drilling and groove-cutting machine for drilling holes and making grooves	SVP-2	Largest drilling size: diameter 40 mm, depth 100 mm. Largest size of machined grooves: depth 100 mm, length 200 mm	2.2	1420×650×1775	450
Bench drill	2M112	Greatest drilling diameter 12 mm	0.6	770×370×825	120
Manual combination lever shears	N-970	These shears cut a sheet up to 6 mm thick, a strip to 7×80 mm, bar up to 13 mm in diameter, and angle material to 30×30×4 mm	-	340×145×1260	30

[Table 38, contd]

1	2	3	4	5	6
Two-way tool grinding and grinding machine	3B633	Grinding disc diameter 300 mm	1.7	810 610 1280	280
		Section for Preliminary Dressing, Cleaning and Priming of Steel			
Sheet straightening machine	-	Straightens sheets from 15 to 50 mm thick, up to 4500 mm wide	260.0	12330×7500×7570	469850
Sheet straightening machine	-	Straightens sheets from 4 to 16 mm thick, up to 3200 mm wide	114.0	9150×4760×3960	74300
Stretching machine	PRM-700	Straightens intricately shaped rolled products from 2.8 to 20 m long, stretching force 700 tons	265.0	33725×10000×7105	407300
Device for shot-blasting and priming of steel	-	Machines sheets in a horizontal position to maximum sizes of 16000×4500 mm. Width of layout of intricately shaped rolled products 2000 mm. Speed 0.5-0.7 m/min	1000	67100×9300×8400	8000
		Hull Platers Sections			
Measuring and marking machine	-	With programmed control. Measures and marks sheets up 16000×3200 mm	7.0	1500×3810×750	6500
Stationary machine for thermal cutting of sheet metal	"Kristall TP1-3,2"	With digital programmed control. Cuts steel sheets to 16000×3200 30 mm	2.5	1500×3810×700	6300
The same	"Telereks"	With digital programmed control. Simultaneously cuts two steel sheets to 16000×3200 mm	3.5	Gauge 10200 mm	8000

[Table 38, contd]

1	2	3	4	5	6
The same	"Kristall TK-3,2"	With digital programmed control. Cuts steel sheets to 16 000×3 200××100 mm	2.5	1 500×3 810×750	-
Stationary machine for thermal cutting of sheet metal	"Kristall TP1-3,2×2"	With digital programmed control. Simultaneously cuts two steel sheets up to 16 000×3 200×30 mm or one sheet 16 000×4500×30 mm	3.2	-	-
The same	"Baltika-3,2"	Three-portal. Cuts steel rectangular sheets and strips to 16 000×3200×50 mm	2.0	Gauge of machine 4200 mm	6700
Hydraulic press	P3241	Force 1250 tons. Sweep 2500 mm	126.0	18 450×9680×2000	300 000
The same	P3239	Force 800 tons. Sweep 1500 mm	94.0	6390×11 015×6605	157 000
The same	PB192	Force 400 tons. Sweep 1500 mm	82.0	4785×2550×6095	62 560
Edging press	LS200	Force 200 tons	22.2	4250×2150×3950	20 000
Sheet straightening machine	-	Straightens steel sheets from 4 to 16 mm thick and to 3200 mm wide	114.0	9150×4760×3960	74 300
Bending rolls	-	Bend steel sheets to 12 mm thick and up to 6000 mm long	45.0	12 592×5290×4795	98 650
The same	-	Bend steel sheets from 12 mm to 32 mm thick up to 10 000 mm long	120.0	16 600×4720×3800	200 000
The same	-	Bend steel sheets from 12 mm to 50 mm thick up to 16 000 mm long	1000.0	27 670×7850×15630	781 912
Section bending machine	PGM-400	Programmed control and HFC installation Bends profile with wall height to 400 mm	850.0	3800×6470×1400	24 680

[Table 38, contd]

1	2	3	4	5	6
Guillotine shears	NB-478	Cut steel sheets to 16 mm thick blade length 3200 mm	28.6	3550×4730×2000	27 000
Press for cutting Section and cutting out holes with AK-16 automatic stamping and marking machine	PGA $\frac{200}{250}$	With program control. Cuts and cuts out without marking bulb strip No 24, angles No 16 and strip 240×20 mm	28.0	10 000×4000×1900	15 000
The same	-	Cuts and cuts out holes without marking section with web height from 200 to 450 mm	50.0	12 000×4000×1900	12 000
Radial drilling machine	2L53	Maximum drilling diameter 35 mm. Sweep 1160 mm	2.2	2000×790×2390	2 300
The same	2N58	Maximum drilling diameter 100 mm. Sweep 3150 mm	18.0	4850×1730×4910	18 000
	Welding Equipment of the Assembly-Welding Shop, the Module Building Shop and Shipbuilding Shed				
Multistation welding rectifier	VDM-1601	Rated welding current 1600 amps, rated welding current of one station 300 amps. Number of welding stations 9	115 kv-amperes	Rectifier 1035×820×1630	750
Automatic machine for submerged arc welding of parts made of low-carbon steel. Power supply TDF-1001	ADS-1000-4	Rated welding current 1000 amps. Electrode wire diameter 2-5 mm. Welding speed 12-120 m/hr	82.0 kv-amp	Tractor 1010×370×665 Power supply 1200×830×1200	65 720

[Table 38, contd]

1	2	3	4	5	6
Automatic machine for submerged arc welding of butt, lapped and fillet welds in the lower position. Power supply TDF-1001	TS-17M1U3	Rated welding current 1000 amps. Electrode wire diameter 1.6-5 mm. Welding speed 16-126 m/hr	82.0 kV-amps	Tractor 345×540×715 Power supply 1200×830×1200	-
Automatic submerged arc welder for welding T-joints. Power supply PSM-1000	ASU-5	Rated welding current 750 amps. Electrode wire diameter 2-3 mm. Welding speed 10-45 m/hr	55.0	Tractor 595×265×345 Control bay 770×370×690 Power supply 820×1430×620	29 90 950
Semiautomatic machine for carbon dioxide shielded arc welding using a consumable steel electrode in all spatial positions. Power supply PSG-500	"Granit-2"	Rated welding current 400 amps. Electrode wire diameter 0.8–1.6 mm. Feed rate of the electrode wire 150-1350 m/hr. CO_2 consumption 500-1200 ℓ/hr	28.0	Feed mechanism 375×245×130 Control bay 570×425×520 Power supply 1030×650×1135	9 50 500
Semiautomatic machine for consumable electrode gas-shielded welding with built-in power pack	"Aeromag-12"	Rated welding current 300 amps. Electrode wire diameter 0.8–1.2 mm. Electrode wire feed rate to 450 m/hr	12.0 kV-amps	1080×590×1010	186
Semiautomatic hose type welder for carbon dioxide shielded welding of steel. Power supply VSU-300	A-547U	Rated welding current 250 amps. Electrode wire diameter 0.8–1.2 mm. Feed rate of the electrode wire 140-450 m/hr	21.5 kV-amps	Feed mechanism 360×130×260 Control panel 390×190×250 Power supply 910×612×960	6.25 5.5 330

[Table 38, contd]

1	2	3	4	5	6
Semiautomatic hose type carbon dioxide shielded or open submerged arc welder for welding in locations that are inaccessible for welding by automatic welders. Power supply PSG-500-1	A-1197	Rated welding current 500 amps. Electrode wire diameter 1.6-2.0 mm. Feed rate of the electrode wire 90-920 m/hr	31.0 kV-amps	Unit 450×950×609} Control bay 195×360×315}	124
				Power supply 1050×560×1015	460
Automatic universal welder for electroslag welding of longitudinal and annular butt welds of angle and Tee connections. Power supply TShS-1000-3	A-535	Rated welding current 1000 amps. Electrode wire diameter 3 mm. Welding speed 0.4-9.0 m/hr. The feed rate of the electrode wire 1.0-7.5 m/min	60.0 kV-amps	Welder 1500×820×1300	380
				Control bay 940×696×1442	340
				Power supply 1442×1000×1763	1250
Electroslag welder for welding vertical welds in metal. Power supply TShS-1000-3	A-820K	Rated welding current 700 amps. Electrode wire diameter 2.5-3.0 mm. Electrode wire feed rate 58-580 m/hr	60.0 kV-amps	Head 585×415×365	29
				Feed mechanism 210×250×320	22
				Control bay 385×780×880	165
				Power supply 1442×1000×1763	1250
Semiautomatic machine for shielded gas arc welding. VDG-301 power supply	PDG-304-1	Rated welding current 315 amps. Electrode wire diameter 0.8-2.0 mm. Feed rate of the electrode wire 3-12 mm/min	23.0 kV-amps	Feed mechanism 320×330×100	5
				Control bay 500×500×500	30
				Power supply 960×690×775	225

[Table 38, contd]

1	2	3	4	5	6
Universal welding rectifier for carbon dioxide shielded, submerged arc welding and for manual welding	VDU-504	Rated welding current 500 amps. Welding current adjustment limits 100-500 amps	40.0 kV-amps	1100×440×816	400
Single-station welding converter for arc welding	PSO-300	Rated welding current 315 amps. Adjustment limits of the welding current 115-315 amps	16.0	1070×620×1030	435
Ultrasonic defectoscope for monitoring welds	DUK-8M	Monitored metal thickness 2-230 mm	0.25	500×330×240	30
Portable gamma unit	"Gamma-RID-21"	For gamma exposure of steel 1-40 mm thick	-	-	320
The same	"Stapel'-5M	For gamma exposure of steel 6-60 mm thick	-	-	71
Electric annealing and heat treatment furnace	OKB-8084	Operating temperature 150-600°C. Operating speed 600×600×1000 mm	27	1000×1630×1815	1250
Drier	TsEP-282A	Temperature 200°C	7.5	1205×1020×1780	570
Machine for straightening and winding wire on spools	SPIP-2	Wound wire diameter 0.5-2 mm	1.0	1240×476×1043	100
Portable gas cutting machine	PK-2	Cuts sheets up to 100 mm thick	0.055	430×825×235	28

[Table 38, contd]

1	2	3	4	5	6
Equipment of the Installation Sections of the Module Building Shop and the Shipbuilding Shed					
Hull and Hull Fitting Sections					
Combination press-shears	S-229A	Cut sheets up to 13 mm thick, strips to 20×40 mm	2.2	1505×600×1200	1130
Guillotine shears	ND-3314	Cut sheets up to 2.5 mm thick	2.7	2100×1270×2500	2900
Edger	PPG-1250	Thickness of bent metal: steel 2 mm, light alloy 3 mm	-	1534×650×1222	500
Single-crank press	KA1428	Rated force 63 tons	7.0	1660×1880×2070	6750
Bead-forming machine	I2716	Thickness of machine material to 4 mm	4.5	770×1285×1500	1200
Vertical drilling machine	2G-125	Greatest diameter of drilling 25 mm	3.0	910×730×2104	780
Bench type drill	2M-112	Greatest drilling diameter 12 mm	0.6	770×370×825	120
Machine for electric resistance spot welding of parts made of low-alloy grades of steel	MT-1617	Thickness of welded parts from 0.8+0.8 to 2.3+2.3 mm. Output capacity 200 welds/min	100 kV-amps	1820×490×1425	800
Universal welding rectifier	VDU-504	Rated welding current 500 amps	40 kV-amps	1100×440×816	400
Semiautomatic hose type gas shielded electric arc welder. Power supply VSU-300	A-547U	Rated welding current 250 amps. Welding wire diameter 0.8-1.2 mm. Feed rate of the electrode wire 140-450 m/hr	21.5 kV-amps	Feed mechanism 360×130×260 Control panel 390×190×250	6.25 5.5

[Table 38, contd]

1	2	3	4	5	6
				Power supply 910×612×960	630
Tool grinding and grinding machine	3B-634	Grinding disc diameter 400 mm	3.0	1000×655×1230	430
		Mechanical Installation Section			
Portable Sterntube boring machine	LR-203	Boring diameter 600-1350 mm. Facing diameter 600-1200 mm. Length of machined product 12000 mm	15.0	18 650×1200×1190	16000
Boring machine for machining holes in shaft flanges	SRVP-140	Boring diameter 120-140 mm	3.0	1810×840×860	600
Portable vertical boring machine for boring steering gear holes	-	Boring diameter 400-700 mm	15.0	-	3000
Portable milling machine	SPF-1	Width of machinedsurface 575 mm, length 4800 mm	1.7	5200×1440×1045	1882
Screw-cutting lathe	1AB16	VTs-160; RMTs-710	4.5	2135×1225×1220	1500
The same	16K-20	VTs-200; RMTs-1400	10.0	3195×1190×1500	2220
Vertical milling machine	6R-12B	Bench operating surface 320×1250 mm	7.5	2340×1840×2020	3180
Horizontal milling machine	6R81G	Operating surface of bench 250×1000 mm	6.3	1470×1975×1610	2210

[Table 38, contd]

1	2	3	4	5	6
Transverse planar	7V36	Slide travel 30-700 mm	6.6	2950×1430×1650	3100
Vertical drilling machine	2A-135	Greatest drilling diameter 35 mm	4.0	380×825×2300	870
Bench type drilling machine	2AM112	Greatest drilling diameter 12 mm	0.6	770×370×825	120
Two-way tool grinding and grinding machine	3B364	Grinding disc diameter 400 mm	3.0	1000×655×1230	430
		Pipe Fitting Section			
Hacksaw cutting-off machine	872M	Greatest diameter of cut pipe 250 mm	2.8	1470×690×885	1170
Pipe bending machine with hydraulic drive	STG-1M	Bent pipe diameter 14-38 mm	2.8	965×456×1082	400
The same	STG-2S	Diameters of bent pipe: steel 38-76 mm, copper to 105 mm	10.0	6600×1202×1230	3750
Pipe threading machine	VMS-2A	Greatest length of thread 120 mm	3.0	1560×625×1160	570
Single crank press	KD-2320	Rated force 10 tons	1.7	860×1275×1795	930
Vertical drilling machine	2A-135	Greatest drilling diameter 35 mm	4.0	980×825×2300	870
Bench drill	2M112	Greatest drilling diameter 12 mm	0.6	770×370×820	120

[Table 38, contd]

1	2	3	4	5	6
Two-way tool grinding and grinding machine	3B364	Disc diameter 400 mm	3.0	1000×655×1230	430
Silicon welding rectifier	VD-303	Rated welding current 300 amps	21.0 kV-amps	1200×770×830	270
Semiautomatic hose type carbon dioxide shielded electric welder. Power supply VSU-300	A-547U	Rated welding current 250 amps. Welding wire diameter 0.8-1.2 mm.	21.5	Feed mechanism 360×130×260 Control panel 390×140×250 Power supply 910×612×960	6.25 5.5 330
Manual argon-shielded pipe welder. Power supply PSG-500-1	"Shtorm-2"	Rated welding current 350 amps. Adjustment limit of welding current for ordinary arc welding 10-375 amps	31.0 kV-amps	Control bay 942×817×1805 Power supply 1050×500×1015	470 460
Hydraulic pump with pneumatic drive for hydraulic tests	PGI-100	Highest pressure 100 kg/cm^2	-	542×255×360	40
The same	PGI-300	Greatest pressure 300 kg/cm^2	-	430×240×525	58
		Woodworking Section			
Combination woodworking machine	K	Greatest width of jointing and surface gauging 315 mm. Planing height 5-120 mm	3.8	1455×1120×910	985
Band saw	LS-80-01	Sawing height 400 mm	4.5	2075×1100×2415	1400
Sand grinder	-	Disc diameter 500 mm	2.8	875×750×1000	183

[Table 38, contd]

1	2	3	4	5	6
		Painting and Insulating Section			
Paint mixer	SO-11	Output capacity 350-400 ℓ/hr. Capacity 63 liters.	0.6	570×550×950	35
Two-shaft mixer	SO-8	Output capacity 120-150 ℓ/hr. Capacity 55 liters.	2.8	90C×690×950	210
Band saw	LS-80-01	Greatest thickness of cut material 400 mm	4.5	2075×1100×2415	1400
Machine tool for thermal cutting of slabs type PSB-S	-	Greatest thickness of cut material 100 mm	1.5	2600×1200×1300	220
		Electric Wiring Section			
Vertical drilling machine	2G-125	Greatest drilling diameter 25 mm	3.0	910×730×2104	780
Bench drill	2M112	Greatest drilling diameter 12 mm	0.6	770×370×825	120
Two-way tool grinding and grinding machine	3B634	Grinding disc diameter 400 mm	3.0	1000×655×1230	430
Polyethylene welding device	LGS-1.5	Welded film thickness from 0.6 to 1.0 mm	1.0	1140×1200×1650	40
Device for applying fireproofing insulation (with pneumatic drive)	-	Output capacity applying the insulation: 6 m^2/hr with layer thickness of 15 mm and 4.5 m^2/hr with layer thickness of 30 mm	-	1000×700×800	75

[Table 38, contd]

1	2	3	4	5	6
		Shop Mechanical Workshop			
Screw cutting lathe	1A616P	VTs-160, RMTs-710	4.5	2135×1225×1220	1500
Vertical drill	2G-125	Greatest drilling diameter 25 mm	3.0	910×730×2104	730
Bench drill	2M112	Greatest drilling diameter 12 mm	0.6	770×370×825	120
Two-way tool grinding and grinding machine	3B633	Grinding disc diameter 300 mm	3.0	810×610×1280	280
		Power Engineering Workshop of the Shop			
Pipe bending machine with hydraulic drive	STG-1M	Bent tube diameter 14-38 mm	2.8	965×456×1082	400
Vertical drill	2G-125	Greatest drilling diameter 25 mm	3.0	910×730×2104	730
Bench drill	2M-112	Greatest drilling diameter 12 mm	0.6	770×370×825	120
Manual lever shears	N-970	Cuts sheet metal to 6 mm thick	-	340×145×1260	30
Two-way tool grinding and grinding machine	3B633	Grinding disc diameter 300 mm	3.0	810×610×1280	280
		Pipe Fabrication Shop			
		Equipment for Making Pipe			
Machine tool for gas-electric cutting of pipe	-	Cut pipe 40-378 mm in diameter	20.0	1250×1400×1735	3000

[Table 38, contd]

1	2	3	4	5	6
Machine tool for cutting and cleaning pipe with an emery wheel	SRZT-1M	Machines pipe 14-76 mm in diameter. Diameter of cutting off disc 400 mm, finishing disc 60 mm	4.1	1950×920×1280	1100
Cutting-off milling machine	8B66A	Cuts off pipe to 240 mm in diameter	9.5	2570×1600×1725	3980
The same	8B67	Cuts pipe to 350 mm in diameter	14.65	3110×1575×2160	6800
Pipe bending machine with HFC heating	TGSV-1	Bends steel pipe 89-273 mm in diameter	18.0	5090×1890×1140	4350
Pipe bending machine with induction heating	TGSV-2	Bends pipe 100-426 mm in diameter	33.0	8826×2000×1620	14000
Pipe bending machine	STG-3SA	Bends pipe with diameter of 76-133 mm (steel), 75-160 mm (copper)	22.8	7150×1700×1330	13000
The same	STG-22	Bends pipe with diameters of 38-76 mm (steel), to 105 mm (copper)	10.0	6600×1202×1230	3750
The same	STG-1M	Bent pipe diameter 14-38 mm	2.8	830×370×1000	300
Pipe bending machine with program control	STGP-2	Bent pipe diameters 38-89 mm (steel), 38-110 mm (copper)	16.0	6700×1400×1400	5720
Pipe bending machine	TGM9-20	Bends pipe 9-20 mm in diameter	1.7	800×600×950	183

[Table 38, contd]

1	2	3	4	5	6
Thread cutting machine	VMS-2A	Metric thread diameter 14-76 mm, pipe diameter 1/2 to 2-1/2 inches	2.8	1560×750×1160	600
Hydraulic press with pipe cutter	PG-100	Force 100 tons. Diameters of clamped products: flanges and rings 56-300 mm, pipe 28-300 mm	24.5	1700×1580×2900	8500
Hydraulic press with pipe cutter	PG-50	Force 50 tons. Clamped product diameters: flanges and rings 56-155 mm, pipe 14-155 mm	14.5	1580×1200×2150	4500
Machine tool for cutting out holes in the pipe and machine holes	SVO	Diameter of machined pipe 45-310 mm, diameter of opened holes 10-290 mm	11.3	2810×1470×3028	6730
Portable machine for gas flame cutting of holes	PGO-2	Machined pipe diameter 150-500 mm. Hole cutting diameter 50-400 mm. Cutting speed 300-500 mm/min	-	600×428×545	13.75
Machine tool for flaring the ends of pipe on a cone	-	Cone flares the ends of pipe 30-300 mm in diameter	5.5	2000×1080×1556	3000
Vertical drilling machine	2A-135	Greatest drilling diameter 35 mm	4.0	980×825×2300	870
Flange boring machine	FP-450	Diameter of machine flanges 55-455 mm	2.1	940×1250×1650	1300
Machine tool for finishing the ends of pipe for welding by needle milling tool	SZKT-2	Greatest finished tube diameter 45-165 mm. Width of finished surface 50 mm	3.0	895×670×1425	420

[Table 38, contd]

1	2	3	4	5	6
Two-way tool grinding and grinding machine	3B634	Disc diameter 400 mm	3.0	1000×655×1280	430
Multistation welding rectifier	VDM-1601	Rated current 1600 amps	37 kV-amps	1630×1035×820	750
Semiautomatic hose type carbon dioxide shielded steel welder. Power supply VSU-300	A-547U	Rated welding current 250 amps. Electrode wire diameter 0.8-1.2 mm. Feed rate of the electrode wire 140-450 m/hr	21.5	Feed mechanism 360×130×260 Control panel 390×190×250 Power supply 910×612×960	6.25 5.5 330
Semiautomatic consumable electrode carbon dioxide shielded arc welder for welding steel structures and argon or nitrogen shielded welder for copper and copper nickel structures. The power supply PSG-500-1	"Granit-2"	Rated welding current 400 amps. Adjustment limits of welding current 100-400 amps. Electrode wire diameter 1.0-1.6 mm. Feed rate of the electrode wire: stage I 150-750 m/hr; stage II 500-1350 m/hr. Shielding gas consumption 8-20 ℓ/min	31.0 kV-amps	Feed mechanism 375×245×130 Control bay 570×425×520 Power supply 1050×590×1015	9.0 50.0 460
Manual tungsten electrode gas shielded welder for welding aluminum and its alloys. Power supply IPP-300P	UDG-301	Welding current 300 amps. Adjustment limits of welding current 15-300 amps. Electrode diameter 018-6 mm. Shielding gas consumption 240-600 ℓ/hr.	23.0 kV-amps	Welder 900×815×1800 Power supply 630×1076×880	600 240
Welding station for manual argon arc welding by a tungsten electrode. Power supply PSO-300-2-U2	PRS-3M	Adjustment limits of welding current 20-485 amps. Tungsten electrode diameter 3, 4 and 5 mm	16.0 kV-amps	Equipment module 330×240×225 Ballast rheostat 710×695×480 Power supply 1070×620×1030	9.0 80.0 435

[Table 38, contd]

1	2	3	4	5	6
Device for manual welding of pipe. Power supply PSO-300-2-U2	"Shtorm-2"	Rated welding current 350 amps. Adjustment limits of welding current 10-375 amps. Tungsten electrode diameter 2, 2.5, 3, 4 and 5 mm. Shielding gas consumption in the torch 3-20 ℓ/min, for blowing 3-20 ℓ/min. Cooling water consumption 0.6-2 ℓ/min	16.0 kV-amps	Control bay 942×817×1805 Power supply 1070×620×1030	470 435
Furnace for calcining electrodes and flux	OKB-8115	Heating temperature 300°C. Working space 640×600×1150 mm	9.4	1050×950×1950	630
Machine tool for straightening and winding wire on spools	SPNP-2	Wound wire diameter 0.5-2 mm	1.0	1240×476×1043	100
Electric furnace for annealing pipe	-	High-frequency current used to heat straight pipe to 350 mm in diameter	140.0	1200×500×1500	1200
Electric furnace	-	Heats pipes to 450 mm in diameter	60.0	2250×700×1515	1850
Mechanized sand packing device with electric vibrator	-	For sand packing of pipe of different diameters	12.0	2700×2700×6900	~2100
Machine for laying out insulating material	RL-3A	Lays out packages to 50 mm	1.1	2700×1500×1755	445

[Table 38, contd]

1	2	3	4	5	6
Machine tool for winding pipe with cord for insulation	-	Insulated pipe diameter to 125 mm	0.6	900×1500×2100	400
Equipment for Copper Smithy and Fitting Operations					
Downcut shears	N-533	Cut sheets to 4 mm thick	2.8	1875×630×1945	1000
Combination press shears	S-229A	Cut steel sheets to 13 mm thick, strips to 20×40 mm	2.2	3070×1200×1894	4100
Manual combination lever shears	N-970	Cut sheets to 6 mm thick, strips to 7×80 mm, bar to 13 mm in diameter, angles to 30×30×4 mm	-	340×145×1260	30
Bead-forming machine	I-2714	Machines steel sheets to 2.5 mm thick	2.2	1505×600×1200	1130
Sheet bending machine	I-2116	Bends steel sheets to 4 mm thick	4.5	3070×1200×1894	4100
Edging machine	PPG-1250	Thickness of bent metal, steel 2 mm, light alloys 3.0 mm	-	1534×650×1222	500
Vertical hydraulic press	P-6330	Force 100 tons. Bench 2000×420 mm	22.0	2250×2000×2700	6530
Two-way tool grinding and grinding machine	3B634	Disc diameter 400 mm	3.0	1000×655×1280	430
Device for plasma cutting of nonferrous metals	URPD-67	Cuts sheets from nonferrous metals with thickness of 5-50 mm (aluminum); 5-30 mm (copper)	30.0 kV-amps	1100×700×1160	1200
Hearth for copper smithing	-	Gas	-	1270×1270×840	1000

CHAPTER X. MATERIALS-HANDLING EQUIPMENT. PROCESS CHARACTERISTICS OF THE BUILDINGS AND SUBSTANTIATION OF THE BAY DIMENSIONS

§31. Calculation and Selection of Crane Equipment

The crane equipment of a shipyard is one of the principal forms of materials-handling equipment of the shipyard. It is designed both to insure modern methods of shipbuilding (large-section and modular) and for mechanization of the labor-consuming materials-handling and loading and unloading operations in the shipyard production process.

For movement of various structural components at the shipyards, bridge, gantry, tower, portal and portable railroad, truck, pneumatic-tired, caterpillar and floating boom cranes are used. With respect to type of load grappling devices, primarily hook cranes are used (for piece goods), with magnetic (for magnetic materials) and pneumatic vacuum grapples. The parameters of the cranes are taken in accordance with the catalog specifications, the certificates and standard designs of the manufacturing plants; the initial specifications are compiled for unique cranes when developing the shipyard designs or individual projects. As a rule, the building docks, uncovered shipbuilding ways, the covered-in berths, and sometimes the shops for building modules and the assembly-welding shops are equipped with the indicated cranes.

The proper calculation and selection of cranes has great economic significance, for in the assembly-installation shops -- assembly-welding, the module building shop, the shipbuilding shed, and also in the covered slipways, on the open building berths and building docks -- it is necessary to perform loading, erection and installations operations with structural components, machinery and equipment that differs with respect to weight and size. When defining the crane equipment at these shops all of the products are divided by weight into groups (for example, 321-500; 201-320; 126-200; 81-125; 51-80; 33-50; 21-32; 11-20; 6-10 and up to 5 tons), then the required number of cranes are defined with respect to each group for the loads.

The final decision regarding the number of cranes n_{cr} corresponding to the drifting capacity is made as a function of their load coefficient and the composition of the shop buildings or the arrangement of the building slips, using the consolidated method of calculation,

$$n_{cr} = n_{load} n_{ship} n_{cycle} t_{cr.o} / \Phi_{cr} K_{cr},$$

where n_{load} is the number of loads per ship; n_{ship} is the number of ships in the annual design program; n_{cycle} is the average number of cycles per unit load; $t_{cr.o}$ is the duration of the crane operation cycle, hours; Φ_{cr} is the actual calculated annual time available of the crane, hours; K_{cr} is the use coefficient of the crane with respect to time.

The indicated calculation of the number of cranes in the shop is made in tabular form (Table 39).

The duration of the crane operation cycle $t_{cr.o}$ in the assembly-installation shops of the shipyard is made up of the time for processing the load t_{load} and the time for participation in the installation and setup of the product t_{inst}. Here

$$t_{load} = 2.5h_{lift}/V_o+2(\ell_{av}/V_1+\ell_{cr}/V_2+n_{ave.cr}/V_3+t_{op}),$$

where h_{lift} is the lift height (amount of lowering) of the load, m/min; V_0 is lift (lowering) speed, m/min;
ℓ_{ave} is the average path of the trolley, hoist, carriage, boom on varying the bay, meters; ℓ_{cr} is the average path of the crane, meters; $n_{ave.cr}$ is the average number of turns of the crane (boom) in a cycle; V_1 is the rate of displacement of the trolley, hoist, carriage, boom (on variation of the bay), m/min; V_2 is the speed of movement of the crane, m/min; V_3 is the speed of rotation of the crane (boom), rpm; t_{op} is the expenditure of time on auxiliary operation (slinging and unslinging of the load, more precise determination of the approaches, and so on), minutes.

The speeds are taken by the certificate of technical specifications of the cranes, and the time for participation when installing and setting up the product t_{inst} taken beginning with an analysis of the operation of the crane performing analogous operations. The average data on the duration of the operating cycles of the cranes in the basic shipyard shops are presented in Table 40.

The use factor of the crane with respect to time K_{cr} when performing ordinary crane operations for a magnetic crane are taken equal to 0.80-0.95; for a hook crane it is 0.65-0.85, including for operation in hull platers shop 0.75-0.85, the assembly-welding shop 0.7-0.8, the shop for assembling modules and the shipbuilding shed 0.65-0.75.

When designing the shipyards, the presented calculations are primarily performed by shops (covered slipways, open building slips, building docks) equipped with unique crane equipment, and with respect to the remaining shops, selectively. In the last-mentioned shops, on the basis of the data taken from the previously performed calculations, the number of cranes is taken as a function of the length of the bays and with consideration of the investigated floor-type transport units.

The capacity of the cranes is established as a function of the weight of the load; in individual cases for transporting a small number of heavy loads, paired operation of the cranes is permitted.

For example, at the present time in accordance with the effective norms provision is made for electric bridge cranes with a maximum capacity in the hull platers shops of class I and II shipyards of 30 tons, in the assembly-welding shops of class I shipyards, 200/32 tons, in the assembly-welding shops, the shops for building the modules and shipbuilding sheds (covered slips) of the class II shipyards, 160/32 tons.

Table 39

Calculation of the Number of Cranes in the Shop

Наименование грузов (1)	Масса единицы груза, т (2)	Количество грузов на одно судно $n_г$ (3)	Количество судов в расчетной программе $n_с$ (4)	Количество циклов на единицу груза $n_ц$ (5)	Продолжительность цикла $t_{к.о}$, ч (6)			Время на годовую программу, крано-ч (10)	Годовой расчетный фонд времени работы крана $Ф_к$, ч (11)	Коэффициент загрузки крана по времени $K_к$ (12)	Потребное количество кранов $n_к = \frac{n_г n_с n_ц t_{к.о}}{Ф_к K_к}$ (13)
					при обработке груза (7)	при установке и монтаже (8)	всего (9)				

Key:

1. Load designation
2. Weight of a unit load, tons
3. Number of loads per ship n_{load}
4. Number of ships in the calculated program n_{ship}
5. Number of cycles per unit of load, n_{cycle}
6. Cycle time $t_{cr.o}$, hours
7. When handling a load
8. When installing and setting up
9. Total
10. Annual time available, crane-hours
11. Annual calculated time available of crane Φ_{cr}, hr
12. Load factor of the crane with respect to time K_{cr}
13. Required number of cranes $n_{cr} = n_{load}n_{ship}n_{cycle}t_{cr.o}/\Phi_{cr}K_{cr}$

The load capacity of the cranes is established as a function of the weight of the load and in individual cases, for transporting a small number of heavy loads, paired operation of the cranes is permitted.

§32. Engineering Description of Buildings

The basic and auxiliary production buildings are a component part of the industrial production basic means of the shipyard. The primary component part of a building is the bays [24, 27].

The bay of a building is the part of the building bounded by two adjacent rows of columns or longitudinal subdivision axes of the buildings. The bay of the building is characterized by the principal dimensions: width, column spacing and height.

Table 40

Approximate Average Data on the Operating Cycle Time of the Crane Equipment of the Main Shipyard Shops

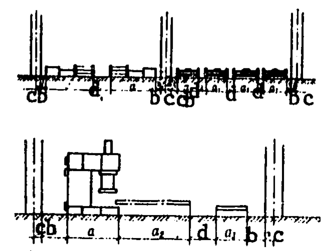
Loads	Weight of a unit load, tons	Cycle time, hours: When processing a load	Cycle time, hours: During setup and installation	Cycle time, hours: Total
	Hull Platers Shop			
Sheets, section and hull ports	21-32	0.17	-	0.17
	11-20	0.16	-	0.16
	6-10	0.15	-	0.15
	to 5	0.14	-	0.14
	Assembly-welding Shop			
Hull sections	201-320	1.2	-	1.2
	126-200	1.0	-	1.0
	81-125	0.8	3.0	3.8
	51-80	0.5	2.5	3.0
	33-50	0.25	2.0	2.25
Sections, subassemblies and parts of the hull	21-32	0.18	1.5	1.68
	11-20	0.17	1.0	1.17
	6-10	0.16	0.60	0.76
	to 5	0.15	0.3	0.45
	Shops for Building Modules and Shipbuilding Sheds			
Hull sections, machinery and unitized units	321-500	1.4	6.5	7.9
	201-320	1.2	5.0	6.2
	126-200	1.0	3.8	4.8
	81-125	0.8	3.0	3.8
	51-80	0.5	2.5	3.0
	33-50	0.25	2.0	2.25
Sections, hull subassemblies, machinery, unitized units, various equipment and products	21-32	0.18	1.5	1.68
	11-20	0.17	1.0	1.17
	6-10	0.16	0.60	0.76
	to 5	0.15	0.25	0.40
Auxiliary loads not entering into the weight load of the ship (staging sections, accessories, portable equipment, and so on)	11-20	0.16	0.5	0.66
	6-10	0.15	0.35	0.50
	to 5	0.14	0.15	0.29

Table 41

Width and Height of the Bays of the Hull Platers Shop

(1) Показатели, определяющие размеры пролетов	(3) Класс верфи				
	I	II	III	IV	V
(2) По ширине	(4) Размеры пролетов, м				
(6) *Участок правки листового металла*					
a	11,0×2	11,0×2	9,0×2	9,0×2	7,0×2
b	0,8×2	0,8×2	0,8×2	0,8×2	0,8×2
c	1,0×2	1,0×2	0,75×2	0,5×2	0,5×2
d	0,8×1	0,8×1	0,8×1	0,8×1	0,8×1
Ширина пролета по технологическим требованиям (7)	26,4	26,4	21,9	21,4	17,4
Унифицированные пролеты (8)	30,0	30,0	24,0	24,0	18,0
Участок газовой резки (9)					
a_1	5,35×4	5,35×4	4,0×4	3,5×4	3,1×4
b	0,8×2	0,8×2	0,8×2	0,8×2	0,8×2
c	1,0×2	1,0×2	0,75×2	0,5×2	0,5×2
d	0,8×3	0,8×3	0,8×3	0,8×3	0,8×3
Ширина пролета по технологическим требованиям (10)	27,4	27,4	21,5	19,0	17,4
Унифицированные пролеты (8)	30,0	30,0	24,0	24,0	18,0
Участок станочной гибки (пресс) (11)					
a	9,0	9,0	6,5	6,0	5,5
a_2	16,0	16,0	10,0	8,0	6,0
a_3	4,5	4,5	2,4	2,0	1,6
b	0,8×2	0,8×2	0,8×2	0,8×2	0,8×2
c	1,0×2	1,0×2	0,75×2	0,5×2	0,5×2
d	0,8×1	0,8×1	0,8×1	0,8×1	0,8×1
Ширина пролета по технологическим требованиям (10)	33,9	33,9	23,3	19,4	16,5
Унифицированные пролеты (8)	36,0	36,0	24,0	24,0	18,0

(5) Эскизы и условные обозначения к ним

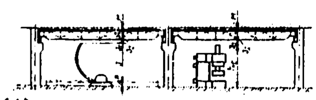


(12)
a — размер оборудования (средний);
a_1 — размер линии газовой резки (средний);
a_2 — размер средств механизации или мест обслуживания;
a_3 — размер площадки складирования готовых деталей;
b — расстояние от кромки колонны до оборудования;
c — расстояние от оси колонны до кромки;
d — расстояние между оборудованием или местами обслуживания.

Key:
1. Indices defining the bay dimensions
2. With respect to width
3. Class of shipyard
4. Sizes of the bays, meters
5. Drawings and provisional notation for them
6. Section for straightening sheet metal
7. Width of bay according to process specifications
8. Standardized bays
9. Gas cutting section
10. Bay width with respect to the process requirements
11. Machine tool bending section (presses)
12. a -- equipment dimensions (average);
    a_1 -- size of gas cutting lines (average);
    a_2 -- size of mechanization means or service location;
    a_3 -- size of the area for storing the finished parts;
    b -- distance from the edge of the cone to the equipment;
    c -- distance from the column axis to the edge;
    d -- distance between the equipment or the service locations

[Table 41, continued]

(1) По высоте	(2) Размеры пролетов, м				
(3) *Участок станочной гибки (вальцы)*					
g	0,8	0,8	0,8	0,8	0,8
h	9,0	9,0	5,5	4,5	4,0
h_1	1,0	1,0	1,0	1,0	1,0
h_2	0,85	0,85	0,6	0,45	0,82
j	2,8	2,8	2,1	1,8	1,0
k	0,2	0,2	0,2	0,2	0,2
Высота до отметки подкранового рельса по технологическим требованиям (5)	11,65	11,65	7,9	6,75	...
Унифицированные пролеты (6)	11,45	11,45	8,15	8,15	—
Высота до низа несущих конструкций покрытия (7)	14,65	14,65	10,2	8,75	7,82
Унифицированные пролеты (8)	14,4	14,4	10,8	10,8	9,6
(9) *Участок станочной гибки (пресс)*					
h_0	8,0	8,0	7,0	7,0	7,0
h_3	0,4	0,4	0,4	0,4	0,4
h_2	0,85	0,85	0,6	0,45	0,82
j	3,2	3,2	2,4	2,1	1,0
k	0,2	0,2	0,2	0,2	0,2
Высота до отметки подкранового рельса по технологическим требованиям (5)	9,25	9,25	8,0	7,85	—
Унифицированные пролеты (6)	9,65	9,65	8,15	8,15	—
Высота до низа несущих конструкций покрытия (7)	12,65	12,65	10,6	10,15	9,42
Унифицированные пролеты (6)	12,6	12,6	10,8	10,8	9,6



(4)
g — расстояние от пола до нижней кромки верхнего валка гибочных вальцов;
h — гибка листов наружной обшивки радиусом 5700 мм;
h_1 — расстояние от верхней кромки листа до нижней кромки фермы крана;
h_2 — расстояние от нижней кромки фермы крана до отметки подкранового рельса;
h_3 — расстояние от нижней кромки фермы крана до верхней кромки пресса;
j — высота фермы крана от отметки подкранового рельса;
k — зазор между фермой крана и покрытием;
h — высота гидравлического пресса.

Key:
1. With respect to width
2. Sizes of the bays, meters
3. Machine tool bending section (rolls)
4. g -- distance from the floor to the lower edge of the upper roll of the roll bending machine;
   h -- bend of the shell plating 5700 mm in radius;
   h_1 -- distance from the upper edge of the sheet to the lower edge of the crane beam;
   h_2 -- distance from the lower edge of the crane beam to the crane rail level;
   h_3 -- distance from the lower edge of the crane beam to the upper edge of the press;
   j -- height of the crane beam from the crane rail level;
   k -- clearance between the crane beam and the cover;
   h -- height of hydraulic press.
5. Height to the level of the crane rail by technological specifications
6. Standardized bays
7. Height to the bottom of the bearing structures of the ceiling
8. Standardized bays
9. Machine tool bending section (press)

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The bay width is the distance between longitudinal axes of two rows of columns forming the bay in the direction perpendicular to the bay axis.

The bay of a bridge crane is the distance between the vertical axes of the rails of the crane track.

The column spacing is the distance between the axes of two adjacent columns of one row in the direction of the longitudinal bay axis (or the distance between the subdivision axes of the columns of the building in the longitudinal direction). The spacing of the columns, in accordance with the process design norms, is taken as a function of the process requirements (for example, the necessity for transfer of parts from bay to bay in the hull platers shop or subassemblies and sections in the assembly-welding shop) and the resolving capacity of the supporting beams or the prefabricated reinforced concrete beams.

The column grid gives the dimensions of the cell representing a rectangle, the sides of which are equal to the bay width and the column spacing; the dimensions of the column grid are designated in the form of the product of the column spacing times the bay width (for example, 12×24, 12×30, 12×36, 24×42 m).

The bay height (total) is the distance from the floor level to the bottom of the bearing structures of the ceiling of the building.

The height to the crane tracks is the distance from the floor level to the top of the head of the crane track (in crane bays).

§33. Substantiation of the Dimensions of the Bays and the Doorways. Floor Specifications

The bay dimensions of the basic hull and the assembly-installation shops of the shipyard are determined considering the effective norms for the distances between the operating platforms, the work places, the installations and elements of the buildings.

The bay width is taken beginning with the placement of an efficient number of flow lines in the bay, maximum width of these lines, the distance from the edge of the columns to the equipment or the accessories of the work spaces, distances from the column axis to its edge, the distances between the equipment or the work places and the width of the service zone.

The bay height to the upper edge of the crane tracks in the shops with machine tool equipment is determined beginning with the distance from the floor to the operating part of the equipment, the required distance for raising the part during the processing of it from the operating plane of the equipment to the upper point of the parts, the distance from the upper edge of the part to the lower edge of the crane girder, the distance from the lower edge of the crane girder to the crane rail level.

The height of the bay to the upper edge of the crane tracks in the assembly-welding shops is found, as a rule, from the condition of manipulation of the sections of maximum dimensions, summing the height of the accessories or the manipulation area, the clearance between the accessories or the manipulation area and section, the maximum height of the manipulated section, the distance between the section and the hook axis, the distance from the hook axis to the lower edge of the crane girder and the distance from the lower edge of the crane girder to the crane rail level.

The height of the bay to the upper edge of the crane tracks and the module assembly shop and the shipbuilding shed (covered slipway) is determined beginning with the height of the ship cradle, the height of the main hull of the ship, the required clearance between the ship's hull and the loaded module of the superstructure, the height of the superstructure module, the clearance between the cross arm and the loaded module of the superstructure, the height of the cross arm, the clearance between the cross arm and the crane girder, the distance from the lower edge of the crane girder to the crane rail level.

When establishing the height of the bay to the crane tracks in the module assembly shop and the shipbuilding shed, the possibility of loading the machinery of the largest dimensions is checked.

The approximate maximum dimensions of the ships and products of the main shipyard shops are presented in Table 1.

Examples of determining the width and height of the bays of the main shops of the shipyards are presented in Tables 41-44.

In the given examples, the overall dimensions of the crane with the bays and lift height are greater than provided for by the effective All-Union State Standards; they were adopted considering the existing design practice and they are subject to more precise definition when creating specific designs.

More precise definition is also carried out in cases where in accordance with the process flow chart of construction of the ships provision is made for a different capacity of the cranes (for example, when installing the superstructures in larger modules and the primary machinery in unitized units).

The height of the cab on the upper level of the cranes in the module-building shops and shipbuilding sheds (covered slipways) is taken considering the installation of the air conditioning. In these shops the second level cranes (transfers) are placed within the structural height of the bearing structures of the ceiling. When determining the required height the bottom of the bearing structures of the ceiling, the position of the bottom of the second level crane cab and the bottom of the bearing structures of the ceiling is taken as the same level.

In cases where the flow diagram for the construction of ships provides for installation of superstructure modules as part of all of the levels on the hull of the ship in the module-building shop, the height of the module-building shop is taken equal to the height of a shipbuilding shed (covered slipway).

In example calculations (see Tables 41-44), provisional data are presented, and with the specific design calculations they are taken in accordance with the existing normative materials and design solutions.

The main entrances of the shipyard shop buildings must also have openings which will provide both for entrance and exit of a finished production from the shops in these buildings (see Table 45).

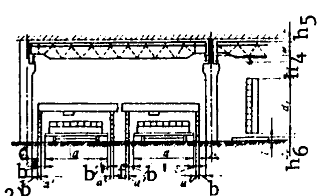
The floors of the shops must correspond to the corresponding nature of production and rules for storing products and parts and also safety engineering requirements.

The approximate floor specifications for the main shipyard shops are presented in Table 46.

Table 42

Width and Height of the Bays of the Assembly-Welding Shops

Показатели, определяющие размеры пролетов (1)	(2) Класс верфи					(3) Размеры пролетов
	I	II	III	IV	V	
(4) По ширине	(5) Размеры пролетов, м					
a	17,5×2	17,5×2	11,3×2	9,3×2	8,0×2	
a'	0,7×4	0,7×4	0,6×4	0,5×4	0,5×4	
b'	0,7×4	0,7×4	0,7×4	0,7×4	0,7×4	
b	1,0×2	1,0×2	1,0×2	1,0×2	1,0×2	
c	1,25×2	1,25×2	1,0×2	0,75×2	0,75×2	
f	3,0	3,0	3,0	3,0	3,0	
Ширина пролета по технологическим требованиям (6)	48,1	48,1	34,8	29,9	27,3	
Унифицированные пролеты (7)	48,0	48,0	36,0	30,0	30,0	
(8) По высоте	(9) Размеры, м					
d_1	16,5	16,5	10,5	8,5	6,5	
ℓ	0,3	0,3	0,3	0,3	0,3	
h_6	0,2	0,2	0,2	0,2	0,2	
h_4	4,0	4,0	4,0	3,5	3,0	
h_5	1,1	1,25	0,5	0,4	0,45	
м	6,0	5,6	3,5	2,8	2,3	
н	0,3	0,3	0,3	0,2	0,2	
Высота до отметки подкранового рельса по технологическим требованиям (10)	22,1	22,25	15,5	12,9	10,45	
Унифицированные пролеты (7)	22,5	22,5	16,1	12,65	11,45	
Высота до низа несущих конструкций покрытия (11)	28,4	28,15	19,3	15,9	12,95	
Унифицированные пролеты (7)	28,8	28,8	19,8	16,2	14,4	

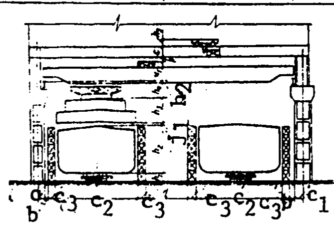


(12)
a — ширина платформы;
a' — ширина ноги портала;
b' — расстояние от платформы до ноги портала;
b — расстояние от ноги портала до колонны;
c — расстояние от оси до наружной кромки колонны;
f — ширина проезда;
d_1 — высота кантуемой секции;
ℓ — высота кантовочной площадки;
h_4 — расстояние от верхней кромки кантуемой секции до оси гака;
h_5 — расстояние от оси гака до отметки подкранового рельса «крайнее положение гака по высоте»;
h_6 — расстояние между нижней кромкой кантуемой секции и площадки;
м — высота фермы крана от отметки подкранового рельса;
н — зазор между фермой крана и покрытием.

Key: 1 -- Indices defining the bay dimensions; 2 -- Shipyard class; 3 -- Bay dimensions; 4 -- With respect to width; 5 -- Bay dimensions, meters; 6 -- Bay width by the process specifications; 7 -- Standardized bays; 8 -- With respect to height; 9 -- Dimensions, meters; 10 -- Height to the crane rail level by the process specifications; 11 -- Height to the bottom of the bearing structures of the ceiling; 12 -- a - platform width; a' - width of portal leg; b' - distance from the platform to the portal leg; b - distance from the portal leg column; c - distance from the axis to the outer edge of the column; f - width of passageway; d_1 - height of manipulated section; ℓ - height of manipulating area; h_4 - distance from the upper edge of the manipulated section to the hook axis; h_5 - distance from the hook axis to the crane rail level (extreme position of the hook with respect to height); h_6 - distance between the lower edge of the manipulated section and the platform; M - height of the crane girder from the crane rail level; H - clearance between the crane girder and the ceiling.

Width and Height of the Module-Building Shop Bays. Table 43

(1) Показатели, определяющие размеры пролетов	(2) Класс верфи: II		III		IV	
	(3) Количество линий в пролете: 1	2	1	2	1	2
(4) По ширине	(5) Размеры, м					
c_2	24,0	24,0×2	19,0	19,0×2	15,0	15,0×2
c_3	1,5×2	1,5×4	1,5×2	1,5×4	1,5×2	1,5×4
d	9,5	12,0	8,5	10,5	7,5	8,5
b	1,5	1,5×2	1,5	1,5×2	1,5	1,5×2
c	2,0	2,0	1,5	1,5	1,0	1,0
c_1	2,5	2,5	2,0	2,0	1,5	1,5
Ширина пролета по технологическим требованиям	42,5	73,5	35,5	61,0	29,5	50,0
Унифицированные пролеты	42,0	72,0	36,0	66,0	30,0	54,0
(8) По высоте	(5) Размеры, м					
h_2	15,0		12,0		9.5	
h_1	3,0		3,0		2,5	
j_1	1,0		1,0		1,0	
h_3	7,0		5,0		4,0	
h_4	4,5		3,5		2,5	
h_2	0,35		0,75		0,85	
k_1	5,1		3,5		2,9	
p	0.4		0,4		0,3	
c	3,1		2,95		—	
h_6	2,2		1,9		—	
Высота до отметки подкранового рельса по технологическим требованиям	30,85		23,0		20,35	
Унифицированные пролеты	30,5		24,9		20.3	
Высота до низа несущих конструкций покрытия	36,35		29,0		23,55	
Унифицированные пролеты	36,0		28,8		23,4	



(11)

c_2 — максимальная ширина корпуса судна;
c_3 — ширина башни лесов;
d — площадка хранения секций и расконсервации механизмов;
b — расстояние от наружной кромки колонны до башни лесов;
c — расстояние от оси до кромки колонны;
c_1 — расстояние от оси до кромки колонны с учетом размещения трансформаторных подстанций;
h_1 — высота судовозной тележки и выступающей части корпуса ниже основной линии;
h_2 — высота корпуса судна;
j_1 — зазор между верхней кромкой блока судна и блоком надстройки;
h_3 — высота блока надстройки или оборудования (агрегата);
h_4 — расстояние между верхней кромкой надстройки или оборудования и нижней кромкой фермы крана;
h_2 — расстояние от нижней кромки фермы крана до отметки подкранового рельса;
k_1 — расстояние от отметки подкранового рельса до верхней точки крана;
p — зазор между верхней точкой крана и кабиной крана второго яруса (нижней кромкой несущей конструкции покрытия);
c — расстояние от низа кабины крана до отметки подкранового рельса второго яруса;
h_6 — расстояние от отметки подкранового рельса до верхней точки крана второго яруса.

Key: 1 -- Indices defining the bay dimensions; 2 -- Class of shipyard; 3 -- No of lines of the bay; 4 -- with respect to width; 5 -- Dimensions, meters; 6 -- Bay width with respect to the process specifications; 7 -- Standardized bays; 8 - With respect to height; 9 -- Height to the crane rail level by the process specifications; 10 -- Height to the bottom of the bearing structures of the ceiling; 11 -- c_2 - the extreme beam of the ship's hull; c_3 - width of scafffolding tower; d - storage area for sections and demothballing the machinery; b - distance from the outer edge of the column to the scaffolding tower; c - distance from the axis to the edge of the column; c_1 - distance from the axis to the edge of the column considering the siting of the transformer substation; h_1 - height of ship cradle and part of the hull protruding below the base line; h_2 - hull height; j_1 - clearance between the upper edge of the ship module and the superstructure module; h_3 - height of the superstructure module or equipment (unitized unit); h_4 - distance between the upper edge of the superstructure equipment and the lower edge of the crane girder; h_2 - distance from the lower edge of the crane girder to the crane rail level; k_1 - distance from the crane rail line to the upper point of the [continued]

[Key to Table 43, contd]:

crane; p - clearance between the upper point of the crane and the second level crane cab (lower edge of the bearing structure of the ceiling); c - distance from the bottom of the crane cab to the second level crane rail mark; h_5 - distance from the crane level to the upper point of the second level crane.

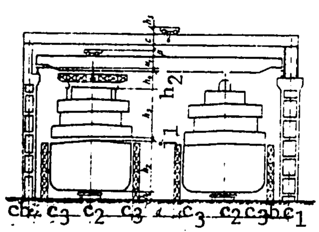
Table 44

Width and Height of the Bays of Shipbuilding Sheds -- Covered Slipways

(1) Показатели, определяющие размеры пролетов	(2) Класс верфи: II		III		IV		V	
(3) Количество линий в пролете	1	2	1	2	1	2	1	2
(4) По ширине	(5) Размеры, м							
c_2	24.0	24,0×2	19,0	19×2	15,0	15×2	10,0	10×2
c_3	1,5×2	1,5×4	1,5×2	1,5×4	1,5×2	1,5×4	1,5×2	1,5×4
d	9,5	12,0	8,5	10.5	7,5	8,5	6,0	7,0
b	1,5	1,5×2	1,5	1,5×2	1,5	1,5×2	1,5	1,5×2
c	2,0	2,0	1,5	1,5	1,0	1.0	1.0	1.0
c_1	2,5	2,5	2,0	2,0	1,5	1,5	1,5	1,5
(6) Ширина пролета по технологическим требованиям	42,5	73,5	35,5*	61,0	29,5	50,0	23,0	38,5
(7) Унифицированные пролеты	42,0	72,0	36.0	66,0	30.0	54.0	24,0	42,0
(8) По высоте	(5) Размеры, м							
h_2	15,0		12,0		9,5		8,5	
h_3	13,0		10,0		7,5		3,5	
h_1	3,0		3,0		2,5		2,0	
j_1	1,0		1,0		1,0		1,0	
h_4	5,0		4,5		4,0		3,5	
h_2	0,35		0,75		0,85		0,45	
k_1	5,1		3,6		3,0		2,6	
p	0,4		0,4		0,3		0,2	
c	3,1		2,95		—		—	
h_5	2,2		1,9		—		—	
(9) Высота до отметки подкранового рельса по технологическим требованиям	37,35		31,25		25,35		18,95	
(10) То же в унифицированных пролетах	37,7		32,0		25,5		18,8	
(11) Высота до низа несущих конструкций покрытия	42,85		35,25		28,65		21,75	
(10) То же, в унифицированных пролетах	43,2		36,0		28,8		21,8	

(12)

c_2 — максимальная ширина корпуса судна;
c_3 — ширина башни лесов;
d — площадка хранения секций и расконсервации механизмов;
b — расстояние от наружной кромки колонны до башни лесов;
c — расстояние от оси до кромки колонны;
c_1 — расстояние от оси до кромки колонны с учетом размещения трансформаторной подстанции;
h_1 — высота судовозной тележки и выступающей части корпуса ниже основной линии;
h_2 — высота корпуса судна;
h_3 — высота блока надстройки или оборудования (агрегата);
j_1 — зазор между корпусом судна и погружаемым блоком надстройки;
h_4 — расстояние между верхней кромкой надстройки или оборудования и нижней кромкой фермы крана;
h_2 — расстояние от нижней кромки фермы крана до отметки подкранового рельса;
k_1 — расстояние от отметки подкранового рельса до верхней точки крана;
p — зазор между верхней точкой крана и кабиной крана второго яруса (нижней кромкой несущей конструкции покрытия);



c — расстояние от низа кабины крана до отметки подкранового рельса второго яруса;
h_5 — расстояние от отметки подкранового рельса до верхней точки крана второго яруса.

Key: 1 -- Indices defining the bay dimensions; 2 -- Class of shipyard; 3 -- No of lines in the bay; 4 -- With respect to width; 5 -- Dimensions, meters; 6 -- Bay width with respect to process requirements; 7 -- Standardized bays; 8 -- With respect to height; 9 -- Height to the crane rail level by the process specifications; 10 -- The same, in standardized bays; 11 -- Height to the bottom of the bearing structures of the ceiling; 12 -- c_2 - extreme beam of the ship's hull; c_3 - scaffolding tower width; d - storage area for sections and demothballing of machinery; b - distance from the outer edge of the columns to the scaffolding tower; [continued]

[Key to Table 44, contd]:

c - distance from the axis to the edge of the column; c_1 - distance from the axis to the edge of the column considering the location of the transformer substation; h_1 - height of ship cradle and the part of the hull protruding below the base line; h_2 - hull height; h_3 - height of the superstructure module or equipment (unitized unit); j_1 - clearance between the hull and the submerged superstructure module; h_4 - distance between the upper edge of the superstructure or equipment and lower edge of the crane girder; h_2 - distance from the lower edge of the crane girder to the crane rail level; k_1 - distance from the crane rail level to the upper plate of the crane; p -- clearance between the upper point of the crane and the second level crane cab (lower edge of the bearing structure of the ceiling); c - distance from the bottom of the crane cab to the second level crane rail level; h_5 - distance from the crane rail level to the upper part of the second level crane.

Table 45

Dimensions of the Entrance Openings of the Main Shipyard Shops

Shop	Shipyard class				
	I	II	III	IV	V
	Dimensions of openings (width × height), m				
Hull platers shop	5.6×6.0	5.6×6.0	5.6×6.0	4.8×5.4	4.8×5.4
Assembly-welding	Entrances 5.6×6.0	5.6×6.0	5.6×6.0	4.8×5.4	4.8×5.4
	Exits Width: End openings -- the entire width of the bay; side openings -- the entire spacing of the columns Height: End -- to the crane track; side -- to the bottom of the crane beam				
Module construction	Entrances Width: End -- to the entire width of the bay; side -- to the entire column spacing Height: End -- to the crane track; side -- to the bottom of the crane beam Exits Width -- the entire width of the bay; Height -- to the cranr track				
Shipbuilding shed (covered slipway)	Entrances and exits Width -- to the entire width ot the bay; Height -- to the crane track				

[Table 45, contd]

Shop	Shipyard class				
	I	II	III	IV	V
	Dimensions of openings (width×height), m				
Pipe preparation	4.8×5.4	4.8×5.4	4.8×5.4	3.6×3.6	3.6×3.6

Note. In the module building shop and the shipbuilding shed in the presence of transverse cranes (second level cranes) or gantry cranes the height of the exit openings is taken to the tie-beam. The dimensions of the exits of the module building shop with transverse transfer of the modules is determined during the design process beginning with the dimensions of the modules and the structural components.

Table 46

Approximate Floor Specifications of the Main Shipyard Shops

Name of facilities	Floor requirement Floor requirements	Load on the floor, tons/m^2	
		Total	Concentrated
Hull platers (basic bays)	Must not be deformed when stacking individual parts, containers with parts or bundles of sheets and parts on the floor. The covering surface must be sufficiently elastic to avoid excess fatigue of the workers' legs. The floor coverings must tolerate wet cleaning (washing with water).	2.0	10.0
Assembly-welding shop (basic bays)	When stacking the bundles of parts, containers, subassemblies and sections on spaces, the floors must not be deformed. The material of the covering must be noncombustible, it must permit wet washing, it must be sufficiently elastic to avoid excess fatigue to the legs of the workers. The floors in the vicinity of the work places for the assembly of sections are designed and specially built in each individual case.	2.0	20.0
Pipe preparation shop (basic bays)	Must not deform from the levels of pipe and containers with pipe; must be sufficiently elastic to avoid excess fatigue to the legs of the workers, the covering must be noncombustible and provide for the possibility of wet washing.	1.5	10.0

[continued]

[Table 46, contd]

Name of facility	Floor requirements	Load on the floor, tons/m² Total	Concentrated
Module assembly shop and shipbuilding shed (basic bays)	The floors in the bays must not deform from the spacers placed on the floors for the sections, unitized units, machinery and containers with other equipment. The floor coverings must not be especially rigid in order to avoid excess fatigue to the legs of the workers; they must permit wet cleaning and not burn from sparks formed during electric welding and gas cutting. The building slips in the shipbuilding shed and the places for assembling modules are specially designed in each specific case.	2.0	20.0
Auxiliary sections of the module assembly shop and shipbuilding shed:			
Hull fitting section	Must not deform from parts put in stacks or piles or from the battery operated trucks carrying the parts. The floor covering must be sufficiently elastic, noncombustible and permit wet cleanup.	1.0	5.0
Mechanical installation section	The same	1.0	10.0
Pipe preparation section	The same	1.0	5.0
Woodworking section	The floors must be elastic, they must permit dry and wet cleaning and not have high heat transfer.	0.4	1.0
Paint-insulation section and paint stores of the shops	The floor covering must be resistant to paint solvents (gasoline, turpentine, white spirit, solvate, and so on), noncombustible and permit wet cleanup.	1.0	3.0
Material and tools stores	The floors of the stores must withstand loads from the racks, permit dry and wet dust removal; For normal operation of the stackers, the floors must have an admissible heat assimilation index.	2.0	5.0

[continued]

[Table 46, contd]

Name of facility	Floor requirements	Load on the floor, tons/m^2	
		Total	Concentrate
Stores and workshops for minor repairs of pneumatic tools	In the workshop the floor must be heat insulated and offer the possibility of dry and wet dust removal. In the pneumatic tool washing area the floor must be waterproof and withstand the effects of kerosene.	1.0	2.0
Makeup storage	The floor must withstand loading from the filled racks and also permit dry and wet cleanup.	2.0	5.0

CHAPTER XI. SHOP AREAS AND LAYOUTS

§34. Characteristics and Determination of the Size of the Shop Area

The area of production buildings is characterized by the builtup area and undeveloped area.

By the builtup area we mean the area defined on the basis of measuring the outside perimeter of a building at the level of its foundation or the protrusion of the edge of the foundation from the ground.

The developed area of the building is the total area of all floors, galleries, basements and mezzanines used for production needs.

With respect to purpose the shop areas are divided into production, auxiliary and administrative and general services.

The production area is the area of the sections of the divisions in which the technological process of manufacturing the given shop products is realized directly.

For example, this area includes the following areas occupied by:

Production equipment and work places for the operators of the equipment;

The building slips for building ships, the positions and lines for building modules, the manual labor work places and benches, stands, and so on;

Ground transport equipment (roller conveyors, conveyors, and so on);

The cabinets and shelves for the tools and attachments;

The makeup areas for the billets and finished parts and subassemblies of the equipment, stands, building slips, and so on; work places for operation and interoperation monitoring of the parts, subassemblies and products (in addition to the areas of the enclosed facilities of the technical control division);

Test stands for testing parts, subassemblies and finished products, places for eliminating defects and acceptance of the annual production;

Passages between equipment and work places inside the production sections and divisions (in addition to the main passages along which the movement of trucks, truck loaders, cleaning machines).

The auxiliary shop area includes the following:

The areas of the repair and equipment service sections, power systems and tools (the mechanical and power engineering workshops of the shop, the workshops for the repair of attachments, the repair and turning of tools, the facilities for the duty electricians, fitters, adjusters, and so on);

Facilities (enclosed) of the shop technical-control division (OTK);

Facilities of the shop power engineering and sanitary engineering units, areas of the main shop passages;

Facilities for tool, material, electrode, makeup and other stores.

The administrative and general services areas include the following:

The administrative area occupied by the administrative office services of the shop: the offices of the chief and his assistants, the facilities for the departments, the office and other services;

The general services area occupied by the facilities designed to service the sanitary-hygienic and the general social needs of the workers in the shop (dressing rooms, toilets, lavatories, showers, personal hygiene facilities, dining rooms, buffets, saturation equipment, smoking facilities for the workers to rest and for public organizations).

When developing the engineering design, the production and auxiliary areas are defined, setting aside a preliminary area for the power engineering facilities, electrical and ventilation units, about which a final decision is made after development of the special parts of the design.

Here the sum of the production (the areas of the sections and divisions directly intended for implementing the technological process in the shop) and auxiliary (the equipment repair and service sections, power systems and tools, main passages and different stores) areas is provisionally called the total shop area.

The area of the administrative and general services facilities is calculated in the architectural-structural design by the assignments published by the process engineers.

Let us present several methods of determining the amount of production area.

1. The most accurate method of determining the required production area is scaled planning of the location of the adopted equipment, work places and transport units in accordance with the technology and organization of production of the shop considering the required breaks between equipment and work places, the width of the passages and also the location of all the auxiliary services in accordance with the safety engineering rules and the process design norms.

2. It is possible to calculated the amount of production area by the specific norms for a unit of equipment or the work places by the formula

$$S_{prod} = S_{e.w} n_{equip},$$

where S_{prod} is the production area of the shop, m^2; $S_{e.w}$ is the production area for a unit of equipment or work places, m^2/equipment or work place; n_{equip} is the adopted amount of equipment or number of work places.

3. It is possible to determine the magnitude of the production area by the technical-economic indices -- the production output per year from 1 m^2 of area, the area for one production worker, and so on. Then the production area S_{prod} is found by the formula

$$S_{prod} = B_{sh}/\rho_{sh} \text{ and } S_{prod} = S_w n_{p.w},$$

where B_{sh} is the calculated annual shop program, tons; ρ_{sh} is the production output per year from 1 m^2 of production area of the shop, tons/m^2; S_w is the production area of the shop for one production worker, m^2/worker; $n_{p.w}$ is the number of production workers.

The auxiliary area of the shop (including the storage) is determined by planning or by the engineering design norms. As an example in Table 47 the norms are presented for calculating the areas of the shop stores for tools and accessories.

The total shop area can be calculated by the formula

$$S_{sh} = S_{e.w} n_{equip} (1+a_{spec}/100) = (B_{sh}/\rho_{sh})(1+a_{spec}/100) = S_w n_{p.w}(1+a_{spec}/100),$$

where S_{sh} is the total shop area, m^2; a_{spec} is the specific value of the auxiliary (including stores) area of the shop out of the production area, %.

In the technical-economic indices of the engineering design shop, as a rule, the production output per year per square meter of total shop area is presented. In this case the formula for the consolidated determination of shop area with respect to production output per year from 1 square meter of total area can be simplified

$$S_{shop} = B_{shop}/\rho_o,$$

where ρ_o is the production output per year from 1 square meter of total shop area, tons/m^2.

For the consolidated calculations, the total shop area can be defined beginning with the number of production workers of the shop and the area per production worker and also beginning with the labor consumption of the shop operations for the annual program and the annual labor consumption normative for 1 square meter of total shop area by the corresponding formulas

$$S_{shop} = S_o n_{w.sh} \text{ and } S_{sh} = A_{pr}/I_{s.a},$$

where S_o is the total area per production worker, m^2/worker; $n_{w.sh}$ is the number of production workers; A_{pr} is the labor consumption of the shop operations for the annual program, man-hours; $I_{s.a}$ is the total labor consumption for 1 square meter of total shop area, man-hours/m^2.

The total area of the basic assembly-installation shops can be determined in consolidated fashion also by the following formulas:

The module building shop $S_{sh}=\ell_{mod}b_{mod}n_{w.p}K_{s.mod}$ where ℓ_{mod} is the average length of a module, meters; b_{mod} is the maximum width of a module, meters; $n_{w.p}$ is the required number of work places (positions) for building the module; $K_{s.mod}$ is the general coefficient taking into account the servicing of the module building locations;

The shipbuilding shed $S_{sh}=L_c b_c n_{bs} K_{s.bs}$ where L_c is the length of the designed ship, meters; b_c is the beam of the designed ship, meters; n_{bs} is the number of required building slips; $K_{s.bs}$ is the general coefficient taking into account the servicing of the building slips.

The general coefficient taking into account the servicing of the locations can be approximately taken equal to the following:

2.4 for the module building locations at class II shipyards and 3.9 at class III and IV shipyards;

2.0 for the building slips at the class I shipyards, 2.4 at the class II shipyards and 3.7-3.9 at the class III, IV and V shipyards.

The approximate annual production output from 1 square meter of total area of the main shipyard shops, the total area for one production worker of the shop and the annual labor consumption of the operations per square meter of total shop area are presented in Tables 48-50, respectively.

Table 47

Norms for Calculating the Storage Area for Tools and Attachments

Кладовые (1)	Показатель для подсчета площади (2)	(3) Норма площади на один станок при работе в две смены, м²							
		(4) Тип производства							
		(5) Единичное и мелкосерийное				(6) Серийное			
		(7) Габариты установленных в цехе станков, мм							
		(8) до 1800×800	(8) до 4000×2000	до 8000×4000	до 16 000×6 000	до 1800×800	до 4000×2000	до 8000×4000	до 16 000×6 000
Инструментальная раздаточная (9)	Количество производственных металлорежущих станков (10)	0,7	1,0	1,4	1,8	0,4	0,6	0,8	1,0
Приспособлений (11)	То же (12)	0,6	0,8	1,2	1,6	0,35	0,5	0,7	0,9
Кладовые (1)	(13) Норма площади на одного производственного рабочего сборочно-монтажных цехов, м²								
	Показатель для подсчета площади (2)	(4) Тип производства							
		(5) Единичное и мелкосерийное				(6) Серийное			
		(14) Масса собираемых изделий, т							
		(8) до 0,2	(8) до 2,0	до 15,0	до 50,0	до 0,2	до 2,0	до 15,0	до 50,0
Инструментов и приспособлений (15)	Количество производственных рабочих (16)	0,5	0,6	0,8	1,0	0,35	0,4	0,5	0,6

Key:
1. Storage area
2. Index for calculating the area
3. Area norm per machine tool for two-shift operation, m^2
4. Type of production
5. Unit and small-series
6. Series
7. Overall dimensions of the machine tools installed in the shop, mm
8. to ...
9. Tool distribution
10. No of production metal-cutting machines
11. Accessories
12. The same
13. Area norm per production worker of the assembly and installation shops, m^2
14. Weight of assembled products, tons
15. Tools and accessories
16. Number of production workers

Table 48

Approximate Annual Production Output from 1 Square Meter of Total Area of the Main Shipyard Shop

	Цехи и участки (1)	Класс верфи (2)									
		I		II		III		IV		V	
		(3) Годовой выпуск продукции, т	(4) Годовой выпуск продукции с 1 м² общей площади, т/м²	(3) Годовой выпуск продукции, т	(4) Годовой выпуск продукции с 1 м² общей площади, т/м²	(3) Годовой выпуск продукции, т	(4) Годовой выпуск продукции с 1 м² общей площади, т/м²	(3) Годовой выпуск продукции, т	(4) Годовой выпуск продукции с 1 м² общей площади, т/м²	(3) Годовой выпуск продукции, т	(4) Годовой выпуск продукции с 1 м² общей площади, т/м²
(5)	Участок предварительной правки, очистки и грунтовки стали	115 000	39,0	92 000	32,0	46 000	20,0	23 000	10,0	5800	5,0
(6)	Корпусообрабатывающие участки	100 000	9,5	80 000	8,2	40 000	6,6	20 000	4,7	5000	3,2
(7)	Сборочно-сварочный цех	100 000	4,0	80 000	3,1	40 000	2,4	20 000	2,0	5000	1,5
(8)	Участок окраски и сушки секций	100 000	26,0	80 000	20,0	40 000	14,0	20 000	11,0	5000	6,0
(9)	Цех конструкций из алюминиево-магниевых сплавов	4 200	0,45	4 100	0,35	1 750	0,25	—	—	—	—
(10)	Цех конструкций из синтетических материалов	2 800	1,20	3 100	1,0	3 600	0,9	—	—	—	—
(11)	Участок изготовления агрегатов и зональных блоков	14 000	2,0	13 700	1,65	11 200	1,45	5 200	1,3	1100	0,95
(12)	Цех постройки блоков	—	—	116 000	4,3	75 000	4,0	34 000	2,9	—	—
(13)	Судостроительный цех	135 000	2,4	130 000	4,4	82 000	4,0	38 000	3,0	8500	1,5
(14)	Электромонтажный цех	1 550	0,8	1 500	0,8	2 300	0,9	—	—	—	—
(15)	Достроечно-сдаточный цех	140 000	50	136 000	48	88 000	35	—	—	—	—
(16)	Слесарно-корпусный цех	4 500	1,0	3 400	0,75	2 600	0,6	700	0,55	520	0,5
(17)	Трубозаготовительный цех (трубозаготовительные участки)	4 800	1,1	3 700	0,75	3 200	0,65	1 100	0,60	320	0,50
(18)	Деревообрабатывающий цех	3 100	0,95	4 200	0,8	3 900	0,6	2 400	0,55	950	0,5
(19)	Цех гальванических покрытий	8 000	2,8	8 300	2,7	9 500	2,8	—	—	—	—
(20)	Малярно-заготовительный цех	1 400	2,3	1 500	2,5	1 200	2,0	—	—	—	—

Key: 1 -- Shops and sections; 2 -- Class of shipyard; 3 -- Annual production output, tons; 4 -- Annual production output from 1 m^2 of total area, tons/m^2; 5 -- Section for preliminary straightening, cleaning and priming of steel; 6 -- Hull platers section; 7 -- Assembly-welding shop; 8 -- Section for painting and drying the sections; 9 -- Shop for making structural components from aluminum-magnesium alloys; 10 -- Shop for making structural components from synthetic materials; 11 -- Section for making unitized units and zonal modules; 12 -- Shop for module construction of the shipbuilding shed; 13 -- Shipbuilding shed; 14 -- Electric wiring shop; 15 -- Outfitting-acceptance shop; 16 -- Hull fitting shop; 17 -- Pipe preparation shop (pipe preparation sections); 18 -- Woodworking shop; 19 -- Galvanizing shop; 20 -- Paint preparation shop.

Note. The annual production output and the output from 1 m^2 of total shop area are presented from the condition with respect to the electric wiring shop of installation of equipment on the ship weighing up to 15 kg and cables of all types, and with respect to the outfitting-acceptance shop, the weight of the ships outfitted and undergoing trials afloat.

Table 49

Approximate Total Area for One Production Worker of the Shop

Цехи и участки (1)	(2) Класс верфи I (3) Общее количество производственных рабочих цеха	I (4) Общая площадь на одного производственного рабочего цеха, м²/производственный рабочий	II (3)	II (4)	III (3)	III (4)	IV (3)	IV (4)	V (3)	V (4)
Участок предварительной правки, очистки и грунтовки стали (5)	19	160	17	170	13	180	11	220	5	240
Корпусообрабатывающие участки (6)	200	53	210	50	120	49	95	45	35	44
Сборочно-сварочный цех (7)	480	53	600	46	380	45	230	44	100	33
Участок окраски и сушки секций (8)	65	58	65	58	48	58	34	54	12	46
Цех конструкций из алюминиево-магниевых сплавов (9)	120	82	160	72	90	90	—	—	—	—
Цех конструкций из синтетических материалов (10)	85	28	125	25	150	23	—	—	—	—
Участок изготовления агрегатов и зональных блоков (11)	330	22	390	22	360	22	200	22	55	21
Цех постройки блоков (12)	—	—	1100	25	950	20	500	24	—	—
Судостроительный цех (13)	1650	34	1100	28	850	25	470	28	340	18
Электромонтажный цех (14)	190	10	220	8	370	7	—	—	—	—
Достроечно-сдаточный цех (15)	400	7,2	500	5,8	280	9	—	—	—	—
Слесарно-корпусный цех (16)	260	17	280	16	260	17	75	17,5	55	18
Трубозаготовительный цех (трубозаготовительные участки) (17)	240	18	270	18	270	18	100	19	30	21
Деревообрабатывающий цех (18)	90	36	160	32	200	31	130	33	55	34
Цех гальванических покрытий (19)	21	135	24	125	33	100	—	—	—	—
Малярно-заготовительный цех (20)	23	27	24	25	21	29	—	—	—	—

Key: 1 -- Shops and sections; 2 --Class of shipyard; 3 -- Total number of production workers of the shop; 4 -- Total area per production worker of the shop, m²/production worker; 5-20 [see note for Table 48].

Note. In the section for making unitized units and zonal modules, in the module-building shop, the shipbuilding shed and the outfitting-acceptance shop the production workers are considered with respect to their own shipyard operations without the production workers of outside enterprises.

Table 50. Approximate Annual Labor Consumption of Operations per Square Meter of Total Shop Area

Цехи и участки (1)	(2) Класс верфи									
	I		II		III		IV		V	
	(3) Трудоемкость работ цеха на годовую программу, чел.-ч	(4) Годовая трудоемкость на 1 м² общей площади цеха, чел.-ч/м²	(3) Трудоемкость работ цеха на годовую программу, чел.-ч	(4) Годовая трудоемкость на 1 м² общей площади цеха, чел.-ч/м²	(3) Трудоемкость работ цеха на годовую программу, чел.-ч	(4) Годовая трудоемкость на 1 м² общей площади цеха, чел.-ч/м²	(3) Трудоемкость работ цеха на годовую программу, чел.-ч	(4) Годовая трудоемкость на 1 м² общей площади цеха, чел.-ч/м²	(3) Трудоемкость работ цеха на годовую программу, чел.-ч	(4) Годовая трудоемкость на 1 м² общей площади цеха, чел.-ч/м²
Участок предварительной правки, очистки и грунтовки стали (5)	33 000	11	30 000	10,5	23 000	10	18 400	8	8 700	7,5
Корпусообрабатывающие участки (6)	350 000	34	370 000	36	220 000	37	172 000	40	63 000	41
Сборочно-сварочный цех (7)	850 000	34	1 100 000	39	670 000	40	410 000	41	180 000	54
Участок окраски и сушки секций (8)	100 000	26	100 000	26	72 000	26	52 000	28	17 500	33
Цех конструкций из алюминиево-магниевых сплавов (9)	210 000	22	290 000	25	158 000	20	—	—	—	—
Цех конструкций из синтетических материалов (10)	134 000	58	200 000	65	250 000	72	—	—	—	—
Участок изготовления агрегатов и зональных блоков (11)	590 000	84	700 000	84	650 000	84	350 000	84	100 000	85
Цех постройки блоков (12)	—	—	2 000 000	73	1 700 000	92	880 000	75	—	—
Судостроительный цех (13)	3 000 000	53	1 950 000	66	1 560 000	72	840 000	66	600 000	100
Электромонтажный цех (14)	340 000	175	400 000	220	670 000	260	—	—	—	—
Достроечно-сдаточный цех (15)	700 000	250	900 000	310	510 000	200	—	—	—	—
Слесарно-корпусный цех (16)	470 000	106	500 000	110	470 000	106	130 000	103	100 000	100
Трубозаготовительный цех (трубозаготовительные участки) (17)	430 000	100	480 000	100	480 000	100	175 000	95	55 000	85
Деревообрабатывающий цех (18)	160 000	50	3 000 000	56	370 000	57	240 000	55	100 000	53
Цех гальванических покрытий (19)	32 000	11	37 000	12	50 000	15	—	—	—	—
Малярно-заготовительный цех (20)	34 000	55	37 000	62	31 000	52	—	—	—	—

Key: 1 -- Shops and sections; 2 -- Class of shipyard; 3 -- Labor consumption of shop operations for the annual program, man-hours; 4 -- Annual labor consumption per square meter of total shop area, man-hours/m^2; 5-20 [see Table 48];

Note. With respect to the section for making unitized units and zonal modules, the module-building shop, the shipbuilding shed and outfitting-acceptance shop the labor consumption is presented with respect to their own shipyard operations without the labor consumption of the operations of outside enterprises.

§35. Basic Principles of the Development of Shop Layouts. Layouts of the Main Shipyard Shops

When designing shops, it is necessary to consider the following basic principles:

The location of equipment, work places and mechanization means with respect to the adopted technological process;

Replacement of the production sections of the shop and auxiliary services considering the advanced forms of production organization;

Insurance of the largest production output from 1 m^2 of shop area when observing conditions for revival and safe work of the production personnel;

Uninterrupted delivery of materials, parts and subassemblies to the work places, linearity of the material flows and the shortest paths of moving the material, billets and products during the production process using mechanized transport means;

Parts and products output for various ships analogous to those adopted in the design program and corresponding to the class of shipyards;

Provision for interoperation storage of materials, parts and subassemblies, intershop and intraplant transportation, access of transport means to the equipment on the equipment loading and work place front side and also access to the points for connection of portable equipment and fans, methods of picking up and transferring parts and products to subsequent operations or out of the shop;

Efficient distribution of the technical personnel with maximum closeness of them to the production sections which they serve;

Provision for operation, maintenance and repair of equipment, monitoring, planning and dispatching of production by hardware components.

The most efficient will be the version of the shop layout which provides for minimum cost of production output and which corresponds to the requirements of continuous improvement of the productivity of labor of the workers.

The architectural construction plan is taken as the plan for locating the equipment and work places. The dividing axes of the building on the plan preserve the marking used in the construction drawings and layout.

The following data are presented on the shop layout:

The outside and inside walls, columns, partitions, door and window openings, doors, basements, tunnels, basic ducts, traps for removal of water to sewage, manholes, hatches, mezzanines, galleries, and so on;

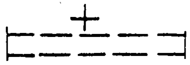
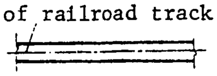
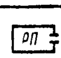
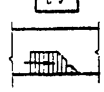
The process equipment and the outlines of the basic foundations for it, the flow and flow-positional lines, the places (positions) for building modules and the ships as a whole, the basic production organizational equipment, the storage areas, main, intershop and intrashop passages, and also the points for connection of portable electric tools, automatic welders, semiautomatic welders, portable electric users, 60-volt dc welding arcs, low-voltage electric lighting, production and fire water lines, compressed air, acetylene, oxygen, carbon dioxide, argon, and so on;

Various cranes with indication of their lifting capacity, conveyors, roller conveyors, monorails, carriages, elevators, rail tracks and other means of mechanizing the materials handling operations;

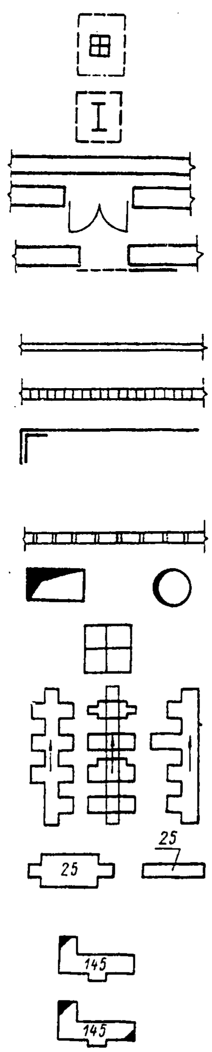
The location of the auxiliary facilities and workshops, warehouses and stores, transformer and generator substations, ventilation chambers and also office facilities and bathrooms and laundries located in the shop area.

Table 51

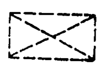
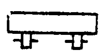
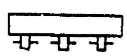
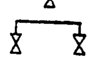
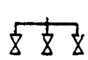
Provisional Notation Used on the Engineering Plans of Shipyard Shops

Provisional notation	Interpretation
	A. Layout
	Main wall
	Light partitions of all types
	Unenclosed shop (division, section) boundary
	Building column
	Passage
	Tunnel, duct Light shading Electrical engineering - light blue Waterlines and sewage -- blue Heating and ventilation -- red Thermomechanical -- green
Axis of railroad track 	Railroad track
	Central distribution station
	Transformer substation
	Bathroom and laundry
	Stairs in plan view

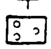
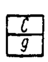
[Table 51, contd]

Provisional notation	Interpretation
	B. Equipment Layouts
	1. Structural Elements
	Column with foundation, reinforced concrete
	The same, metal
	Main wall
	Gates, door in an opening, double
	The same, sliding
	Solid partition
	The same, glass
	The same, metal (sheet metal)
	Barrier
	Hatch
	Floor drain
	2. Production Equipment
	Automatic line
	Production equipment (machine tools, and so on) with number according to the layout
	Production equipment existing in the shop (with number according to layout), relocatable
	The same, nonrelocatable

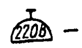
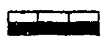
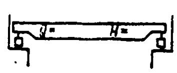
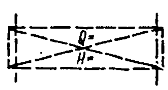
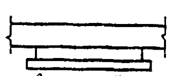
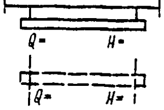
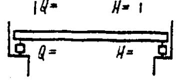
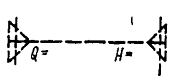
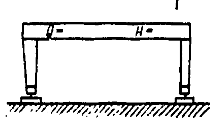
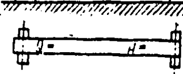
[Table 51, contd]

Provisional notation	Interpretation
	Work place
	Multiple machine tool servicing by one worker
	Plates and slabs (bench, control, bending, and so on)
	Reserved by equipment location
	Storage area for billets or parts
	Work bench for one place
	The same for two work places
	The same for three work places
	3. Feeds for industrial fluids, gas and electric current, ventilation and evacuation
	Cold water feed (general and production)
	Water feed (fire extinguishing)
	Sprinkler head
	Steam feed
	Compressed air feed for one connection
	The same, for two connections
	The same for three connections
	Emulsion feed
	Gasoline feed
	Soda solution feed
	Fuel oil feed

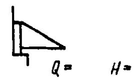
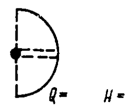
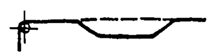
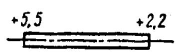
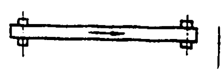
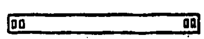
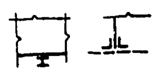
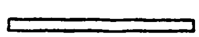
[Table 51, contd]

Provisional notation	Interpretation
	Oil (sulfafresol) feed
	Acetylene feed
	Gas fuel feed
	Argon feed
	Oxygen feed
	Nitrogen feed
	Propane feed
	Butane feed
	The same, carbon dioxide
	Cold water feed to a sink on the wall or partition
	Cold and hot water feed to a sink
	Local ventilation exhaust
	Drain for draining spent coolant into sewage
	Saturator
	Drinking water fountain
	Local lighting (two-pin socket)
	Connection point (the number of connections is indicated in the denominator)
	A -- automatic welding; ПА -- semiautomatic welding; Пр -- other equipment; Ш -- boring trials
	60-volt welding arc connection (the number of arcs is indicated in the denominator)

[Table 51, Contd]

Provisional notation	Interpretation
 Key: 220 volts	Two-pin socket with third ground contact (for connecting instruments, tools, and so on), dc
 Key: 220 volts	The same, ac
	Special current feed (laboratory panel)
	Three-pin socket with four ground contact (for connecting instruments, equipment, tools, and so on)
	Panel for connecting repair lighting (portable electric light)
	c. Material-handling Equipment (Compositional Layouts and Equipment Siting Plans)
	Bridge crane in section
	The same, in plan
	Suspended overhead single-gib crane in section
	The same, in plan
	Single-gib bridge (supported) crane in section
	The same, in plan
	Gantry crane in section
	The same, in plan

[Table 51, contd]

Provisional notation	Interpretation
	Bracket-swing crane in section
	The same in plan
	Overhead chain conveyor with adjacent monorail
	Ascent and descent of overhead chain conveyor
	Belt conveyor
	Roller conveyor
	Monorail, monorail with hoist in section
	The same in plan
	Chute, slide
	Elevator

The names of the shops, sections and divisions, auxiliary facilities are given on a layout, and the basic dimensions of the building as a whole (length, width of the building, bay width, column spacing) are also indicated.

The equipment is depicted on the layout by a simplified provisional outline with maximum overall dimensions considering the extreme positions of the moving parts of a machine tool.

The provisional notation used for the design developments of shop layouts are presented in Table 51.

The specifications for the production equipment, the tool attachments and accessories and the production office accessories for planning the shop, as a rule, are combined with the list for the indicated equipment, tool attachments, accessories and office accessories and the order specifications for the designated production equipment and equipment requiring a long manufacturing cycle, drawn up by the forms (Tables 52, 53) and presented together with the plan or layout diagram of the shop.

Table 52

(a) Наименование проектной организации ____________________

(b) Наименование предприятия ____________________

(c) Наименование объекта ____________________

(d) **Ведомость на технологическое оборудование, технологическую оснастку и приспособления и производственную оргоснастку**

№ пп. (e)	Шифр по общесоюзной классификации (f)	Наименование и техническая характеристика основного и комплектующего оборудования (g)	Мощность, кВт (h)	Тип, модель, нормаль, ГОСТ, № чертежа (i)	№ чертежа и № позиции по плану (j)	Единица измерения (k)	Потребное количество (l)		Масса, кг (o)		Стоимость оборудования (r)		Заводизготовитель (u)	Примечание (v)
							новых (m)	используемых (n)	единицы (p)	общая (q)	единицы (s)	общая (t)		
		1. Оборудование, серийно выпускаемое промышленностью 1.1 1.2 и т. д. 2. Нестандартизированное оборудование 3. Нестандартное оборудование 4. Технологическая оснастка и приспособления 5. Производственная оснастка												

(w) *Главный инженер проекта*
(x) *Начальник отдела*
(y) *Руководитель группы*
(z) *Составил*

Key: a -- Name of design organization; b -- Name of enterprise; c -- Name of project; d -- Production equipment, machine tool attachments and accessories and production office accessories; e -- Item number; f -- Code with respect to all-union classification; g -- Nomenclature and technical data of the main and accessory equipment; h -- Power, kilowatts; i -- Type, model, standard, All-Union State Standard, drawing number; j -- Drawing number and position No according to the layout; k -- Unit of measure; l -- Required number; m -- new; n -- used; o -- Weight, kg; p -- unit; q -- total; r -- Equipment cost; s -- unit; t -- total; u -- Manufacturer; v -- Remarks.
1. Equipment, industrially series-produced; 1.2. and so on; 2. Nonstandardized equipment; 3. Nonstandard equipment; 4. Tool attachments and accessories; 5. Production accessories
w -- Chief project engineer; x -- Department head; y -- Group leader; z -- Drawn up.

The shop plans are basically on a 1:200 scale. It is permissible also to use other scales, for example, the plans for small shops or shops heavily saturated with equipment are drawn up on a 1:100 scale, and the plans for large module building shops and shipbuilding sheds (covered-in berths) on scales of 1:400 and 1:500.

Example plans or layouts of the main shipyard shops are presented in Figures 33-53, and fragments of the detail drawings of the plans for the hull platers and assembly-welding shops, in Figures 54 and 55.

In the indicated example diagrams one of the possible versions of laying out the shipyard shops is presented. There are other layouts dictated, for example, by the peculiarities of the production process, the shipyard site conditions, and so on.

Table 53

УТВЕРЖДАЮ (a)

(руководитель организации)

«__» __________ 19__ г. (b)

(c) Коды	
форма № (d)	0801017

(e) Генеральная проектная организация
(f) Проектная организация-разработчик
(g) Комплектующая организация
(h) Отрасль народного хозяйства
(i) Министерство (ведомство) — заказчик
(j) Главное управление Министерства (Объединение)

(k) Предприятие
(l) Объект (производственная мощность)
(m) ГУМТС (УМТС)
(n) Часть (раздел) проекта
(o) Срок ввода объекта в эксплуатацию

(c) Коды	
форма № (d)	0801017

(p) Заказная спецификация № ____ от « » __________ 19__ г.
на технологическое именниковое оборудование и оборудование, требующее длительного цикла изготовления

(q) Всего листов
(r) Лист №

№ пп.	№ позиции по технологической схеме. Место установки	Наименование и технологическая характеристика основного и комплектующего оборудования	Тип и марка оборудования, каталог, № чертежа, № опросного листа. Материал оборудования	Завод-изготовитель (для импортного оборудования — страна, фирма)	Единица измерения (s)		Код оборудования, материала	Потребность по проекту	Цена единицы, тыс. руб.	Потребность на пусковой комплекс	Ожидаемое наличие на начало планируемого года, в том числе на складе	Заявленная потребность на планируемый год	Принятая потребность на 19 г. (t)					
					наименование	код							Всего	(u) В том числе по кварталам				Стоимость всего оборудования, тыс. руб.
														I	II	III	IV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

(v) Указание: графы 1—9 и 11 заполняют проектанты, графы 12—13 — заказчики проекта, графы 14—19 и коды (форма № 0801017) — комплектующая организация.

(w) *Главный инженер проекта*
Начальник отдела
Руководитель группы
Составил

[Key on following page]

[Key to Table 53]:
a. Approved (organization director)
b. year
c. Codes
d. Form No
e. General design organization
f. Design organization-developer
g. Coordinating organization
h. Branch of the national economy
i. Ministry (department) - plant
j. Main Administration of the Ministry (association)
k. Enterprise
l. Project (production capacity)
m. GUMTS (UMTS)
n. Part (section) of the design
o. Time of putting into operation
p. Order specification No___ from " " ______ 19__ year for designated production equipment and equipment requiring a long manufacturing cycle
q. Total sheets
r. Sheet No

1. Item No
2. Position No with respect to flow diagram. Installation point
3. Name and technical specifications of the main and accessory equipment
4. Type and trademark of the equipment, catalog, drawing No, questionnaire No. Equipment material
5. Manufacturer (for imported equipment -- country, company)
s. Unit of measure
6. Name
7. Code
8. Equipment code, material
9. Requirement according to the design
10. Unit price, thousands of rubles
11. Requirement for a complex about to start up
12. Expected presence at the beginning of the planned year, including in storage
13. Claimed demand for the planned year
t. Adopted requirements for 19 __
14. Total
u. Including by quarters
19. Cost of all equipment, thousands of rubles
v.
Instructions: Columns 1-9 and 11 are filled out by the persons submitting the project, columns 12-13, by the project clients, columns 14-19 and codes (Form No 0801017), by the coordinating organization
w. Chief project engineer
Department head
Group leader
Drawn up

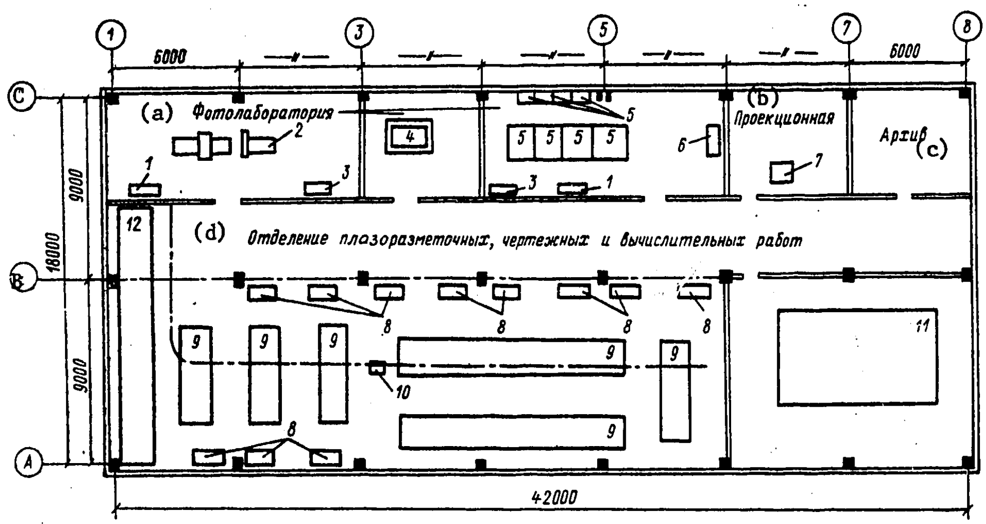


Figure 33. Layout of the mold loft operations department. Department of mold loft layout operations, drawing and calculating operation; photo laboratory
1 -- Clerical desk; 2 -- photographic setup; 3 -- locker; 4 -- photocopier with vacuum suction devices; 5 -- developer bath; 6 -- drying cabinet; 7 -- projector for template workshop; 8 -- drawing table; 9 -- scale adjustment table; 10 -- electric telpher; 11 -- drawing machine; 12 -- rack for panels

Key:
- a. Photo laboratory
- b. Projection room
- c. Archive
- d. Division of mold loft layout, drawing and computational operations

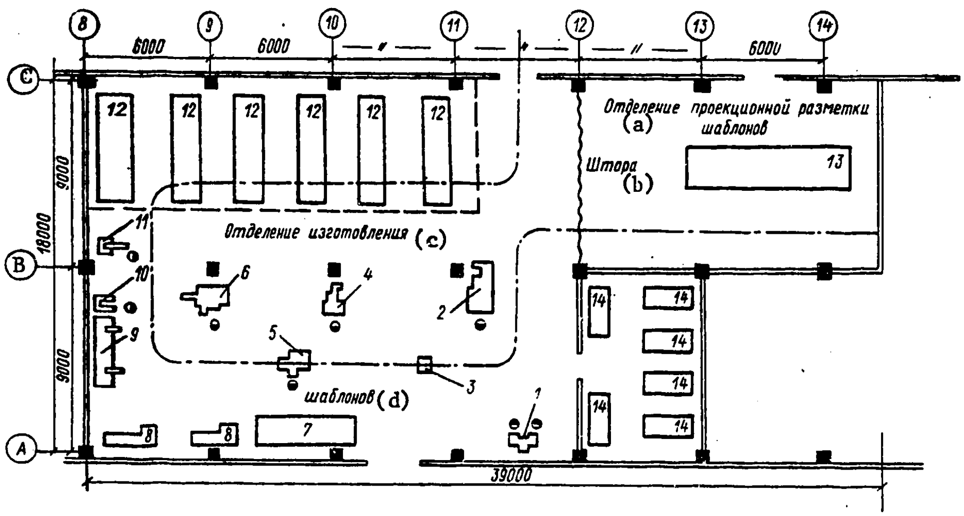


Figure 34. Plan of the mold loft operations department. Template workshop and warehouse
1 -- Grinder; 2 -- band saw; 3 -- electric telpher; 4 -- milling machine; 5 -- circular saw; 6 -- jointing machine; 7 -- board rack; 8 -- carpenter's bench; 9 -- fitter's bench; 10 -- bench drill; 11 -- manual lever shears; 12 -- rack for large template; 13 -- laying-out table; 14 -- rack for small templates.
For laying out the templates it is possible to use drawing machines with program control.

Key:

a. Projection template layout division
b. Blind
c. Manufacturing division
d. Templates

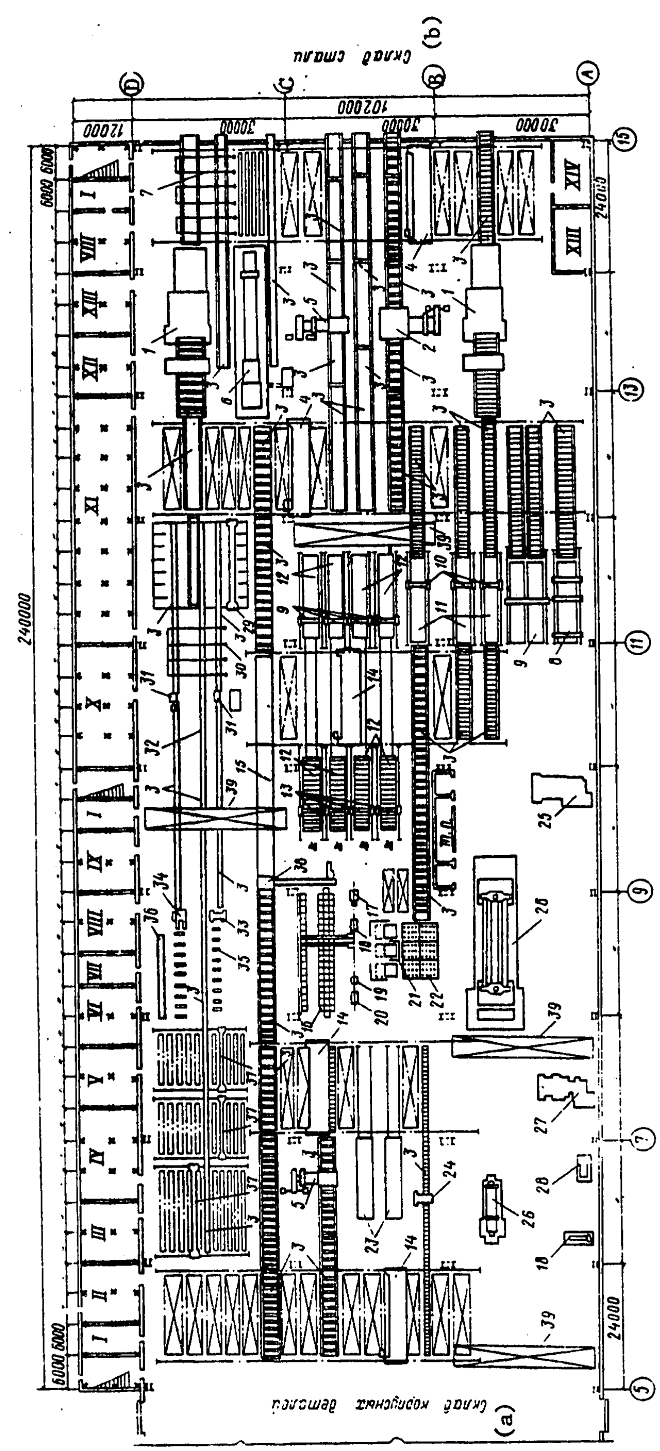


Figure 35. Layout of the hull platers shop with section for preliminary straightening, cleaning and priming of the steel at class I and II warehouses

[See legend on following page]

[Legend to Figure 35]:

I -- Public bathroom and laundry; II -- transformer substation; III -- foremen's room; IV -- medical aid station; V -- materials stores; VI -- tool stores; VII -- die stores; VIII -- transformer substation; IX -- boiler room; X -- repair section of the shop; XI -- template workshop and warehouse; XII -- shot stores; XIII -- ventilation chamber; XIV -- primer stores. 1 -- unit for shot blasting and priming of sheet and shaped steel; 2 -- sheet straightening machine; 3 -- roller conveyor; 4 -- sheet and shaped steel loader; 5 -- sheet straightening machine; 6 -- straightening and stretching machine; 7 -- transfer for entrance profile; 8 -- three-portal machine for oxygen cutting of rectangular sheets and strips; 9 -- gas-cutting machine with program control; 10 -- measuring and marking machine with program control; 11 -- marking bench; 12 -- two-position gas-cutting unit; 13 -- machine for gas-electric cutting with program control; 14 -- sheet parts loader and sorter; 15 -- belt conveyor for sheet parts; 16 -- makeup section for small sheet parts; 17 -- friction press, Q=100 tons; 18 -- radial drilling machine; 19 -- bench for manual gas cutting; 20 -- hydraulic press, Q=250 tons; 21 -- guillotine shears; 22 -- platform with roller bearings; 23 -- gas cutting bench for finish cutting; 24 -- press for straightening strips; 25 -- hydraulic press, Q=1250 tons; 26 -- roll bending machine; 27 -- hydraulic press, Q=800 tons; 28 -- edging press, Q=200 tons; 29 -- stacker-loader; 30 -- transfer for intricately shaped rolled products; 31 -- press for cutting intricately shaped rolled products with program control and marking unit; 32 -- manual gas cutting area; 33 -- press for bending shaped products; 34 -- profile bending machine with program control; 35 -- bearing rollers; 36 -- bench for finish cutting of intricately shaped parts; 37 -- device for multitier makeup of shaped parts; 38 -- device for sorting small shaped parts; 39 -- electric traveling bridge crane, Q=30 tons. H=11.15 meters.

Key:

a. Hull parts storage area
b. Steel storage

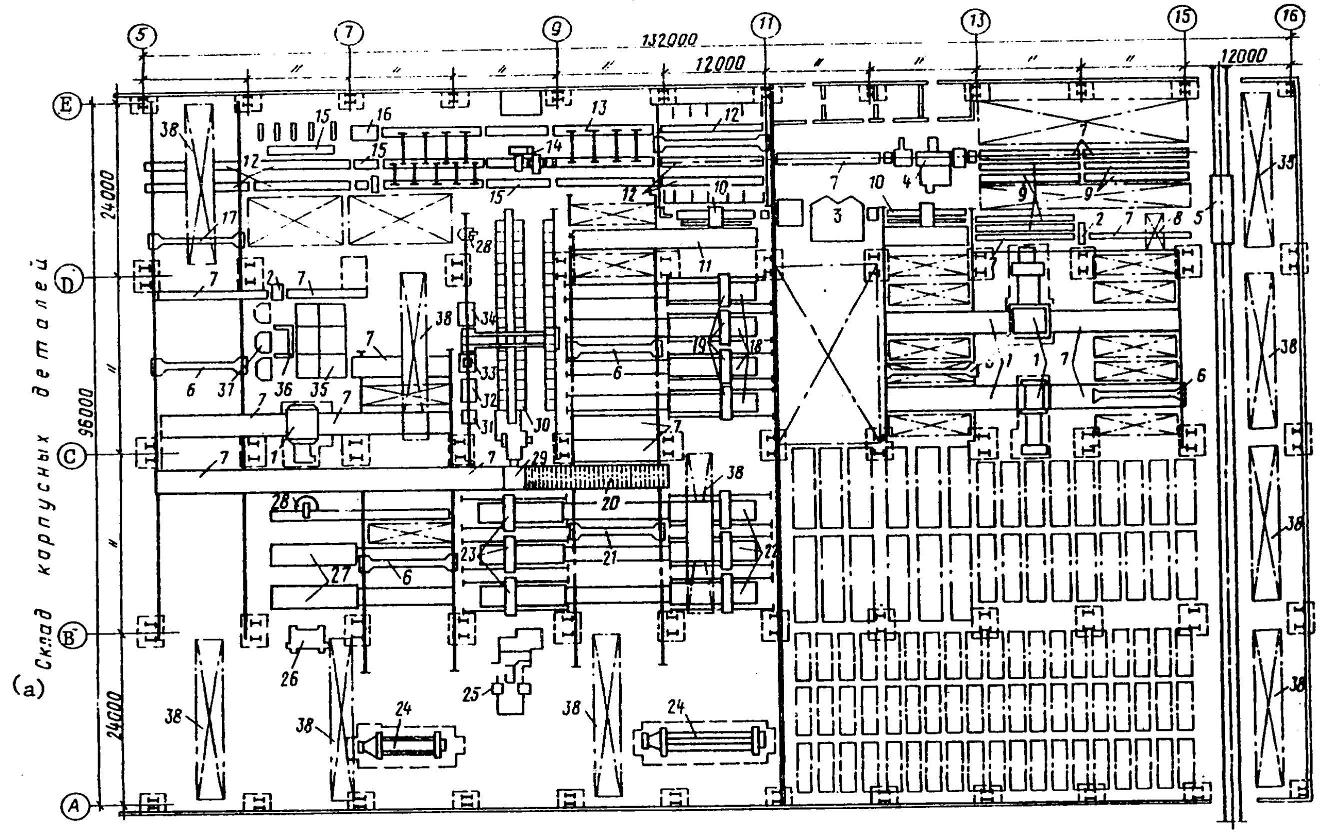


Figure 36. Layout of hull platers shop with steel warehouse, section for straightening, planing and priming steel at class III shipyards.

[Legend on following page]

[Legend to Figure 36]:

1 -- Sheet straightening machine; 2 -- press for straightening and bending section; 3 -- setup for shot blasting and priming sheet steel; 4 -- setup for shot blasting and priming shaped steel; 5 -- railroad platform; 6 -- sheet steel loader; 7 -- roller conveyor; 8 -- bicycle loaders; 9 -- container; 10 -- manipulator; 11 -- receiving table; 12 -- belt conveyor for shaped parts; 13 -- shaped steel feeder; 14 -- press with automatic marker; 15 -- bench for manual gas cutting of shaped steel; 16 -- machine tool for bending parts made of shaped rolled products with program control; 17 -- device for multitier makeup of shaped parts; 18 -- marking bench; 19 -- measuring and marking machine with program control; 20 -- belt conveyor; 21 -- sheet parts loader; 22 -- gas-cutting machine with program control; 23 -- machine for gas-electric cutting with program control; 24 -- roll bending machine; 25 -- hydraulic press, Q=800 tons; 26 -- edging machine; 27 -- two-position gas-cutting unit; 28 -- radial drill; 29 -- device for flanging small sheet parts; 30 -- small sheet parts makeup unit; 31 -- machine tool for finishing the edges for welding sheet steel parts; 32 -- combination press-shears; 33 -- hydraulic press, Q=160 tons; 34 -- edging machine; 35 -- plate with roller bearing; 36 -- guillotine shears; 37 -- mechanized unit for guillotine cutting of steel; 38 -- electric bridge crane, Q=10 tons, H=8.15 meters.

Key:

a. Hull parts warehouse

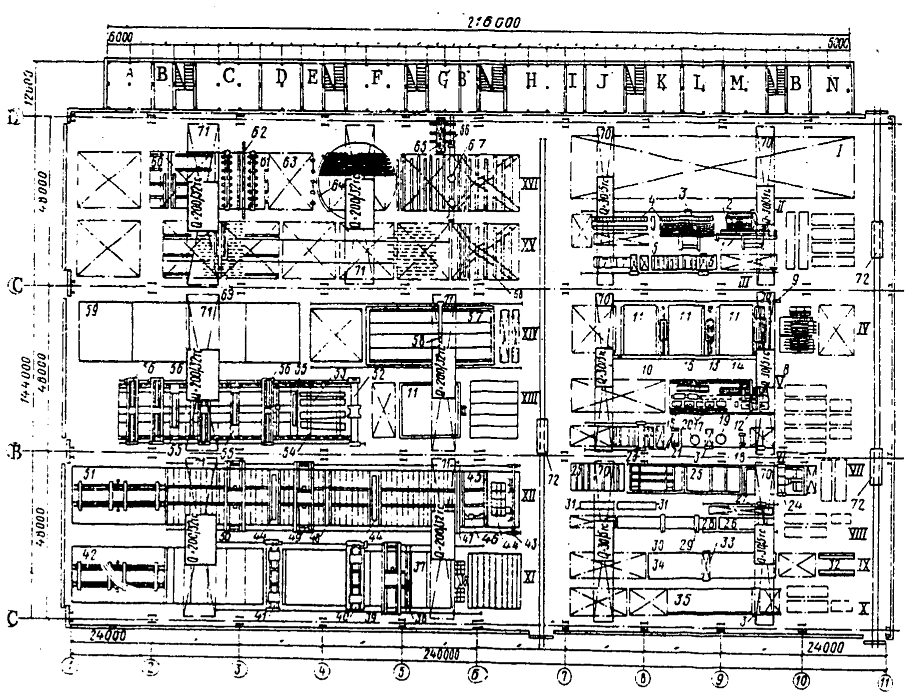


Figure 37. Layout of the assembly-welding shop at a class I shipyard [Legend on following page]

[Legend to Figure 37]:

A -- Accessory storage; B -- bathroom and laundry; C -- medical aid station; D -- foremen's room; E -- administrative stores; F -- repair division; G -- central heating; H -- stores for section fittings; I -- drying and sintering of electrodes; J -- welding material storage; K -- materials storage; L -- tool storage; M -- distribution station; N -- isotope storage.
I -- production line for assembly and welding of other structural components; II -- flow line for assembly and welding of T-beams; III -- production line for assembly and welding of foundation; IV -- production line for assembly and welding of hatch covers; V -- flow line for assembly and welding of bottom frames; VI -- flow line for assembly and welding of brackets and knees; VII -- production line for assembly and welding of stem and stern posts; VIII -- production line for assembly and welding of bulwark and enclosure section; IX -- production line for assembly and welding of masts and booms; X -- production line for assembly and welding of rudders, pipe casings, and so on; XI -- flow line for assembly and welding of bottom section; XII -- flow line for assembly and welding of deck section; XIII -- flow line for assembly and welding of side section; XIV -- production line for assembly and welding of corrugated bulkheads; XV -- production line for assembly and welding of volumetric sections of the extremities; XVI -- flow line for assembly and welding of flat sections.

1 -- unit for mechanized manufacture of MIB-700A beams; 2 -- unit for mechanized manufacture of curvilinear and rectilinear tees SKT12-1; 3 -- bicycle crane; 4 -- receiving or output roller conveyor; 5 -- bending and stamping type press "Bul'dozer"; 6 -- stands for assembly and welding of foundations; 7 -- specialized stands for checking foundations; 8 -- storage for vertical parts of the hatch covers; 9 -- gantry for reduction of framing; 10 -- pallets for sheet steel; 11 -- benches for assembly, welding and testing of hatch covers; 12 -- assembly gantry; 13 -- assembly bench for large framing; 14 -- welder; 15 -- assembly bench for small framing; 16 -- straightening bench; 17 -- framing gantry; 18 -- jig for assembly of brackets; 19 -- machine tool for assembly of brackets; 20 -- machine tool for welding of brackets; 21 -- bench for welding of brackets; 22 -- flat benches for assembly and welding of large brackets and knees; 23 -- traveling gantry loader for assembly of large brackets and knees; 24 -- machine for assembly and welding of stem and stern posts; 25 -- benches for assembly, welding and testing of stem and stern posts; 26 -- flat bench for assembly and welding of bulwark sections and enclosures; 27 -- traveling gantry loader for assembly of bulwark sections and enclosures; 28 -- mechanized bench for assembly and welding of bulwark sections and enclosures; 29 -- unit for installation and tack welding of framing to panels; 30 -- unit for straightening bulwark sections and enclosures; 31 -- storage for finished bulwark sections and enclosures; 32 -- storage for mast and boom parts; 33 -- loader with semiautomatic welders; 34 -- bench for assembly and welding of masts and booms; 35 -- bench for assembly and welding of rudders; 36 -- holder for parts of the bottom sections; 37 -- mechanized bench for assembly and welding of bottom sections; 38 -- device for clamping the bottom section panels to the framing; 39 -- machine for installing and tack welding the framing; 40 -- machine for tack welding the cross framing; 41 -- machine for clamping the panels to the framing and tack-welding the framing; 42 -- bench for joining bottom halfsections; 43 -- all-purpose framing reloader; 44 -- holder for deck section parts; 45 -- portable bench-frame; 46 -- device for reducing panels to the templates;

47 -- unit for automated installation and tack welding of a main direction framing to the plating; 48 -- device for clamping the deck section panels to the framing; 49 -- machine for installing framing; 50 -- welding gantry; 51 -- bench for joining the sections; 52 -- sheet layer with vacuum cross arm; 53 -- all-purpose mechanized jig with flux troughs; 54 -- bench frame; 55 -- machine for installing framing; 56 -- unit for tack welding framing; 57 -- jig for assembly and welding of corrugated bulkheads; 58 -- gantry for assembly and welding of corrugated bulkheads; 59 -- jig for assembly and welding of end sections; 60 -- magnetic unit with pusher; 61 -- bench for assembly of panels; 62 -- butt welding grantry; 63 -- manipulator; 64 -- 90° turning unit; 65 -- framing storage; 66 -- frame feeding unit; 67 -- machine for installing and tack welding frame; 68 -- roller unit with chain conveyor system; 69 -- unit for consolidation of plane sections; 70 -- electric bridge crane, Q=30/5 tons, H=22.5 meters; 71 -- the same, Q=200/32 tons, H=22.5 meters; 72 -- platform.

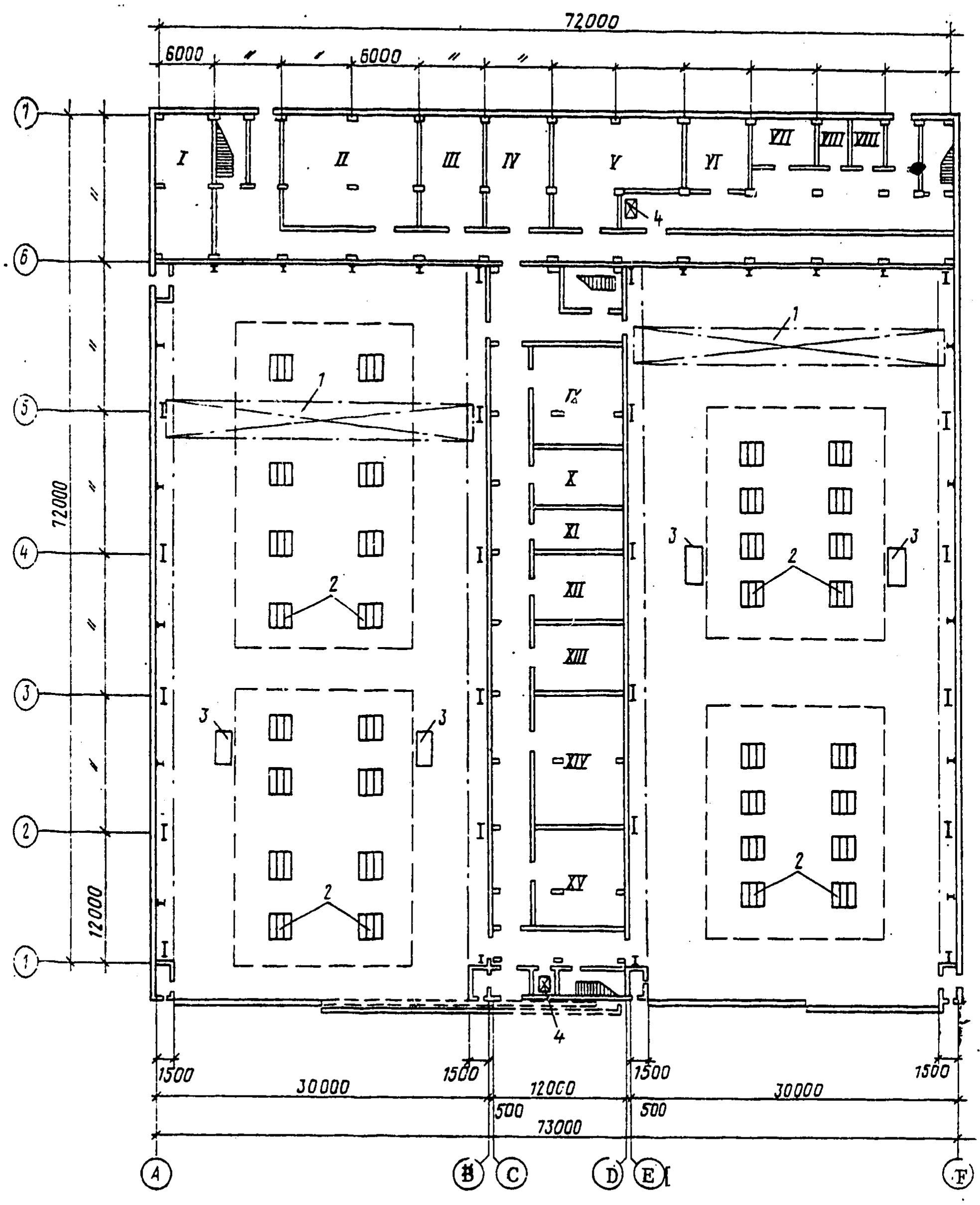


Figure 38. Layout of the section painting and drying section at class I and II shipyards

1 -- transformer substation; II -- distribution station; III -- storage for protective means; IV -- foremen's room; V -- storage for cleaning units for painting; VI -- medical aid station; VII -- smoking room; VIII -- bathroom and laundry; IX -- storage area for personal tools; X -- storage for materials; XI -- rag storage; XII -- respirator storage; XIII -- tool storage; XIV -- repair shop; XV -- heating station. 1 -- electric bridge crane, Q=50/10 tons, H=16 m; 2 -- chairs for setting up the sections for painting; 3 -- portable lift; 4 -- elevator.

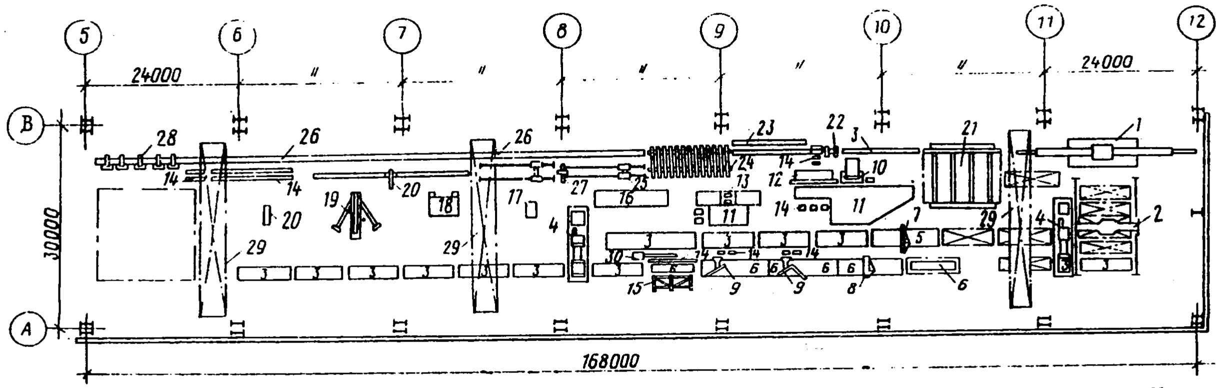


Figure 39. Layout of hull platers section of the shop for constructing aluminum-magnesium alloy structural element s at the class I and II shipyards.
1 -- unit for demothballing sheets and section; 2 -- sheet loader with vacuum section cup; 3 -- roller conveyor; 4 -- roll straightening machine; 5 -- marking table; 6 -- unit for feeding sheets along the automatic marking and gas-electric cutting line; 7 -- measuring and marking machine; 8 -- marking machine; 9 -- machine for gas-electric cutting; 10 -- guillotine shears; 11 -- platform with roller bearings; 12 -- strip stacker at the guillotine shears; 13 -- band saw; 14 -- containers of different dimensions; 15 -- device for pushing off refuse; 16 -- copy blowing machine; 17 -- single-crank press; 18 -- edging machine; 19 -- sheet bending machine; 20 -- radial drilling machine; 21 -- rolled section storage; 22 -- PGA 200/250 type conveyor with automatic marking machine; 23 -- bench for cutting rolled sections; 24 -- shaped parts transfer; 25 -- trolley; 26 -- apron conveyor; 27 -- bending and straightening machine; 28 -- pneumatic pusher; 29 -- electric bridge crane, Q=10 tons, H=11.45 meters; 30 -- free-standing, full swing frame.

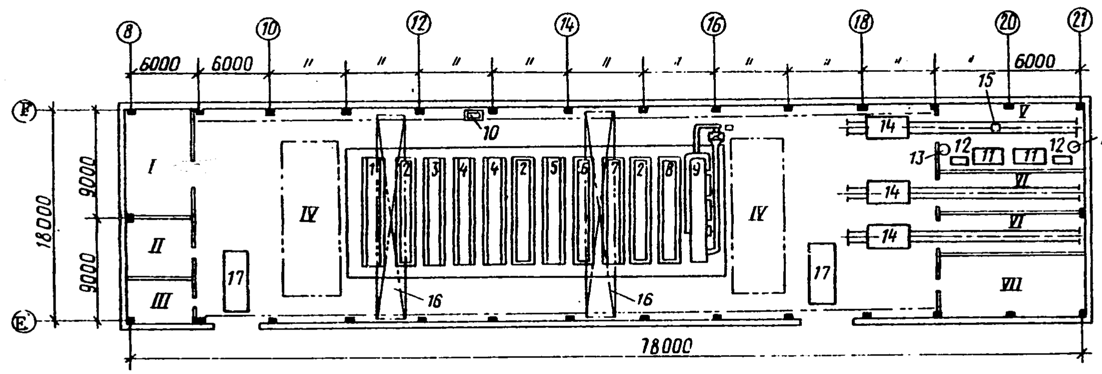


Figure 40. Layout of the anodic oxidation section of the shop for making aluminum-magnesium alloy structural components
I -- paint storage; II -- proximate analysis laboratory; III -- generator; IV -- parts platform; V -- spray chamber; VI -- drying chamber; VII -- chemicals storage.
1 -- chemical degreasing bath; 2 -- cold-water washing bath; 3 -- brightening bath; 4 -- anodic sulfuric acid oxidation bath; 5 -- anodic chromic acid oxidation bath; 6 -- recovery bath; 7 -- chromate filling bath; 8 -- hot-water washing bath; 9 -- drying bath with fan and heating element; 10 -- chemical pump; 11 -- hydraulic filter; 12 -- centrifugal pump; 13 -- delivery tank; 14 -- trolley; 15 -- electric hoist; 16 -- overhead crane, Q=2 tons, H=6.0 meters; 17 -- portable trolley.

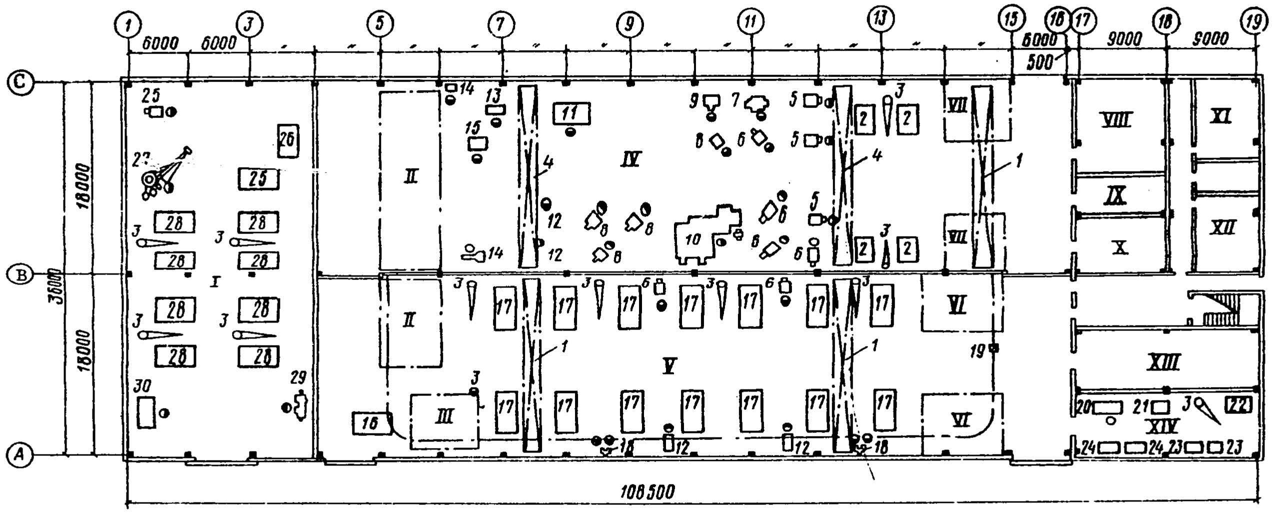


Figure 41. Layout of the shop for making structural components from synthetics
I -- section for bending and welding plastic pipe; II -- parts and products makeup section; III -- volumetric welding location; IV -- machining section; V -- section for welding and bonding structural components; VI -- finished products makeup; VII -- billets storage; VIII -- mechanical and power engineering sections; IX -- tool storage; X -- accessory storage; XI -- materials storage; XII -- fittings storage; XIII -- container washing facility; XIV -- section for preparation of mastic and glue. 1 -- electric bridge crane in the explosion-safe execution, Q=5 tons, H=8.4 meters; 2 -- marking bench; 3 -- pneumatic crane with swinging boom; 4 -- light electric bridge crane in the explosion-safe execution, Q=2 tons, H-8.4 meters; 5 -- Ts-6 circular saw; 6 -- band saw; 7 -- jointing machine; 8 -- milling machine; 9 -- surface gauging machine; 10 -- TsF-2 circular saw; 11 -- porolon cutting tool; 12 -- vertical groove-cutting machine; 13 -- belt grinder; 14 -- grinding machine with disc and spool; 15 -- adjusting drill; 16 -- bench for running out linoleum; 17 -- slab for assembly of structural elements; 18 -- two-way grinder; 19 -- electric telpher in explosion-safe execution (0.5 tons); 20 -- gluing rolls; 21 -- adhesive mixer; 22 -- device for preparing mastics; 23 -- exhaust hood; 24 -- locker for storing mastic components; 25 -- pipe cutting machine; 26 -- glycerine bath; 27 -- pipe bending machine; 28 -- slab for welding pipe; 29 -- lathe; 30 -- machine tool for welding foam plastic slabs

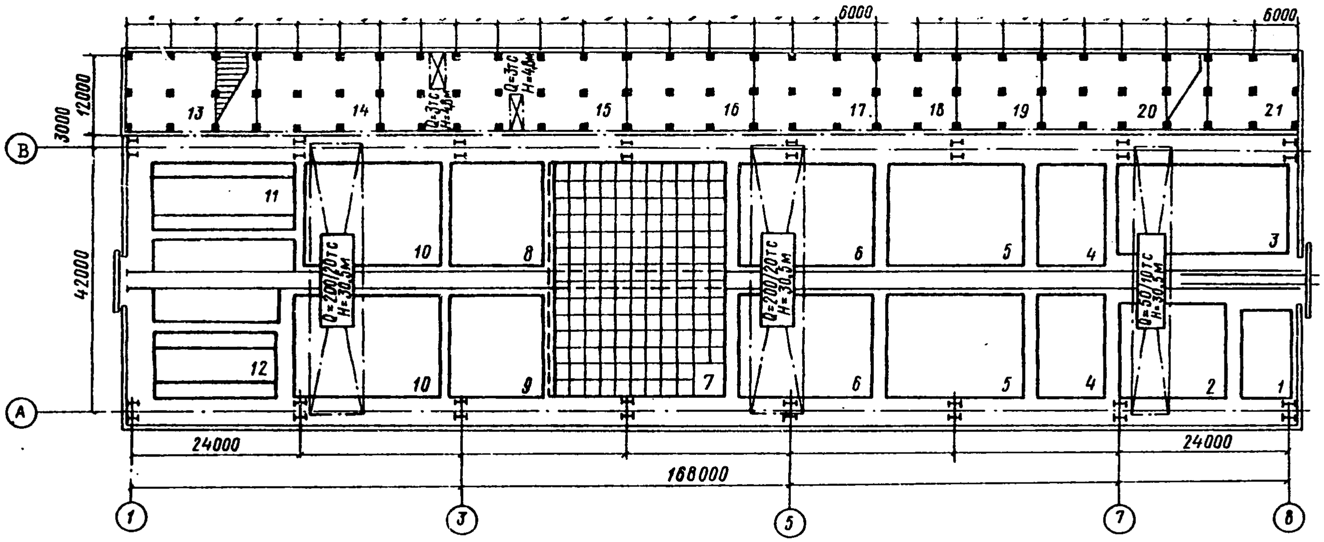


Figure 42. Layout of the section for making unitized units and zonal modules at the class I and II shipyards
1 -- division for working with combustible lubricants; 2 -- demothballing stand; 3 -- hull fitting operations stand; 4 -- makeup platform; 5 -- small zonal module assembly stand; 6 -- large zonal module assembly stand; 7 -- volumetric section assembly stand; 8 -- fitting and installation equipment stand; 9 -- mechanical fitting operations stand; 10 -- makeup platform for subassemblies and parts of main engines to be assembled; 11 -- main engine assembly stand; 12 -- stand for assembling the large subassemblies of the main engines; 13 -- transformer substation; 14 -- machine tool division; 15 -- small machinery makeup division; 16 -- fitting and installation division; 17 -- small parts and products makeup storage; 18 -- materials storage; 19 -- tool storage; 20 -- fuel system and injector testing division; 21 -- oil storage.

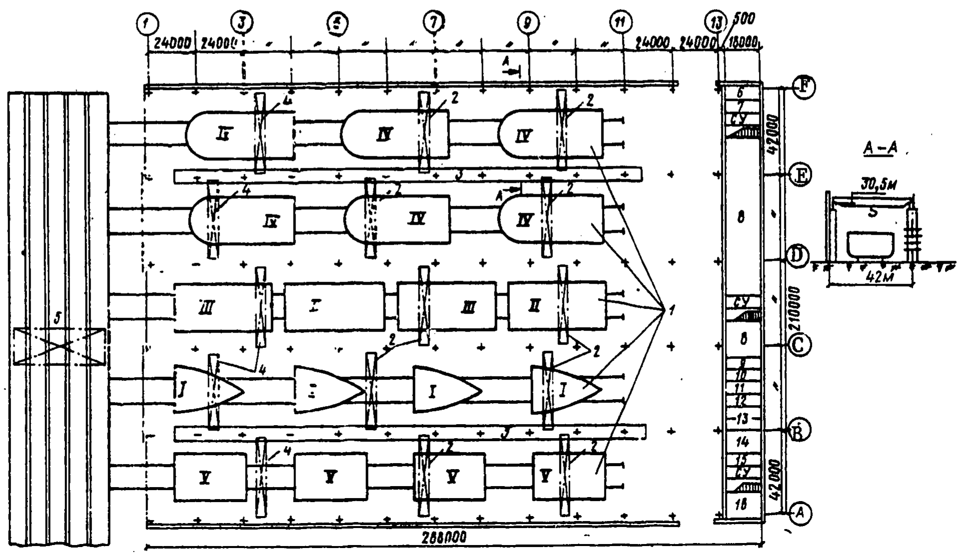


Figure 43. Layout of the module building shop at a class II shipyard
1 -- flow-position lines for assembly and installation of modules;
2 -- electric bridge cranes, Q=160/32 tons, H=30.5 meters; 3 -- "stack" for placement of makeup storages, power engineering devices and the fitting subdivisions of the installation sections; 4 -- electric bridge crane, Q=30 tons, H=30.5 meters; 5 -- module transfer transporter; 6 -- paint section; 7 -- administrative storage; 8 -- machine tool division of the assembly-installation sections; 9 -- medical aid station; 10 -- mechanical and power engineers' workshop of the shop; 11 -- welding materials storage; 12 -- materials storage; 13 -- tool storage; 14 -- electric wiring sections; 15 -- woodworking section; 16 -- insulating section. I-V -- module numbers; CY -- bathroom and laundry

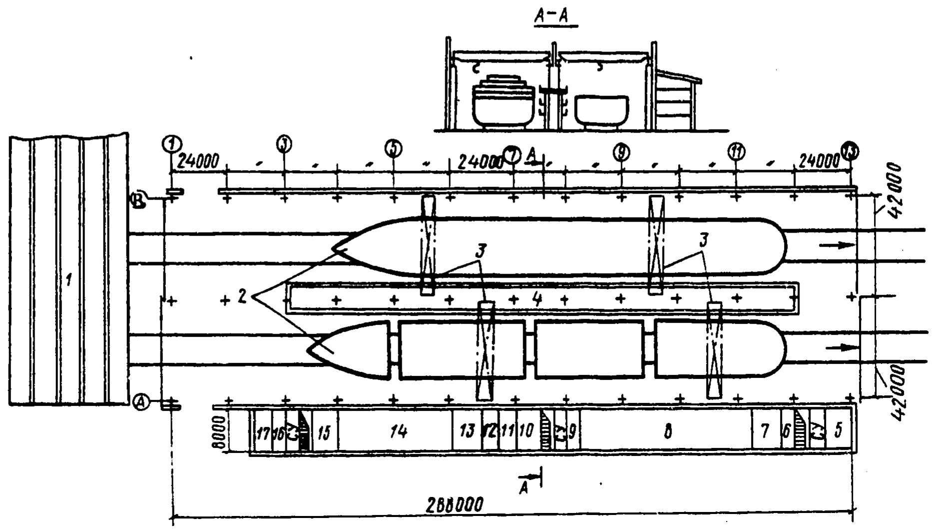


Figure 44. Layout of a shipbuilding shed (covered slipway) at a class II shipyard
1 -- transporter for feeding modules; 2 -- building slip; 3 -- electric bridge crane, Q=160 tons, H=37.7 meters; 4 -- "stack" for the makeup storage, the power engineering devices and the fitting subdivisions for the installation sections; 5 -- insulation section; 6 -- paint section; 7 -- electric wiring section; 8 -- machine tool division of the assembly and installation sections; 9 -- woodworking section; 10 -- tool storage; 11 -- materials storage; 12 -- welding materials storage; 13 -- generator and transformer substations; 14 -- makeup storage; 15 -- medical aid station; 16 -- administrative storage; 17 -- mechanical and power engineers' workshop of the shop.
CY -- bathroom and laundry.

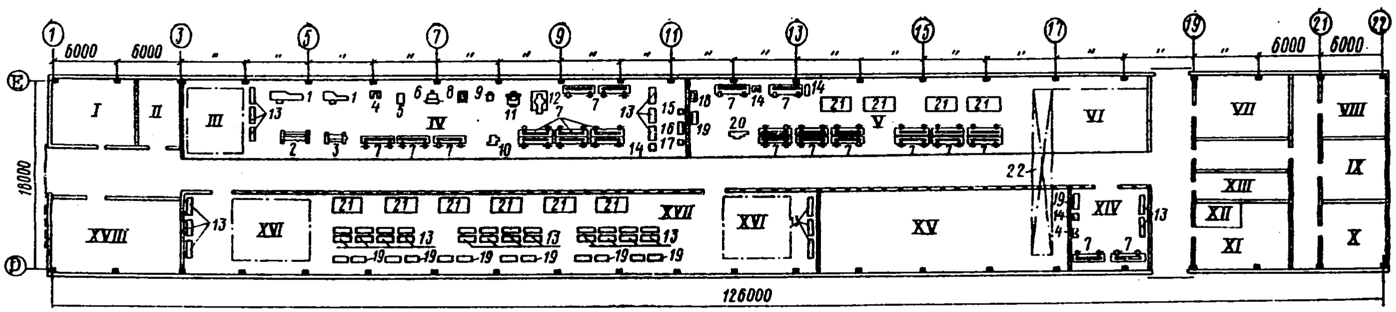


Figure 45. Layout of the electric wiring shop at class I, II and III shipyards
I -- tool storage; II -- auxiliary material storage; III -- distribution panel storage area; IV -- mechanical fitting section; V -- installation and assembly section; VI -- assembly area; VII -- generator room; VIII -- navigational instruments stand; IX -- instruments and equipment storage; X -- measuring instrument stand; XI -- radio communications stand; XII -- shielded chamber; XIII -- radar stand; XIV -- mechanical engineers' workshop of the shop; XV -- high-power current circuitry stand; XVI -- makeup area; XVII -- makeup section; XVIII -- materials storage.
1 -- screw cutting lathe; 2 -- inclined throat shears; 3 -- sheet bending machine; 4 -- two-way grinder; 5 -- copy milling machine; 6 -- universal milling machine; 7 -- fitter's bench; 8 -- vertical drill; 9 -- hydraulic press, manual; 10 -- combination shears; 11 -- single-crank press; 12 -- hydraulic press; 13 -- shelf rack; 14 -- bench type drill; 15 -- single-station welding converter; 16 -- bench for welding operations; 17 -- spot welder; 18 -- winding machine; 19 -- work bench; 20 -- manual lever shears; 21 -- makeup bench; 22 -- electric bridge crane, Q=5 tons, H=8.4 meters.

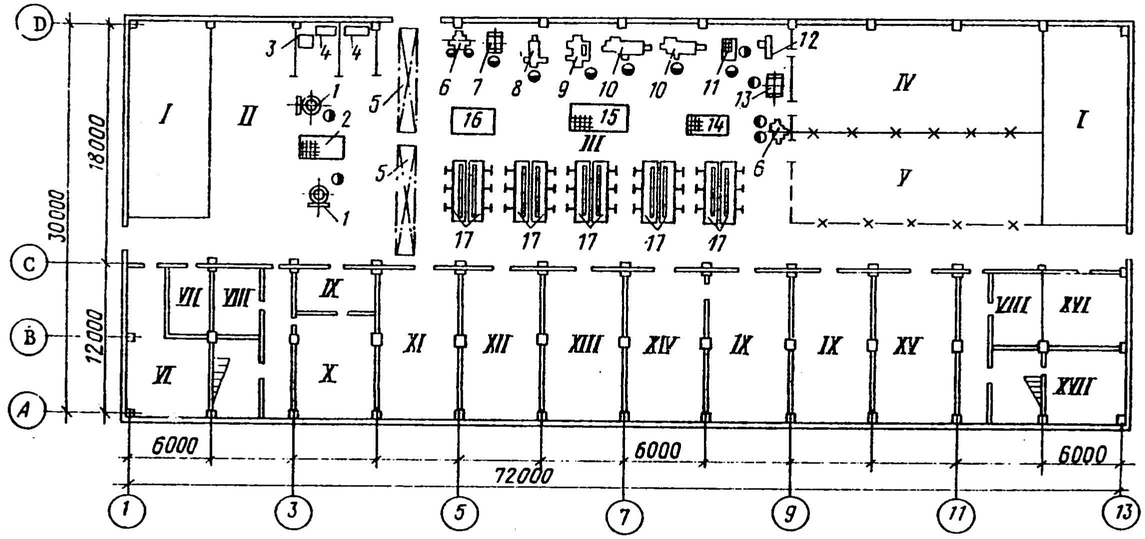


Figure 46. Layout of the outfitting-acceptance shop at the class II and III shipyards
I -- transformer substation; II -- area for material; III -- machine tool division of the installation-outfitting sections; IV -- rigging workshop (under the administration of the captain's section); V -- makeup storage; VI -- paint section; VII -- paint storage; VIII -- bathroom and laundry; IX -- storage; X -- insulation section; XI -- tool storage; XII -- material storage; XIII -- foremen's room; XIV -- woodworking section; XV -- electric wiring shop branch; XVI -- captain's section storage; XVII -- boiler room.
1 -- pipe bending machine; 2 -- bending slab; 3 -- welding converter; 4 -- bench for welding operations; 5 -- electric overhead-track hoist, Q=3 tons, H=6.6 meters; 6 -- grinding and sharpening machine; 7 -- vertical drill; 8 -- universal milling machine; 9 -- transverse gouging machine; 10 -- screw-cutting lathe; 11 -- combination press-shears; 12 -- shears with manual drive; 13 -- sheet bending machine; 14 -- bench plate; 15 -- assembly plate; 16 -- assembly table; 17 -- fitter's bench.

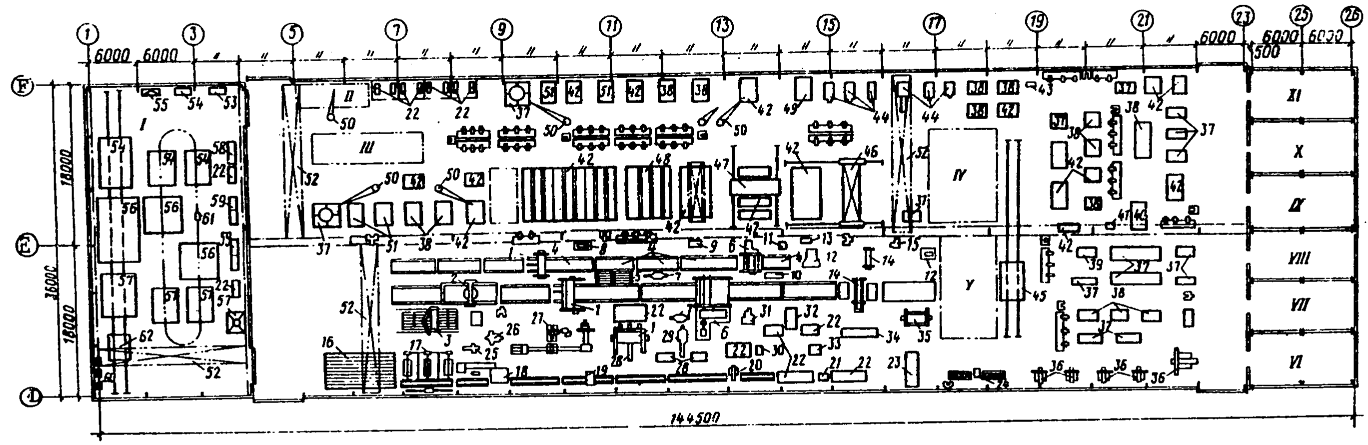


Figure 47. Layout of the hull fitting shop at class I, II and III shipyards
I -- painting section; II -- test stand; III -- product makeup; IV -- parts and subassembly makeup; V -- parts makeup; VI -- transformer substation; VII -- makeup storage; VIII -- mechanical and power engineering workshop of the shop; IX -- material storage; X -- tool storage; XI -- die and accessory storage. 1 -- guillotine shears; 2 -- measuring and marking machine; 3 -- gas-cutting machine; 4 -- apron conveyor; 5 -- transmitter; 6 -- roll straightening machine; 7 -- upcut shears; 8 -- packing hammer; 9 -- beading machine; 10 -- edge rounding machine; 11 -- flange bending machine; 12 -- press; 13 -- mechanism for bending curvilinear edges; 14 -- roll bending machine; 15 -- vertical drill; 16 -- rolled section feed; 17 -- rolled section storage; 18 -- combination press-shears with automatic stamping and marking machine for rolled section; 19 -- abrasive disc saw; 20 -- press-shears; 21 -- trimming machine for parts made of rolled section; 22 -- table; 23 -- bending machine for rolled section; 24 -- vertical drill; 25 -- lathe; 26 -- universal milling machine; 27 -- automatic line for making electrical conduit parts; 28, 47 -- machinery for upsetting the edges of sheets; 29 -- disc saw; 30 -- gas-electric cutting machine; 31 -- band saw; 32 -- radial drill; 33 -- driven flange bending machine; 34 -- device for flanging ventilation pipe; 35 -- edge bending machine; 36 -- crank press; 37 -- jig; 38 -- plate; 39 -- device for pressing rubber into covers; 40 -- device for automatic welding of air ducts; 41 -- attachment for contouring ventilaion pipe; 42 -- bench; 43 -- machine for marking ventilation pipe; 44 -- resistance welder; 45 -- self-propelled trolley; 46 -- stacker with reducer; 48 -- one-way manipulator; 49 -- machine tool for cleaning the edges of sheets for resistance welding; 50 -- electric bracket-sling crane; 51 -- welding manipulator; 52 -- electric bridge crane, Q=5 tons, H=8.4 meters; 53 -- tumbler; 54 -- shot blasting chamber; 55 -- container washing unit; 56 -- spray chamber for painting products; 57 -- product drying chamber; 58 -- degreasing bath; 59 -- paint bath; 60 -- locker with exhaust ventilation for storing paint materials; 61 -- pneumatic telpher; 62 -- manual trolley with lift platform.

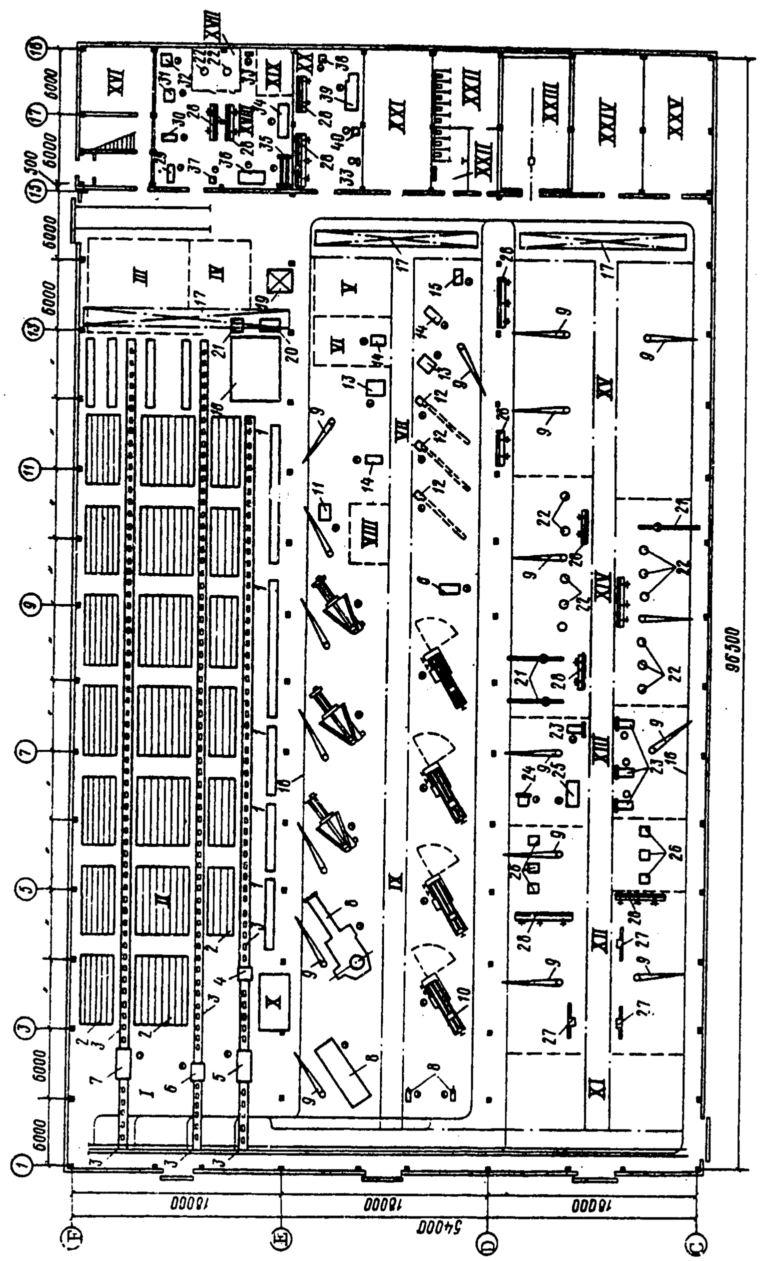


Figure 48. Layout of pipe preparation shop at class II shipyard

[Legend on following page]

[Legend to Figure 48]:

I -- Procurement section; II -- pipe storage; III -- sorting area; IV -- demothballing area; V -- area for preparing pipe for welding; VI -- machining taps in the pipe; VII -- preliminary machining section; VIII -- area for gas cutting of pipe after bending; IX -- bending section; X -- transformer substation; XI -- marking and makeup section; XII -- hydraulic testing section; XIII -- final machining section; XIV -- welding section; XV -- assembly section; XVI -- foremen's room; XVII -- product welding; XVIII -- copper fitting section; XIX -- area for assembling bellows; XX -- mechanical and power engineers' workshop; XXI -- materials storage; XXII -- bathroom and laundry; XXIII -- x-ray laboratory; XXIV -- tool storage; XXV -- reinforcing storage.

1 -- Christmas tree racks; 2 -- gravity racks; 3 -- roller conveyors; 4 -- electric furnace for annealing copper and copper-nickel tube; 5, 6 -- pipe cutting machines; 7 -- gas pipe cutting machines; 8 -- pipe bending machines; 9 -- electromechanical breaking-boom crane; 10 -- pipe bending machines with program control; 11 -- cutoff machine with hacksaw; 12 -- pipe cutoff machine; 13 -- hydraulic press; 14 -- machine tool for cutting holes in pipe; 15 -- device for preparing pipe for durite connections; 16 -- overhead conveyor with self-propelled trolleys and automatic addressing; 17 -- electric overhead crane, Q=5 tons, H=8.4 meters; 18 -- plate for hot bending of pipe; 19 -- mechanical sand filling machine with electric drive; 20 -- electric furnace; 21 -- pipe bending capstan; 22 -- rotating table; 23 -- pipe turning machine; 24 -- flange turning machine; 25 -- machine tool with cones for flaring pipe along the flanges and tack-welding rings; 26 -- pneumatic portable vice for clamping machined pipe; 27 -- hydraulic pipe testing stand; 28 -- fitter's bench; 29 -- downcut shears; 30 -- jointing machine; 31 -- plate for working with copper tubing; 32 -- copper smithy's hearth; 33 -- grinding and sharpening machine; 34 -- press for making bellows; 35 -- sheet bending machine; 36 -- edging machine; 37 -- lever shears; 38 -- bench type drill; 39 -- screw cutting lathe; 40 -- vertical drill.

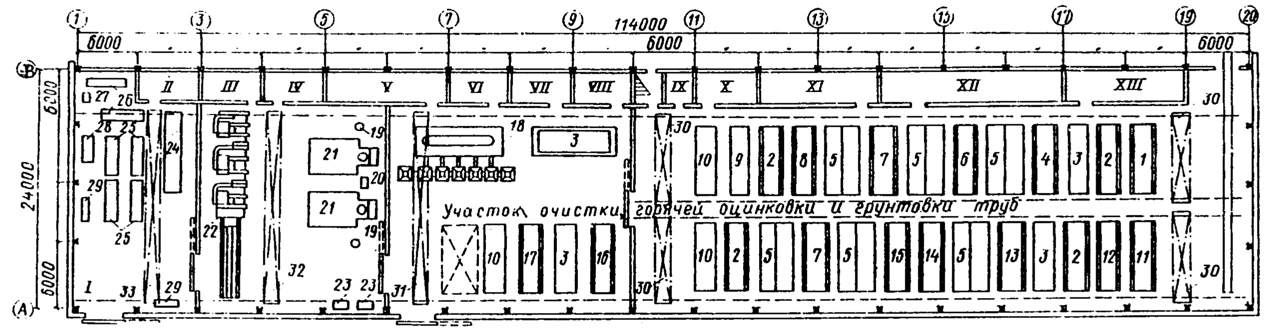


Figure 49. Layout of section for chemical cleaning, hot galvanizing and priming of pipe and also pipe insulation section in the pipe preparation shop of a class II shipyard

I -- pipe insulation section; II -- insulating materials storage; III -- primer storage; IV -- foremen's room; V -- acid storage; VI -- zinc storage; VII -- alkali storage; VIII -- transformer substation; IX -- bathroom and laundry; X -- material storage; XI -- accessories storage; XII -- section repair division; XIII -- chemical storage.

1 -- chemical degreasing bath; 2 -- hot washing bath; 3 -- cold washing bath; 4 -- carbon steel pickling bath; 5 -- cold staged washing bath; 6 -- aluminum brightening bath; 7 -- neutralization bath; 8 -- parkerizing bath; 9 -- passivating bath; 10 -- drying chamber; 11 -- bath for chemical degreasing of stainless stee; 12 -- bath for chemical degreasing of copper; 13 -- bath for pickling stainless steel; 14 -- copper pickling bath; 15 -- stainless steel brightening bath; 16 -- pickling bath; 17 -- fluxing bath; 18 -- hot pipe galvanizing bath-furnace; 19 -- paint delivery tank; 20 -- manual electrostatic paint unit; 21 -- chamberless painting unit; 22 -- furnace for drying primer; 23 -- locker for storing paint and lacquer materials; 24 -- insulation winding machine; 25 -- pipe insulating bench; 26 -- bench for layout and other operations; 27 -- stitcher; 28 -- four-pulley belt cloth-cutting machine; 29 -- shelf rack; 30 -- overhead electric crane, Q=5 tons, H=9.6 meters; 31 -- overhead electric single-track, single-bay crane, Q=5 tons, H=9.6 meters; 32 -- overhead electric single-track, single-bay crane in explosion-safe execution, Q=2 tons, H=9.6 m; 33 -- overhead electric general-purpose single-track crane, Q=2 tons, H=9.6 meters.

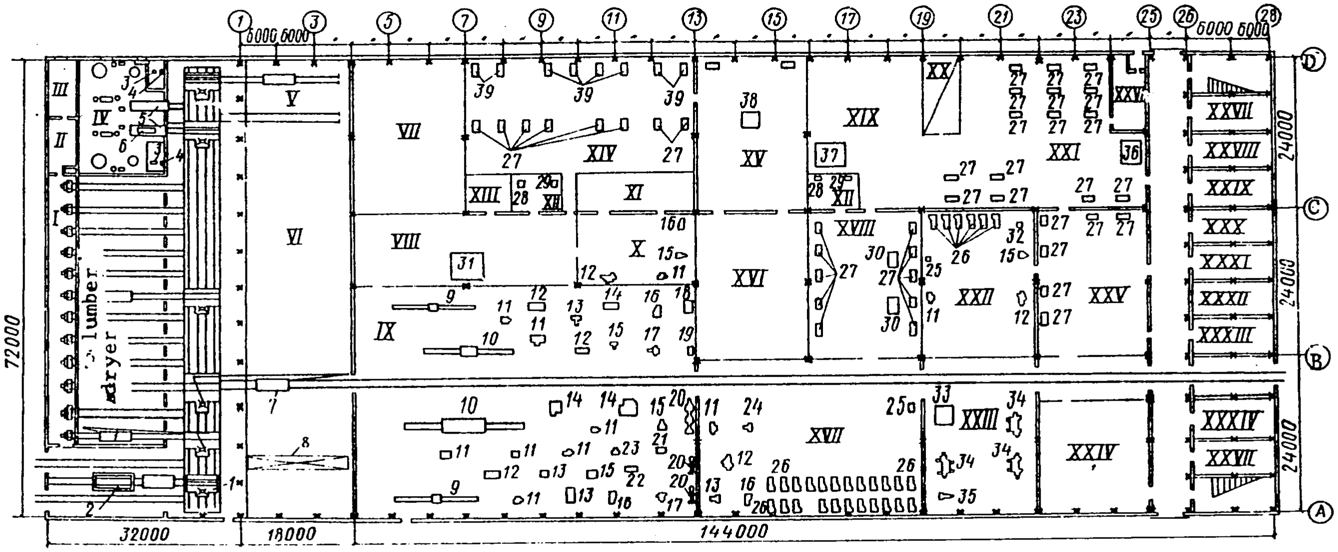


Figure 50. Layout of woodworking shop at class I, II and III shipyards

I -- control corridor; II -- automation and monitoring and measuring instruments; III -- laboratory; IV -- wood impregnating section; V -- cooling division; VI -- dry lumber warehouse; VII -- finished products warehouse; VIII -- veneering press section; IX -- machine tool and fabrication section; X -- section for working veneered subassemblies and parts; XI -- upholstery material storage; XII -- glue heater; XIII -- veneer sheet storage; XIV -- upholstery and sail loft -- XV -- polishing section; XVI -- intermediate furniture billeting warehouse; XVII -- carpentry-assembly section; XVIII -- bonding section; XIX -- drying section; XX -- ventilation chamber; XXI -- painting and varnishing section; XXII -- wood model section; XXIII -- grinding section; XXIV -- intermediate storage for finishing products; XXV -- spackling section; XXVI -- paint and varnish storage; XXVII -- bathroom and laundry; XXVIII -- foremen's room; XXIX -- materials storage; XXX -- tool storage; XXXI -- tool grinding facilities; XXXII -- mechanical engineer's workshop; XXXIII -- attachments and template storage; XXXIV -- thermal station. 1 -- traversing trolley; 2 -- lumber transfer elevator; 3 -- telpher; 4 -- commercial scales; 5 -- impregnating cylinder; 6 -- trolley for feeding material to the impregnating cylinder; 7 -- the same, to the drying chamber; 8 -- overhead single-track crane, Q=3 tons, H=7.2 m; 9 -- pendulum type cross-cutting machine; 10 -- four-way plane; 11 -- circular saw; 12 -- jointing machine; 13 -- surface gauge; 14 -- dovetailing machine; 15 -- drilling machine; 16 -- band saw; 17 -- chain-type slotter; 18 -- horizontal drilling machine; 19 -- drill; 20 -- lathe; 21 -- drilling and groove-cutting machine; 22 -- rounding machine; 23 -- copy milling machine; 24 -- vertical drill; 25 -- sand grinder; 26 -- joiner's bench; 27 -- table; 28 -- adhesive mixture; 29 -- electric glue heater; 30 -- hydraulic jack [continued]

[Legend for Figure 50, continued]:
31 -- hydraulic press; 32 -- universal machine tool; 33 -- three-drum grinder; 34 -- belt grinder; 35 -- disc and spool grinder; 36 -- spray cubicle with wet air cleaning; 37 -- two-way drying chamber; with steam heating; 38 -- surface grinding machine; 39 -- stitcher.

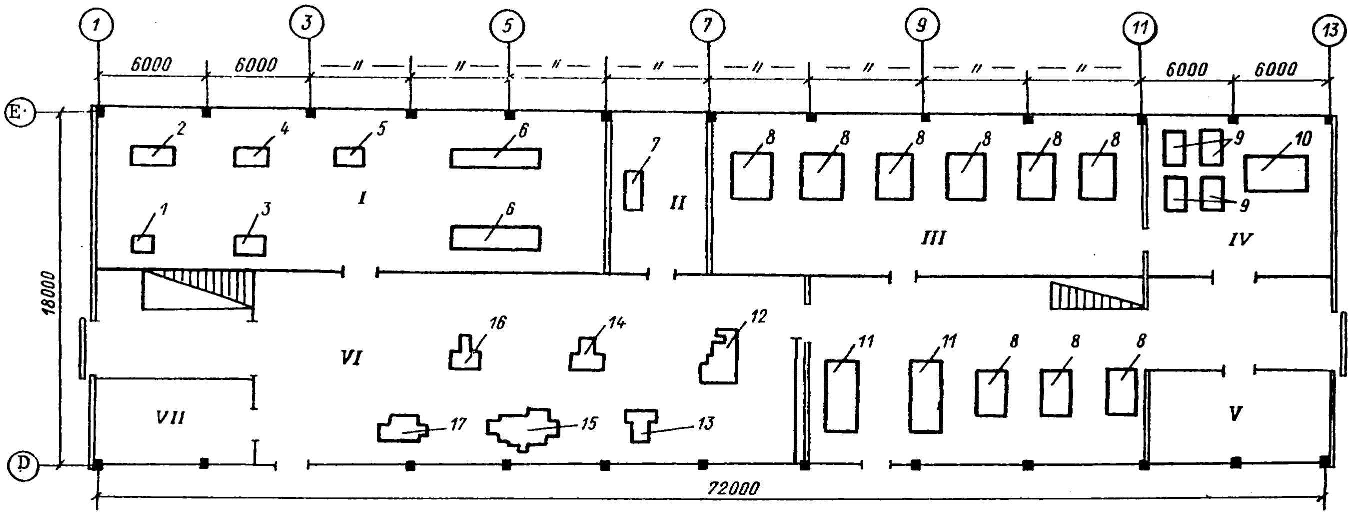


Figure 51. Layout of insulation billeting section
I -- mastic and shell section; II -- glue heater; III -- package-board insulation division; IV -- paint and drying division; V -- products storage; VI -- machine tool billeting section; VII -- materials storage. 1 -- driven paint grinder; 2 -- mixing machine; 3 -- cylindrical chalk seeder; 4 -- ball mill; 5 -- paint mixer; 6 -- bench for gluing operations; 7 -- electric glue heater; 8 -- benches for assembling packages; 9 -- benches for painting operations; 10 -- drying chamber with steam heating; 11 -- benches for sewing operations; 12 -- band saw; 13 -- surface gauger; 14 -- milling machine with top spindle; 15 -- jointing machine; 16 -- milling machine; 17 -- circular saw.

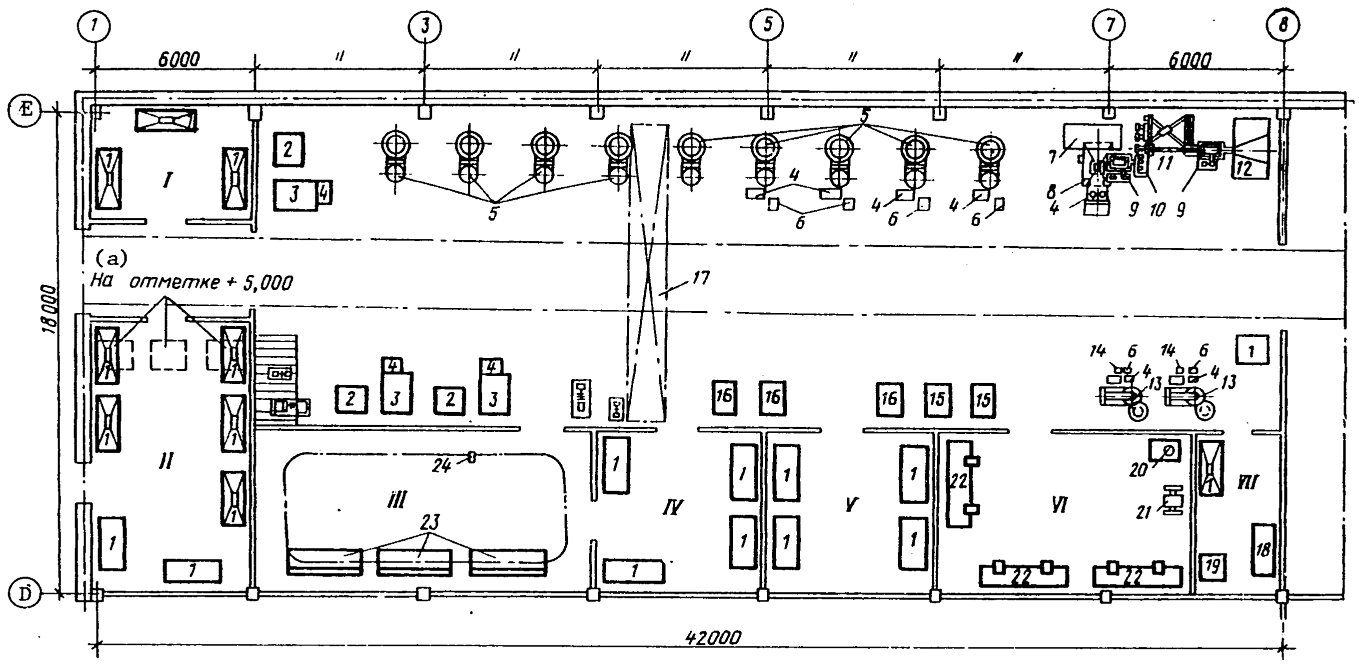


Figure 52. Layout of the paint preparation shop at class I, II and III shipyards
I -- finished product; II -- solvent, pigment and paint storage; III -- container cleaning storage; IV -- container storage; V -- tool storage; VI -- workshop; VII -- proximate analysis laboratory.
1 -- racks, lockers, tanks; 2 -- pigment unloading chamber (lead and iron minion); 3 -- primer preparing unit; 4-- paint grinder; 5 -- unit for preparing paint and varnish materials; 6 -- vibration screens; 7 -- bin; 8 -- spackling mixer; 9 -- elevator; 10 -- chalk grinder; 11 -- chalk drier; 12 -- ball mill for grinding iditol glue; 13 -- planetary mixers; 14 -- pneumatic lift; 15 -- glue mixer; 16 -- two-channel mixer for putty and paste; 17 -- overhead crane, Q=3 tons, H=8.4 meters; 18 -- bench for laboratory work; 19 -- wet chamber; 20 -- vertical drill; 21 -- stripping and grinding machine; 22 -- joiner's bench; 23 -- container washing machine; 24 -- electric hoist
Key:
a. At the 5000 mark

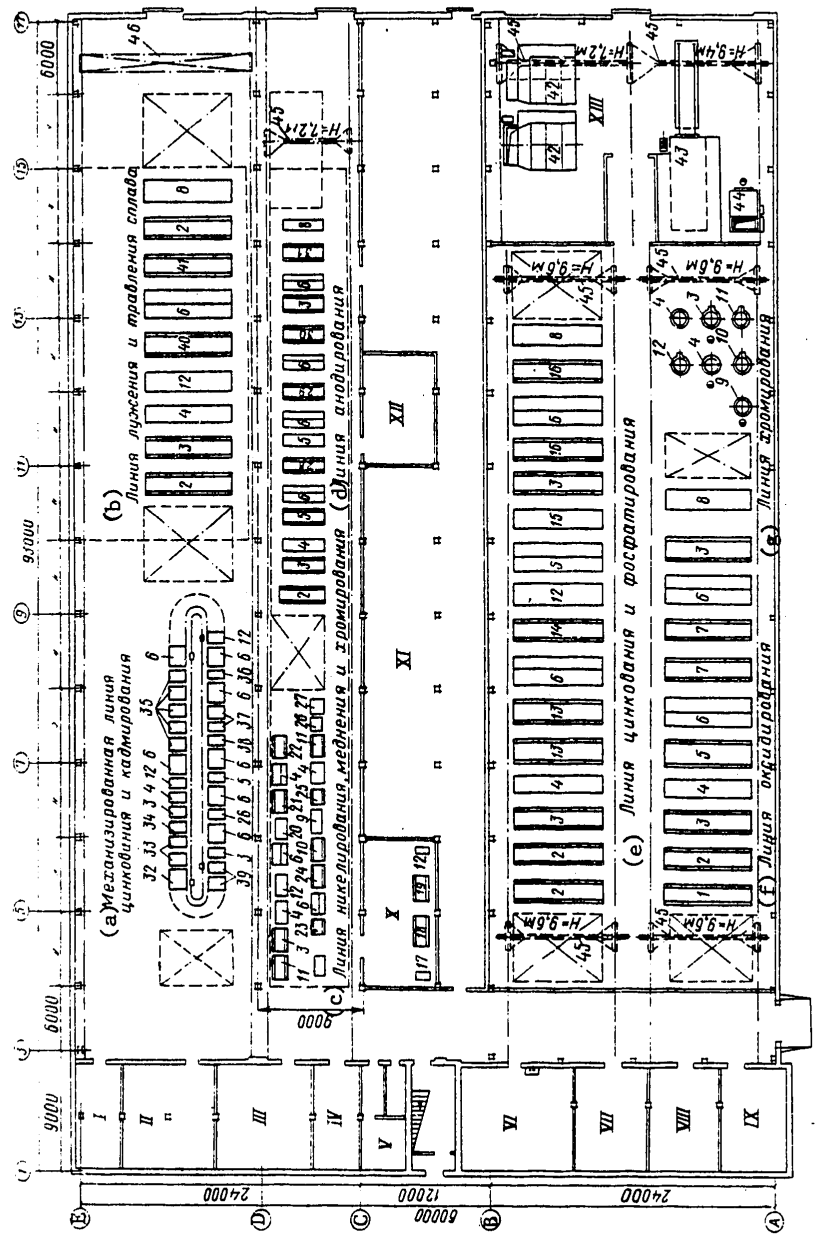


Figure 53. Layout of the galvanizing shop at a class II shipyard
[Legend for Figure 53 on following page]

[Legend for Figure 53]:

I -- Foreman's office; II -- section for repair and insulation of suspensions; III -- proximate analysis laboratory; IV -- central heating; V -- bathroom and laundry; VI -- acid storage; VII -- alkali storage and preparation section; VIII -- grinding and polishing section; IX -- section for degreasing in organic solvents; X -- electrolyte preparation section; XI -- ventilation chambers; XII -- refrigeration facilities; XIII -- priming section.
1 -- demothballing bath; 2 -- chemical degreasing bath; 3 -- hot washing bath; 4 -- cold washing bath; 5 -- brightening bath; 6 -- cold staged washing bath; 7 -- chromic acid oxidation bath; 8 -- drying bath; 9 -- chromium recovery bath; 10 -- chrome plating bath; 11 -- electrochemical degreasing bath; 12 -- pickling bath; 13 -- carbon steel pickling bath; 14 -- neutralization bath; 15 -- galvanizing bath; 16 -- parkerizing bath; 17 -- electric distillation unit; 18 -- chemical bath for preparing electrolyte; 19 -- electrochemical bath for preparing electrolyte; 20 -- copper pickling bath; 21 -- matte nickel plating bath; 22 -- acid copper plating bath; 23 -- pyrophosphate copper plating bath; 24 -- bright nickel plating bath; 25 -- unit for decorative chrome plating of small parts in loose form; 26 -- passivating bath; 27 -- electric drier; 28 -- electrochemical polishing bath; 29 -- sulfuric acid oxidation bath; 30 -- adsorption coloring bath; 31 -- anodic film sealant bath; 32 -- rotating charging section; 33 -- suspended electrochemical degreasing bath; 34 -- bath for electrochemical degreasing in a drum; 35 -- suspended galvanizing bath; 36 -- drum galvanizing bath; 37 -- suspended cadmium plating bath; 38 -- drum cadmium plating bath; 39 -- chamber type drier; 40 -- alloy pickling bath; 41 -- tin-plating bath; 42 -- chamberless painting unit; 43 -- drying chamber; 44 -- painting chamber; 45 -- overhead electric single-track, general-purpose crane, Q=3.2 tons; 46 -- single-track bridge crane with electric hoist and floor control, Q=3 tons, H=8.4 meters.

Key:

a. Mechanized zinc and cadmium plating line
b. Tin-plating and alloyed pickling line
c. Nickel, copper and chrome plating line
d. Anodizing line
e. Galvanizing and parkerizing line
f. Oxidation line
g. Chrome plating line

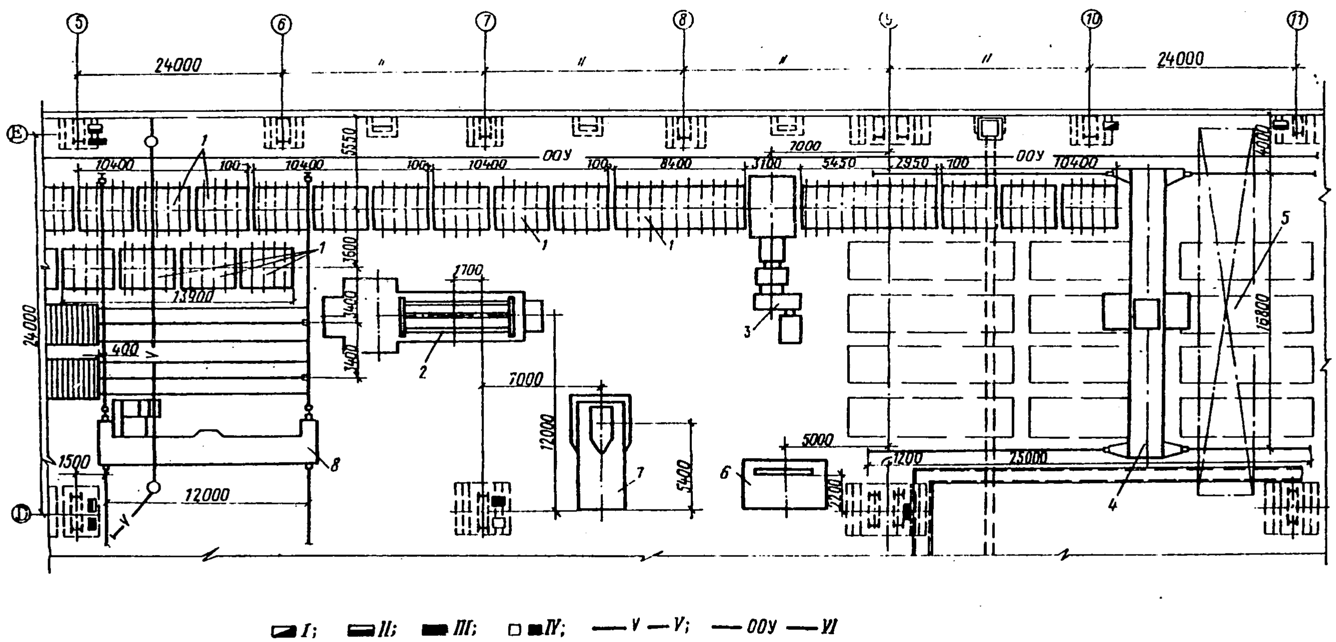


Figure 54. Fragment of a detailed drawing of the layout of the hull platers shop
I -- Electric lighting distribution panel; II -- power panel; III -- electric lighting panel; IV -- acetylene and oxygen connections; V -- production shower channeling; VI -- soft water (return) line.
1 -- roller conveyor for horizontal displacement of sheet steel; 2 -- roll sheet bending machine; 3 -- roll sheet straightening machine; 4 -- sheet parts sorter; 5 -- electric bridge crane, Q=10 tons, H=8.15 meters; 6 -- edge bending machine; 7 -- hydraulic press; 8 -- sheet parts transfer loader

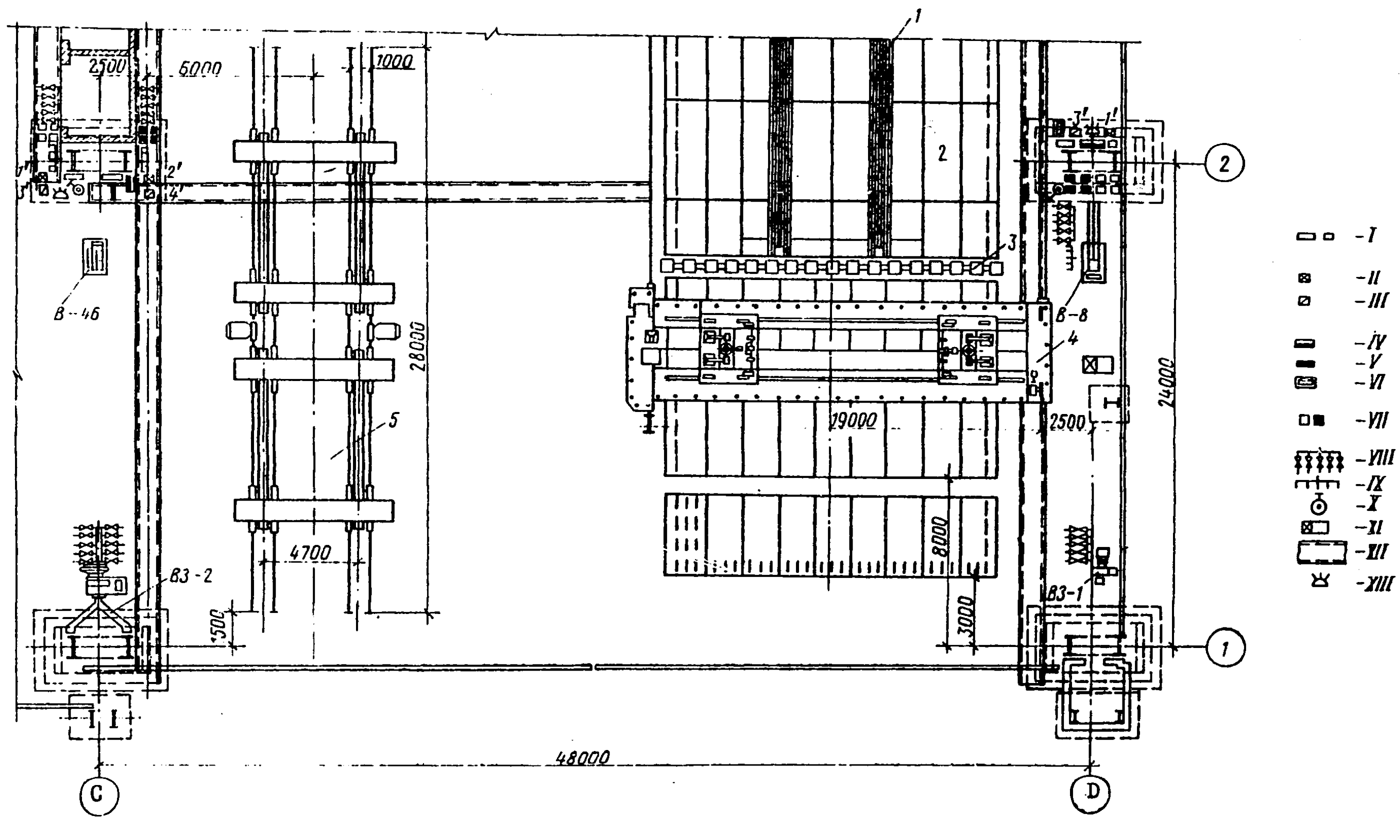


Figure 55. Fragment of a detailed drawing of the layout of the assembly-welding shop of class I and II shipyards

I -- connections for manual welding for 6 and 3 welding arcs; II -- 1000 amp connection for welding; III -- 500 amp connection for welding and electric arc cutting; IV -- power panel; V -- lighting panel; VI -- low voltage lighting panel for five portable lamps; VII -- acetylene and oxygen connections; VIII -- water hydrant header; IX -- carbon dioxide header; X -- production water hydrant; XI -- STD-300 heating unit; XII -- electric cable conduit; XIII -- three-pin socket.
1 -- transfer, ℓ=38 meters; 2 -- mechanized stamp for assembly and welding of bottom sections; 3 -- device for clamping panels to framing; 4 -- machine for clamping panels to framing; 5 -- stand for consolidation of bottom sections; VZ-1, VZ-2, V-8, V-46 -- ventilation equipment; 1', 2', 3', 4' -- number of positions at the connection station.

CHAPTER XII. SHIPBUILDING WAYS AND LAUNCHING FACILITIES

§36. Shipbuilding Ways and Launching Facility Features as a Function of the Class of Shipyards

Inclined shipbuilding ways are considered to be old forms of shipbuilding and launching facilities for building and launching medium and large ocean-going essels.

The modern types of shipbuilding ways and launching facilities for building and launching the ships include the following structures:

Dry docks, the bottom of which is below the level of the water area, thus permitting the built ships to be launched from the dock into the water;

Flooding docks with bottom above the water area with exit of the ships from them through a flooding basin surrounded by walls or dams;

Horizontal shipbuilding ways at the level of the shipyard land in combination with devices for moving the ships and pulling and launching structures.

In these horizontal shipbuilding ways the launching structures can be flooding docks, floating transfer docks, adapted for accepting ships under construction from the shore; vertical ship lifts or inclined slips.

The enumerated modern shipbuilding ways and launching facilities can be used both for building ships and for repairing them in the horizontal position.

The shipbuilding ways and launching facilities are among the basic production means of a shipyard, and their technical level to a significant degree determines the technical level of the production means of the shipyard as a whole.

Thus, the complex of shipbuilding ways and launching facilities, including the launching structure servicing several horizontal shipbuilding lines on which large-module construction of the ships is carried out by the flow-position method, is the most modern and advanced structure for all cases where the dimensions and weight of the modules and ships permit them to be transported from position to position and to the launching structure and when the scale of production provides for keeping the flow-assembly lines loaded.

At the shipyards, depending on their class, the characteristic features of the land and water areas, as a rule, the following shipbuilding ways and launching structures are erected:

	Class of shipyard
Shipbuilding docks and inclined shipbuilding ways (Figures 56-59)	I
Shipbuilding docks and inclined shipbuilding ways and also horizontal shipbuilding ways if the ships are launched through a flooding dock chamber or using a transverse two-level slip or a floating transfer dock (Figures 59-64)	II
Horizontal shipbuilding ways if the ships are launched through a flooding dock chamber or using a transverse two-level slip, floating transfer dock or vertical ships lift (Figures 62-66)	III
Horizontal shipbuilding ways if the ships are launched by a two-level slip, vertical ships lift or ordinary sideway launch facility (Figures 63, 65, 66)	IV
Horizontal shipbuilding ways (conveyor lines) if the ships are launched using a slip with longitudinal stand or a special crane type launching setup or floating crane (Figures 67, 68)	V

At the present time when designing shipyards inclined slips are, as a rule, not planned as shipbuilding ways or launching facilities, for it is appreciably more complicated to form the hull from sections on them than on horizontal ways, in particular if the hull is formed from large sections, module-sections and modules. In addition, with inclined slipways it is more complicated to install and rig the machinery, equipment and large units and launch the ship.

The large semidock type building slips with drainable section under the surrounding water level if placed in areas with large fluctuations of the water level (tides, floods), are similar to drydocks with respect to structural design and cost, but, in contrast to the latter, they do not have reversibility, that is, they cannot be used for hauling ships for inspection and repair.

In recent years, especially for the medium-weight shipbuilding, wide use of floating transfer docks has been made as hauling and launching facilities servicing several horizontal shipbuilding ways. Under defined conditions they have a number of advantages by comparison with other hauling and launching facilities (the possibility of servicing several nearby shipyards, use in the interim periods between launches or repair and inspection of ships, parallel conduct of construction work at the shipyard and work on building a floating dock at specialized enterprises, and so on).

In recent times the application of vertical lifts with a lift capacity exceeding 6000 tons has increased significantly at foreign shipyards [40].

The primary elements of vertical ship lifts are the lift platform with keelblocks and supports for the ship, the device for raising the platform with the ship and a guide which provides for horizontal positioning of the platform during hauling and launching.

The basic and most widespread type of vertical ship lifts are the mechanical lifts with hydraulic jack or with electromechanical winches.

The vertical lifts -- synchrolifts -- which consist of a platform which is raised and lowered by electric winches installed on two lateral piers have received the most development.

All of the synchrolift equipment is made of standardized elements, which insures easy replacement and repair of them in case of failure. The structural elements of these lifts are relatively simple (two parallel piers) and they do not require large financial or labor expenditures.

For example, these structural elements take up a minimum of land and water area, nd they can be efficiently located within the shipyard territory; they are convenient to operate, and the launching and hauling operations can be mechanized and automated insuring minimum time spent on launching operations. They, just as the floating transfer docks, permit any required number of horizontal shipbuilding ways combined with the transport systems for longitudinal and transverse movement of the ships. A large volume of operations with respect to building the ship lift can be performed at specialized enterprises which has great significance when building shipyards in remote areas.

One of the characteristic features of the development of technical progress in shipbuilding is the equipment of the new shipbuilding ways and building docks with the technically most advanced gantry and portal cranes.

A rough description of cranes for equipping uncovered shipbuilding ways and docks of new shipyards is presented in Table 54, and example diagrams of their siting are presented in Figures 69-71.

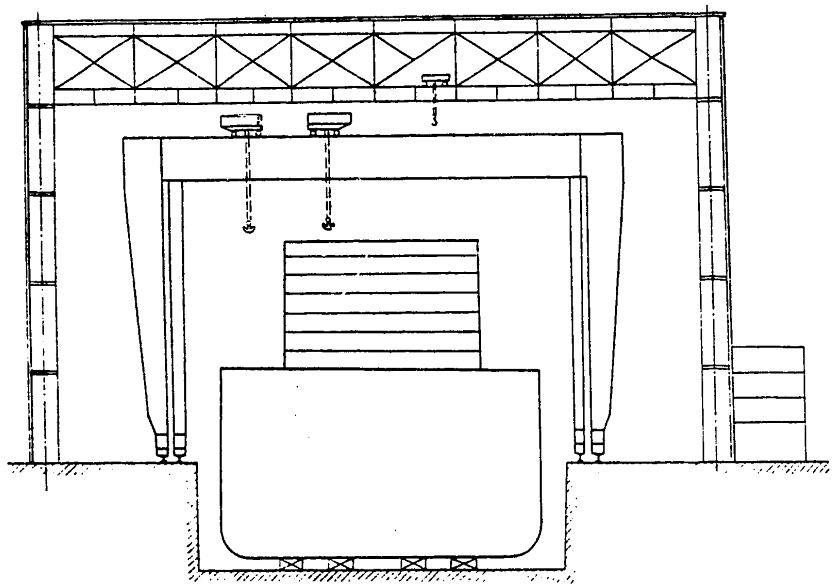


Figure 56. Section of a covered slipway with construction dock for building large ships, with gantry and electric bridge cranes placed in the girders of the slip cover and moving perpendicularly to the movement of the gantry cranes.

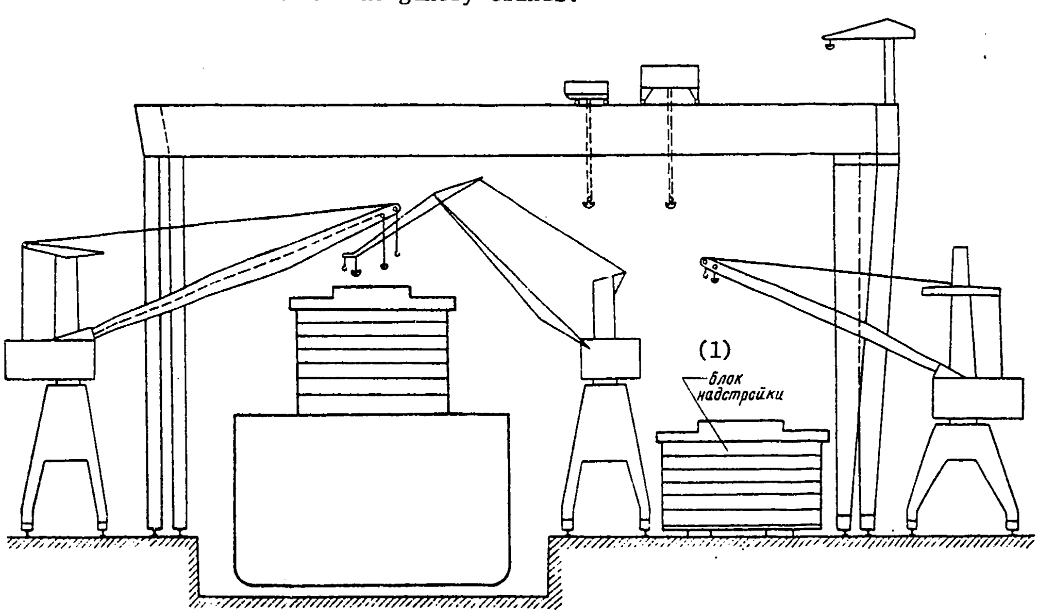


Figure 57. Section of an uncovered building dock for building large ships with lateral platform for the assembly of superstructural modules, consolidation of sections and unitizing of diesel engines.

Key: 1 -- superstructural module

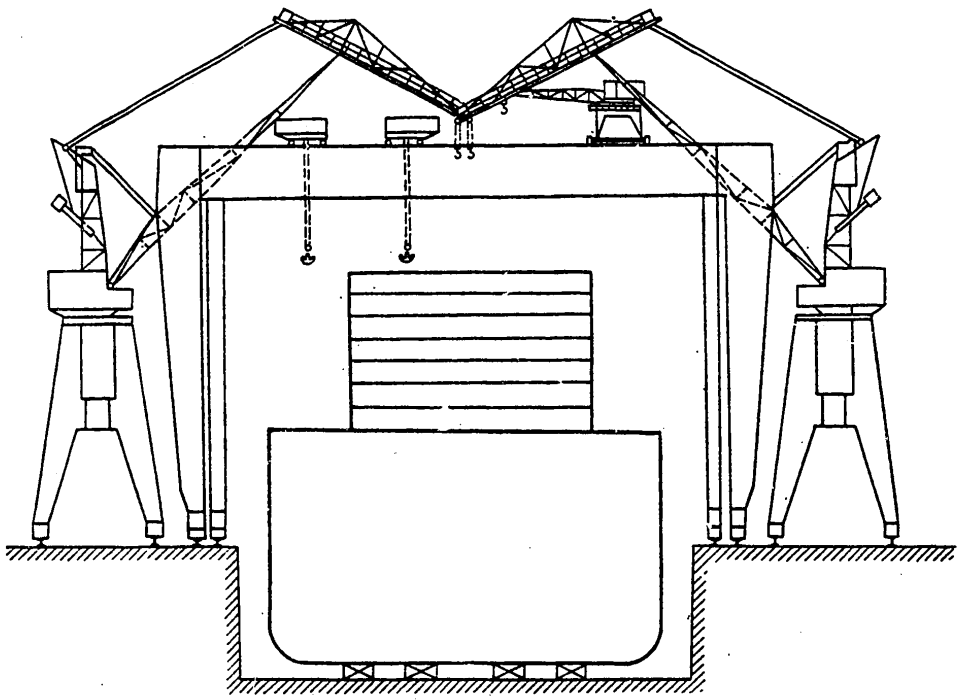


Figure 58. Section of an uncovered building dock for building large ships with end area for the assembly of superstructure modules, consolidation of sections and unitization of diesel engines, with gantry and portal cranes

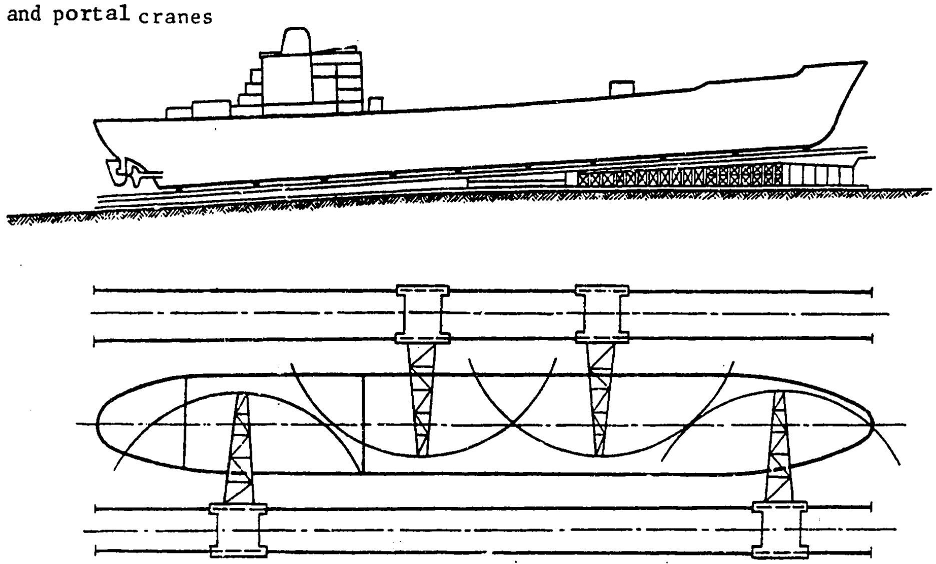


Figure 59. Inclined building berth

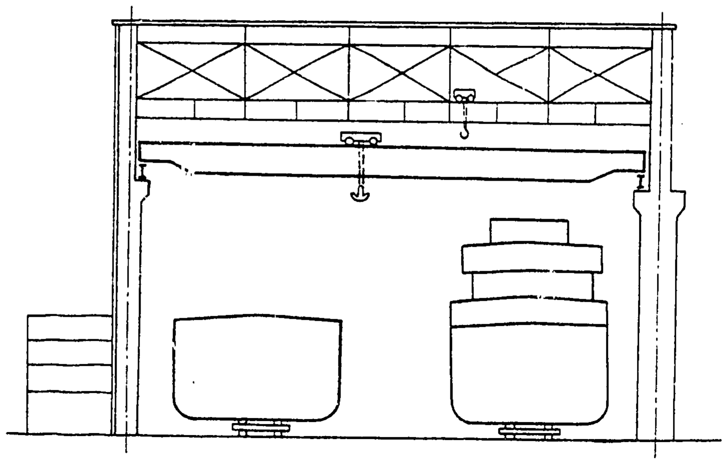


Figure 60. Section of a covered-in berth with horizontal shipbuilding ways, with electric bridge cranes for longitudinal (with large lift capacity) and transverse (smaller lift capacity) movement

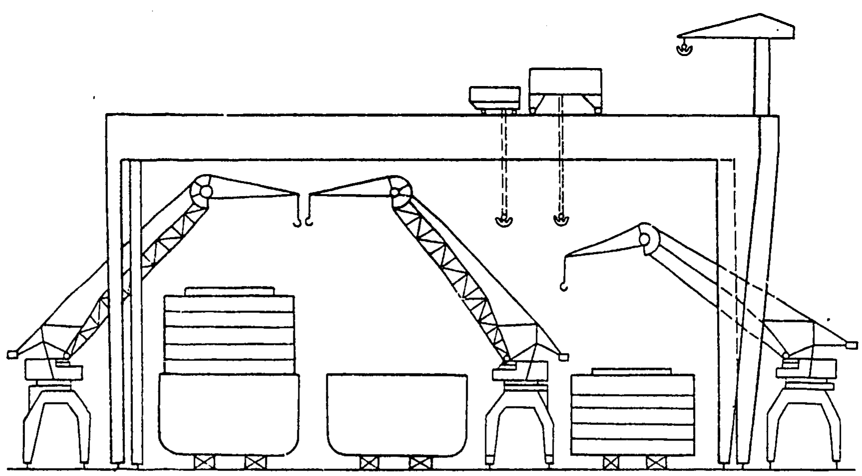


Figure 61. Section of uncovered horizontal shipbuilding ways with gantry and portal cranes

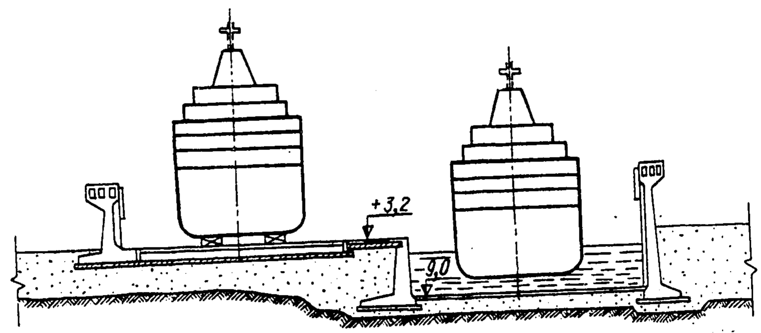


Figure 62. Section of a flooding docking basin

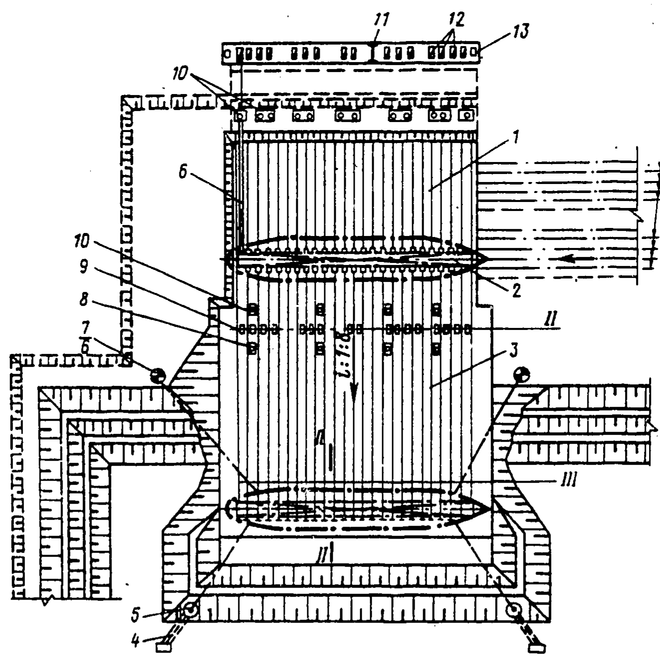


Figure 63. Plan of a transverse two-tier slip
1 -- horizontal section; 2 -- transporter; 3 -- inclined section; 4 -- anchor chain; 5 -- mooring buoy; 6 -- steel cable; 7 -- capstan; 8 -- double snatch block; 9 -- guide roller; 10 -- single snatch block; 11 -- overhead crane; 12 -- winch; 13 -- device for leveling transporter misalignments.
I -- access of the shipbuilding lines; II -- bend line of the lower tracks; III -- axes of the slip launching tracks

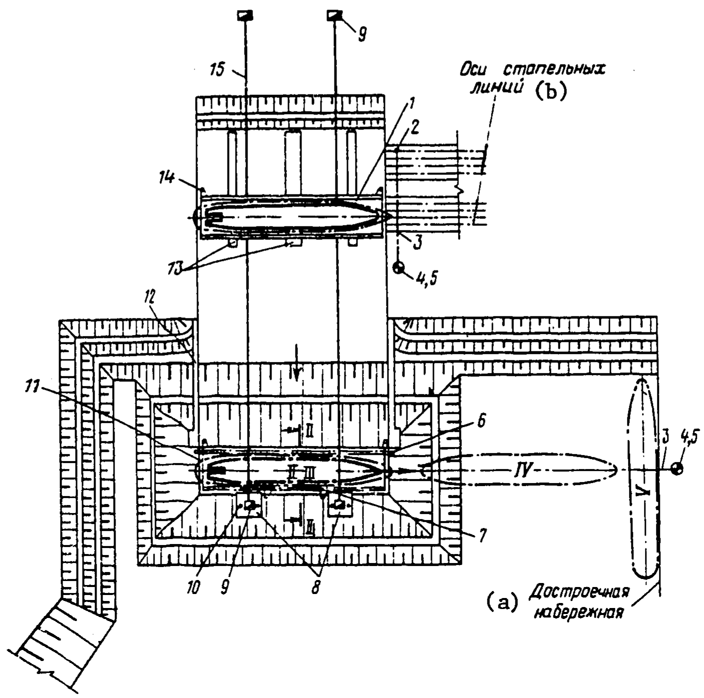


Figure 64. Plan view of a launching facility with floating transfer dock.
1 -- floating dock; 2 -- single snatch block; 3 -- steel cable for capstan; 4 -- capstan; 5 -- cable drum; 6 -- telescopic shore on the dock; 7 -- cantilever on the dock; 8 -- dolphin; 9 -- winch; 10 -- mooring bollard; 11 -- pit for submerging the floating dock; 12 -- guide trestle; 13 -- supports under the floating dock; 14 -- rotating fenders on the side walls of the floating dock; 15 -- steel cable for the winch.
I-IV -- ship launching sequence.

Key:
a. Outfitting quay
b. Axes of shipbuilding lines

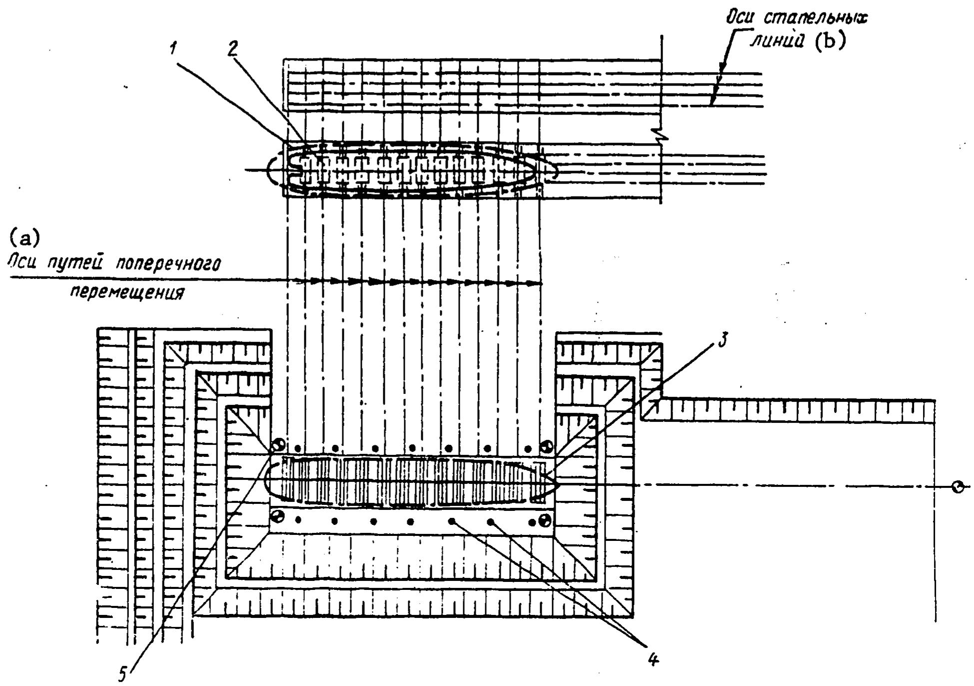


Figure 65. Plan view of launching facility with vertical ships lift. 1 -- cradle for longitudinal displacement (self-propelled); 2 -- cradle for transverse displacement (nonself-propelled); 3 -- hydraulic ships lift; 4 -- bollards; capstan and steel cable

Key:
a. Axes of transverse displacement tracks
b. Axes of shipbuilding lines

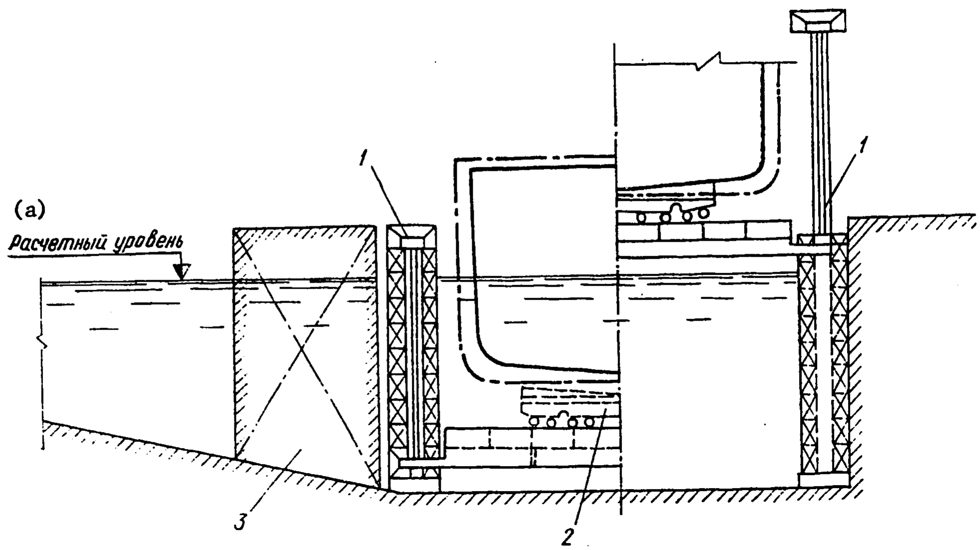


Figure 66. Section of launching structure with vertical ships lift for launching and raising the ship.
1 -- hydraulic ships lift; 2 -- nonself-propelled cradle for transverse displacement; 3 -- dolphin

Key: a. calculated level

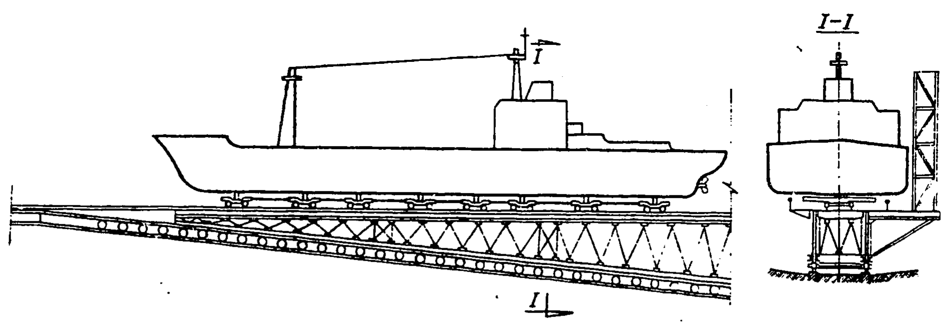


Figure 67. Slip with longitudinal stand in the extreme upper position

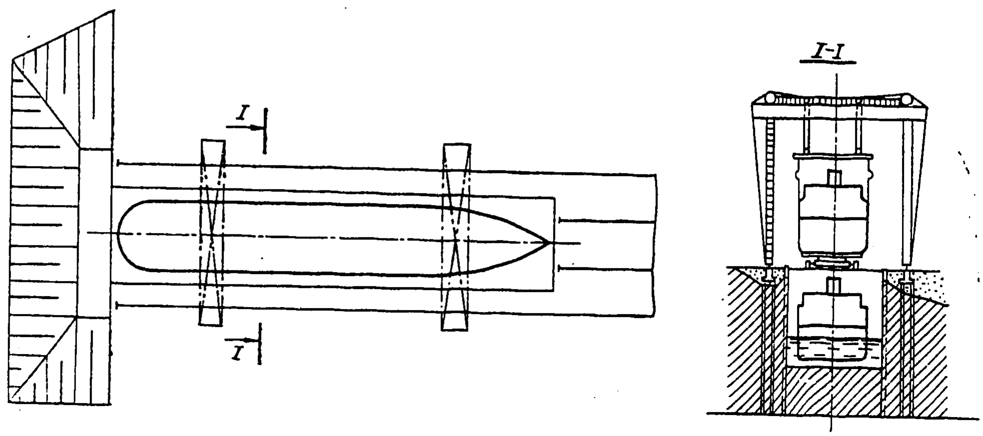


Figure 68. Launching facility with two gantry cranes

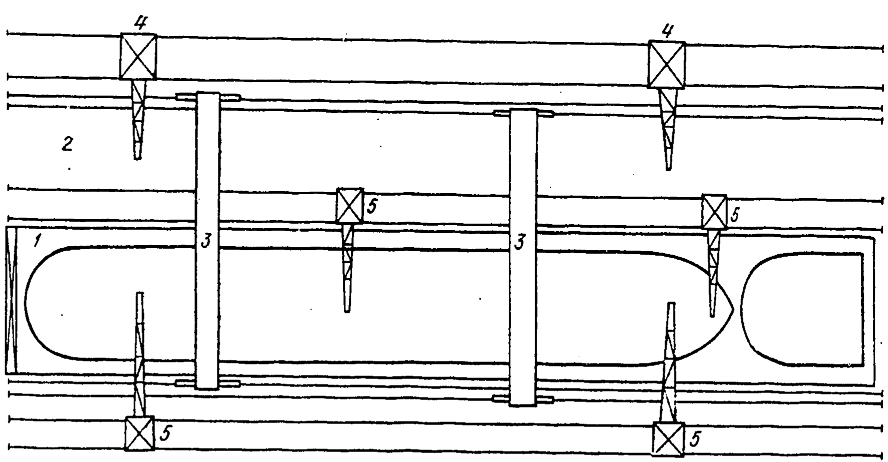


Figure 69. Layout of the crane equipment of a shipbuilding drydock for building large tankers by the modular-sectional method with a side platform for consolidation of the sections and unitized units. 1 -- shipbuilding drydock; 2 -- side platform for consolidation of sections and unitized units; 3 -- gantry crane; 4 -- 250-ton portal crane; 5 -- 80-ton portal crane

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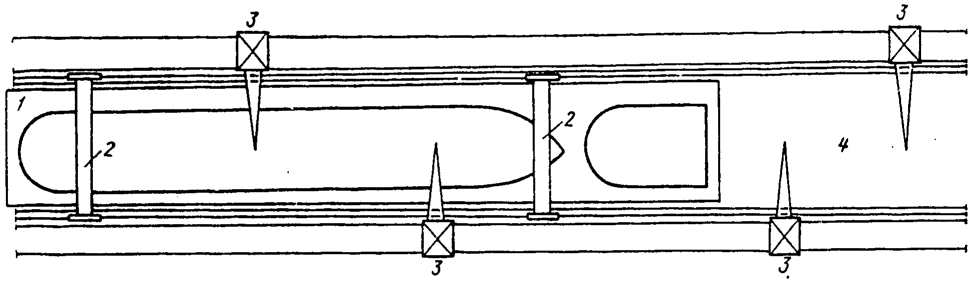


Figure 70. Layout of the crane equipment of a shipbuilding drydock for building large ships by the modular-sectional method with end platform for consolidation of sections and unitized units
1 -- shipbuilding drydock; 2 -- gantry crane; 3 --portal crane; 4 -- end platform of dock

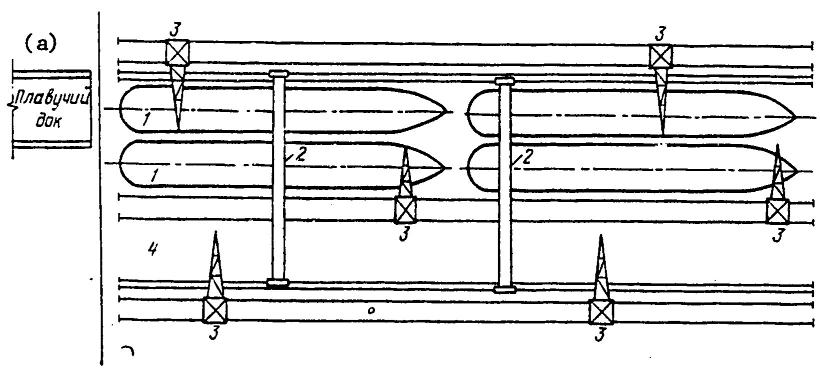


Figure 71. Layout of the cranes at an uncovered shipbuilding line for constructing ships by the modular-sectional method with lateral platform for consolidation of sections and unitized units (launching the ships using a floating transfer dock).
1 -- horizontal shipbuilding line; 2 -- gantry crane; 3 --portal crane; 4 -- lateral platform for consolidation of sections and unitized units

Key:
a. Floating dock

Table 54. Rough Description of Cranes for Equipping the Uncovered Shipbuilding Ways and Docks of New Shipyards

Класс верфи (1)	Тип стапельных мест и доков (2)	Тип крана (3)	Количество, ед. (4)	(5) Характеристика кранового оборудования			
				Грузоподъемность, тс (6)	Пролет или вылет, м (7)	Высота подъема, м (8)	Колея, м (9)
I	Сухой док с боковой площадкой для судов дедвейтом 350 000 т и более (10)	Козловой (11)	1	1500	140—160	70	—
		Козловые (11)	2	800	140—160	70	—
		Портальные (12)	—	250/120	24/50	50	15,3—20,0
			—	80/40	35/70	50	15,3
			—	80/40	25/50	50	15,3
	Сухой док с боковой площадкой для судов дедвейтом до 300 000 т (13)	Козловой	1	1200	120—130	55—60	—
		Козловые (11)	2	650	120—130	55—60	—
		Портальные (12)	—	150/100	35/50	45	15,3
			—	80/40	25/50	50	15,3
			—	60/40	30/45	50	10,5 (10,0)
	Сухой док с торцевой преддоковой площадкой для судов дедвейтом до 300 000 т (14)	Козловые (11)	2	320	69,5	45	—
		Портальные (12)	—	80/40	25/50	50	15,3
II	Горизонтальное стапельное место (при отсутствии цеха постройки блоков) (15)	Козловой	1	900	100—120	40	—
		Козловые	2	480	100—120	40	—
		Портальные (12)	—	80/50	25/40	30	10,5 (10,0)
			—	50/30	25/40	40	10,5 (10,0)
			—	50/30	22/35	40	10,5 (10,0)
	Горизонтальное стапельное место (при наличии цеха постройки блоков) (16)	Портальные (12)	—	80/50	25/40	30	10,5 (10,0)
			—	50/30	22/35	40	10,5 (10,0)
III	Горизонтальное стапельное место (при наличии цеха постройки блоков) (17)	Портальные (12)	—	50/30	22/30	28	10,0 (10,5)
			—	30/25	22/30	28	10,0 (10,5)

Key:
1. Class of shipyard
2. Type of shipbuilding ways and docks
3. Type of crane
4. Number, units
5. Characteristic of crane equipment
6. Lifting capacity, tons
7. Span, meters
8. Lift height, meters
9. Gauge, meters.
10. Drydock with lateral platform for ships with a deadweight of 350,000 tons or more
11. Gantry
12. Portal
13. Drydock with lateral platform for ships with deadweight to 300,000 tons
14. Drydock with end predock platform for ships with deadweight to 300,000 tons
15. Horizontal shipbuilding ways (in the absence of a module building shop)
16. Horizontal shipbuilding ways (in the presence of a module building shop
17. Horizontal shipbuilding ways (in the presence of a module construction shop)

Note. When designing shipbuilding ways and docks the number of portal cranes is taken according to calculation.

§37. Modern Drydocks and Equipment of Them with Cranes

The most important element of technical progress in modern shipbuilding is the construction of drydocks equipped with 1500-ton gantry cranes at shipyards being rebuilt or new ones for building large ships [40]. The process of technical improvement of drydocks is continuously connected with systematic improvement of the methods of building large ships.

Initially, in connection with an increase in the deadweight of the ships and the impossibility of building them on the operating inclined shipbuilding ways, dry building docks were built providing for the sectional and large-sectional methods of building large ships. Then in connection with the introduction of the "tandem" method of building large ships in Japan drydocks were built with two-way exit of the ships (the shipyards in Tsu of the "Nippon Kokan Kabusiki Kaysya" Company and in Oppame of the "Sumitomo Shipbuilding and Machinery" Company) with T-layout of the main shops and docks of the shipyard.

After the drydocks were built for flow-position building of large ships which are distinguished from each other by structural design and dimensions permitting organization of different versions of the flow-position building of ships.

The indicated building drydocks include, for example, the docks at the Japanese shipyards in Tiba of the "Mitsui Shipbuilding and Engineering" Company, in Koyagi of the "Mitsubishi Heavy Industries" Company, in Ariake of the "Hitati Shipbuilding and Engineering" Company and in Tita of the "Isikavadzima-Kharima Heavy Industry" Company.

The development and technical improvement of the building of drydocks for building large ships are determined by the following basic factors:

In the case of horizontal arrangement of the shipbuilding ways in the building dock, the formation of the hull from sections and, in particular, from large sections and section-modules and also the installation of the main machinery, units and other equipment are facilitated;

The shipbuilding drydock can be used for the repair and inspection of ships;

The expenditures connected with launching of the ship are reduced to the minimum;

In the countries of Northern Europe where there are no tides, a large inclined building slip of the usual type actually approaches a building dock with respect to structural design.

During the design work the dimensions of the building docks are determined considering the methods of building ships in these docks assumed in the design. Thus, for the "tandem" method of building large ships the dock length must provide for construction of the simultaneously calculated ship of maximum length and the hull part of the next ship, and for the flow-position method the dock length must provide for location of the calculated number of positions with corresponding clearances between positions, clearance between the headgate and the staging near the ship, the clearance between the end wall of the dock and the stagings near the ship. Depending on the location of installation of the shafting and rudder in the corresponding clearances, provision must be made for the required distance allowing for performance of these operations.

It is especially necessary to emphasize that when designing dry building docks, the most responsible operation is the choice of their width. This is explained by the fact that it is complicated to increase the width of the dock during rebuilding of it, for, in addition to expanding the docking basin and erecting another dock wall, it is necessary to rebuild the expensive gate and sill, and in a number of cases it is necessary to reinforce the bottom structures of the dock. The building of ships in the dock during reconstruction of it is also complicated.

As an example below a procedure is presented for calculating the dimensions of a building drydock for single-position building of ships.

The total length of the dock at the bottom L_H, reckoning from the rear end wall to the headgate when building one ship is calculated by the formula:

$$L_H = L_c + 2b_\ell + \ell_1 + \ell_2,$$

where L_c is the extreme length of the designed ship, meters; b_ℓ is the width of the stagings along the columns, meters; ℓ_1 is the clearance between the headgate and the stagings near the ship, meters; ℓ_2 is the clearance between the end wall of the dock and the stagings near the stern of the ship considering the installation of shafting and rudder, meters.

The useful width of the dock B_{use} is calculated by the formula

$$B_{use} = B_c + 2b_\ell + 2\ell_{c\ell},$$

where B_c is the extreme beam of the calculated ship, meters; b_ℓ is the width of the stagings along the course columns, meters; ℓ_{c1} is the clearance between the dock wall and the stagings considering possibility of recessing them, meters.

The width of the opening of the dock gates in the majority of cases is equal to the useful width of the dock basin at the bottom. The depth of the water in the dock is determined depending on the method of installing the ships.

Under the condition of building the ship at one location on permanent keelblocks and cribbings, the depth of the water in the dock h_B can be calculated by the formula

$$h_B = T_o + h_k + h_{Bc} + \ell_4,$$

where T_o is the extreme draft of the designed ship, meters; h_k is the height of the keelblocks, meters; h_{Bc} is the clearance under the bottom of the ship for raising over the keelblocks, meters; ℓ_4 is the amount the lateral cribbings are over the keelblocks.

When building ships by the flow position method if the ships or modules are moved from position to position, for example, on sliding ways, the depth of the water in the dock can be found by the formula

$$h_B = T_o + h_b + h_{standard} + h_{Bc},$$

where h_b is the total height of the transverse beams, wooden ties of the skids and runners, meters; $h_{standard}$ is the height of the standard side blocks above the baseline of the ship, meters.

The level of the top of the walls of a dry building dock is taken considering the level of the shipyard land. The running load on the bottom with respect to the central axis of the dock is determined by the data on the design ship. The time for draining the drydocks, for example, with 150,000 to 300,000 m^3 is taken at 2.5–5 hours, and the time for them to fill with gravity feed is 1.5–2.5 hours.

When equipping the shipbuilding ways with materials-handling units for constructing large ships, gantry cranes are widely used which, by comparison with the previously used portal cranes, have a number of advantages during transportation and installation of large sections and modules; their lifting capacity is not limited by conditions of strength and maximum load on the wheel.

The primary advantage of the gantry cranes by comparison with portal cranes is their greater capacity and simplicity in manufacture. They have broad possibilities for paired operation, they can provide not only end, but also lateral feed, they provide for maneuvering the sections suspended, they can cover the entire assembly area of the dock, and also the platforms near it and service all parts of the ship under construction with constant lift capacity.

The building docks for building large ships are equipped with high-capacity gantry cranes primarily in two configurations: two 200–600-ton gantry cranes and one 500–1500-ton gantry crane.

The building docks of shipyards located in regions with a warmer climate (primarily the shipyards of Japan) are basically equipped with two gantry cranes considering their use not only for transportation and installation at the dock, but also for consolidation of sections in the uncovered areas near the dock.

At the shipyards in regions with most severe climate (for example, Western European countries) large sections and module-sections are assembled in covered assembly-welding shops serviced by their own materials-handling equipment, and therefore the primary functions of the dock gantry crane are transportation and installation of the sections and module-sections of maximum possible weight on the shipbuilding ways of the dock.

Beginning with this fact, at the indicated shipyards the building docks are, as a rule, equipped with one high-capacity gantry crane, considering that the cost per ton of lifting capacity when equipping the dock with two gantry cranes is appreciably higher than when equipping it with one gantry crane with a lifting capacity equal to that of the two indicated cranes.

Along with the high-capacity gantry cranes, for building large ships the building docks are equipped with portal cranes for loading and installing the lightweight parts and equipment on the ships being built. The lifting capacity of these cranes is primarily within the limits of 15-120 tons.

Brief descriptions of some of the building drydocks and their gantry cranes of a number of modern shipyards in western countries are presented in Table 55 [40].

A characteristic feature of modern shipyards for flow-position building of large ships is also equipment of them with portable intermediate gates providing for dividing the docking basin considering the shipbuilding positions and exit of the ships from the last position into the water area and also construction of them with inclined bottoms.

The inclined dock bottoms are used in order to economize on capital investments, considering that large ships will be built by the flow-position method by which the ships at the positions have different degree of technical completion and the corresponding drafts (in the first position they have less draft, and in the last position, the maximum draft). The last position can be used also for dock repairs of large ships with simultaneous building of ships in the first positions. In addition, the constructed ship, as a rule, will have a trim when floating without ballast, and therefore with a horizontal bottom when lifted there will be additional pressure on the bearing structures. The presence of an incline permits avoidance or significant decrease in the indicated pressure.

A sloping dock bottom also promotes accelerated drainage of the dock.

A building dock for flow-position of large ships at the shipyard in Koyagi owned by the "Mitsubishi Heavy Industries" Company has an extraordinary structural design: in the midsection there is an additional lateral basin 19x70 meters for forming the aft part of the ship's hull. The stern of the ship built in this basin is moved transversely to the main dock where it is joined to the finished midships section assembled from large sections in the main dock.

In Japan the building dock 6 (Figure 72) which has two parts of different length and depth is provided for the new patented shipbuilding procedure [1].

The length of the dock section 1 corresponds to the length of the afterpart 4 of the ship 7. The length of section 9 of the dock is determined by the length of the midships and forward sections 8 of the ship, and it is shallower.

The aft part of the ship with superstructure 5 is constructed on a pontoon 3, and then the section of the dock 1 is filled with water through the gates 2, the pontoon with the constructed stern of the ship floats and is put in the required position for joining the stern to the midships section of the ship built in a shallower part of the dock.

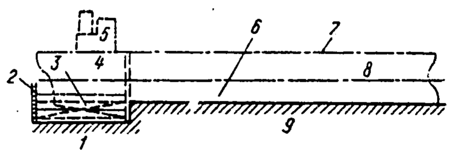


Figure 72. Building dock with two parts of different length and depth.

Table 55. Brief Descriptions of Some of the Shipbuilding Drydocks of a Number of Modern Shipyards in Foreign Countries

Country	City	Company	Drydocks: Dimensions, m: Length	Breadth	Depth	Gantry Cranes: Number, units	Distance between the crane tracks, m	Lifting capacity, tons
Great Britain	Belfast	"Harland and Wolf"	556	92.9	8.4*	1	140	800
Denmark	Copenhagen	"Burmeister and Wain"	240	38	7.25	2	–	300
Italy	Monfalcone	"Italcontieri"	350	56	8.5	2	–	300
Korea	Ulson	"Kh'yundey Construction"	600	80	–	2	140	450
France	Saint Nazer	"Chantier de L'Atlantik"	415	69.3	16.0	1	130	750
Sweden	Malmo	"Kokums Mekaniska Werkstad"	405	75	11.5	1	81.5 174	800 1500
Japan	Koyagi	"Mitsubishi Heavy Industries"	970	100	9.65–14.5	2	185	600
	Nagasaki	The same	375	56	14.0	2	–	300
	Oppama	"Sumitomo Shipbuilding and Machinery"	560	80	12.6*	2	–	300
	Sakaido	"Kawasaki Heavy Industries"	380	62	10.3	2	102	200
	Sakai	"Hitati Shipbuilding and Engineering"	400	56	12.5	2	–	200
	Tita	"Isikavadzima-Kharima Heavy Industries"	810	92	14	2	–	350
	Tsu	"Nippon Kokan Kabusiki Kaysya"	500	75	11.8	2	140	200

*Depth at sill.

§38. Selection of the Optimal Number of Shipbuilding Ways, Launching Facilities and Berths on the Outfitting Quay

The capital investments with respect to individual shops and structures for the various functional layouts and primary structures of the shipyard (the module building shops, the transfer paths and devices for transporting modules, the shipbuilding sheds with building ways, the devices for transporting the ships, launching facilities, outfitting quay and construction equipment) fluctuate within significant dimensions.

In addition to the volume of capital investments in the design of a shipyard it is necessary also to consider the technical advantages of the structures themselves (for example, the advantages of horizontal shipbuilding ways as compared to inclined ones for building ships), the effect of climatic conditions on the productivity of labor of the workers and also the expenditures on operation and maintenance of the structures. Under unfavorable climatic conditions the presence of covered slipways, the working conditions in which dictate the expediency of the performance of the maximum possible installation and outfitting operations in them when building the ship, have a large influence on the distribution of the shipbuilding operations between the building slip and outfitting periods.

With an increase in the number of building slips, the relative amount of capital investments for the versions with independent launching facilities servicing them decreases as a result of intensification of the use of these structures.

The capital investments decrease correspondingly by comparison with the versions in which launching facilities are provided which combine the functions of shipbuilding ways and launching facilities (drydocks and inclined building slips).

The usual drydocks are individual structures. In the case of adjacent location of several docks in an area some decrease in the average cost of one building slip is achieved only as a result of constructing common crane tracks, the use of group pumping stations, the construction of common coffer dams and common pit structures, more intense operation of common temporary structures during the building period, and so on.

The cost of the shipbuilding ways and launching facilities and, in particular, drydocks, is greatly influenced by local conditions, especially the geological conditions (on a rock foundation their cost is reduced significantly). When building a ship a number of operations after the forming of its hull and acquisition of buoyancy by the ship can be performed both on the shipbuilding ways and on the outfitting quay after the ship is launched. The space taken up by the ship on the outfitting quay equipped with cranes, power lines and access routes is a position equivalent to a shipbuilding way.

When the ships are brought to the maximum possible technical completion on the shipbuilding ways, the operations cycle will have the longest duration, and the number of building slips will be maximal.

The number of places on the outfitting quays and their extent for outfitting the ships afloat will be minimal in this case.

A comparison of the cost versions of shipbuilding ways and outfitting quays is made beginning with the cost of one running meter of the indicated structures.

Example cost relations for shipbuilding ways and berths on the outfitting quay are presented below with respect to individual design developments:

For class I shipyards the cost of one building slip at an uncovered drydock is 12-14 times greater than the cost of one berth when the ship is placed alongside the quay for outfitting it on the corresponding outfitting the quay with 30-ton portal cranes;

The cost of an uncovered inclined building slip with 75-ton portal cranes is two or three times higher than a berth on the outfitting quay with 30-ton portal cranes;

For a class II shipyard the cost of a horizontal building slip (if it is taken as 100% of the cost of the corresponding berth on the outfitting quay with 15-ton traveling cranes) will be the following: under an uncovered trestle equipped with 50-ton electric bridge cranes, 145%; on an uncovered platform serviced by 80-ton portal cranes, 120%; in an open area serviced by 15-ton portal cranes, 57%;

For a class III shipyard the cost of uncovered, horizontal shipbuilding ways with 30-ton portal cranes is 1.6 times greater than the corresponding berth on the outfitting quay with 10-ton portal cranes.

The presented approximate data are individual examples. They show that when designing shipyards serious attention must be given to the technical-economic substantiations of the determination of the optimal number of building slips and berths on the outfitting quay and also determination of the corresponding degree of completion of the ship before launching and its building time in the building slipways and on the outfitting quay. This permits the conclusion to be drawn that when building large transport and factory ships in uncovered drydocks and on uncovered inclined building slips, it is expedient only to form the hull, load and install the superstructures, large pieces of machinery and equipment before launching. The remaining volume of installation and outfitting operations are performed on the outfitting quay equipped with cranes with appreciably less lifting capacity than the lifting capacity of the cranes with which the shipbuilding ways are equipped.

§39. Determination of the Number and Capacity of the Cranes on the Shipbuilding Ways and Docks

When determining the optimal number and capacity of the cranes of the shipbuilding ways, it is necessary to consider that the cost of the cranes, in particular, the gantry and portal cranes, in the overall capital investments for constructing the shipyard has noticeable specific value.

The number and capacity of the cranes on the shipbuilding ways are determined beginning with the number and weight of the ship's elements provided for installation when building the ships in the building slip in accordance with the design and process of building them.

The specific number of ship elements installed on the building slips depends on the technical degree of completion of the ships before launching provided for by the building practice of the shipyard.

The number of auxiliary loads depends on the type and size of the ships and the peculiarities of the production process and organization of their construction. When calculating the number of cranes, the number of auxiliary loads can be taken on the average every 10-25% of the total number of loads.

An example calculation of the number of cranes for a building dock is presented in table 56 for the construction of four tankers a year with a deadweight of 150,000 tons by the modular-sectional method at two positions: the aft section of the ship is formed in the first position, including the engine and boiler room, and the ship is completed in the second position.

Table 56. Example Calculation of the Number of Cranes of the Building Dock when Building Four Tankers a Year with a Deadweight of 150,000 Tons Each

Грузы (1)	Масса груза, т (2)	(3) Количество грузов, ед.		(6) Продолжительность одного цикла работ крана, ч	(7) Среднее количество циклов на единицу груза	(8) Время работы крана, крано-ч			(12) Время на годовую программу, крано-ч	(13) Расчетное количество кранов, ед.
		(4) На одно судно	(5) На годовую программу			(9) на обработку единицы груза	(10) на участие в монтаже	(11) общее		
(14) Блоки надстроек, секции корпуса, механизмы и агрегаты	321—500	10	40	1,4	1,2	1,7	6,5	8,2	300	0,11
	201—320	39	156	1,2	1,3	1,56	5,0	6,56	1 020	0,36
	126—200	38	152	1,0	1,4	1,4	3,8	5,2	790	0,27
	81—125	28	112	0,8	1,5	1,2	3,0	4,2	470	0,16
	51—80	28	112	0,5	1,5	0,75	2,5	3,25	365	0,13
	33—50	29	117	0,25	1,5	0,37	2,0	2,37	275	0,09
(15) Секции, узлы и детали корпуса, механизмы и агрегаты, различное оборудование, изделия и детали	21—32	35	140	0,18	1,5	0,26	1,5	1,76	245	0,08
	11—20	36	144	0,17	1,5	0,25	1,0	1,25	180	0,06
	6—10	76	304	0,16	1,5	0,24	0,6	0,84	265	0,09
	0,05—5	6100	24 400	0,15	1,2	0,18	0,25	0,43	10 400	3,55
(16) Вспомогательные грузы, не вошедшие в весовую нагрузку судна (секции лесов, оснастка, переносное оборудование и т. д.)	11—20	10	40	0,16	1,5	0,20	0,5	0,70	30	0,01
	6—10	20	80	0,15	1,5	0,23	0,35	0,58	45	0,015
	0,05—5	700	2 800	0,14	1,2	0,17	0,15	0,32	900	0,31
(17) Итого	—	7150	28 597	—	—	—	—	—	15 315	~ 5,235

Key:
1. Loads
2. Load weight, tons
3. No of loads, units
4. Per ship
5. For the annual program
6. Crane operating cycle time, hours
7. Average number of cycles per unit load
8. Operating time of the crane, crane-hours
9. For handling a unit load
10. For participation in installation
11. Total
12. Time for the annual program, crane-hrs
13. Calculated number of cranes, units
14. Superstructure modules, hull sections, machinery and unitized units
15. Sections, subassemblies and parts of the hull, machinery and unitized units, various equipment, parts and products
16. Auxiliary loads, not entering into the weight load of the ship (staging sections, accessories and portable equipment, and so on)
17. Total

The indicated calculation of the number of dock cranes by weight categories of the ship's elements is performed by the formula

$$n_{crane} = n_{s.e} n_s (t_c n_c + t_{inst}) / \Phi_{cr} K_{cr},$$

where $n_{s.e}$ is the number of ship elements installed per ship on the dock, unit; n_s is the number of ships in the calculated annual program, unit; t_c is the cycle time of the crane operation for handling one ship component, hours; n_c is the average number of work cycles of the crane for handling one ship component, unit; t_{inst} is the average crane operating time for the installation of one ship's component, hours; Φ_{cr} is the actual (calculated) annual operating time available of the crane, hours; K_{cr} is the use coefficient of the crane with respect to time.

When performing the calculation it is assumed that 10% of the ship components weighing 0.05-5 tons are installed when outfitting the tankers afloat; the annual operating time available of the cranes for two-shift operation is 3890 hours, and the use coefficient of the crane with respect to time is 0.75.

The presented use coefficient of the crane with respect to time depends on the number of building positions, the practice and organization of the performance of materials-handling operations when building ships on the shipbuilding ways.

With single-position building of the ships on the shipbuilding ways, the value of this coefficient is smaller, and with an increase in the number of building positions, it increases.

From the data presented in Table 56 it is obvious that the calculated number of cranes is distributed as follows as a function of the weight of the ship components:

Weight of ship components, tons	No of cranes
321-500	0.11
201-320	0.36
81-200	0.43
33-80	0.22
11-32	0.15
0.05-10	3.965
Total required	5.235

With a different breakdown of the hulls into sections and a different volume of unitization of the machinery, the number of cranes can be different, but the presented data sufficiently accurately characterizes the distribution of the installed loads when building the ships, and they permit a proper solution to be found when selecting the lift capacity of the cranes for the dock and the pre-dock area. In addition, these calculations show that the high-capacity cranes can be used in minimum number and only in accordance with the requirements of the planned production process and organization of the construction of the ships. If the operations with large ship components is small in volume, it is expedient to provide for paired operation of the cranes.

When equipping the building docks with cranes it is necessary to consider that the transfer of assembly-installation operations from the building slips of the dock to the predock or near-dock areas permits a significant increase in carrying capacity and efficiency of use of the docks, that equipment of the docks with high-capacity gantry cranes is expedient and economically advantageous, where the cost benefit will be the greatest with distribution of the shipbuilding operations between the dock (uncovered) and the outfitting quay considering the loads corresponding to the capacity of the cranes.

CHAPTER XIII. MECHANIZATION AND AUTOMATION OF THE PRODUCTION PROCESSES AND TECHNICAL LEVEL OF PRODUCTION. SHOP PRODUCTION CONTROL HARDWARE

§40. Basic Principles of the Mechanization and Automation of Production Processes and Shipyard Shop Production Hardware

The mechanization of production is the process of replacing manual labor by machines. This is the process of systematic improvement of the production techniques and equipment, beginning with the operations in which the technical and economic expediency of replacing manual labor by machines exists before encompassing the maximum possible number of operations in the production process by mechanical labor, retaining direct participation of man in the control of the machines and monitoring of their operation [8].

Automation of production is the mechanical production phase in which the production process control functions are performed by various automated devices, and man does not participate directly in them.

Automation of production is a continuous process running from partial automation to all-around automation, and then to complete automation.

Partial automation is the phase of automation of production in which the individual basic and auxiliary operations of the process are performed automatically.

All-around automation is the automation in which all of the basic and auxiliary operations are performed by automatic machines and devices with a common control system. Complete automation is the phase of automation of production in which the system of automatic machines performs all operations of the production process, including the selection of the operating conditions insuring the best indices under the given conditions without direct participation of man.

When resolving the problems of the mechanization and automation of production processes and the technical equipment of the shipyard shop production facilities as a whole, we are guided by the following basic principles:

The scale and level of mechanization and automation of the production processes and the technical level of production as a whole must correspond to the volume of production output and insure the requirement cost benefit;

The level of technical equipment of production must insure a significant increase in productivcity of labor, it must improve the quality of production output, decrease the volume of heavy physical operations in all phases of building the ships, reduce the manual labor and operations harmful to human health to a minimum;

The mechanization and automation of production processes and the technical equipment of the shop production as a whole are realized on the basis of advanced technological processes and flow production, the organization of specialized production facilities and maximum possible transfer of labor-consuming installation and outfitting operations from the uncovered areas to the shops;

Broad application of production control hardware on the flow lines;

The application of partially unitized, nonstandardized equipment for mechanization of the materials-handling operations and use of unitized transport, joining and towing means for mechanization of the transport and moving operations of the large sections, modules and ships as a whole.

Along with mechanization and automation of the production operations which are provided by the selected calculated production equipment, when developing the shipyard shop designs a great deal of attention is given to mechanizing the materials-handling operations.

Thus, in the hull platers shops, by one of the possible versions, the mechanization of materials-handling operations, in addition to electric bridge cranes, is realized using various types of roller conveyors, loaders, stackers, transfers, and so on. The sheet steel and parts are moved by roller conveyors, sorters, loaders and roller carriers, and the rolled section and parts, by roller conveyors, transfers and stackers.

The measuring and marking machines and the gas and gas-electric cutting machines are equipped with special stands in the form of floor layout frames and trestles on which the indicated machines are moved.

The section for mechanical cutting of sheet parts is equipped with drive roller conveyors and plates with roller bearings.

The makeup of the sheet parts fed along the roller conveyor lines into packages and containers is accomplished by a special sorter-loader and electric bridge cranes, and the makeup of parts made of rolled section into multitier devices is also accomplished by special sorter-loaders.

The containers and packages are transferred to the hull parts storage area by electric bridge cranes.

The level of mechanization and automation of the production processes in the assembly-welding shops, just as in the other shipyard shops is taken as a function of their effectiveness for the given calculated program of the shop and the series nature of building the ships.

Along with the mechanization and automation of the production operations provided for by the corresponding equipment selected in accordance with the calculation, a great deal of attention is given to the mechanization of the materials-handling and assembly operations of the flow lines making the subassemblies and sections used for the optimal volume of production.

For the indicated volume of production, the flow lines for making the subassemblies are equipped with assembly units, rotary tables, self-propelled sheet stackers, various types of loaders, roller conveyors, self-propelled portal sheet stackers, units for the assembly and welding of panels and for automatic installation and tack welding of framing. An all-around mechanized flow line is used to manufacture the framing.

The flow lines for manufacturing the sections are equipped with mechanized stands and portable stand-frames, beds, aligning and fluxing beams, units for stacking bent sheets, gantries for the welding equipment, special transport units, manipulators, and so on.

Along with using cranes of different capacity, the creation of mechanized transport systems both for longitudinal and transverse movement of the ships (modules) during flow-position construction of them has special significance in equipping the shipyards with means of mechanizing the materials-handling operations.

The mechanized transport means include, for example, self-propelled trains for longitudinal movement of the ships made up of rail type building trolleys with a capacity of 200 or 320 tons each and a total capacity of up to 20,000 tons or more, and for transverse movement of the ships, transporters with a capacity of up to 12,000 tons.

In a self-propelled train the hydraulic jacks of the building dollies are connected by a united centralized system which offers the possibility of reducing the calculated coefficient of nonuniformity of loading from 1.5-1.6 to 1.3 and the total weight of the train by 15-20% by comparison with the hydraulic jacks of the train dollies having individual drive. Recently the indicated mechanized transport systems for longitudinal movement of the ships have been used when building them not only on horizontal shipbuilding ways located in the shipyard area, but also on large building docks.

In mechanizing the materials-handling operations for building ships on the shipbuilding ways, equipment of them with small-capacity lifts, for example, elevators and portable cranes, has great significance.

The cranes and the floor type materials-handling devices provided for in the shipyard design for mechanization of the materials-handling operations are not excluded, and they complement each other.

On the modern level of development of shipbuilding when developing the designs the highest level of mechanization and automation of the production processes and technical level of production are assumed in the production operations such as straightening, cleaning and priming the steel (65-80 and 0.70-0.85 respectively), machining the hull parts (65-70 and 0.65-0.80), assembly and welding of sections and panels (60-70 and 0.70-0.80). In the assembly-installation and outfitting operations, for example, for assembly and installation of modules and the building slip operations, the level of mechanization and automation of the production processes and the technical level of production are lower (45-55 and 0.60-0.70).

§41. Determination of the Level of Mechanization and Automation of Production Processes and the Technical Level of Production

The consolidated determination of the level of mechanization and automation of production processes in all branches of machine-building, including shipbuilding, are carried out by the united procedure of the State Committee on Automation and Machine-building [11], which permits determination of the parameters characterizing the level of mechanization of labor both for the designed, newly constructed or rebuilt and the operating shipyards, shops, sections and work places. The following system of basic indices is adopted here: the degree to which the workers are encompassed by mechanized labor, the degree of mechanized labor in the overall labor expenditures, the level of mechanization and automation of production processes.

When developing the designs for shipyards, their shops and production sections considering the characteristic features of the shipbuilding operations, provision is made for mechanized manual production, completely mechanized production and all-around mechanized production. The initial data are the data from the calculations for the shop or section on the amount of equipment, the number of production and auxiliary workers and also specialization of the production and materials-handling equipment and the list of manual, mechanized tools.

The overall degree to which the workers are encompassed by mechanized labor C is defined as the sum of the indices of the degree to which the workers are encompassed by mechanized labor C_{mech} and the degree to which the workers are encompassed by mechanized manual labor $C_{mech.man}$, that is,

$$C = C_{mech} + C_{mech.man}.$$

The degree to which the workers are encompassed by mechanized labor C_{mech}, %, is calculated by the ratio of the number of workers performing work by the mechanized method to the total number of workers

$$C_{mech} = (P_{mech}/(P_{mech}+P_{mech.man}+P_{man}))100 = (P_{mech}/P)100,$$

where P_{mech} is the number of workers performing work by the mechanized method; $P_{mech.man}$ is the number of workers performing work using manual mechanized tools; P_{man} is the number of workers performing manual labor; P – the total number of workers.

The index C_{mech} quantitatively describes the mechanization, but it does not reflect its qualitative aspect; therefore it must be considered together with other indices.

The degree to which the workers are encompassed by mechanized manual labor $C_{mech.man}$ in percentages is determined by the ratio of the number of workers performing work with the application of manual mechanized tools to the total number of workers employed in the given section,

$$C_{mech.man} = (P_{mech.man}/P)100.$$

The degree of mechanized labor in the overall labor expenditures Y_{mech} is calculated by the total of the indices of the level of mechanized labor $Y_{mech.\ell}$ and the level of mechanized-manual labor $Y_{mech.man}$, that is,

$$Y_{mech} = Y_{mech.\ell}+Y_{mech.man}.$$

The degree of mechanized labor in the overall labor expenditures $Y_{mech.\ell}$ in percentages is found by the ratio of the time of mechanized labor to the total process time

$$Y_{mech.\ell} = (T_{mech.p}/(T_{mech.p}+T_{mech.man}+T_{man}))100,$$

where $T_{mech.p}$ is the mechanized labor time in the process; $T_{mech.man}$ is the mechanized manual labor time when using manual mechanized tools; T_{man} is the manual labor time in the process.

For determination of $Y_{mech.\ell}$ on the whole for the shop or section, the following approximate formula can be used:

$$Y_{mech.\ell}=(\Sigma P_a K/(P_{mech}+P_{mech.man}P_{man}))100=(P_{mech}K/P)100,$$

where P_a is the number of workers in all shifts at the given work place employed in mechanized labor: $P_{mech}=\Sigma P_a$ is the number of workers in all shifts in the shop (in the section) engaged in mechanical labor; K is the mechanization coefficient.

The degree of mechanized-manual labor $Y_{mech.man}$ in the overall labor expenditures is defined by the formula

$$Y_{mech.man} = (\Sigma P_{a\ man}U/P)100,$$

where $P_{a\ man}$ is the number of workers in all shifts in the given work place performing work by manual mechanized tools; U is the coefficient of simplest mechanization.

The index $Y_{mech.man}$ gives a characterization of the direction of operations with respect to mechanization and automation of the production processes. However, it does not include the productivity of the equipment or multimachine tool servicing; therefore its value is low.

This is considered in the index of level of mechanization and automation of production processes Y_p which must be considered together with the first two indices C and Y_{mech}.

The total level of mechanization and automation of the production processes is found by the formula

$$Y = Y_p + Y_{simp},$$

where Y_{simp} is the level of simplest mechanization.

The value of Y_p is calculated by the ratio of the reduced expenditures of time of the machine processes to the total reduced expenditures by the formula

$$\underset{(1)}{У_п} = \frac{\sum P_a K M П}{\sum P_a K M П + \sum P_a (1 - K) + \underset{(2)}{P_{м.р}} + \underset{(3)}{P_р}} 100.$$

Key: 1. p; 2. mech.man; 3. man

Since

$$\sum P_a (1 - K) + \underset{(1)}{P_{м.р}} + \underset{(2)}{P_р} = P \left(1 - \frac{\overset{(3)}{У_{м.т}}}{100}\right),$$

Key: 1. mech.man; 2. man; 3. mech.ℓ

then

$$\underset{(1)}{У_п} = \frac{\sum P_a K M П}{\sum P_a K M П + P \left(1 - \frac{\overset{(2)}{У_{м.т}}}{100}\right)} 100 = \frac{\sum P_a K M П}{p'} 100$$

Key: 1. p; 2. mech.ℓ

(p' is the provisional notation for the denominator of the formula). Here M is the service coefficient or the multimachine tool factor expressing the number of units of equipment serviced by one worker. When servicing the equipment by several workers it is less than one; П is the equipment output capacity coefficient.

In addition to the quantitative ratio of mechanized and manual labor the index Y_p also reflects the qualitative aspect of mechanization giving rise to increased productivity of labor as a result of the application of improved machinery and multimachine tool servicing.

The value of Y_{simp} is determined by the ratio of the reduced expenditures of time of mechanized-manual processes to the total reduced expenditures of time by the formula

$$\underset{(1)}{У_{пр}} = \frac{\sum \overset{(2)}{P_{ар}} U П}{\sum P_a K M П + P \left(1 - \frac{\overset{(3)}{У_{м.т}}}{100}\right)} 100,$$

Key: 1. simp; 2. a man; 3. mech.ℓ

where

$$P = P_{mech} + P_{mech.man} + P_{man} \cdot$$

Thus, the total level of mechanization and automation of the production process can be expressed by the formula

$$\underset{(1)}{У} = У_{п} + \underset{(2)}{У_{пр}} = \frac{\sum P_a KM\Pi + \sum \overset{(3)}{P_{ap}} U\Pi}{\sum P_a KM\Pi + P\left(1 - \frac{У_{м.т}^{(4)}}{100}\right)} 100.$$

Key: 1. p; 2. simp.; 3. a man; 4. mech.ℓ

The discussed system of three indices of level of mechanization and automation of production processes, that is, the degree to which the workers are encompassed by mechanical labor, the mechanization of labor in the overall labor expenditures, mechanization and automation of production processes will permit the following:

Estimation of the state of mechanization and automation of production and discovery of reserves to improve the productivity of labor;

Comparison of the levels of mechanization (automation) used in the design with the level of mechanization of advanced shipyards, shops and sections and also the branches as a whole;

Comparison of the levels of mechanization of the corresponding facilities (or the versions developed in the design) by periods and determination of the variation in the state of mechanization and direction of further improvement of the production processes.

When designing the shipyard shops the calculations of the indices of the level of mechanization and automation of the production processes are performed in two steps: first the initial data for the calculation are determined, and then the calculations themselves are made (Table 57, 58).

The level of mechanization and automation of the production processes as a whole for the shipyard is also calculated in the table analogous to the table for calculating the level of mechanization with respect to the shop. Instead of sections, the shops are taken into account, and instead of the nature of operations, the basic and auxiliary production facilities of the shop, the data on which are summed for each shop.

The coefficients presented in the formulas for calculating the indices of the level of mechanization and automation of the production processes are determined as follows. The coefficient of mechanization K expresses the ratio of the time of mechanized labor to the total expenditures of time on the given equipment or the work place; it is always less than one or equal to one.

The coefficient of output capacity of the equipment Π characterizes the ratio of the labor consumption of manufacture of the part on universal equipment with the lowest output capacity (taken as the base) to the labor consumption of the manufacture of a part on the existing or designed equipment. The universal equipment with respect to all types of production is taken as the initial equipment having an output capacity provisionally taken as one. By comparison with the universal equipment, all forms of equipment have higher coefficients Π; the coefficient Π for the manual mechanized tools and the given simplest machinery is provisionally also taken equal to one.

The approximate mean values of the coefficients K and П for certain forms of special equipment of the main shipyard shops are presented in Table 59.

The coefficient of simplest mechanization U characterizes the proportion of the time of mechanized-manual labor in the overall work time of a worker using a manual mechanized tool. It is determined depending on the use time of the driven simplest machinery and manual mechanized tools per shift by the worker.

Approximate Values of the Coefficient U

Use time of tools per shift, hours	When using driven simplest machinery and manual mechanized tools	For manual welding and manual gas cutting
1	0.04	0.07
2	0.08	0.14
3	0.12	0.21
4	0.16	0.28
5	0.22	0.35
6	0.26	0.42
7	0.3	0.5

The introduction of mechanization and automation into shipbuilding is one of the component parts of improving the technical level of production. Therefore, along with the presented definition of the level of mechanization and automation of production processes in shipbuilding, the index of technical level of production is used, by which we mean the aggregate index numerically characterizing the degree of improvement of the engineering and technology of performance of the production processes provided for by the design.

For determination of the technical level of production, five basic states of the technical level are assumed for all forms of production characterized by the following factors:

0.200 corresponds to the lowest degree of improvement of the equipment and practice at the present time;

0.400 and 0.600 corresponds to production facilities in which the productivity of labor as a result of the application of improved engineering and technology will be approximately 120 and 160%, respectively, with respect to the output capacity for the 0.200 level taken as 100%;

0.80 corresponds to all around mechanized production in which the productivity of labor is approximately 250% with respect to the output capacity for the 0.200 level;

1.00 corresponds to automated production.

The actual values of the indices of technical level of production in the section, shop or shipyard design process are determined on the basis of calculations performed by the existing corresponding procedure and assumed in designing the production equipment and process.

During the design process, the technical level of production is calculated in the following sequence.

The types of operations as the arithmetic mean of all of the estimates obtained with respect to individual determinants is found by the formula

$$D_j = \frac{A_1 + A_2 + \cdots + A_m}{m},$$

where D_j is the technical level of the j-th type of operation; A_1, A_2, ..., A_n are the numerical values of the estimates of the technical level with respect to each determinant of the j-th type of operation (by the existing procedure); m is the number of determinants of the j-th type of operations by which the estimates are made.

The technical level of production of the shop or section (type of production facility) is calculated by the formula

$$Y_{Ti} = 0{,}01 \sum_{j=1}^{n} D_j g_j = 0{,}01\,(D_1 g_1 + D_2 g_2 + \cdots + D_n g_n),$$

where Y_{Ti} is the technical level of production of the shop or section (type of production facility); D_1, D_2, ..., D_n are the numerical values of the technical level of the types of operations calculated by the above-presented formula; g_1, g_2, ..., g_n are the specific values of the types of operations in the overall volume of shop or section operations (with respect to labor consumption), %; n is the number of types of operations in the shop or in the section.

The technical level of the shipyard as a whole as the weighted mean value of the technical levels of production with respect to individual shops and sections is defined by the formula

$$Y_T = 0{,}01 \sum Y_{Ti} P_i,$$

where Y_T is the technical level of production of the shipyard; Y_{Ti} is the technical level of the production of individual shops or sections of the shipyard; P_i is the specific value of the production of individual shops or sections in the overall volume of shipyard operations (with respect to labor consumption), %.

During the design work, the calculation of the technical level of the types of operations and production of the shop is performed in tabular form (Tables 60, 61).

Table 57. Determination of the Initial Data for Calculating the Level of Mechanization and Automation of the Shop Production Processes

Участки	(19) Основное и вспомогательное оборудование		(20) Количество рабочих, чел.							Коэффициенты (25)				Коэффициенты (25)			
						(21) С учетом всех смен											
						(22) в том числе рабочих											
						(23) использующих		(24) занятых									
	Наименование	Количество	Профессия	В наибольшую смену	Всего Р	машины и механизмы $Р_м$ (P_a)	ручной механизированный инструмент $Р_{м.р}$ (P_{ap})	ручным трудом $Р_р$	из них тяжелым ручным трудом $Р_{р.т}$	механизации $К$	простейшей механизации U	$Р_а К$ = гр. 7 × гр. 11	$Р_{пр} U$ = гр. 8 × гр. 12	обслуживания М	производительности оборудования П	$Р_а КМП$ = гр. 13 × гр. 15 × гр. 16	$Р_{ар} UП$ = гр. 14 × гр. 16
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Key:
1. Section
2. Name
3. Quantity
4. Occupation
5. In the largest shift
6. Total P
7. Machinery and machines P_{mech} (P_a)
8. Manual mechanized tools $P_{mech.man}$ ($P_{a\ man}$)
9. Manual labor P_{man}
10. Of these workers, those engaged in heavy manual labor, $P_{man\ \ell}$
11. Mechanization K
12. Of simplest mechanization, U
13. $P_a K$=col. 7 × col. 11
14. $P_{simp} U$=col. 8 × col. 12
15. Of servicing M
16. Of output capacity of the equipment П
17. $P_a KМП$=col. 13 × col. 15 × col. 16
18. $P_{a\ man} UП$=col. 14 × col. 16
19. Basic and auxiliary equipment
20. No of workers, men
21. Considering all shifts
22. Including workers
23. Using
24. Engaged in
25. Coefficients

Table 58. Calculation of the Indices of the Level of Mechanization and Automation of Shop Production Processes

Участки	Характер производства	(19) Степень охвата рабочих механизированным трудом, %						(22) Уровень механизированного труда в общих трудозатратах, %					(23) Уровень механизации и автоматизации производственных процессов, %				
		(20) Механизированное производство			(21) Механизированное ручное производство			(20) Механизированное производство		(21) Механизированное ручное производство			(20) Механизированное производство		(21) Механизированное ручное производство		
		$P_м$	P	$C_м = \frac{гр. 3}{гр. 4} 100$	$P_{м.р}$	$C_{м.р} = \frac{гр. 6}{гр. 4} 100$	$C = гр. 5 + гр. 7$	$\sum P_a K$	$Y_{м.т} = \frac{гр. 9}{гр. 4} 100$	$\sum P_{ap} U$	$Y_{м.р} = \frac{гр. 11}{гр. 4} 100$	$Y_м = гр. 10 + гр. 12$	$\sum P_a KМП$	$Y_п \overset{(a)}{=} \frac{\sum P_a KМП}{\sum P_a KМП + P\left(8 - \frac{Y_{м.т}}{100}\right)^{(b)}} 100$	$\sum P_{ap} UП$	$Y_{пр} \overset{(a)}{=} \frac{\sum P^{(b)}_{ap} UП}{\sum P_a KМП + P\left(1 - \frac{Y_{м.т}}{100}\right)^{(c)}} 100$	$Y = гр. 15 + гр. 17$
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Key:
1. Section
2. Nature of production
3. P_{mech}
5. C_{mech}=(col. 3/col. 4)100
6. $P_{mech.man}$
7. $C_{mech.man}$=(col. 6/col. 4)100
8. C=col. 5 + col. 7
9. $\Sigma P_a K$
10. $Y_{mech.\ell}$=(col. 9/col. 4)100
11. $\Sigma P_{a\ man} U$
12. $Y_{mech.man}$=(col. 11/col. 4)100
13. Y_{mech}=col. 10 + col. 12
14. $\Sigma P_a KМП$
15. (a) = p; (b) = mech.ℓ
16. $\Sigma P_{a\ man} UП$
17. (a) = simp; (b) = a man; (c) = mech.ℓ
18. Y=col. 15 + col. 17
19. Degree to which the workers are encompassed by mechanized labor, %
20. Mechanized production
21. Mechanized manual production
22. Level of mechanized labor in overall expenditures of labor, %
23. Level of Mechanization and automation of production processes, %

Table 59. Approximate Mean Values of the Coefficients K and Π for Certain Types of Special Equipment of the Main Shipyard Shops

Equipment	Coefficient K			Coefficient Π		
	Without mechanization of auxiliary processes	With partial mechanization of auxiliary processes	For all-around mechanization	Without mechanization of auxiliary processes	With partial mechanization of auxiliary processes	With all-around mechanization
1	2	3	4	5	6	7
Drawing machine of the "Start" type with programmed control for drawing the loftings	-	0.75	0.9	-	12.0	12.4
Drawing machine of the "Vega" type with programmed control for mechanized preparation of copies of the drawings by the photographic method for gas cutting machines	-	0.5	0.9	-	12.4	12.7
Photoprojector type EDI-457 for making full-scale accessories	0.8	-	-	2.5	-	-
Stationary shot blasting unit for cleaning steel	-	0.6	-	-	6.0	-
Flow line for cleaning and priming steel	-	0.8	0.9	-	12.0	12.0
Multiroll sheet straightening machines for straightening sheets with a thickness:						
from 4 to 14 mm	0.15	0.25	0.6	1.6	2.5	3.0
from 11 to 30 and from 12 to 40 mm	0.2	0.35	0.7	3.0	4.5	6.0
from 18 to 50 mm	0.25	0.5	0.8	3.0	4.5	6.0
Horizontal presses of the "Bul'dozer" type for straightening rolled section	0.1	0.2	0.75	2.8	3.2	5.0
Unit for photoprojection marking	0.35	0.6	-	1.3	1.6	-
Measuring and marking machine with programmed control	-	-	0.7	-	-	4.0
Eccentric marking press	0.3	-	-	2.5	-	-
Automated marking machine with programmed control	-	-	0.7	-	-	3.0
Stationary machine for thermal cutting of sheet metal, "Kristall" type with programmed control	0.5	0.8	0.9	2.0	3.0	4.5
The same, three-portal "Baltika" type with programmed control	-	0.9	0.9	-	2.0	5.0

[Table 59, contd]

1	2	3	4	5	6	7
The same with photocopying servo system of the "Zenit" type:						
for machining a single sheet	0.5	0.8	0.8	1.2	1.4	2.5
for machining two sheets	-	-	0.8	-	-	4.5
Gas cutting machines for cutting by a master copy types ASSh-1 and ASP-1	-	0.6	-	-	1.4	-
N-633 type press-shears	0.15	-	-	1.3	-	-
Guillotine shears type NB-475	0.2	0.50	-	2.0	4.0	-
Press type PGA-200/250 with programmed control for cutting and marking section	-	0.8	-	-	5.7	-
Press type PGA-400 with programmed control for machining section	-	0.7	-	-	5.0	-
Three-roll bending machine:						
folding type	0.2	0.4	0.7	2.2	4.0	4.5
closed type	0.2	0.4	0.65	2.2	3.8	4.5
Hydraulic, vertical, open type presses with a force, tons:						
to 400	0.2	0.45	0.85	2.8	4.0	5.5
from 400 to 800	0.2	0.5	0.8	2.5	3.8	5.0
above 800	0.15	0.5	0.75	2.2	3.5	4.5
LGS-2 and LGS-3 sheet bending machines	0.3	0.45	0.7	2.5	3.0	3.5
Vertical guillotine type sheet bending presses	0.2	0.4	0.6	2.2	2.8	3.0
"Bul'dozer" type horizontal section bending press	0.1	0.2	0.75	2.8	3.2	4.5
Press for template-less bending with programmed control, type SPG-3	-	0.75	0.8	-	3.5	4.0
ADS-1000-4 and TS-17 MU automatic welding for submerged arc welding of subassemblies and sections with sheet steel thickness, mm:						
from 4 to 12	0.4	0.5	-	4.5	5.0	-
from 12 to 30	0.4	0.6	0.7	5.0	5.0	6.0
More than 30	0.45	0.7	-	5.0	6.0	-
Automatic welders for carbon dioxide shielded welding of steel subassemblies and sections	0.2	-	-	3.0	-	-
Automatic welders for butt submerged arc welding when building modules and forming the hulls of ships on the shipbuilding ways, types ADS-1000-4, TS-17MU, ADS-500, with sheet steel thickness, mm:						
to 30	0.3	0.5	-	4.5	5.0	-
More than 30	0.4	0.55	-	5.0	7.0	-

[Table 59, contd]

1	2	3	4	5	6	7
The same, automatic welders for electro-slag welding of installation joints with steel thickness, mm:						
to 30	0.5	-	-	4.0	-	-
More than 30	0.55	-	-	7.0	-	-
The same, automatic welders for vertical automatic welding with forced forming of the weld in carbon dioxide	0.2	-	-	4.0	-	-
Machine tool for machining ship foundation	-	0.6	-	-	2.5	-
Portable milling machines, types GF-30 and SPF-1	0.5	-	-	2.8	-	-
Portable drills with electromagnetic fastening, types SPS-32 and SPS-50	0.5	-	-	2.0	-	-
Portable LR-203 boring machines for boring the stem and stern posts	0.6	-	-	1.2	-	-
Machine tool for cutting and trimming tubes with abrasive disc, type SRZT-1m	0.4	0.6	-	3.0	3.5	-
Gas-electric pipe cutter for cutting pipe 40-377 mm in diameter	-	0.6	0.7	-	3.5	4.0
Pipe cutting-off machine	0.5	-	-	2.5	-	-
HFC unit for annealing copper and copper-nickel pipe 14-820 mm in diameter	-	0.6	0.7	-	1.5	1.8
Mechanized sand filling unit with electric vibrator for pipes of all sizes	-	0.6	-	-	2.0	-
Pipe bending machines:						
STG-1m	0.2	0.3	-	1.2	1.6	-
STG-2s	0.2	0.4	0.5	1.1	1.6	2.0
STG-3SA	0.2	0.4	-	1.2	2.6	-
Pipe bending machine with programmed control:						
STGP-2	-	0.6	-	-	4.0	-
STGP-3	-	0.6	-	-	5.0	-
Pipe bending machine for bending pipe with HFC heating:						
TGSV-1	0.3	0.4	-	3.0	3.5	-
TGSV-2	0.3	0.4	-	3.2	4.0	-
Machine tool for cutting off and machining holes in pipe (diameter of the opened holes 10-220 mm, machined pipe diameter 45-810 mm)	0.4	0.5	-	1.2	1.5	-
Hydraulic horizontal presses types PG-50 and PG-100	0.4	-	-	3.0	-	-

[Table 59, contd]

1	2	3	4	5	6	7
Machine tool for beading pipe	0.4	0.5	-	2.5	3.0	-
Machine tool for winding pipe with asbestos cord for insulation of straight and bent pipe at an angle of 45°, to 125 mm in diameter	0.4	-	-	3.0	-	-
Resistance welding machine:						
roll	0.4	0.5	0.6	3.5	4.0	5.0
spot	0.25	0.35	0.5	3.5	4.0	5.0

Table 60. Determination of the Technical Level of Types of Shop Operations

Шифр и наименование вида работ (1)	Шифр и наименование определителя (2)	Численное значение технического уровня по определителю A_j (3)	Численные значения технического уровня вида работ $D_j = \frac{A_1+A_2+\cdots+A_m}{m}$ (4)

Key:
1. Code and name of type of operation
2. Code and name of determinant
3. Numerical value of the technical level with respect to the determinant A_j
4. Numerical value of the technical level of type of operations

Table 61. Determination of the Technical Level of Shop Production

Виды работ (1)	Шифр работ (2)	Технический уровень вида работ D_j (3)	Удельное значение вида работ от общего объема работ цеха g_j, % (4)	Средневзвешенная величина $D_j g_j$ (5)
Технический уровень производства цеха	(6) $У = 0{,}01 \sum_{j=1}^{n} D_j g_j$			

Key:
1. Types of operations
2. Operations code
3. Technical level of type of operations D_j
4. Specific value of type of operation in the total volume of shop operations g_j, %
5. Weighted mean value of $D_j g_j$
6. Technical level of shop production

Table 62. Approximate Level of Mechanization and Automation of Production Processes and Technical Level of Production of the Basic Shipyard Shops

Shops	Class of shipyard	Level of mechanization and automation of production process, %	Technical level of production
1	2	3	4
Hull platers:			
Section for preliminary straightening, cleaning and priming of steel	I-II	80	0.85
	III	75	0.80
	IV	70	0.75
	V	65	0.70
Hull platers sections	I-II	75	0.80
	III	70	0.75
	IV	65	0.70
	V	60	0.65

[Table 62, contd]

1	2	3	4
Welding-assembly shop:			
Sections for assembling and welding subassemblies and sections	I-III	70	0.80
	IV	65	0.75
	V	60	0.70
Sections for priming and drying the ship sections	I-V	65	0.75
Shop for making structural components from aluminum-magnesium alloys	I-II	70	0.75
	III	65	0.70
Shop for making structural components from synthetic materials	I-III	65	0.70
Module-building shop	II	45	0.60
	III	50	0.65
	IV	55	0.70
Shipbuilding shed	I-II	45	0.60
	III	50	0.65
	VI-V	55	0.70
Hull fitting shop	I-II	65	0.70
	III	55	0.65
	VI-V	50	0.60
Pipe preparation	I-II	60	0.70
	III	55	0.65
	IV	50	0.60
	V	45	0.55
Woodworking	I-III	60	0.70
	IV	55	0.65
	V	50	0.60

The technical level of production for the shipyard as a whole is also calculated in a table analogous to the table for determining technical level of production with respect to the shop, in which instead of the type of operations in the "Numerical Values of the Technical Level of Type of Operations" column, we use the values for the shop, and in the column "Specific Value of Type of Operations" we write the specific value of the shop operations.

The system of indices of the technical level of production permits comparison of the technical levels with respect to the developed design with the technical levels of individual types of operations: types of production facilities and advanced operating shipyards as a whole and the best design solutions; it permits estimation of variation in state of the technical level and planning of means of further improvement of the production process. It also serves in planning the comparative estimates of the results of operating the shipbuilding enterprises.

The approximate level of mechanization and automation of production processes and the technical level of production of the main shipyard shops are presented in Table 62.

§42. Composition and Technical Data on the Means of Mechanizing Materials-Handling and Assembly Operations in the Main Shipyard Shops and Shop Production Control Hardware

In addition to various crane equipment, the shipyard shops are equipped with various means of mechanizing the materials-handling and assembly operations.

In Table 63, as an example we have the composition of the technical data for the basic means of mechanizing materials handling and assembly operations in the hull platers and assembly-welding shops at class I and II shipyards.

A hardware complex is provided to support the operative monitoring and control of the course of production in the design for the main shipyard shops in accordance with the volume and organization of production for the shipyard as a whole.

Thus, under the conditions of the automated production control system the dispatch service of the shop, just as the central dispatch service of the shipyard, is equipped with the subscriber stations of the remote data processing system based on the united system of computers which are joined by communication channels to the united system computers installed at the information computer center, and they permit organization of man-machine dialog in real time.

The hardware for controlling the shop production providing for receiving information, also includes the operative telephone communications, search signal system, call signal system, television for production purposes and, in individual cases, teletype and phototelegraphic communications. In addition, the shop services are equipped with telephones from the city telephone offices and administrative-management communications, and the shop management is connected by direct communications with the director and chief engineer. Protection and fire systems, secondary electric clocks, and so on are also installed in the shop.

Along with the general operating indices of a shop and the ASUP [automated production control system] sections, the shop production control hardware must also provide for obtaining the following information: information about the presence of the required material reserves in the storage areas; availability of the complement of production parts and products for acceptance and also the complements of parts accepted by the shop; the practical times for beginning and ending operations of the shop with respect to each process complement; the arrival of materials, parts and products at the flow lines; provision of the flow lines and work places with reports and other documents, accessories, tools and auxiliary materials; operation of the flow lines and the main, unique production equipment.

Table 63. Composition and Technical Data on the Basic Means of Mechanizing Materials-Handling and Assembly Operations in the Hull Platers and the Assembly-Welding Shops of Class I and II Shipyards

Mechanization means	Technical data	Installed unit capacity, kilowatts	Dimensions (ℓ×b×h), mm)	Unit weight, kg
1	2	3	4	5
	Hull Platers Shop			
	Section for Preliminary Straightening, Cleaning and Priming of Steel			
Roller conveyor for horizontal movement of sheet steel	Stationary, driven, for transporting sheets with maximum dimensions of 16000×4500 mm. Speed of moving the sheet 17.6 m/min	4.0	15400×4066×840	4570
The same	Stationary, driven, for transporting sheets with maximum dimensions of 16000×3200 mm. Speed of moving a sheet 17.6 m/min	4.0	15400×3450×840	4384
Roller conveyor, receiving-feeding to the roll machines	Stationary, driven for transporting sheets with dimensions to 16000×4500 mm	7.5	9480×3245×840	7115
The same	Stationary, driven, for transporting sheets to 16000×3200 mm	4.0	9480×2665×840	4889
Loader	Semiportal with electromagnetic traverse for sheet and section to 16000 mm long, sheet width to 4500 mm, useful lift capacity 20 tons	69.4	18970×5480×5775	26125
The same	Bridge with electromagnetic traverse for sheet and section to 16000 mm long, sheet width to 4500 mm, useful lift capacity 20 tons	69.4	18000×6580×5250	23460
Entry transfer for transporting rolled section	For transporting rolled section from 6000 to 16000 mm long and weighing to 1 ton	8.0	16500×9670×840	9500

[Table 63, contd]

1	2	3	4	5
	Hull Platers Sections			
Marking stand	Maximum dimensions of marked sheets 16000×3200 mm	4.0	16380×3400×840	11050
Roller conveyor for horizontal movement of sheet metal	Maximum sizes of transported sheet parts 16000×4500 mm. Speed of moving the sheets 17 m/min	4.0	15400×4066×840	4520
Two-position gas cutting machine	Maximum dimensions of machined sheet steel 16000×3200 mm	8.0	56000×4500×1550	28650
Sheet parts sorter	Bridge with electromagnetic traverse for transferring sheet parts to 16000×3200×40 mm	116.0	17600×6280×5950	36000
Belt conveyor	Stationary for transporting sheet parts. Payload 1 ton/m	7.0	57070×3510×840	39120
Unit for sorting small sheet parts	Maximum width of transported sheet parts 3200 mm	-	3010×3560×1330	2720
Sheet parts sorter-loader	With electromagnetic traverse, transfers and sorts sheet parts 16000×4500×40 mm	90.0	18100×6110×5800	23600
Manipulator for returning parts and removal of waste from the guillotine	Handles sheet parts to 10000×2400×16 mm	12.0	10000×7400×840	6820
Platform with roller supports	For feeding sheets to the guillotine	-	3600×3600×840	~1533
Transfer for transporting rolled section	For transporting rolled section to 16000 mm long and weighing to 2 tons	8.0	16500×9670×840	9600
Roller conveyor for transporting rolled section	For transporting rolled section to 16000 mm long and weighing up to 2 tons	2.0	16500×1114×880	2750

[Table 63, contd]

1	2	3	4	5
Device for multi-tier makeup of section parts	Makes up section parts to 16000 mm long. Number of tiers 3, containers in each tier 9. Container capacity 5 tons	-	Structure 16200×19600×920 Containers 16200×1624×324	53000 43000
The same	Makes up section parts to 8000 mm long. No of tiers 3, containers in each tier 9. Container capacity 2.5 tons	-	Structure 8200×15200×920 Containers 8200×1624×324	40000 30000
Stacker-loader	For transporting rolled section	22.0	8200×1624×324	16100
	Assembly-Welding Shop (Characteristic Flow Lines)			
	Flow Line for Assembly and Welding of T-Beams			
MIB-700A unit for mechanized manufacture of beams	Makes beams from 3500 mm to 16000 mm long, web height to 700 mm, weighing to 2050 kg	15.4+ 80 kV-amps	30090×6000×4530	34000
Unit for mechanized manufacture of curvilinear and rectilinear T-beams, SKT12-1	Makes T-beams from 3000 mm to 12000 mm long, web height 170-1000 mm and weighing to 1500 kg	62.0	24000×5000×5000	37000
Magnetic sheet loader	Capacity 3.2 tons	85.6	Span 17600	4800
Magnetic section loader	Capacity 3.2 tons	46.0	Span 17600	4700
Receiving or output roller conveyor	Assembly-welding structures. Speed of displacement of the cab 16.2 m/min	2.7	18400×2500×810	1550
Trolley	Assembly-welding structures. Speed of the trolley 37 m/min	5.4	10100×2500×680	3500
Thermal straightening stand	Metallic, welded structure	-	1800×3000×700	4100

[Table 63, contd]

1	2	3	4	5
Holder for holding billets for the MIB-700A beam making line	Metal, welded structure	–	13000×1000×600	3400
Holder for the T-beams for the SKT12-1	Metal, welded structure	–	16250×2300×2250	5060
Container for the finished product	The same	–	16500×1000×600	4700
	Flow Line for Assembly of Brackets and Knees			
Semitraveling loader	Capacity 1000 kg. Speed of movement 20 m/min. Lift speed 8 m/min	2.08	7330×2970×6000	2200
Machine tool for assembling brackets	Dimensions of the assembled brackets: length 800-3000 mm; width 80-300 mm; height 300-1600 mm. Bracket weight 30-500 kg. Force of pumping mechanism 2800 kg. Speed of displacement 0.736 m/min	1.04	4200×4400×3250	4300
Bracket welder	Weight of welded brackets to 500 kg. Welding speed 8-32 m/hr	3.0 (without welding equipment)	8000×2500×3027	2950
Container for small sub-assemblies and parts	Self-dumping. For transporting structural components to 1100×700 mm. Capacity 1000 kg	–	1200×900×800	195
Container for medium and large sub-assemblies and parts	In the form of a frame pallet with sides 300 mm high. For transporting structural components to 3000×1500 mm. Capacity 5000 kg.	–	3100×1700×300	570

[Table 63, contd]

1	2	3	4	5
	Flow Line for Assembly and Welding of Bottom Sections			
Machine for installing and tack welding framing	Transports and installs framing 3.5x1.2x0.2 to 16.0x3.2x0.5 m. Useful capacity 10 tons. Speed of movement of the portal cruising 20 m/min; installation 0.1 m/min. Speed of movement of the trolley: cruising 25 m/min; installation 0.1 m/min	5.2	20620x5500x10720	39000
Device for clamping a panel to a frame	With pump. Clamping force 15 tons	1.9	1440x1190x650	670
Mechanized band for assembly and welding of bottom sections	With transfer. For assembly and welding of sections with maximum dimensions of 13.5x16.0 m	-	82800x15200x650	192000
Transfer ℓ=12.0 m	Moves sections 3.2x16.0 to 12.8x16.0 m and weighing to 100 tons. Speed of displacement of sections 14 m/min	2.2	12720x1120x750	1220
Transfer ℓ=38 m	Moves panels 3.2x16.0 to 12.8x16.0 m and weighing to 100 tons. Speed of displacement 14 m/min	2.2	38725x1120x750	2930
Machine for tack welding cross framing	Self-propelled, with two trolleys, two platforms each. Maximum height of tack welded framing of sections 3600 mm. Speed of movement of the machine 40 m/min. Useful capacity of one platform 160 kg	5.3	20150x6440x8100	28800
Machine for clamping a panel to framing and tack welding the framing	Semitraveling, self-propelled, with two trolleys and pumping station. Maximum height of the received and tack welded framing 3600 mm. Speed of movement of the machine 40 m/min and the trolley 24.5 m/min. Force of the clamping machine 11.5 tons	8.0	20150x6444x8100	30800

[Table 63, contd]

1	2	3	4	5
	Flow Line for Assembly and Welding of Side Sections			
Semitraveling sheet stacker with vacuum traverse	Transports and stacks sheets 6.0×1.8 to 16.0×3.2 m. Capacity 12 tons. Speed of displacement of the semiportal: cruising 20 m/min, installation 0.1 m/min	5.2	19470×15050×9200	41000
Universal mechanized jig with flux troughs	Maximum overall dimensions of assembled panels 16.0×16.0 m. No of beams with flux troughs 4. Speed of displacement of the beams 1.7 m/min. Pressure of the compressed air in the flux trough phases 1.5-4.0 atmospheres	83.8	17500×13400×2320	45600
Unit for welding cross framing to the plating	Part of the free standing, 500 kg jib crane and container for two semiautomatic welders	5.0	5700×2800×4650	1804
Machine for installing framing	Transports and installs section framing 1.0×0.1×0.2 to 16.0×0.35×1.0 m. Bulb bar to 16 m long from Nos 10 to No 40. Capacity 4 tons	14.1	19760×5400×9650	26600
Frame-stand	For assembly and welding of curvilinear sections weighing to 80 tons from sheets 6.0×1.8 to 16.0×3.2 m	-	13000×19000×1930	77200
Device for clamping the panel to the framing	Force 5000 kg. Displacement speed 8 m/min, bearing beam 12 m/min	1.2	11960×2300×1460	5060
Beam with supports	For equipping the positions for maneuvering and acceptance of sections of different sizes	-	12000×600×1200	3220
Holder	Welded metal construction with device for placement of framing. Capacity 16.0 tons	-	10360×2500×6000	2816

[Table 63, contd]

1	2	3	4	5
	Flow Line for Assembly and Welding of Deck Sections			
Universal framing loader	Loads framing with maximum sizes of 16000×850×200 mm. Capacity 2 tons. Speed of displacement 20 and 13 m/min	1.1	18450×2430×4665	8500
Holder for curvilinear framing	For transporting rectilinear and curvilinear framing with greatest rise of curvature of 300 mm	-	8000×2730×760	2510
Portable frame-stand	For making sections under the conditions of mechanized flow line with dimensions in plan of 16000×12800 mm	-	16870×15270×990 (without standards)	34600
Device for clamping the panel to the standard	With pump. Force on magnets 2 tons. Speed of the trolley 8 m/min, boom 26 m/min	1.2	11872×1800×1360	3015
Unit for automatic installation and tack welding of framing in the main direction to the plating	Installs framing for panels of sections 6-16 m long, 3.2-12.8 m wide. Bulb bar framing No 12-27. Welded section 160/90-630.160 mm. Cruising speed 20 m/min. Force of clamping the panel to the framing beam 300-4000 kg	5.2	23500×8450×7200	41520
Device for clamping panel to framing	With pump. Force of clamping 5 tons. Speed of movement of the trolley 8 m/min. Speed of moving the bearing beam 26 m/min	1.2	11400×1100×1735	3100
Machine for installing framing	With pump. Capacity 5 tons. Height of installed framing 600-2000 mm. Maximum framing flange width 270 mm. Speed of moving the portal and carriage: installation 0.1 m/min, cruising 20 m/min	5.0	20000×4700×9030	23200
Welding portal	For tack welding the cross framing to the panel and between. Speed of moving the portal and carriage 20 m/min. No of containers 2. No of installed semiautomatic machines in a container 4.	3.6	20050×4660×[illegible]	21490

CHAPTER XIV. SAFETY ENGINEERING, LABOR AND ENVIRONMENTAL PROTECTION. SHOP MATERIAL TURNOVER

§ 43. Basic Requirements on Safety Engineering, Environmental and Labor Protection

The engineering part of the shop designs is executed in accordance with the existing rules of safety engineering and industrial sanitation. The different shop production facilities with identical conditions with respect to harmfulness and fire hazard are located in the same building, they are placed next to each other; sections with more harmful conditions are segregated from those with less harmful conditions, and the most dangerous sections with respect to fires are located at the outside walls in one-story buildings and on the top floors of multistory buildings. These sections include the anodic oxidation sections in the shops for making structural components from aluminum-magnesium alloys; the sections for painting and drying ship sections, preparing mastics and glues and washing the containers in the shops for making structural components from synthetic materials; the sections for chemical cleaning, hot galvanizing and priming of pipe in the pipe preparation shops and also the galvanizing shops and the paint preparation, woodworking and insulation fabrication sections.

The effective norms and rules [21, 35] stipulate the following spacings between the work areas, work places, installations and elements of the buildings:

	Spacing, meters (no less than)
Height the load is raised above objects during horizontal displacement of it	0.5
Passage between stacks of materials, parts, and so on, no more than 1 meter high	1.0
Passages around the gas-cutting and gas-welding work places	1.0
Passages between automatic welding units	1.5
Distance from the floor of work areas to the lower edge of structural elements above ("work zone")	1.8
Spacing between the wall (column) and automatic welding units	1.0
Spacing between the outside dimensions of hoisting machinery which moves on a ground railroad track and objects directly below at a height:	
to 2 meters	0.7
more than 2 meters	0.4

Distance from lower protruding parts of hoisting machinery (not considering the grappling element) to equipment located within its range	0.4
Distance from the wall (column) to the side or rear of a machine tool	0.8
Distance from a ship being built to the column	3.0
Passage width:	
on width decking	1.0
between the sides of machine tools:	
with oneway traffic	1.1
with two-way traffic	1.6
Width of main corridor	3.0

Note. When designing a shipyard the data presented for specific shop equipment are more precisely defined by the effective normative materials.

As an example, the norms for the work space dimensions for servicing basic types of production equipment in the hull platers, assembly-welding and pipe preparation shops are presented in Table 64.

The production facility of the shipyard shops is divided into categories, and production areas, into classes, depending on the explosion, explosion-fire and fire hazard.

The construction norms and rules [33] establish that six production facility categories of industrial enterprises are distinguished with respect to explosion, explosion-fire and fire hazard.

Category A (Explosion-Fire Hazardous Production Facility). The handled materials are combustible gases, the lower limit of explosiveness of which is 10% or less of the volume of air; liquids with a vapor flash point to 28° C inclusively under the condition that the indicated gases and liquid can form explosion hazardous mixtures in a volume exceeding 5% of the volume of the facilities; the materials capable of exploding and burning on interaction with water, oxygen of the air or one with the other.

Category B (Explosion-Fire Hazardous Production Facility). Handled materials -- combustible gases, the lower limit of explosiveness of which is more than 10% of the volume of air; liquids with vapor flash point above 28 to 61° C, inclusively; liquids heated under production facility conditions to the flash point and higher; solids forming combustible dusts or fibers under the condition that the indicated gases, liquids and solids can form explosive mixtures in a volume exceeding 5% of the volume of the facilities.

Category V (Fire Hazardous Production Facility). The handled materials -- liquids with vapor flash point of more than 61° C; materials capable of burning only on interaction with water, oxygen of the air or one with the other; solid combustibles and materials.

Category G (Fire Hazardous Production Facility). Handled materials -- incombustible materials and materials in the hot, incandescent or molten state, the processing of

Table 64. Minimum dimensions of work places for servicing basic types of production equipment in the hull platers, assembly-welding and pipe preparation shops

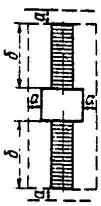
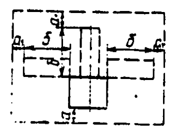
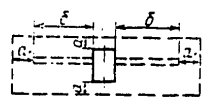
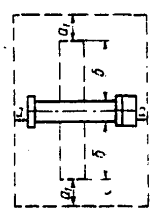
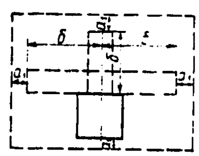
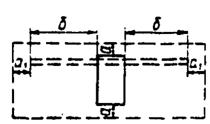
Equipment	Drawings
Hull platers shops Provisional notation: a -- no less than 0.8 meters; a_1 no less than 0.8-0.5 meters; b -- length of part	
Roll straightening machines	
Press-shears (sheet)	
Press-shears (section)	
Bending rolls	
Hydraulic bending press	
Straightening and bending press (bulldozer)	

Table 64 (continued)

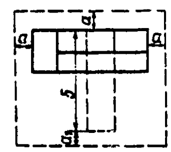
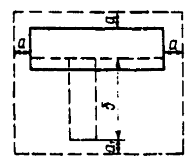
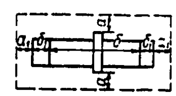
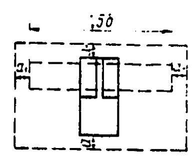
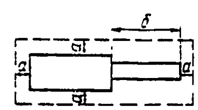
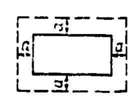
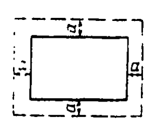
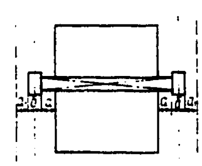
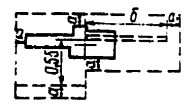
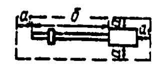
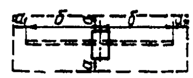
Equipment	Drawings
Edging machine	
Edge planing machine	
Automatic gas cutting machine [for an automatic device as part of a flow line the dimension a_1 is not considered; the dimension b_1 -- the length of the bench for the automatic machine carriage (no less than 2 meters) -- is taken from one side.]	
Radial drilling machine	
Annealing furnace (a -- no less than 1.5 meters)	
Work place of the gas cutting machine operator (gas welder) when working manually (a -- no less than 1.0 meters)	
Assembly-welding shops	
Stationary assembly-welding accessories (stand, bed, jig) (a -- no less than 1.0 meters)	
Assembly-welding position of a flow line (a -- no less than 0.8 meter; a_1 -- no less than 1.0 meter)	

Table 64 (continued)

Equipment	Drawings
Pipe preparation shops	
Provisional notation: a -- no less than 0.8; a_1 -- no less than 0.8-0.5; б -- length of part	
Pipe bending machine	
Pipe cutter	
Cutting-off machine	

Note. When determining the maximum dimensions of the work place for equipment not indicated in the table, the designers were guided by the data for analogous equipment. When laying out the equipment and work places it is necessary to consider the area for storing accessories, parts and billets.

which is accompanied by the release of radiant heat, sparks and flames; solids, liquids and gases which burn or are utilized as fuel.

Category D Handled materials -- incombustibles and materials in the cold state.

Category Ye (Explosion Hazardous Production Facility). The handled materials -- combustible gases and vapor in a quantity such that they can form explosive mixtures in a volume executing 5% of the volume of the production areas, and by the production process conditions only explosion (without subsequent combustion) is possible; materials capable of exploding (without subsequent combustion) on interaction with water, oxygen of the air or one with the other.

The presented production categories with respect to explosion, explosion-fire and fire hazard are determined considering the corresponding instructions approved by the USSR Gosstroy [46].

According to the Rules for Setting up Electrical Installations [22] the production facilities are classified with respect to explosion and fire hazard.

Classification of Production Areas by Explosion Hazard

Class V-1 -- production areas in which combustible gases or vapors are released in a quantity and with properties such that they can form explosion hazardous mixtures with the air or other oxidants under normal operating conditions.

Class V-Ia -- production areas in which during normal operations explosive mixtures of combustible vapor or gases with air or other oxidants do not occur, and are possible only as a result of emergencies or failures.

Class V-Ib -- production areas the same as Class V-1a, but distinguished by one of the following characteristics:

The combustible gases in these production areas have high lower limit of explosiveness (15% or more) and pungent odor at maximum permissible concentrations with respect to the sanitary norms;

The formation of a general explosive concentration under emergency conditions is excluded by the production process conditions, and only a local explosive concentration is possible;

Combustible gases and easily inflamable combustible liquids exist in the production areas in small amounts not creating a general explosive concentration, and they are handled without the use of an open flame. These production areas are nonexplosive hazardous if the work in them is done in vent or exhaust hoods.

Class V-II -- production areas in which combustible dust or fiber which go into the suspended state are released, having properties such they are capable of forming explosive mixtures with air and other oxidants under normal operating conditions.

Class V-IIa -- production areas in which dangerous states characteristic of class V-II do not occur during normal operation, but are possible only as a result of emergencies or failures.

The classes of production facilities, which although they do not contain production equipment and materials, are dangerous in fire or explosion respects but border on explosion hazardous production areas are defined in accordance with Table 65.

Table 65. Classification of production areas adjacent to explosion hazardous production areas

Class of explosion hazardous production area	Class of adacent production area, segregated from the explosion hazardous production area	
	by one wall with a door	by two walls and doors forming a corridor or vestibule
V-1	V-1a	Nonexplosion and nonfire hazardous
V-1a	V-1b	The same
V-1b	Nonexplosion and nonfire hazardous	The same
V-II	V-IIa	The same
V-IIa	Nonexplosion and nonfire hazardous	The same

Classification of Production Areas with Respect to Fire Hazard

Class P-1 -- production areas in which combustible liquids with vapor flash point of more than 45° C are used or stored.

Class P-II -- production areas in which combustible dust or fiber are released which go into the suspended state. The hazard arising here is limited to fire (but not explosion) either on the basis of the physical properties of the dust or fiber or on the basis of the fact that their content in the air does not reach explosive concentrations by the operating conditions.

Class P-IIa -- production facilities and storage production areas containing solid or fibrous combustibles (wood, fabrics, and so on) where attributes characteristic of class P-II are absent.

The approximate data of the production facility categories with respect to fire hazard (according to SNiP II-M.2-72 and SN 463-74) and the classes and production are s with respect to explosion and fire hazard (according to PUE) of the basic shipyard shops are presented in Table 66.

Using the approximate data presented in Table 66 when developing the contract-detail (contract) design, it is necessary to be guided by the effective construction norms and rules, the all-union and branch guidance materials.

With respect to a number of operations the categories are determined by calculation on the basis of the Instructions of the USSR Gosstroy SN 463-74 [46] depending on the volumes of the production areas, the quantities and concentrations of the handled materials and other specific conditions of each individual case.

On the drawings of the engineering part of the shop design after designating each section or production area, the production facility category and class of production area are indicated with respect to explosion, explosion-fire and fire hazard (for example, $\frac{B}{V\text{-}1b}$ where the numerator is the production category with respect to explosion, explosion-fire and fire hazard according to the SNiP; the denominator is the class of production area with respect to explosion hazard according to the PUE).

The individual processes of performing shipbuilding operations are accompanied by the pollution of the air of the production facilities with harmful materials.

Thus, the processes of electric welding and gas cutting of metal are accompanied by pollution of the air in the production facilities with finely dispersed dust containing toxic elements, harmful gases and by the release of a small quantity of heat.

The priming and painting of individual structural components and ships on the whole are accompanied by release of vapor from solvents in the primers and paints (acetone, benzine, benzene, and so on) which are toxic, into the air.

The basic means of controlling dust and gases are local exhaust and total-exchange ventilation. A local exhaust must be provided for all types of welding and cutting in stationary locations. When working in nonstationary locations, vacuum pump units with small receivers are used. When working in closed spaces it

Maximum permissible concentrations of the most characteristic aerosols, gases and vapor of solvents released in shipyard shops in the air of the work zone of production facilities [26]

	Maximum permissible concentration, mg/m^3
Aerosols	
Aluminum oxide (including with the application of silicon dioxide) in the form of condensation aerosol	2
Boron anhydride	5
Vanadium, pentoxide fumes	0.1
Tungsten	6
Iron oxide with manganese oxide admixture to 3%	6
Iron oxide with fluoride admixture or from 3 to 6% manganese compounds	4
Metallic cobalt and cobalt oxide	0.5
Manganese	0.3
Copper	1
Molybdenum, soluble compounds in the form of condensation aerosol	2
Nickel and its oxide (recalculated for Ni)	0.5
Lead and its inorganic compounds	0.01
Titanium and its dioxide	10
Thorium	0.05
Silicon anhydride	0.01
Zinc oxide	6
Zirconium dioxide	6
Cast iron	6
Gases	
Nitrogen oxides (recalculated for NO_2)	5
Ozone	0.1
Carbon monoxide	20
Hydrogen fluoride	0.5
Solvent vapor	
Acetone	200
Benzine	300
Benzene	5+
Xylene	50
Solvent naphtha	100
Toluene	50
White Spirit	300

is necessary to have total exchange ventilation realized by forced exhaust of the polluted air through rubberized fabric hoses and natural intake of pure air through openings and slots. When performing individual operations in accordance with the safety engineering rules, individual protection means are used.

Table 66. Approximate data on the categories of production facilities with respect to fire hazard and classification of production areas by explosion-fire hazard of the main shipyard shops

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Hull platers shop including:				
Steel storage in open area equipped with gantry cranes and in a closed facility equipped with electric bridge cranes	Sheet metal and section storage	--	D	--
Mold loft operations section	Scaled lofting of the hull. Preparation of sketches, master panels, drawings and master drawings	Paper, photographic film, punchtape	V	P-IIa
Templet workshop and storage area	Manufacture and storage of templets	Wood	V	P-IIa
Section for preliminary dressing of steel	Dressing of metal in sheet straightening rolls, on straightening and stretching machines, and on horizontal bending presses	--	D	--
Section for cleaning and priming sheet steel and section	Cleaning metal to remove dust and scale, priming the cleaned metal (in a chamber or within the chamberless priming limits)	Acetone	A	B-Ia
Hull platers sections:				
Machining steel parts	Marking, gas and mechanical cutting, bending and straightening	--	G	--
Machining AMg parts	Machining	AMg tips	V	P-IIa
Makeup section	Hull parts makeup	--	D	--
Assembly-welding shop -- sections for assembly, welding and fitting of subassemblies and sections	Assembly and welding of steel structural elements	--	G	--
Section (shop) for painting and drying sections made up of the following:				

Table 66 (continued)

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Shot blasting division	Cleaning rust off the hull structural components	Rust and scale	V	P-II
Division for degreasing, priming and painting the sections	Surface degreasing, priming and painting	Acetone, xylene	A	V-Ia
Unitizing section (shop) made up of following:				
Division for demothballing machinery in easily flamable liquids	Washing parts in baths with kerosene, gasoline	Gasoline, acetone	A	V-1a
Division for demothballing machinery in baths with hot water	Demothballing of machinery by dipping in baths with hot water	--	D	--
Division for assembly of the unitized units of the machinery	Fitting and assembly operations	--	D	
Module building shop and shipbuilding shed made up of: Module building lines and shipbuilding ways	Hull shops, hull fitting shops, mechanical installation, pipe fitting, woodworking, paint-insulation and other operations	--	G	--
Hull fitting and pipe fitting sections	Odd jobs coming up during installation in modules and on ship as a whole with respect to hull fitting and pipe parts and products	--	G	--
Mechanical fitting section	Preparation of machinery for installation (dismantling, checking, assembly) fitting-welding operations, machining on machine tools	--	D	--
Section of the electric wiring shop	Preparation of electrical equipment for installation, various odd jobs arising during process of installation operations on the ships	Cables, insulation materials	V	P-IIa
Woodworking section	Working of wooden parts and assembly operations with respect to wood products	Wood materials, shavings, sawdust	V	P-II

Table 66 (continued)

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Insulation section	Cutting of insulation materials on the woodworking machines	Heat insulating materials, expansite, and so on	V	P-II
Electric wiring shop including the following:				
Mechanical fitting section	Machining of parts and subassemblies	--	D	--
Installation-assembly section	Installation-assembly electric wiring operations	Wires, cables	V	P-IIa
Makeup section	Finished parts makeup	Rubber, cables	V	P-IIa
High Current test board circuitry	Testing of electrical equipment by direct purpose	Cables, insulating materials	V	P-IIa
Radio communications test board	Checking out modules and equipment	Wires, valuable equipment	V	P-IIa
Radar test board	The same	The same	V	P-IIa
Navigational instruments test board	The same	The same	V	P-IIa
Measuring instruments test board	The same	Cables, wires	V	P-IIa
Instrument and equipment storage	Storage of instruments and equipment	Instruments and equipment	V	P-IIa
Outfitting-acceptance shop made up of the following:				
Hull fitting and mechanical installation sections	Odd jobs arising during outfitting of the ships afloat with respect to hull fitting and mechanical installation parts and products	--	D	--
Pipe fitting section	The same, for pipe	--	G	--
Woodworking section	The same, for wooden parts and products	Wood	V	P-II
Hull fitting shop made up of the following:				

Table 66 (continued)

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Billeting section	Cutting of sheet metal into section, stamping, drilling, bending and straightening parts, makeup and dispatch of them to product assembly and welding sections	--	G	--
Assembly-welding section	Assembly and welding of subassemblies and products made of steel	--	G	--
Paint section	Painting of products in the painting chambers, drying in the drying chambers	Acetone, xylene	A	V-Ia
Pipe preparation shop made up of the following:				
Pipe storage area	Storage of pipe and fittings made of various incombustible types of materials	--	D	--
Preparation division	Cutting off billets on the milling machines, gas electric cutting machines, machines with abrasive discs, annealing	--	G	--
Cold pipe bending section	Cold bending of pipe of different types on machine tools	--	D	--
Sections for hot bending and welding of pipe and preliminary machining of them	Bending pipe on a plate and on the HFC machine tools, welding, cutting off tolerances, cutting threads, drilling out, bead forming, and so on	--	G	--
Final machining section	Trimming of welds, grinding of contact surfaces of flanges and rings, rolling the flanges of steel, copper and stainless steel pipe	--	D	--
Hydraulic testing, makeup and marking sections	Hydraulic strength testing of pipe, makeup and marking	--	D	--
Pipe insulation section	Insulation of pipe	Asbestos lint cord, asbestos fabric, expansite shells	V	P-IIa

Table 66 (continued)

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Sections for unitized and panel assembly of pipe and copper fitting	Assembly of pipe subassemblies of ship systems, preparation of copper products	--	D	--
Woodworking shop made up of the following:				
Wood drier with dry lumber storage	Drying of lumber in special chambers to a defined moisture content in storing the dried boards in stacks	Various types of wood	V	P-IIa
Machine tool preparation section	Mechanical working of the wood (fabrication of intermediate products, furring, sawing plywood, and so on)	Wood, shavings, sawdust	V	P-II
Joiners-assembly section	Making furniture and other products for ships under construction	Wood	V	P-IIa
Veneer-bonding section	Veneering of furniture panels, bonding various parts and subassemblies going onto the ships	Wood, joiners glue	V	P-IIa
Finishing section	Finishing of carpentry products	Acetone, xylene	A	V-Ia
Grinding section	Surface working of the products before finishing	Sawdust	B	V-IIa
Upholstery-sail section	Manufacture of soft and semisoft furniture	Textiles, porolon, sailcloth	V	P-IIa
Sharpening section	Sharpening of woodcutting and carpenter's tools	--	D	--
Glue heating facility	Preparation of glues	Joiner's glue, casein	V	P-IIa
Galvanizing shop madeup of the following:				
Pickling section	Pickling of metals in aqueous solutions of acids	--	D	--
Galvanizing room	Application of protective coatings to the surface of a product with the application of electrolysis	--	D	--

Table 66 (continued)

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Grinding and polishing section	Grinding and polishing of metals	Fiber, lower explosiveness limit of dust of which is >65 g/m^3 of air volume	V	P-II
Parts insulation section	Insulation of various parts of the surfaces	Solvents based on vinyl perchloride R-4 & R-5	A	V-Ib
Parts painting section	Painting of parts	Acetone, gasoline, xylene, white spirits	A	V-Ia
Metal plating section	Application of a coating by spraying molten metal from a spray gun on a bench with side exhaust	--	G	--
Mechanical fittings section	Machinery and parts, assembly and dismantling of subassemblies	--	D	--
Chemicals storaged	Storage of chemicals	Container, packing	V	P-IIa
Paint preparation shop made up of the following:				
Section for preparing primers, paints, spackling, mastic	Preparation of primers, paints and varnishes, spackling, mastics.	Acetone, benzine, "kalosha"	A	V-Ia
Container washing section	Washing of containers in baths with hot alkaline solutions and in organic solvents	Paint and mastic residue	A	V-Ib
		Benzine	A	V-Ia
Section for preparing chalk, cement	Drying of chalk and cement	--	D	--

Table 66 (continued)

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Container storage	Storage of containers	Paint & mastic residue	A	V-Ib
Proximate analysis laboratory	Performance of operations in exhaust hoods	Xylene, white spirit, turpentine	B	V-1b
Common facilities for all shops of the shipyard:				
Mechanical engineer's workshop	Repair of production equipment	--	D	--
Power engineer's workshop	Repair of power engineering and electrotechnical equipment	Cables, acetylene materials	V	P-IIa
Mechanical and power engineer's workshop	Repair of machinery and equipment without the application of combustibles	--	D	--
Tool sharpening division	Sharpening of tools	--	D	--
Material storage	Storage of auxiliary materials	Rags, textiles, wood	V	P-IIa
Welding materials storage	Storage of welding materials	--	D	--
Storage for distribution of ready paints	Storage and distribution of paints and varnishes	White spirit, acetone	A	V-Ia
Facility for washing containers and painters' tools	Washing containers and tools with soda solution to remove paint and varnish contaminants	Paint residue	A	V-Ib
Storage for painter's tools	Storage of painter's tools in special lockers with exhaust ventilation	Paint residue	V	P-I
Storage for insulating materials	Storage of insulating materials	Expansite shells, asbestos fabric	V	P-IIa

Table 66 (continued)

Production facilities and areas	Brief description of production operations	Explosion-fire hazardous substances and materials handled in production facility	Category of production facilities with respect to fire hazard	Class of production areas with respect to explosion-fire hazard
Makup storage	Storage of madeup parts	Wood, hoses	V	P-IIa
Storage for tools with-washing division	Storage of cutting, measuring tools and attachments	--	D	--
Pneumatic tool storage	Storage of pneumatic tools	Kero-sene	B	V-Ia
	Washing of tools in a kerosene bath			
Storage of paints and varnishes and sol-vents	Storage of paints and varnishes and solvents	White spirit, acetone, xylene	A	V-Ia

Notes. 1. Independently of the adopted class of the production areas on the whole when using explosion hazardous and combustible gases and also easily flamable liquids, the vapor of which is heavier than air, all of the electrical equipment, in the radius of 5 meters vertically and horizontally from the boundary for the operations are performed and also the equipment of the exhaust hoods, driers and the ventilation units are executed just as for class V-Ia. The possibility of classifying these devices in class V-Ib must be confirmed by calculation. 2. If equipment with the release of dust, the ignition limit of which is 65 g/cm^3 and lower is installed in a shop (in a section) not classified as category B, in a small area (no more than 200 m^2 and 10% of the entire shop or section area), then this equipment must be placed in isolated production area with dustproof enclosures at the outside walls observing the requirements of the SNiP II-M.2-72, and all of the electrical equipment must be made as for class V-IIa. 3. The fan and all the electrical equipment of the exhaust hoods of the laboratories and sections with the application of easily flamable liquids and combustible gases are made as for class V-Ia; sections with the application of explosive dust (the lower limit of explosiveness is less than 65 g/m^3), just as for class V-IIa.

One of the factors having harmful influence on working conditions is noise, especially high-frequency noise which predominates at the shipyards.

In all the production facilities in which the noise level in the workplace exceeds the established norms, it is necessary to take measures to attenuate it.

These measures include the following:

The application of gas and electric-air gouging instead of pneumatic cutting and also attachments on the pnenumatic tools that absorb noise;

Replacement of pneumatic tools by electric tools;

Machine parts and manufacture of structural elements without tolerances, as a result of which the fitting operations during assembly using pneumatic tools are excluded;

Application of methods of welding the structural elements which exclude trimming of the wells by pneumatic tools;

Application of highly pure oxygen for gas cutting of metal which insures burrless cutting;

Application of hydraulic and pneumatic attachments for welding and straightening structural elements that reduce noise during these operations;

Application of fast-hardening plastics when installing machinery and equipment on foundations that exclude fitting operations with the application of pneumatic tools;

Lining of the walls of the production areas with special materials that absorb noise;

Installation of special noise absorbing shields;

Concentration of operations accompanied by noise, in special production areas;

Application of individual protection means for workers performing operations accompanied by noise.

Admissible noise pressure levels and sound levels at the permanent work places in the production areas of the basic shipyard shops are characterized by the following data [26]:

Geometric mean frequencies of octave bands, hertz	Noise pressure levels, decibels
63	99
125	92
250	86
500	83
1000	80
2000	78
4000	76
8000	74

Depending on the nature of the noise and the time of its effect, the values of the octave levels of sound pressure presented above are subject to correction [26] according to the data of Table 67.

In all of the shipyard shops, in accordance with the effective norms [26, 29, 30] provision is made for maintaining the required temperature and corresponding lighting, and in individual cases, humidity.

In necessary cases, special requirements with respect to safety engineering and industrial sanitation are presented in the designs (sections for painting, the radioactive isotope storage chambers, and so on).

Table 67. Corrections to octave levels of sound pressure, decibels

Total duration of effect in a shift (work day)	Noise characteristics	
	wide band	voice-frequency or pulsed
From 4 to 8 hours	0	-5
From 1 to 4 hours	+6	+1
From 15 min. to 1 hr.	+12	+7
From 5 to 15 minutes	+18	+13
Less than 5 minutes	+24	+19

Note. The duration of the sound is substantiated by calculation or confirmed by the technical reports.

When executing designs of shipyard shops, plans are developed for environmental protection measures connected with protecting the air, water areas and soil (with reclamation of the band) from pollution by waste water and industrial waste.

For the development of the indicated drafts of the measures, the production engineers participate in determining the corresponding initial data (description of the production processes accompanied by the release of harmful materials; data on industrial discharge into the atmosphere with indication of the maximum amount of harmful materials with respect to individual types and state of aggregation; data on water consumption and water release with indication of the nature of pollution of production wastewater with respect to production waste; here the structure, the sludge, oil waste, garbage, and so on are included) with respect to individual shops, they develop and distribute the required assignments to specialized departments or organizations.

The description and calculations with respect to providing for safety engineering, protection of labor and environmental protection in accordance with the engineering assignments and the effective norms are presented in the architectural-construction part of the design, and the environmental protection in other parts of the design.

§ 44. Distribution of Workers by Groups of Production Occupations as a Function of the Sanitary Characteristics of the Production Processes.

The corresponding sanitary-hygienic and general services facilities are provided for all shop personnel.

Accordingly, in the engineering part of the design of new and rebuilt shipyards (or individual shops) the workers are distributed by groups of production occupations in accordance with the construction norms and rules [34]. A brief description of the indicated groups is presented below.

Group I -- production processes taking place under normal meteorological conditions and in the absence of harmful gases and dust discharge:

a) not causing contamination of clothing and hands;

b) causing contamination of clothing and hands;

c) causing contamination of clothing, hands and body.

Group II -- production processes occurring under unfavorable meteorological conditions connected with the release of dust or stressed physical labor:

a) with the release of convective heat;

b) with the release of radiant and convective heat;

c) with the application of water;

d) with the release of large quantities of dust or specially dirty materials (in addition to harmful);

e) occurring under the joint effect of dust and moisture;

f) occurring in the open air or in production areas with air temperature at the work places below 5° C.

Group III -- production processes with sharply expressed harmful factors with the contamination of work clothing by them:

a) connected with the production, release or application of harmful substances or irritants;

b) connected with the production, release or application of harmful or foul smelling substances.

The arrangement of the general services facilities for the engineering-technical workers (ITR), office workers and junior service personnel (MOP) is determined by groups of production processes.

If the individual ITR must be considered in another group of production processes by the nature of the work done by them, special instructions are included in the general services facilities design.

The approximate distribution of workers by groups of production occupations as a function of the sanitary characteristics of the production processes with respect to the main shipyard shops is presented in Table 68.

§ 45. Shop Materials Turnover

The data on the shop materials turnover are needed for designing the most direct production process possible (transporting waste, not interfering with the main flow of goods are also taken into account) and for proper calculation of transport means and the storage areas of the shop. When calculating the materials turnover, the

Table 68. Approximate distribution of workers by groups of production occupations as a function of the sanitary characteristics of production processes with respect to the main shipyard shops

Shops and professions	Ratio of workers by groups of production occupations, %										Ratio of men and women, %	
	I			II					III		men	women
	a	b	c	a	b	c	d	e	a	b		
Hull platers shops												
Measuring and marking	—	100	—	—	—	—	—	—	—	—	70	30
Straightening machine and pneumatic drill operators	—	—	100	—	—	—	—	—	—	—	100	—
Cutting machine operators	—	70	30	—	—	—	—	—	—	—	75	25
Mechanical and manual gas cutting tool operators	—	—	—	—	70	—	—	—	30	—	70	30
Roll bending machine and cold stamping machine op.	—	—	100	—	—	—	—	—	—	—	90	10
Manual bending and straightening mach. operators	—	—	—	70	—	—	—	30	—	—	100	—
Drill operators	—	—	100	—	—	—	—	—	—	—	70	30
Workers engaged in clean. hull steel by sand blast.	—	—	—	—	—	—	100	—	—	—	100	—
Crane operators and electric truck drivers	—	100	—	—	—	—	—	—	—	—	—	100
Sling operators	—	—	100	—	—	—	—	—	—	—	100	—
Auxiliary workers	—	40	40	—	10	—	5	—	5	—	60	40
Assembly-welding shops												
Inspectors and markers	—	50	50	—	—	—	—	—	—	—	70	30
Assemblymen	—	40	60	—	—	—	—	—	—	—	100	—
Straighteners	—	—	—	—	30	—	—	—	70	—	100	—
Pneumatic tool operators (cutters, riveters, stampers and drill ops.)	—	—	—	—	100	—	—	—	—	—	100	—
Manual and mechanical tac welders and elect. weld.	—	—	—	—	100	—	—	—	—	—	70	30
Gas cutters	—	—	—	—	70	—	—	—	30	—	70	30
Trials and test workers	—	—	70	—	—	30	—	—	—	—	100	—
Hull fitters, pipe fitters	—	70	30	—	—	—	—	—	—	—	100	—
Painters	—	—	—	—	—	—	—	—	80	20	60	40
Crane operators and electric truck drivers	—	100	—	—	—	—	—	—	—	—	—	100
Sling operators	—	—	100	—	—	—	—	—	—	—	100	—
Auxiliary workers	—	40	40	—	10	—	—	—	10	—	60	40
Module building shops and shipbuilding sheds												
Inspectors and markers	—	50	50	—	—	—	—	—	—	—	70	30
Assemblymen	—	40	60	—	—	—	—	—	—	—	100	—
Straightners	—	—	—	—	30	—	—	—	70	—	100	—
Pneumatic tool operators (cutters, riveters, et al)	—	—	100	—	—	—	—	—	—	—	100	—
Gas cutting tool operator	—	—	—	—	70	—	—	—	30	—	70	30
Electric tac welders and electric welders	—	—	—	—	100	—	—	—	—	—	70	30
Hull fitters and pipe fitters	—	70	30	—	—	—	—	—	—	—	100	—
Mechanical install. fitt.	—	—	100	—	—	—	—	—	—	—	80	20
Carpenters and joiners	—	100	—	—	—	—	—	—	—	—	100	—
Ship insulation workers	—	—	—	—	—	—	100	—	—	—	30	70
Painters	—	—	—	—	—	—	—	—	80	20	60	40
Workers that test for water tightness	—	—	—	—	—	100	—	—	—	—	100	—

Table 68 (continued)

Shops and professions	Ratio of workers by groups of production occupations, %										Ratio of men and women, %	
	I			II					III			
	a	b	c	a	b	c	d	e	a	b	men	women
X-ray technicians	—	100	—	—	—	—	—	—	—	—	30	70
Crane operators, elevator operators, elect. tr. dr.[1]	—	100	—	—	—	—	—	—	—	—	—	100
Sling opertors	—	—	100	—	—	—	—	—	—	—	100	—
Auxiliary workers	—	40	40	—	10	—	—	—	10	—	60	40
Outfitting-acceptance shops												
Inspectors and markers	—	50	50	—	—	—	—	—	—	—	100	—
Assemblymen	—	40	60	—	—	—	—	—	—	—	100	—
Straightners	—	—	—	—	30	—	—	—	70	—	100	—
Pneumatic tool operators (cutters, riveters, et al)	—	—	100	—	—	—	—	—	—	—	100	—
Gas cutting tool operator	—	—	—	—	70	—	—	—	30	—	70	30
Electric tac welders and electric welders	—	—	—	—	100	—	—	—	—	—	70	30
Hull fitters	—	70	30	—	—	—	—	—	—	—	100	—
Machinery installers	—	—	100	—	—	—	—	—	—	—	70	30
Carpenters and joiners	—	100	—	—	—	—	—	—	—	—	100	—
Pipe fitters	—	70	30	—	—	—	—	—	—	—	100	—
Painters	—	—	—	—	—	—	—	—	80	20	60	40
Riggers	—	70	30	—	—	—	—	—	—	—	100	—
Workers that test for water tightness	—	—	—	—	—	100	—	—	—	—	70	30
Crane operators, elev. op.	—	100	—	—	—	—	—	—	—	—	—	100
Electric truck drivers	—	100	—	—	—	—	—	—	—	—	—	100
Sling operators	—	—	100	—	—	—	—	—	—	—	100	—
Auxiliary workers	—	45	40	—	10	—	—	—	5	—	75	25
Electrical wiring shops												
Preparation fitters, markers and cable workers	—	100	—	—	—	—	—	—	—	—	80	20
Fitters and installers	—	100	—	—	—	—	—	—	—	—	100	—
High-current electricians and acceptance inspector	—	50	50	—	—	—	—	—	—	—	80	20
Low-current electricians and electric equipment servicemen	—	50	50	—	—	—	—	—	—	—	70	30
Radio equipment electricians	—	50	50	—	—	—	—	—	—	—	60	40
Equipment adjustors	—	100	—	—	—	—	—	—	—	—	60	40
Auxiliary workers	—	50	50	—	—	—	—	—	—	—	40	60
Hull fitting shops												
Hull platers, mach. oper.	—	70	30	—	—	—	—	—	—	—	80	20
Markers	—	100	—	—	—	—	—	—	—	—	80	20
Assemblers	—	40	60	—	—	—	—	—	—	—	80	20
Pneumatic tool operators	—	—	100	—	—	—	—	—	—	—	100	—
Grinders	—	—	—	—	—	—	100	—	—	—	100	—
Manual electric welders	—	—	—	—	100	—	—	—	—	—	60	40
Mechanical electr. welders	—	—	—	—	100	—	—	—	—	—	70	30
Gas cutters and gas weld.	—	—	—	—	70	—	—	—	30	—	70	30
Workers testing for water tightness	—	—	—	—	—	100	—	—	—	—	100	—
Fitters	—	70	30	—	—	—	—	—	—	—	80	20
Machining fitters	—	—	100	—	—	—	—	—	—	—	70	30
Machine tool operators	—	—	100	—	—	—	—	—	—	—	80	20

[1] electric truck drivers

Table 68 (continued)

Shops and professions	Ratio of workers by groups of production occupations, %										Ratio of men and women, %	
	I			II					III			
	a	b	c	a	b	c	d	e	a	b	men	women
Painters	—	—	—	—	—	—	—	—	80	20	30	70
Crane operators, ele. op[1]	—	100	—	—	—	—	—	—	—	—	—	100
Electric truck drivers	—	100	—	—	—	—	—	—	—	—	—	100
Sling operators	—	—	100	—	—	—	—	—	—	—	100	—
Auxiliary operatios	—	45	40	—	10	—	—	—	5	—	60	40
Pipe preparation shops												
Templet workers	—	100	—	—	—	—	—	—	—	—	70	30
Pipe cutters	—	60	30	—	—	—	10	—	—	—	50	50
Pipe benders using machine tools and pipe fitt.	—	70	30	—	—	—	—	—	—	—	100	—
Heat technicians and plate pipe benders	—	—	—	—	100	—	—	—	—	—	100	—
Drill operators	—	—	100	—	—	—	—	—	—	—	30	70
Boring tool operators	—	—	100	—	—	—	—	—	—	—	100	—
Lathe operators	—	—	100	—	—	—	—	—	—	—	70	30
Assembly fitters	—	—	100	—	—	—	—	—	—	—	80	20
Welders	—	—	—	—	100	—	—	—	—	—	80	20
Pneumatic tool operators	—	—	—	—	—	—	100	—	—	—	100	—
Hydraulic testers	—	—	—	—	100	—	—	—	—	—	100	—
Insulation specialists	—	—	—	—	—	—	100	—	—	—	20	80
Galvanizing op. and paint.	—	—	—	—	—	—	—	—	—	100	30	70
Copper smiths and X-ray technicians	—	100	—	—	—	—	—	—	—	—	30	70
Auxiliary workers	—	40	40	—	20	—	—	—	—	—	60	40
Woodworking shops												
Carpenters and joiners	—	100	—	—	—	—	—	—	—	—	100	—
Woodworking machine tool operators	—	90	—	—	—	—	10	—	—	—	80	20
Workers who load and unload lumber drying cham.	—	—	—	100	—	—	—	—	—	—	100	—
Lumber drier duty person.	—	—	—	100	—	—	—	—	—	—	20	80
Model makers	—	100	—	—	—	—	—	—	—	—	80	20
Upholsterers	—	100	—	—	—	—	—	—	—	—	40	60
Glue heater operators	—	—	—	—	—	—	—	—	50	50	—	100
Lacquer impregnation operators	—	—	—	—	—	—	—	—	—	100	20	80
Paint preparation shops												
Paint grinders, paint mixers, paint preparers	—	—	—	—	—	—	—	—	100	—	20	80
Glazers	—	—	100	—	—	—	—	—	—	—	100	—
Mural painters	—	—	—	—	—	—	—	—	100	—	80	20
Glue heater operators	—	—	—	—	—	—	—	—	50	50	20	80
Auxiliary workers	—	—	—	—	—	—	—	—	100	—	20	80

[1] elevator operators

Table 68 (continued)

Shops and professions	Ratio of workers by groups of production occupations, %										Ratio of men and women, %	
	I			II					III			
	a	b	c	a	b	c	d	e	a	b	men	women
Galvanizing shops												
Attendants at chemical and galvanizing baths with acid and alkali solutions, operators (adjusters) for servicing automated and semiautomated metal plating units with acid and alkali electrolytes, workers who install and demount parts on the suspensions, attendants at washing and degreasing of parts in organic solution, picklers and degreasers using acid and alkali electrolytes	—	—	—	—	—	—	—	—	—	100	30	70
Equipment repair and service workers and other auxiliary workers	—	—	—	—	—	—	—	—	—	100	60	40
Electricians	—	—	—	—	—	—	—	—	—	100	70	30
Grinders and polishers	—	—	—	—	—	—	100	—	—	—	70	30
Shot blasters	—	—	—	—	—	—	100	—	—	—	90	10
Hydraulic sand blasters and tumbling machine operators	—	—	—	—	—	—	—	100	—	—	100	—
Operators on the galvanizing and chemical stationary baths with cyanide solutions and operators for servicing the automated and semi-automated metal plating units with cyanide solutions of electrolytes	—	—	—	—	—	—	—	—	100 *	—	30	70
Correctors of cyanide solutions and electrolytes; sanitation engineering fitters in the shop working with cyanide solutions and electrolytes; auxiliary workers working with the solutions and electrolytes	—	—	—	—	—	—	—	—	100 *	—	60	40
Workers coating by the hot method (hot galvanizing, tin-plating, gold-plating, etc.)	—	—	—	—	100	—	—	—	—	—	100	—
Metal sprayer operators (applying metal coatings by spraying)	—	—	—	—	100	—	—	—	—	—	100	—
Operators using hot method of leading	—	—	—	—	—	—	—	—	100	—	100	—
Crane operators	—	—	—	—	—	—	—	—	—	100	30	70

*In the case where the baths with cyanide solutions in a common room with oxygen and alkali baths and requiring the largest number of workers for servicing, the latter can be classified in group IIIb.

shop requirement for basic and auxiliary materials, equipment and products coming from other shops or by cooperation from outside enterprises through the corresponding shipyard storage areas are defined; the amount of production waste is also established.

The demand for basic materials and billets and also for equipment in products is calculated in a consolidated manner by the data on the distribution of the weight load of the ship with respect to basic forms of shipyard shop operations and with respect to the materials consumption normatives developed for the given branch of industry.

Table 69. Materials turnover of a shop (with indication of transportation used)

Shop receives				Shop distributes			
Name of goods	Where received from	Weight, tons	Type of transportation	Name of goods	Where goods are sent	Weight, tons	Type of transportation
1. 2. 3. and so on.				1. 2. 3. and so on.			
Total							

Note. The totals of materials inflow and outflow must balance.

In connection with the fact that the net weight of consumable materials is presented in these data, the required amount of them for the annual program considering waste can be found by the formula

$$Q_{w.y} = 100 Q_w n_{ship}/(100-0_{ave}),$$

where $Q_{w.y}$ is the weight of material required by the shop per year, tons; Q_w is the net weight of material for one ship used in the given shop, tons; n_{ship} is the number of ships in the annual calculated program; 0_{ave} is the average percentage waste.

The shop requirements for auxiliary materials is determined by the norms for the consumption per unit of equipment or per worker.

The data from calculating the materials turnover of the ship with indication of the transportation used are presented in a table in accordance with the appropriate form (Table 69).

CHAPTER XV. POWER ENGINEERING AND TECHNICAL-ECONOMIC INDICES OF THE SHOPS

§ 46. Calculation and Approximate Indices for Determining Basic Forms of Energy

The shipyard shops are provided with the following basic forms of energy for their process needs:

Electric power for operation of the machine tools, electric welding, materials-handling and other equipment, mechanization means and tools;

Compressed air at 5-6 kg/cm^2 for operation of pneumatic tools and paint sprayers;

Acetylene and oxygen for manual and mechanical cutting, planing and heating the structural elements for dressing and straightening;

Carbon dioxide and argon for gas-shielded welding;

Production water -- for testing the hull components, pipelines and systems;

Water of appropriate purity for cooling the inert gas-shielded welding torches.

When the shop is supplied with various forms of energy for its process needs, we begin with the following basic data.

The electric power consumption is determined in accordance with the total installed capacity of the machine tools, electric welding, materials handling and other equipment and also the required power for shop testing of the production. The compressed air consumption at 5-6 kg/cm^2 is established beginning with the adopted amount of different types of tools and equipment and their specific use. The amount and type of pneumatic tools are taken in accordance with the number of production workers per shift working with these tools.

The acetylene and oxygen consumption are calculated beginning with the requirements of the gas cutting and gas welding equipment and the amount of tools required to perform the corresponding operations per shift. It is recommended that oxygen no less than 99.5% pure be used for gas cutting without flash formation. The consumption of inert gases (carbon dioxide and argon) used during electric welding is determined as a function of the adopted welding equipment.

The production water consumption is established as a function of the needs of the adopted equipment; in the assembly and installation shops, the largest quantity of water is needed for testing the closed tanks and compartments of the ship's hull. In this case the maximum hourly water consumption is found by the formula

$$M_{max\ hr} = V_{p.\ c} n_c / t_{fill},$$

where $M_{max\ hr}$ is the maximum hourly water consumption, m^3/hr; $V_{p.\ c}$ is the maximum volume of the tank or compartment, m^3; n_c is the number of tanks or compartments simultaneouly filled for testing; t_{fill} is the filling time of the tested tanks or compartment, hours.

The mean diurnal water consumption is defined by the formula

$$M_{md} = V_{mean} n_{tank},$$

where M_{md} is the mean diurnal water consumption, m^3; V_{mean} is the mean tank or compartment size, m^3; m_{tank} is the number of tanks or compartments tested per day on the average.

The amount of water for cooling the equipment is assumed as a function of its consumption per unit of equipment.

When preparing the engineering designs, the data for calculating the energy consumption in the shop is presented in tabular form (see Table 70).

Approximate indices for calculating the basic forms of energy and amounts of tools of a number of the shipyard shops and also approximate average air and gas consumptions per unit of equipment and tools and their use coefficients are presented in Tables 71, 72 and 73, respectively.

The connection points of individual forms of energy considering the safety engineering rules can be divided into two basic groups: electricity and communications; water, air, steam, oxygen, acetylene, and so on. The indicated connection points also provide for the operation of temporary power system, including the ventilation systems providing for normal operation of the electric welding and gas cutting stations, painting the closed compartments of the ships, and so on. Here the temporary systems and ventilation systems are made in accordance with the existing technical guidance materials ("Power supply and ventilation systems for shipbuilding and repair") and the "Safety engineering rules and production sanitation for shipbuilding and ship repair operations."

The connection points are, as a rule, located on the columns of the building at a height of 1.2-1.5 meters from the floor. In the shops for building modules and the shipbuilding sheds when necessary a second level on the level of the upper deck of the hull modules or the entire ship is provided for them. In this case the possibility of connecting the temporary fire-extinguishing systems is taken into account.

The distance between identical connection points is assumed to be within the limits of 24-30 meters; for the outfitting quays this distance can be increased to 50-60 meters.

Table 70. Indices for calculating various forms of energy required for operation of the assembly and welding shop

Forms of energy	Users	Unit of measure	Indices	
			1st shift	2nd shift
Electric power	Electric welding equipment Materials handling equipment Machine tools Other equipment	Installed capacity, kilowatts		
Compressed air at a pressure of 5-6 kg/cm^2	Pneumatic tools	No. of simultaneously operating units		
Acetylene and oxygen	Mechanical cutting Manual cutting and dressing Gas gouging	No. of simultaneous operating torches		
Inert gases (individually with respect to types of gas)	Electric welding	No. of welding arcs		
Production welder	Section testing	Maximum consumption, m^3/hr		
		Average consumption, m^3/day		
	Cooling of the welding torches	Maximum hourly consumption, m^3/hr		
		Mean consumption, m^3/day		

§ 47. Basic Specifications and Tehnical-Economic Indices. Analysis of the Basic Technical-Economic Indices.

The results of the design developments of the shops and also comparison of the technical-economic indices obtained with the normative or best indices by analogous designs and best achievements of the Soviet and foreign shipyards are presented in tabular form (see Table 74).

Table 71. Approximate indices for calculating basic forms of energy and number of tools per 1000 tons of production of the hull platers shops, assembly-welding shops, module building shops and shipbuilding sheds

Shops	Class of shipyard	Initial data		Indices				
		Annual production output, thousands of tons	Aver. thickness of machined and welded metal, mm	Electric power (installed capacity), kwt				Pneumatic tools, units (compressed air at 5-6 kg/cm²)
				For machine tools	For automated and semi-automated welding	For manual welding and tack welding	For cranes	
Hull platers shop	I	100	20	17	—	—	8	0,20
	II	80	14	23	—	—	10	0,23
	III	40	10	30	—	—	14	0,40
	IV	20	8	40	—	—	16	0,70
	V	5	5	70	—	—	20	1,20
Assembly-welding	I	100	20	—	72	6,8	—	2,0
	II	80	14	—	90	7,4	—	2,1
	III	40	10	—	116	9,0	—	2,3
	IV	20	8	—	122	12,5	—	2,5
	V	5	5	—	136	14	—	3,0
Module building shop	II	116	14	—	16	19	—	1,9
	III	75	10	—	16	19	—	1,85
	IV	34	8	—	15	19	—	1,8
Shipbuilding shed	I	135	20	—	14	17	—	2,5
	II	130	14	—	6	7	—	0,75
	III	32	10	—	6	7	—	0,70
	IV	38	3	—	5	7	—	0,73
	V	8,5	5	—	11	19	—	1,8

As a rule, two basic shop indices are subject to analysis: labor consumption per ton of production output and annual production output per square meter of shop area which depend on the following basic factors:

The annual production output and mastery of construction of the subsequent ships in the series;

Level of mechanization and automation of the production processes and technical level of production;

Structural peculiarities of the ships being built.

Production output per m^2 of shop area also depends on the shift index of the workers, the loading of the equipment and work places.

Considering what has been discussed, the indices lead to comparable conditions.

The labor consumption reduced to the design conditions per ton of production output of the shop (man-hours/ton) can be defined by the formula

Table 71 (continued)

Indices									
Acetylene and oxygen			Air and inert gases for gas electric cut.		Welding arcs of automatic and semi-automatic carbon-dioxide shielded welders, units	Production water		Water for cooling welding torches	
Mechanical cutters, units	Manual cutters, units	Dressing and straightening torches, units	Aver. consumption, m^3/day	Maximum consumption, m^3/hr		Average consumption, m^3/day	Maximum consumption, m^3/hr	Average consumption, m^3/day	Maximum consumption, m^3/hr
0,35	0,05	—	1,44	0,12	—	1,68	0,18	—	—
0,45	0,06	—	1,53	0,14	—	1,8	0,20	—	—
0,75	0,10	—	2,40	0,20	—	2,4	0,30	—	—
1,10	0,15	—	6,60	0,56	—	3,0	0,40	—	—
1,20	0,20	—	19,0	1,6	—	5,0	0,6	—	—
—	0,7	0,08	—	—	1,2	8,0	0,8	1,1	0,10
—	0,75	0,12	—	—	1,3	8,5	0,85	1,2	0,10
—	0,80	0,3	—	—	1,4	10,0	1,0	1,9	0,15
—	0,90	0,7	—	—	1,5	15,0	1,5	3,0	0,25
—	1,0	1,6	—	—	2,0	20,0	2,0	4,0	0,60
—	0,35	0,05	—	—	0,38	—	0,6	1,3	0,13
—	0,30	0,05	—	—	0,40	—	0,5	1,2	0,12
—	0,26	0,04	—	—	0,60	—	0,4	1,2	0,12
—	0,50	0,08	—	—	0,5	—	3,6	1,64	0,16
—	0,17	0,034	—	—	0,2	—	0,8	0,60	0,06
—	0,15	0,034	—	—	0,2	—	0,6	0,34	0,03
—	0,13	0,05	—	—	0,2	—	0,6	0,32	0,03
—	0,30	0,12	—	—	0,5	—	1,0	—	—

$$I_{red} = I_{p.s} K_v K_{m.pr} K_{c.\ell},$$

where $I_{p.s}$ is the labor consumption per ton of production output with respect to the normatives or an analogous design or by the report of an existing shop, man-hour/ton; K_v is the coefficient taking into account the variation of the labor consumption as a function of the annual production output volume by the shop and the mastery of the ship construction series; $K_{m.pr}$ is the coefficient which takes into account the level of mechanization and automation of the production processes and the technical level of production when determining the labor consumption per ton of shop production; $K_{c.\ell}$ is the coefficient taking into account the variation of the labor consumption per ton of shop production as a function of the structural design of the ship, including the type of material.

The annual production output per m^2 of shop area reduced to the design conditions, tons/m^2

$$\rho_c = \rho_{t.a} K_{p.o} K_{p.m} K_{c.pr} K_{s.p} K_{wp},$$

Table 72. Approximate indices for calculating basic forms of energy and number of tools per 100 tons of production of the hull fitting and pipe fabrication shops

Shops	Class of shipyard	Initial data		Indices				
		Annual production output, thou. of tons	Mean thickness of machined metal, mm	Electric power (installed capacity), kilowatts				Pneumatic tools, units (compressed air at 5-6 kg/cm^2)
				For machine tools	Automated and semi-automated welding	For manual welding and attack welding	For crane equipment	
Hull fitting	I	4500	4,0	6	20		4	1,35
	II	3400	3,5	7	24		5	1,40
	III	2600	3,0	9	26		6	1,45
	IV	700	2,5	11	30		7,5	1,53
	V	520	2,0	12	32		8	1,60
Pipe fabrication	I	4800	—	15	7		7	0,25
	II	3700	—	17	7,5		6	0,3
	III	3200	—	20	8,0		6	0,35
	IV	1100	—	25	8,5		5	0,35
	V	320	—	—	9,0		4	0,4

Note. In addition to the presented data on the compressed air for the pneumatic tools, the hull fitting shops are provided with compressed air for operation of paint sprayers and contact welders, respectively, class I, 0.08 and 0.19 units per 100 tons of production output; class II, 0.09 and 0.26; class III, 0.11 and 0.30; class IV 0.28 and 0.42; class V, 0.32 and 0.48 units per 100 tons of production output. The indices for the pipe fabrication shops are presented without considering the power of the sections for cleaning, painting, insulating and galvanizing pipe.

where $\rho_{p.a}$ is the annual production output from 1 m^2 of total area according to the normatives or the analogous plan or an existing shop, $tons/m^2$; $K_{p.o}$ is the coefficient taking into account the variation in the production output from 1 m^2 of shop area as a function of the volume of the annual production by the shop and the mastery of the series ship construction; $K_{p.m}$ is the coefficient taking into account the variation in the production output from 1 m^2 of shop area as a function of the level of mechanization and automation of the production processes and the technical level of production; $K_{c.pr}$ is the coefficient taking into account the variation of the annual production output from 1 m^2 of shop area as a function of the structural design of the ship, including type of material; $K_{s.p}$ is the coefficient taking into account the variation in the shop production output as a function of the shift index of the shop workers; K_{wp} is the coefficient taking into account the variation of the production output by the shop as a function of the loading of the equipment and the work places.

In the designs, as a rule, the design ship of the series with an order number which is equal to two calculated ship output programs of the shipyard is provisionally taken. The analysis of the accounting data on the operation of the basic shops of

Table 72 (continued)

Indices									
Acetylene and oxygen			Air and inert gases for gas electric cut.		Welding arcs of automatic and semi-automatic carbon-dioxide shielded welders, unit	Production water		Water for cooling welding torches	
Mechanical cutters, units	Manual cutters, units	Torches for straightening and dressing, un.	Aver. consumption, m^3/day	Maximum consumption, m^3/hr		Average consumption, m^3/day	Maximum consumption, m^3/hr	Average consumption, m^3/day	Maximum consumption, m^3/hr
0,02	0,22	0,06	—	—	0,55	4,2	0,35	0,30	0,17
0,03	0,33	0,09	—	—	0,60	5,6	0,47	0,35	0,18
0,04	0,35	0,11	—	—	—	6,0	0,50	0,40	0,20
0,14	0,42	0,28	—	—	—	10,0	1,50	—	—
0,16	0,48	0,32	—	—	—	11,0	1,70	—	—
0,04	0,05	0,10	—	—	0,25	1,0	0,2	—	—
0,04	0,05	0,12	—	—	0,25	1,0	0,2	—	—
—	0,06	0,15	—	—	0,20	0,8	0,18	—	—
—	0,06	0,15	—	—	0,15	0,6	0,17	—	—
—	—	0,20	—	—	0,10	0,5	0,16	—	—

the shipyards indicate that the nature of the reduction of the labor consumption by shops, depending on the series nature of ship building is analogous to the reduction of the labor consumption as a whole throughout the shipyard. Therefore when designing and comparing the labor consumption indices per ton of shop production output it is possible to use united data for the reduction in labor consumption as the series is mastered with sufficient accuracy (see Figure 13).

The approximate values taking into account the variation of the labor consumption per ton of production output of the shop and the annual production output from 1 m^2 of total shop area as a function of the variation of the annual calculated program are presented in Table 75.

Beginning with the graph for the reduction of the labor consumption of building of ships as the series is mastered (see Figure 13) or the values of the table, the coefficient K_v can be defined by the formula

$$K_v = I_{\ell.d}/I_{\ell.s},$$

where $I_{\ell.d}$ is the value of the labor consumption per ton of shop production for a ship in the series used in the design; $I_{\ell.s}$ is the labor consumption per ton of shop production of a ship in the series adopted by another source (in the normatives or an analogous design or by the reports of an existing shop).

For an identical shop area per production worker with different production volume and different series output of the ships $K_{p.o}$ is inversely proportional to the coefficient K_v, that is,

Table 73. Average air and gas consumption per unit of equipment and tool and the use coefficients of the equipment

Shops	Class of shipyard	Pneumatic tools (compressed air at 5–6 kg/cm²): Air consumption, m³/hr	Pneumatic tools: Use coefficient	Mechanical cutters: Acetylene consumption, m³/hr	Mechanical cutters: Oxygen consumption, m³/hr	Mechanical cutters: Use coefficient	Manual cutters: Acetylene consumption, m³/hr	Manual cutters: Oxygen consumption, m³/hr	Manual cutters: Use coefficient	Straightening and dressing torches: Acetylene consumption, m³/hr	Straightening and dressing torches: Oxygen consumption, m³/hr	Straightening and dressing torches: Use coefficient	Semiautomatic welders: Carbon dioxide consumption, m³/hr	Semiautomatic welders: Mean use coefficient
Hull platers (hull platers sections)	I	75	0,70	0,66	4,00	0,70	0,70	4,0	0,50	—	—	—	—	—
	II	70	0,70	0,66	3,30	0,70	0,68	3,5	0,50	—	—	—	—	—
	III	65	0,65	0,65	2,70	0,65	0,67	2,8	0,45	—	—	—	—	—
	IV	60	0,65	0,63	2,50	0,65	0,65	2,6	0,45	—	—	—	—	—
	V	55	0,60	0,60	2,35	0,60	0,63	2,5	0,40	—	—	—	—	—
Assembly-welding	I	80	0,75	—	—	—	0,7	4,0	0,70	2,0	2,2	0,50	0,9/1,8	0,70
	II	75	0,75	—	—	—	0,68	3,5	0,70	1,5	1,7	0,50	0,7/1,2	0,70
	III	70	0,70	—	—	—	0,67	2,8	0,65	1,2	1,4	0,45	0,6/0,9	0,65
	IV	65	0,70	—	—	—	0,65	2,6	0,65	0,8	1,0	0,45	0,5/ —	0,65
	V	60	0,65	—	—	—	0,63	2,5	0,60	0,6	0,8	0,40	—	0,60
Module building shop	II	75	0,70	—	—	—	0,68	3,5	0,70	1,5	1,7	0,50	0,6	0,70
	III	70	0,65	—	—	—	0,67	2,8	0,65	1,2	1,4	0,45	0,5	0,65
	IV	65	0,65	—	—	—	0,65	2,6	0,65	0,8	1,0	0,45	0,4	0,65
Shipbuilding sheds	I	80	0,70	—	—	—	0,70	4,0	0,70	2,0	2,2	0,50	0,7	0,65
	II	75	0,70	—	—	—	0,68	3,5	0,70	1,5	1,7	0,50	0,6	0,65
	III	70	0,65	—	—	—	0,67	2,8	0,65	1,2	1,4	0,45	0,5	0,60
	IV	65	0,65	—	—	—	0,65	2,6	0,65	0,8	1,0	0,45	0,4	0,60
	V	60	0,60	—	—	—	0,63	2,5	0,60	0,6	0,8	0,40	—	—
Hull fitting	I	70	0,7	0,63	2,65	0,65	0,63	2,5	0,60	0,6	0,75	0,50	0,6	0,70
	II	65	0,7	0,62	2,55	0,65	0,61	2,3	0,60	0,6	0,75	0,50	0,6	0,70
	III	60	0,65	0,61	2,45	0,60	0,60	2,1	0,55	0,5	0,60	0,45	0,5	0,65
	IV	55	0,65	0,6	2,35	0,60	0,58	2,0	0,55	0,5	0,60	0,45	0,5	0,65
	V	50	0,60	—	—	—	0,57	1,9	0,50	—	—	—	0,4	0,60
Pipe fabrication	I	70	0,7	0,7	4,0	0,65	0,65	3,0	0,60	0,55	0,60	0,60	0,6	0,70
	I	65	0,7	0,69	3,5	0,65	0,65	2,8	0,60	0,50	0,55	0,60	0,6	0,70
	III	60	0,65	0,67	3,0	0,60	0,64	2,6	0,55	0,45	0,50	0,55	0,5	0,65
	IV	55	0,65	0,65	2,7	0,60	0,63	2,4	0,55	0,37	0,40	0,55	0,5	0,65
	V	50	0,6	0,63	2,5	0,50	0,62	2,2	0,5	0,23	0,25	0,50	0,4	0,60

Note. In the "Semiautomatic welders" column the numerator is the gas consumption for the semiautomatic welders, and the denominator, for the automatic welders. In addition to the air consumption in the hull fitting shops, air is used for contact welders and paint sprayers, the consumption of which is about 30–45 m³/hr per unit of equipment; the use coefficient of the contact machines is 0.70–0.75, and the paint sprayers, 0.55–0.60.

$$K_{p.o} = 1/K_v.$$

This ratio was taken into account in the values of Table 75.

For determination of the coefficients $K_{m.pr}$ and $K_{p.o}$ it is possible to use approximate values of the variation of the labor consumption per ton of production and the

Table 74. Basic specifications and technical-economic indices of the shop.

Indices	By the present design	Normative	By the previously executed analogous design approved in year of 19__	By the existing analogous shop achieved in 19__
Basic specifications				
Annual production output, tons				
Total labor consumption for the annual program, man-hours				
Personnel list, people:				
production				
auxiliary				
Worker shift index				
Amount of equipment, units:				
production				
auxiliary				
materials-handling				
No. of work places, units				
Total area, m^2				
Technical-economic indices				
Labor consumption per ton of production output, man-hours/ton				
Labor consumption per ship, man-hours/ship:				
design A				
design B				
Percentage auxiliary workers with respect to production workers, %				
Average loading index of equipment and work places				
Annual production output, tons:				
from 1 m^2 of total area				
per industrial worker				
per employee				
Level of mechanization and automation of production processes, %				
Technical level of production				
Electrical equipment available per worker on the largest shift, kw/worker				

Note. Normative sources with respect to a previously executed analogous design and existing analogous shop for comparison with the design data and technical-economic indices are noted provisionally and for a specific design can be expanded, for example, by the data and indices for shops of foreign shipyards.

Table 75. Approximate values taking into account the variation in the labor consumption per ton of shop production output and annual production output from 1 m^2 of total shop area as a function of the variation of the annual calculated program

Recalculation factors	Shipyard class	Specific index of the program					
		1,0	0,9	0,8	0,7	0,6	0,5
Labor consumption per ton of production output	I	1,0	1,02	1.04	1,06	1,10	1.18
	II	1,0	1.02	1.05	1.08	1.12	1.16
	III	1,0	1,01	1,02	1,03	1,06	1.10
	IV	1.0	1,01	1,02	1,03	1,05	1,08
Annual production output per m^2 of total area	I	1,0	0,98	0,96	0,94	0,91	0.85
	II	1.0	0.98	0,95	0,93	0.89	0,86
	III	1,0	0,99	0,98	0,97	0,94	0,91
	IV	1,0	0,99	0.98	0,97	0,95	0,93

Table 76. Approximate values taking into account the labor consumption variation per ton of production with respect to the basic shops of the shipyard depending on the technical level of production

Shops	Ship-yard class	Technical level of production											
		0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,80	0,85
Hull platers shop	I—II	2,25	2,13	2,01	1,89	1,77	1,65	1,52	1,39	1,26	1,13	1,0	0,87
	III	2,0	1,89	1,78	1,67	1,56	1,45	1,34	1,23	1,12	1,0	0,88	0,76
	IV	1,8	1,7	1,6	1,5	1,4	1,3	1,2	1,1	1,0	0,9	0,8	—
	V	1,64	1,55	1,46	1,37	1,28	1,19	1,1	1,0	0,9	0,8	—	—
Assembly-welding shop	I—III	2,25	2,15	2,05	1,90	1,75	1,63	1,51	1,39	1,26	1,13	1,0	—
	IV	2,00	1,90	1,81	1,70	1,58	1,46	1,35	1,24	1,12	1,0	0,89	—
	V	1,80	1,70	1,60	1,50	1,40	1,30	1,20	1,10	1,0	0,90	0,80	—
Module building shop	II	1,46	1,34	1,26	1,18	1,12	1,06	1,0	0,94	0,87	0,80	0,72	—
	III	1,58	1,44	1,33	1,25	1,18	1,12	1,06	1,0	0,94	0,87	0,80	—
	IV	1,72	1,59	1,48	1,40	1,32	1,24	1,16	1,08	1,0	0,92	0,83	—
Shipbuilding shed	I—II	1,46	1,34	1,24	1,18	1,12	1,06	1,0	0,94	0,87	0,80	0,72	—
	III	1,58	1,44	1,33	1,25	1,18	1,12	1,06	1,0	0.94	0,87	0,80	—
	IV—V	1,72	1,59	1,48	1,40	1,32	1,24	1,16	1,08	1,0	0,92	0,83	—
Pipe fabrication shop	I—II	1,70	1,60	1,50	1,40	1,31	1,22	1,14	1,07	1,0	0,94	0,87	0,80
	III	1,58	1,48	1,39	1,30	1,21	1,13	1,06	1,0	0,[illegible]3	0,87	0,81	0,75
	IV	1,50	1,41	1,32	1,24	1,16	1,08	1,0	0,95	0,90	0,84	0,77	0,70
	V	1,38	1,30	1,23	1,15	1,07	1,0	0,93	0,87	0,81	0,76	0,71	—

annual production output from 1 m^2 of total shop area presented, respectively, in Tables 76, 77.

Beginning with the values presented in Tables 76 and 77, $K_{m.pr}$ or $K_{p.o}$ are defined by the formula

Table 77. Approximate values taking into account the variation of the annual production output from 1 m^2 of total shop area as a function of the technical level of production

Shops	Shipyard class	Technical level of production											
		0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,80	0,85
Hull platers shop	I—II	0,45	0,47	0,5	0,53	0,57	0,61	0,66	0,72	0,8	0,9	1,0	1,15
	III	0,5	0,53	0,56	0,6	0,64	0,69	0,75	0,81	0,9	1,0	1,14	1,3
	IV	0,55	0,59	0,63	0,67	0,72	0,77	0,83	0,91	1,0	1,11	1,24	—
	V	0,61	0,65	0,69	0,73	0,78	0,84	0,91	1,0	1,11	1,24	—	—
Assembly-welding	I—III	0,45	0,47	0,49	0,53	0,57	0,61	0,66	0,72	0,80	0,89	1,0	—
	IV	0,50	0,53	0,56	0,59	0,63	0,68	0,74	0,81	0,89	1,0	1,12	—
	V	0,55	0,59	0,63	0,67	0,71	0,76	0,83	0,91	1,0	1,12	1,24	—
Module building shop	II	0,70	0,75	0,80	0,85	0,90	0,95	1,0	1,06	1,14	1,25	1,38	—
	III	0,65	0,70	0,75	0,80	0,85	0,90	0,95	1,0	1,06	1,14	1,25	—
	IV	0,58	0,63	0,68	0,72	0,76	0,81	0,87	0,93	1,0	1,08	1,2	—
Shipbuilding shed	I—II	0,70	0,75	0,80	0,85	0,90	0,95	1,0	1,06	1,14	1,25	1,38	—
	III	0,65	0,70	0,75	0,80	0,85	0,90	0,95	1,0	1,06	1,14	1,25	—
	IV—V	0,58	0,63	0,68	0,72	0,76	0,81	0,87	0,93	1,0	1,08	1,20	—
Pipe fabrication	I—II	0,58	0,63	0,67	0,71	0,76	0,81	0,87	0,93	1,0	1,07	1,15	1,24
	III	0,63	0,68	0,73	0,78	0,83	0,88	0,94	1,0	1,07	1,15	1,24	1,32
	IV	0,67	0,71	0,76	0,81	0,87	0,93	1,0	1,07	1,15	1,24	1,32	—
	V	0,73	0,77	0,82	0,87	0,93	1,0	1,07	1,15	1,24	1,32	1,41	—

$$K_{m.pr} \text{ and } K_{p.o} = K_{p.sh}/K_{s.sh},$$

where $k_{p,sh}$ is the labor consumption per ton of shop production or finished production output from 1 m^2 of total shop area corresponding to the designed technical level of production; $K_{s.sh}$ is the same by another source.

The coefficients $K_{c.\ell}$ and $K_{c.pr}$ taking into account the variation of the labor consumption per ton of shop production and production output from 1 m^2 of total shop area, respectively, can reflect the dependence both on the weight of the structural elements of the ships (one class and type) and the complexity of the ships (different with respect to class and type).

As an example in Table 78 we have the approximate values taking into account the variations and labor consumption per ton of shop production and production output from 1 m^2 of total shop area as a function of the weight of the ship structural components.

Beginning with the indices presented in Table 78, the coefficients $K_{c.\ell}$ or $K_{c.pr}$ are defined by a formula which is analogous to the one presented above:

$$K_{c.\ell} \text{ and } K_{c.pr} = K_{p.sh.m}/K_{s.sh.m},$$

Table 78. Approximate values considering the variation and labor consumption per ton of production output of the shop and production from 1 m^2 of total shop area as a function of the weight of the structural components of the ship

Ships	Weight of structural components of ship Q_c, ton	Shops							
		Hull platers		Assembly-welding		Construction of modules & shipbuilding sheds		Pipe fabrication	
		Labor consumption	Output	Labor consumption	Output	Labor consumption	Output	Labor consumption	Output
Tankers	5 000	1,44	0,7	1,45	0,69	1,40	0,71	1,25	0,80
	15 000	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	25 000	0,86	1,16	0,86	1,16	0,96	1,05	0,96	1,04
	35 000	0,83	1,20	0,83	1,20	0,89	1,12	0,93	1,08
	45 000	0,80	1,25	0,81	1,24	0,86	1,16	0,91	1,10
Dry-cargo vessels	2 000	1,48	0,68	1,40	0,72	1,4	0,71	1,25	0,80
	4 000	1,16	0,86	1,15	0,87	1,15	0,87	1,13	0,88
	6 000	1,0	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	8 000	0,92	1,10	0,94	1,06	0,90	1,10	0,90	1,10
	10 000	0,88	1,14	0,88	1,14	0,85	1,18	0,81	1,24
Trawlers	1 500	1,22	0,82	1,20	0,83	1,12	0,90	1,28	0,78
	2 500	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	3 500	0,93	1,07	0,93	1,07	0,97	1,04	0,90	1,10
	4 500	0,88	1,14	0,90	1,11	0,93	1,08	0,85	1,18
	5 500	0,86	1,16	0,88	1,14	0,91	1,10	0,83	1,20
Seagoing tugs	250	1,45	0,69	1,08	0,92	1,05	0,95	1,12	0,90
	350	1,30	0,77	1,03	0,97	1,03	0,97	1,06	0,94
	450	1,18	0,85	1,02	0,98	1,02	0,98	1,04	0,96
	550	1,09	0,92	1,01	0,99	1,01	0,99	1,02	0,98
	650	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Seiners	90	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	110	0,93	1,07	0,92	1,09	0,85	1,18	0,99	1,01
	130	0,89	1,12	0,88	1,14	0,80	1,25	0,98	1,02
	150	0,85	1,18	0,84	1,19	0,77	1,30	0,97	1,03
	170	0,82	1,22	0,82	1,22	0,76	1,32	0,96	1,04

where $K_{p.sh.m}$ is the labor consumption per ton of shop production or annual production output from 1 m^2 of total shop area corresponding to ships with structural components and mass according to design; $K_{s.sh.m}$ is the same, according to another source.

The coefficient $K_{s.p}$ reflects the ratio $K_{s.p.des}/K_{s.p.s}$, where $K_{s.p.des}$ is the shift index of the shop workers by design; $K_{s.p.s}$ is the shift index of the shop workers according to another source.

The coefficient K_w reflects the ratio $K_w/K_{w.s}$, where K_w is the load factor of the equipment and the shop work places by design; $K_{w.s}$ is the load factor of the equipment and work places of the shop by another source.

Table 79. Comparison of the technical-economic indices of a shop reduced to identical conditions

Sources of indices	Initial data and indices									Reduction of indices to designed conditions									
	Annual production output of the shop, tons	Class of vessels	Weight of ship's structural elements, tons	Order No. of calculated series ships	Technical level of production	Shift index of workers	Load index of equipment and work places	Labor consumption per ton of production output $I_{p.s}$, man-hr/ton	Annual prod. output of 1 m^2 total area $\rho_{t.s}$, t/m^2	Labor consumption per ton of shop production output: Recalculation factors			Labor consumption per ton of production output I_{red}*	Production output from 1 m^2 of total shop area: Recalculation factors					Annual production output from 1 m^2 total shop area ρ_c**
										K_v	$K_{m.pr}$	$K_{c.\ell}$		$K_{p.o}$	$K_{p.m}$	$K_{c.pr}$	$K_{s.p}$	K_{wp}	
By the present design																			
By the normatives																			
By an analogous design																			
By the accounting data of an existing shop, and so on																			

* $I_{red} = I_{p.s} K_v K_{m.pr} K_{c.\ell}$, man-hrs/ton.

** $\rho_c = \rho_{t.s} K_{p.o} K_{p.m} K_{c.pr} K_{s.p} K_{wp}$, tons/$m^2$.

Table 80. Approximate values of the coefficients K_H and K_c

Shops by classes of shipyards	K_H		K_c	
	For producing products			
	for 2 ships	for 3 ships	for 2 ships	for 3 ships
I, II, III	1.05-1.17	1.08-1.25	0.92-0.88	0.0-0.8
IV, V	1.02-1.05	1.05-1.22	0.98-0.95	0.95-0.82

The technical-economic indices reduced to identical conditions are compared in table form (see Table 79).

The presented analysis pertains to the conditions where the annual program of the individual shops is designed for production output by one design. In cases where the program is calculated for products for ships by several designs, when analyzing the shop indices it is necessary to take the corresponding coefficients.

If we take the calculated ship of the series with an order number equal with respect to value to two annual shipyard ship production programs, the indicated coefficients can be defined using the chart presented in Figure 13 by the following formulas:

$$K_H = (I_{sh1}n_1 + \ldots + I_{shn}n_n)/n_{equip}I_{sh};$$

$$K_c = n_{equip}I_{sh}/(I_{sh1}n_1 + \ldots + I_{shn}n_n),$$

where K_H is a coefficient taking into account the variation in labor consumption per ton of shop production as a function of the product output for ships of several designs; K_c is the coefficient taking into account the variation in production output from 1 m^2 of total shop area as a function of the product output for ships of several designs; I_{sh1}, ..., I_{shn} are the labor consumptions by the chart for 1 ton of shop protection consisting of products for ships of several designs; I_{sh} is the labor consumption by the chart for 1 ton of shop production consisting of products for ships of one design; n_1, ..., n_n are the total number of ships by the individual designs for which the shop produces the products; n_{equip} is the total number of ships for which the shop produces products.

The approximate coefficients K_H and K_c for the provisional annual shop production outputs used in this book are presented in Table 80.

The choice of the coefficients presented in the table is defined by the ratio of the ships built by different designs.

Thus, for class I shops when determining the labor consumption per ton of production output the largest values of the coefficients 1.17 and 1.25 correspond to the annual shipyard program (10 ships) consisting of equal proportions with respect to number of ships 5 + 5 for two or 4 + 3 + 3 for three designs of the calculated program; the smallest values of the coefficients 1.05 and 1.08, for the combination 9 + 1 in the case of two or 8 + 1 + 1 in the case of three designs of the calculated program.
Correspondingly, the values of the coefficients in determining the annual production output indices per square meter of area assume values in our example of 0.88 and 0.80 for a combination of 5 + 5 for two designs and 4 + 3 + 3 for three designs or 0.92 and 0.90 for a combination of 9 + 1 for two designs and 8 + 1 + 1 for three designs in the calculated program.

For other combinations of the number of ships of different designs in the program the intermediate values of the coefficients are determined by interpolation.

When analyzing the labor consumption indices per ton of shop production and production output from 1 m^2 of total shop area the formulas for analyzing them for several ships in the calculated program will have the form, respectively:

$$I_{red} = I_{p.os}K_H K_{m.pr} K_{c.\ell};$$

$$\rho_c = \rho_{equip} K_c K_{p.m} K_{c.pr} K_{s.p} K_w.$$

In cases of considering the application of large scale sheet metal in the designs for the hulls of the designed ships, when comparing the shipyard shop indices it is necessary to introduce the corresponding coefficients into the above-presented formulas, considering, for example, that when replacing the steel sheets 12,000 × 3000 mm for the ships' hulls at class I shipyards with 16,000 × 4500 mm sheets which amount to 20% of the total weight of the hull steel for the ship and 16,000 × 3200 mm steel sheets which amount to 30% of the total weight of the hull steel of the ship, the labor consumption of the preliminary straightening, cleaning and priming of the steel per ton of output is reduced by 8%, the manufacture of hull parts, by 6%, the manufacture of subassemblies and sections by 7% and building slip operations by 3.5%. At classroom II shipyards when using 16,000 x 4500 mm sheets in the amount of 10% of the total weight of the hull steel per ship, the labor consumption of preliminary straightening, cleaning and priming of the steel per ton of output is reduced by 5%, the manufacture of hull parts, by 3%, the manufacture of subassemblies and sections by 4% and module construction, by 3%.

The production output per square meter of total area of the shops performing the indicated operations is increased accordingly.

CHAPTER XVI. HEATED, COVERED SLIP WAYS. WINTER STORAGE AREAS FOR SHIPS AND OUTFITTING QUAYS

§ 48. Advantages of Heated, Covered Building Slips

In solving the problem of the location of building slips in heated closed-in berths and in open areas it is necessary to consider the following basic principles:

In the heated, covered slip ways (considering the climate of the USSR) it is possible to create the most favorable conditions completely corresponding to the technical and process requirements for building ships in slip ways (the quality of the welding and painting operations which can be performed under normal temperature conditions is improved; the most efficient methods of lighting the work places, supplying electric power, compressed air and other forms of power are provided for; the process equipment is used more efficiently, and so on);

The conditions of labor are improved significantly, and the productivity of labor rises as a result of elimination of idle time caused by unfavorable meteorological conditions;

The closed covered slip ways are better layed out on a master plan with other shipyard shops, which permits significant reduction in the work time losses for moving people and delivering materials and products to the building slips, and the entire shipbuilding process is more efficiently coordinated.

The additional capital investments in constructing the heated, covered slip ways by comparison with open building slips are paid for in minimal times -- 1 to 3.5 years.

By the calculations of some shipyards, the increase in labor consumption of operations on the shipbuilding ways as a result of auxiliary operations connected with building the ships in the open air, prolonging the finishing and insulating cycle at low temperature, complications with loading and installing the panels, sections, machinery and equipment in windy or freezing weather, the construction of various types of temporary shelters on the ships for warmth and protection against precipitation and wind, amounts to about 10%.

Poor atmospheric conditions can disturb normal production processes when working in the open air; for example, under the conditions of Leningrad during the year this interrelation is manifested as follows [10, 12]:

The welded edges to a width of 75 mm on both sides of the joint must be heated before welding to a temperature of no less than +20° C for killed carbon steel and low-alloy steel with plate thickness of more than 20 mm and for killed carbon steel with plate thickness of 12 mm or more if the welding is performed by ANO-4, ANO-6 and ANO-9 electrodes; with an average number of days a year with a temperature below -25° C, 1.2; for forgings and castings of the ship's hull with an average number of days per year with temperature below -15° C in the amount of 11.4; for killed and rimming steels, with an average number of days per year with a temperature of about -10° C in the amount of 29.5;

The average number of days per year with an air temperature below +5° C when it is impossible to paint (except for special frost-resistant paints) is 189.9;

The average number of days per year when it is also impossible to paint with precipitation is 199, with snowstorms 24, and with fog 57.

During the year the enumerated unfavorable conditions coincide on certain days, but the total number of days per year when the normal production process is disturbed is quite large. As a result, during the winter the productivity of labor when building ships in uncovered ways turns out to be lower by approximately 40% than in the heated covered-in berths, and on the average for the year it is about 10% lower.

If we remember that up to 40% of all of the work of building the ships is done on the shipbuilding ways, then the increase in labor consumption when building the ships on the uncovered shipbuilding ways will be up to 4% of the total labor consumption.

The cost benefit from constructing the covered, heated slip ways at the shipyards can be traced by the data in Table 81. Three types of shipyards are presented in the table:

Shipyard A -- medium shipbuilding -- with 12 ships per year output and complex hull fittings.

Shipyard B -- small shipbuilding with 32 ships per year output, with complex hull fittings;

Shipyard C -- medium shipbuilding -- with 12 ships per year output with simple hull fittings.

From the presented data it is obvious that the most expensive are the open shipbuilding ways with portal cranes, for the manufacture of which up to 50 to 70% of the total cost of the ways is spent.

The operating expenses, heating, minor repairs and depreciation, protective shelters for the ships, wages for the uncovered shipbuilding ways with electric bridge cranes by comparison with heated covered-in berths are as follows: for shipyard A 180%; for shipyard B 570% and for shipyard C 180%. In addition, it must be considered that additional capital investments are required for the boiler rooms to provide for heating of the ships in the uncovered building ways.

Table 81. Relative cost of the shipbuilding ways in covered-in berths and in open areas for different shipyards, %

Shipbuilding ways	Shipyards		
	A	B	C
In heated, overed-in berths	100.0	100.0	100.0
In open a·· as:			
with trestle and electric bridge cranes	76.5	81.6	73.8
with portal cranes	116.4	126.4	113.1

All of the additional expenditures on the heated covered-in berths are paid for in 3.5 years for shipyard A, in 1 year for shipyard B, and 3.6 years for shipyard C.

§ 49. Areas for Winter Storage of Ships

Under the climatic conditions of the Soviet Union, the icy period of various bodies of water around the shipyards and water basins fluctuates within significant limits.

At the shipbuilding enterprises, predominately at the class IV and V shipyards (sometimes class III) located in areas with a significant ice period excluding launching of ships, special areas are created for winter storage of the ships.

When designing class I, II and III shipyards, in order to provide for launching the ships during the ice period in some cases provision is made for such special measures as heating the wet basins with hot water discharged from a thermoelectric power plant nearby, heating the sections of the wet dock chamber with steam, maintaining a lane in the ice in the vicinity of the launching facility by mixing the water with compressed air and, finally, maintaining a lane in the vicinity of the launching facility by operating icebreaker type tugs.

The number of places for winter storage of ships is determined by the slip way shipbuilding schedule at the shipyard or by the following formula:

$$n_{st} = \Phi_{ice}/t_{cycle} = \Phi_{ice}n_c/\Phi_c,$$

where n_{st} is the required number of places for winter storage of the ships, units; Φ_{ice} is the length of the ice period when it is impossible to launch ships, months; $t_{cycle} = \Phi_c/n_c$ is the ship output cycle from the building ways; Φ_c is the annual time available of the building ways, months; n_c is the annual calculated program with respect to ship production, units.

The areas for winter storage of the ships are designed in the form of individual groups of shipbuilding ways. The ships are moved to these locations on special cradles (for the launching facility in the form of a longitudinal slip, slip trolleys are used). On the winter storage shipbuilding ways the ships are transferred on special cribbings. For placing the ships on keel blocks or cribbings the building berths are equipped with metal chairs; foundations are also provided under the cribbings in the form of reinforced concrete slabs. In individual cases the winter storage areas are equipped with a steam line for heating the ships and an electric network for loading them; the power consumption is taken according to the ship design data.

§ 50. Outfitting Quays

The outfitting quay of the shipyard is designed for mooring the ships while they are outfitted afloat and go through trials, and it must provide for the performance of these operations in accordance with the annual calculated program of the shipyard. Depending on the local conditions, in some cases piers are designed for outfitting ships afloat having the same total mooring space as the corresponding quay.

The outfitting quay is connected directly to the shipyard site and has one wall for mooring ships, and the pier juts out into the water basin of the shipyard and has two walls. In the overall shipyard master plan the outfitting quay is not isolated as an independent production unit. All of the outfitting and trials at the quay are performed by the outfitting and acceptance shop and the corresponding contractors. As a rule, it is managed by the captain's part of the shipyard and is serviced by its staff.

The length of the quay is calculated beginning with the placement of the maximum number of ships moored simultaneously on it, in accordance with their building schedules.

Thus, the length of the outfitting quay of 424 meters is determined by the following expression: $190 \times 2 + 24 \times 1 + 10 \times 2$, where 190 is the maximum ship length, meters; 2 is the number of ships simultaneously lying along side the quay; 24 is the maximum breadth of ship, meters; 1 is the number of ships simultaneously lying bow to the quay; 10 is the clearance between the ships, meters; 2 is the number of clearances between ships.

The cordon depth of the quay is calculated beginning with the calculated draft of the ship, the navigational margin and the margin for drifting of the soil. In turn, the navigational margin is taken as a function of soil: for silty bottoms the margin must be 0.20 meters; for sand, silt-clay loose soil from 0.25 to 0.3 meters; for tight, caked sandy and clayey soil from 0.3 to 0.45 meters; for rocky soil from 0.45 to 0.6 meters. The soil drifting margin is usually taken as 0.4 meters.

The surface level (cordon) of the quays is determined in each specific case as a function of the adopted type of industrial service corridors and the elevation of the shipyard territory.

In accordance with the class of shipyard, the outfitting quays are equipped with portal cranes, a description of which is presented in Table 82.

In individual cases the outfitting quays of the class IV shipyards are equipped with tower cranes of the corresponding parameters. The number of cranes is taken calculating one crane for every 200-250 meters of quay length (possible materials handling operations during the installation and outputting work on the ships are considered).

Table 82. Characteristics of the portal cranes of outfitting quays

Class of ship	Carrying capacity of crane, tons	Boom span, meters	Lift height, meters
I	80/40 50/30 32/20 30/25	25/50 45/70 35/50 25/35	50 65 50 30
II	30/25	25/35	30
III	30/25 16	30/35 30	30 28
IV	16 10	30 30	28 28

As a rule, the outfitting quays of the shipyards are designed considering the advanced methods of series shipbuilding insuring in individual cases a high degree of their readiness before launching. In particular, the high degree of readiness of ships before launching is achieved on the building ways enclosed in covered, heated berths and equipped with powerful materials handling machines.

The volume and labor consumption of the operations with respect to outfitting the ships afloat with stable series building conditions are insignificant, and the expenditures of energy on welding, the operation of the pneumatic tools and the gas cutting tools and torches are very small. However, when building the prototype ships of the series or experimental models, the degree of launch readiness of the ships can also be insignificant.

In the operating practice of the shipyards, especially when building ships on open, inclined ways and in shipbuilding docks, cases can occur where only the hull and submerged basic fittings are ready on a ship that is planned for launching, and the entire installation and outfitting operations must be performed afloat. Accordingly, when designing the power service lines it is necessary to assume a greater volume of operations than necessary by the process for building series ships. In addition, it is necessary to consider known nonuniformity in the performance of the operations of outfitting the ships at the quay caused by the fact that the main part of these operations, requiring significant expenditures of energy, must be completed during the first period of outfitting when the loading and securing of all the fixtures are complete. During the second outfitting period, primarily when developing the wiring diagrams and preparing for and performing the mooring trials, the energy consumption is quite low.

Example basic indices with respect to the power engineering of the outfitting quays per 50 meters of length are presented in Table 83.

When determining the distance between two analogous stations for connecting the industrial conduits on the outfitting quay it is necessary to consider possible versions of placement of the ships at the quay, obtaining the shortest cables and cords from the connection stations to the place of use, structural location of the power outlets on the ships for getting power from the quay.

The indicated requirements can be satisfied best with the following distance in meters between stations for connecting the industrial conduits on the outfitting quays:

Shipyard classes	
II	50-60
III	30-50
IV	20-25

Table 83. Indices with respect to power engineering of the outfitting quays (reduced to 50 meters of quay length)

Indices	Class of shipyard		
	I	III	IV
Average thickness of the hull metal, mm	14	10	8
No. of simultaneous operating welding arcs, manual welding, units	5	5	5
Average arc current strength, amps	220	200	180
Number of portable machine tools and fans, units	2	2	1
Power of portable machine tools and and electric fans, kilowatts	10	6	6
Number of simultaneously operating pneumatic tools, units	8	8	8
Average air consumption per tool, m^3/min	1.05	0.95	0.75
Number of simultaneously operating acetylene-oxygen stations, units	2	2	2
Average consumption per station, m^3/hr			
acetylene	0.5-0.6	0.5-0.6	0.45-0.5
oxygen	3.2-4.6	3.2-4.6	2.6-3.4
Number of simultaneously operating hydrants (fire nozzles), units	0.5	0.5	0.5
Required head of water from the lowest level, meters	30	25	25

Note. In addition to the presented basic forms of power for the outfitting quays power is also supplied for heating the ships during the winter and for mooring trials of individual systems.

However, as analysis of the construction and the power engineering solutions indicates, with high degree of saturation of the modern outfitting quays with various forms of power service lines with corresponding connection points, the upper structure of the quay turns out to be overloaded, and the use of the quay for storing goods, just as the conditions for the materials handling operations become significantly worse. Therefore for all types of outfitting quays the arrangment of the groups of power stations and connection of them along the quay allows for 50 meter spacing. Example dimensions of the depths (from the calculated water level) and

Table 84. Example depths and calculated loads on the outfitting quays of shipyards

Parameters of the outfitting quays	Class of shipyard		
	II	III	IV
Calculated draft of ships, meters	7.0	7.0	5.0
Calculated cordon depth from the minimum calculated level, meters	8.0	8.0	6.0
Height of cordon from mean perennial zero-water level, meters	2.5 and 3.5*	2.5 and 3.5*	2.5 and 3.5*
Location of the crane rails from the cordon, meters	2.5 and 2.7	2.5 and 2.7	2.5 and 2.7
Uniformly distributed load, temporary, tons/m^2	3.0	3.0	2.0
Mooring bollards for an effective force, tons	50.0	50.0	50.0
Spacing of bollards, meters	25.0 and 30.0	25.0 and 30.0	25.0 and 30.0
Maximum calculated annual supply levels, %	97.0-99.0	97.0-99.0	97.0-99.0

*For the outfitting quays located on rivers with sharply expressed floods or great tidal amplitude this value is specially determined.

calculated loads for the outfitting quays of the shipyards are presented in Table 84. For the outfitting quays built on estuaries with sharply expressed flooding fluctuation of the water level and also for quays located on marine bodies of water with tidal amplitude of more than 2.5 meters for quays with industrial conduit service corridors and an amplitude of 3.3 meters for quays without through corridors, special attention must be given to the selection of the calculated level.

The width of the strip of territory of the outfitting quay is determined beginning with the distance from the cordon of the quay to the axis of the crane rails and maximum boom span of the crane and also the location of the storage areas, transport and power engineering service lines (roads and railroads, industrial conduit service corridors and intake manholes).

CHAPTER XVII. SHIPYARD SHOP STORAGE AREAS

§ 51. Purpose, Organization and Siting of Storage Areas

The shipyard shop storage areas are designed to store spare materials and intermediate products which provide for continuity of the operation of these shops during shipbuilding.

The storage areas are subordinate to the shops, the operation of which they support:

Steel storage (consumer base) subordinate to the hull platers shops;

Hull parts storage subordinate to the assembly-welding shop;

Section storage, the module building shop for the modular method of shipbuilding and the shipbuilding shed for the section method of building the ships;

Pipe storage (consumer base), the pipe preparation shop;

Stores, sections and makeup areas, the corresponding shipyard shops.

The steel and pipe storage areas are planned to be consumer base areas considering the introduction of all-around mechanization with the corresponding hull platers and pipe preparation shops.

When designing the shipyard shops storage areas approximately the following theoretical solutions are adopted with respect to organization of storage of the corresponding material, parts and products.

In steel storage, the sheet metal and section are stored with respect to types and sizes in special coded areas or shelves in the horizontal position, which offers the possibility of using cranes with magnetic grapples or pneumatic vacuum suction cups and programmed control.

The sheets and rolled section are sent to primary machining on loaders, roller conveyors and belt conveyors.

Before sending the rolled section for machining, if necessary it is straightened on a horizontal press or stretching machine. The previously straightened sheet and rolled section are also stored.

The hull parts are delivered to the sorting areas of the hull parts warehouse in containers, on pallets and in bundles. The sheets and shaped parts are stored in groups in process sets, associated by the subject-nomenclature attributes.

The ship sections are made up from containers, pallets and bundles distributed for subassembly and section assembly. The storage of the hull parts in the storage area depends on size. In class I and II shipyards, the following part sizes can be used:

Flat sheet parts	From 3200 × 16,000 mm To 4500 × 16,000 mm; From 1000 × 16,000 mm To 3200 × 16,000 mm; From 1000 × 8000 mm To 3200 × 8000 mm;
Flat sheets and bent parts	1000 × 1000 mm;
Bent sheet parts	From 3200 × 16,000 mm To 4500 × 16,000 mm; From 3200 × 8000 mm To 4500 × 8000 mm
Section flat and bent parts	From 1000 × 8000 mm To 3000 × 16,000 mm; 1000 × 3000 mm.

The parts of the indicated groups are stored in racks and not directly on the floor. As a rule, the procedure for storing small sheet and flat and bent parts up to 1000 × 1000 mm in containers or on pallets on the racks and the parts in the remaining groups in specially assigned places on the floor of the warehouse, is used.

The parts are stacked on the racks by special stacking cranes, and they are put in the storage locations on the floor by electric bridge cranes with special grapples. The subassemblies and sections are stored in the section warehouse in stacks on spacers, the small flat subassemblies and sections are put on the racks in the vertical position.

The expendable pipe reserve at the warehouse is stored in special mechanized racks which provide conveyor feed of the pipe to the shop for fitting.

In the stores and on the makeup platforms of the assembly-installation shops of the shipyard the pipes and products are placed in the corresponding racks, lockers and on the floor, as a rule, in containers designed for this purpose.

The easily flamable liquids and materials in the stores of the assembly-installations must be stored in tightly closed containers, in special cabinets or boxes equipped with exhaust ventilation.

It is necessary to deliver the easily flamable liquids and materials from storage to the workplace ready for use in a tightly closed container in an amount not exceeding the shift consumption. Glass containers are not allowed.

It is expedient to locate the shipyard shop warehouses considering the maximum closeness to the production shops and sections with minimum length of the path followed by the flow of goods, with modularization in the complex by production shops.

Depending on the geographic location of the shipyard, the warehouses are either open or covered type. Depending on the climatic conditions, the steel storage areas are in closed buildings serviced by electric bridge cranes or in open areas serviced by gantry cranes. In all cases the steel warehouse must be adjacent to the section for straightening, cleaning and priming the steel and must insure mutually related mechanization of automation of the production processes.

The hull parts warehouses are sited considering the process links between the hull platers and the assembly-welding shops, as a rule, in the same building with them.

In the majority of cases the section storage areas are located on open platforms covered with a trestle, serviced by electric bridge cranes, and also on platforms serviced by gantry or portal cranes (or both simultaneously). The latter are used when the section storage area is located next to an open predock or near-dock platform, and it is possible to use the dock cranes.

The pipe storage areas, considering the expediency of storing pipe on mechanized shelves and conveyor delivery of the pipe for working, as a rule, are in the same building and next to the pipe preparation shop.

When organizing warehousing and storage it is necessary to consider that when designing the shipyards it is necessary to work out the problems of transporting large steel plates, large-size and heavy-weight loads and the methods of delivering them.

§ 52. Workers, Equipment and Mechanization of the Materials Handling Operations

The number of workers in the shipyard shop storage areas is determined beginning with their distribution with respect to work places considering the shift system of operation of the storage areas adopted in the plan.

The number of workers at the storages areas can be calculated also by the following formulas, for example:

Crane operators

$$H_{cr}K_{si}\Phi_{cr}/\Phi_{w}n_{si};$$

Sling operators

$$H_{cr}H_{s\ell}K_{si}\Phi_{cr}K_{load}/\Phi_{w}n_{si};$$

Storage area workers

$$K_{prod}K_{si.w}/H_{serv}.$$

The following notation has been used in the formulas: H_{cr} is the number of cranes in the storage area, units; K_{si} is the shift index of operation of the cranes; Φ_{cr} is the annual work time available of a crane, hours; Φ_{w} is the same for a worker, hours; n_{si} is the number of shifts; H_{sling} is the number of sling operators servicing one crane, men, K_{load} is the load factor of the crane per shift; K_{prod} is the number of codes of materials and products stored in the storage area; $K_{si.w}$ is the shift index of the storage area workers; H_{serv} is the service norm per storage area worker per shift, code units.

Depending on the class of shipyard, the shop storage areas are equipped with the corresponding equipment and mechanization means. When designing the storage areas of shipyard shops, the equipment and means of mechanization are selected beginning with the following basic conditions:

Correspondence of the materials handling equipment to the operating conditions of the storage area, a given volume of operations and also the properties and peculiarities of the materials and products stored at the storage area;

Insurance of the highest level of mechanization, productivity of labor and economic expediency.

The stack and container storage of materials and parts permits a number of materials handling operations to be reduced by using special grapples and hoists.

The application of multitier shelves and sets of parts in containers for warehousing offers the possibility of better use of the warehousing and storage space, as a result of which the total storage area is reduced. The application of platform and overhead bridge cranes can be recommended in the warehouses basically for large size and heavy weight loads and also for loading and unloading operations. It is recommended that gantry cranes be used in the open storage areas (steel and section storage areas).

In individual cases where the storage areas are organized under trestles, electric bridge cranes can be used.

At the pipe and rolled section storage areas it is expedient to use special stacking cranes with front and end loading and floor-type motorized and electric stackers with side lift.

The cranes in the steel storage areas must be equipped with special crossarms with magnetic or vacuum suction devices.

The carrying capacity of the warehousing transport means is determined by the maximum weight of the sheets, parts, sections and pipe stored in the storage area and also transportation of them in containers.

Thus, the storage areas for shops in class I and II shipyards are equipped with the following cranes: the open steel storage areas are equipped with 30 and 50 ton gantry cranes; the covered steel storage areas have electric bridges cranes with the same capacities; the hull parts storage areas have 30 ton electric bridge cranes; the section storage areas under trestles have electric bridge cranes, and in open areas, 200 ton gantry cranes (class II shipyards, 160 tons); the pipe storage facilities have 5 ton overhead-track hoists.

In the section warehouses, as a rule, provision is made for the possibility of paired operation of the cranes for transporting sections weighing twice the crane capacity (in the presented example, sections with a weight equal to a capacity of 400 and 320 tons).

When designing the warehouses and storage areas, the technical level of warehousing operations in shipbuilding is defined on the basis of the five initial established technical levels: 0.100; 0.300; 0.500; 0.700 and 0.900, where 0.100 is the lowest level corresponding to the most imperfect organization of the warehousing and storage operations and which reflects the application of manual labor using the simplest mechanisms; 0.300 and 0.500 -- advanced mechanization means are proposed for the individual warehousing operations; 0.700, all-around mechanization of storage and warehousing operations using advanced materials handling equipment; 0.900, a high degree of automation of warehousing processes with the application of computers for accounting and control of the warehousing. The presented numerical values of the initial technical levels of the warehousing operations are somewhat provisional, and later they can be more precisely defined in connection with the preparation of new guidance materials.

The technical level of the warehousing operations is calculated by the formula

$$У_{ct} = (0{,}4A_1 + 0{,}4A_2 + 0{,}1A_3 + 0{,}1A_4)\,M,$$

where 0.4 and 0.1 are the significance factors of the determinants; A_1 is the determinant of the degree of progressiveness of materials handling equipment used when the materials arrive at the warehouse (the unloading operation) and issuing of the materials from the warehouse (loading operations); A_2 is the determinant of the degree of progressiveness of the materials and the equipment used for intrawarehouse transportation and storage; A_3 is the determinant characterizing the degree of perfection of the system for accounting, searching and making up the materials in the storage area; A_4 is the determinant of the degree of progressiveness of the service personnel wage system; M is a coefficient which takes into account the dependence of the numerical value of the technical level on the factor determinants not provided for by the system (improvement of the load grappling attachments, containers, racks, and so on).

The composition and numerical value of the determinants A_1 and A_2 are presented in Table 85.

The mean of the determinant of the system for accounting, searching and makeup of the materials A_3 and the determinant part of the service personnel wage system, A_4 and also their numerical values are presented in Table 86.

The value of the coefficient M is calculated by the formula

$$M = M_1M_2M_3M_4,$$

where M_1 = 1.01 is a coefficient taking into account the application of special load grappling attachments; M_2 = 1.04 is the coefficient taking into account the application of reusable and self-dumping containers; M_3 = 1.01 is a coefficient taking into account the presence of racks; M_4 = 1.05 is a coefficient taking into account the introduction of the specialized equipment of the shops with goods.

Table 85. Composition and numerical values of the determinants of the degree of progressiveness of the basic materials handling equipment used at the shipyard storage areas

Materials handling equipment used	Numerical value of the determinants A_1 and A_2
Nondriven roller conveyors	0.100
Floor-type electric tractors; truck cranes, caterpillar-mounted cranes, railroad cranes, gantry and bridge cranes; all-purpose truck loaders; driven roller conveyors	0.300
Special electric and truck loaders, electric stackers, bridge and gantry cranes with magnetic disc or with special clamp; stacker cranes, stackers	0.500
All-around mechanized storage areas, elevator type mechanized shelves	0.700

Table 86. Determinant of the system for accounting, search and makeup of materials and determinant of the service personnel wage system

Determinants	Numerical value of the determinants				
	0.100	0.300	0.500	0.700	0.500
	Meaning of determinants				
System for accounting, search and packaging of materials A_3	Search and accounting are conducted by the recording log. Makeup provided	Search and accounting by card catalog. Makeup is performed by consumer request	Search and accounting by card catalog with an indexing device. makeup provided by work order system	Retrieval and accounting by computer. Makeup by schedules	—
Service personnel wage system A_4	Loading and unloading operations not normalized	Less than 10% of the loading and unloading operations are normalized by technically substantiated norms	10 to 30% of the loading and unloading operations are normalized by technically substantiated norms	30 to 50% of the loading and unloading operations are normalized by the technically substantiated norms	All of the loading and unloading operations are normalized

Note. The presented coefficients are used under the condition of covering no less than 70% of the volume of operations by the influencing factor. If less than 70% the volume of operations is covered by the influencing factor, the numerical value of the corresponding coefficient is taken as 1.00.

The technical level of the warehousing operations of the group of storage areas of the shipyard shops on the whole can be defined by the formula

$$y_c = \frac{y_{c1}a_1 + y_{c2}a_2 + \cdots + y_{cn}a_n}{a_1 + a_2 + \cdots + a_n},$$

where Y_{c1}, Y_{c2}, ..., Y_{cn} are numerical values of the technical level of individual storage areas; a_1, a_2, ..., a_n are the specific values of the warehousing operations in percentages of the total labor consumption of the warehousing operations of the group of shipyard shop storage areas.

In design practice the specific values of the warehousing operations of individual storage areas in the total volume of the shipyard shop storage areas are calculated by the number of workers assumed in the design.

§ 53. Storage Areas and Methods of Defining Them. Power Engineering and Control Hardware

The storage areas are determined by calculation and planning the location of the storage places (bundles, pallets, containers and racks) in the volume of received storage reserve considering the required passages or corridors or the load consolidation per unit of area according to the norms.

In Table 87, as an example a calculation of the area of a steel warehouse for class I-III shipyards is presented as a function of the application of the types and sizes of sheet and shaped steel.

For the consolidated determination of the areas of the shipyard shop warehouses, in Table 88 example norms are presented for the reserves, loads and the use of the steel, hull parts, hull sections, pipe and materials storage areas.

Notes. 1. The storage norms for the steel and pipe warehouses of the shipyards located in remote regions or regions having the authority to have a large storage reserve, vary in accordance with the basic normatives effective for them. 2. In the steel and pipe reserve storage norms, it is provided that ships of one design will be built in the calculated program. If two or more designs are provided for in the calculated program in the design assignment, it is necessary to introduce the corresponding coefficients for the load per square meter of usable area: for two designs in the calculated program, 0.7-0.8 for steel warehouses; 0.85-0.95 for pipe warehouses; for three designs in the calculated program, 0.6-0.7 for the steel warehouses; 0.75-0.85 for the pipe warehouses. 3. The norms for the loads and the use of the steel and pipe storage areas are presented as applied to the provisional ships and the production volume adopted in this book.

When designing the indicated storage areas, the initial specifications of which differ from the adopted ones, it is necessary to present the normative indices in accordance with the specific conditions.

Example floor plans of the steel and hull parts warehouses are presented in Figures 73 and 74, respectively.

Table 87. Calculation of the steel storage area of class I-III shipyards as a function of the application of types and sizes of sheet and section steel

Class of shipyard	Stored steel	Size of bundle or storage area, meters	No. of types and sizes: %	No. of types and sizes: units	Bundle or location area, m^2	Total usable area, m^2	Ratio of usable area to total area,	Total area, m^2
I	Sheet	16×4,5	20	11	72	790	—	—
		16×3,2	30	18	51	920	—	—
		12×3,0	50	29	36	1050	—	—
	section	16×0,5	—	50	8	400	—	—
	Total	—	—	—	—	3160	0,475	6700
II	Sheet	16×4,5	10	6	72	430	—	—
		16×3,2	20	12	51	610	—	—
		12×3,0	70	38	36	1370	—	—
	Section	16×0,5	—	50	8	400	—	—
	Total	—	—	—	—	2810	0,475	5900
III	Sheet	10×2,4	100	52	24	1250	—	—
	Section	10×0,4	—	50	4	200	—	—
	Total	—	—	—	—	1450	0,425	3400

The floor plan of a pipe warehouse is shown jointly with a pipe preparation shop in Figure 48. The specifications for the floors of the main shipyard storage areas are presented in Table 89.

For operation of materials handling equipment and mechanization means, the storage areas are provided with the required electric power and are equipped with hardware for information about the materials, parts and products coming into the warehouses, the availability of the process sets before starting into production and the actual times for sending them to the corresponding shops.

Table 88. Example norms for the reserves, loads and use of the storage areas of basic shipyard shops

Storage Areas	Class of shipyard	Norms for Reserve Storage Time, months or days	Load per square meter of usable area	Ratio of usable area to the total area
Steel storage area (sheet and section)	I	1.5–2.0 months	5,00–6,00	0,45–0,50
	II	1,5–2,0 »	4,50–5,00	0,45–0,50
	III	1,3–1,6 »	3,50–4,00	0,40–0,45
	IV	1,3–1,6 »	2,60–3,20	0,40–0,45
	V	1,3–1,6 »	2,00–2,20	0,35–0,40
Section for making up hull parts	I	3 calendar days	0,75–0,90	0,40–0,45
	II	The same	0,60–0,75	0,40–0,45
	III	The same	0,45–0,50	0,35–0,40
	IV	The same	0,45–0,50	0,35–0,40
	V	The same	0,24–0,28	0,30–0,35
Hull parts storage area	I	15-20 calendar days	1,20–1,30	0,45–0,50
	II	14-16 calendar days	0,80–1,00	0,45–0,50
	III	12-15 calendar days	0,70–0,90	0,40–0,45
	IV	10-12 calendar days	0,60–0,70	0,40–0,45
	V	6-9 calendar days	0,30–0,40	0,35–0,40
Hull section storage	I	Within limits of 0.25 of given rhythm	0,65–0,75	0,40–0,50
	II	Within limits of 0.6 of given rhythm	0,55–0,65	0,40–0,50
	III	Within limits of given rhythm	0,45–0,55	0,40–0,50
	IV	The same	0,35–0,45	0,40–0,50
	V		0,15–0,25	0,40–0,50
Pipe storage	I	1,5–2,0 months	2,75–2,85	0,45–0,50
	II	1,5–2,0 »	2,05–2,15	0,45–0,50
	III	1,3–1,6 »	1,65–1,75	0,45–0,50
	IV	1,3–1,6 »	1,45–1,55	0,35–0,40
	V	1,3–1,6 »	1,35–1,45	0,30–0,35
Makeup storage and areas for temporary storage of products in the assembly for storage shops of the shipyard	I	10 days	0,55–0,60	0,40–0,45
	II	10 »	0,55–0,60	0,40–0,45
	III	10 »	0,50–0,55	0,35–0,40
	IV	10 »	0,50–0,55	0,35–0,40
	V	10 »	0,45–0,50	0,30–0,35
Storage for easily flamable liquids and materials	I–V	1 day	0,10–0,20	0,30–0,35

Table 89. Specifications for the floors of the main shipyard shop warehouses

Warehouses	Specifications for floor coverings	Load, tons/m^2	
		Total	Concentrated
Steel	The storage area floors and platforms must not be deformed from the stacked sheet and section steel	5.0	15.0
Hull parts	Must not permit deformations during storage of the bundles of parts and containers with parts; must provide for transportation of parts by motor vehicles and battery-powered trucks	2.0	10.0
Sections and panels	Must provide for storage of subassemblies and sections in stacks on pallets and also transportation of the sections by motor vehicles and multi-support conveyors	1.0	10.0

§ 54. Central Makeup Warehouse

The products and parts for the ships of the calculated program under construction in the shipyard are assembled in packages and stored in the central makeup warehouse. Let us present the following example nomenclature of products and parts stored in the central makeup warehouse with subdivision by supplier shops and basic process groups:

The hull fitting shop:

Three dimensional welded structural components -- tanks, cable reels, drums, flappers, mufflers;

Shaped welding structures -- penetrable and water type doors, hatch covers and manholes, louvers, ejection heads and ventilation connections, racks;

Small products for fastening tubes and cables -- suspensions for pipe, small brackets, cable spools, cable boxes, panels and bridge clamps for the cables;

Small three-dimensional welded products -- sockets, portholes;

Ventilation tubes and shafts -- connecting pipes, ventilation tubes and ventilation shafts;

Piping and tubing of the ships structures and fixtures -- tube and step ladders, hand rails and buttresses;

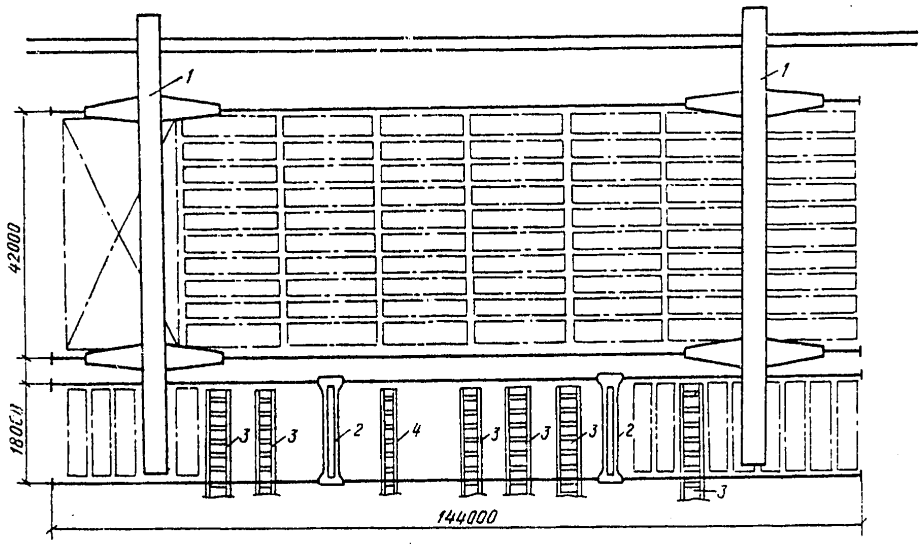


Figure 73. Floor plan of a steel warehouse at class I and II shipyards. 1 -- gantry crane with electromagnetic crossarm, Q = 30 tons; 2 -- loader; 3 -- roller conveyor for horizontal mover of sheets to the section for preliminary straightening, cleaning and priming of steel with the possibility of sending them to the steel warehouse after treatment in this section; 4 -- the same for section steel.

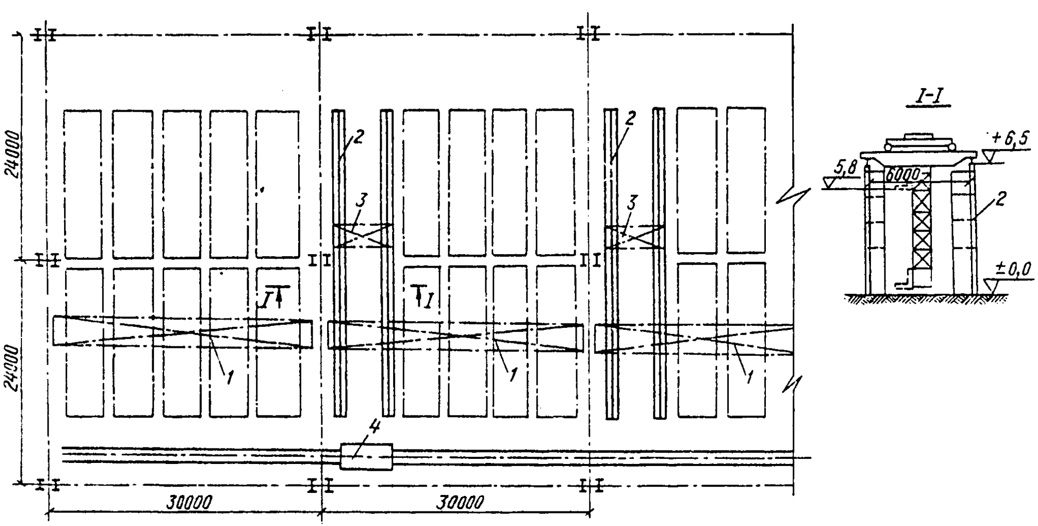


Figure 74. Floor plan of the hull parts warehouse. 1 -- electric bridge crane, Q = 30 tons, H = 11.45 meters; 2 -- racks ; 3 -- stacking crane; 4 -- self-propelled rail trolley.

Nonstandard metal ships' furniture — lockers, ditty boxes, tables, chairs and chests;

Smokestacks and galley ventilation stacks, smoke uptakes. Tin products -- chutes, soap dishes, dropping bottles;

Pipe preparation shop:

Stainless steel, copper, bimetal and aluminum pipe;

Woodworking shop:

Ladders and gratings, wooden furniture (lockers, chairs, tables, shelves, and so on), stores and cargo hold equipment, emergency kit (wedges, boxes, boards, bars), hoods and tents;

Rigging workshop and captain's section;

Cables with thimbles and shackles, masting, mats, fenders;

Galvanizing shop:

Steel pipe, tanks, brackets, shackles, bosses, thimbles, eyebolts, hooks, panels, connecting pipes, shelves, railings, lamps, drive and packing housings, fastenings;

Machine building products;

Surfacing, rivets, sockets, manholes, rudders, rudder drives, capstans, windlasses, shafting, hawse pipes and stem and stern posts, davits, whistles and sirens, spare parts and tools, and hatch covers.

The planning of the central makeup storage area is based on dividing it into specialized zones: unloading, storage of products, makeup and loading (output of the process makeup).

The storage zone for the products in turn is divided into sections with respect to nature of the products, and in the presence of several ships in the calculated program, by classes of ships. The common parts (beading, tacking, sockets, bosses, and so on) are stored together for all classes of vessels.

The products are delivered to the unloading platforms and the storage areas by rail or railless transportation and using electric bridge cranes or stacking cranes they are stacked in the attached storage areas.

The installation products and parts and also small products and parts are sent from the makeup shops to the storage area in transportable form (containers and pallets), first sorting them by types and sizes, which permits organization of the storage of the products in the indicated makeup without additional loading operations.

All of the products and parts except the large-size and heavy products and parts, are stored on racks serviced by the stacking cranes. The height of stacking on these racks is in the majority of cases taken as 5-6 meters. The large size and heavy products and parts (rudders, shafting, pipes more than 75 mm in diameter, and so on) are stored on the floor, with or without stacking.

According to the schedule of assembly-installation operations, the products and parts are fed from the storage zone to a makeup area where they are stacked by process makeups in containers or other transportable makeup. The equipment, products and materials stored in the other storage areas but also entering into the given process makeups are assembled at the corresponding storage areas into subsets and are transferred directly to the assembly and installation shops.

The organization of the storage and transportation of the parts and products in the contrainers or on the pallets with the application of stacking cranes permits maximum mechanization of the warehousing operations. The makeup functions of the central warehouse are performed by the special makeup section.

In accordance with what has been discussed, the makeup storage area consists of unloading and receiving platforms, storage and makeup areas and shipping areas, and it can be expressed by the formula

$$A = S_{rec} + S_{wh} + S_{ship},$$

where S is the total storage area, m^2; S_{rec} is the receiving area, m^2; S_{wh} is the warehousing and makeup area, m^2; S_{ship} is the shipping area, m^2.

When calculating the areas of the central makeup warehouse, we begin with the annual number of parts and products going through the storage area, the norms for simultaneous reserves and products and the specific load on the area.

Table 90. Calculation of areas for warehousing and makeup of parts and products

Objects of warehousing operations	Weight of parts and products for annual program, ton	Simultaneous storage reserve, tons	Load per m^2 of usable area, tons/m^2	Area use factor	Load per m^2 of total area, tons/m^2	Calculated usable area, m^2	Calculated total area, m^2
Parts and products:							
hull fitting shop							
pipe preparation shop							
woodworking shop							
rigging workshop							
galvanizing shop							
machine building section							
Total							

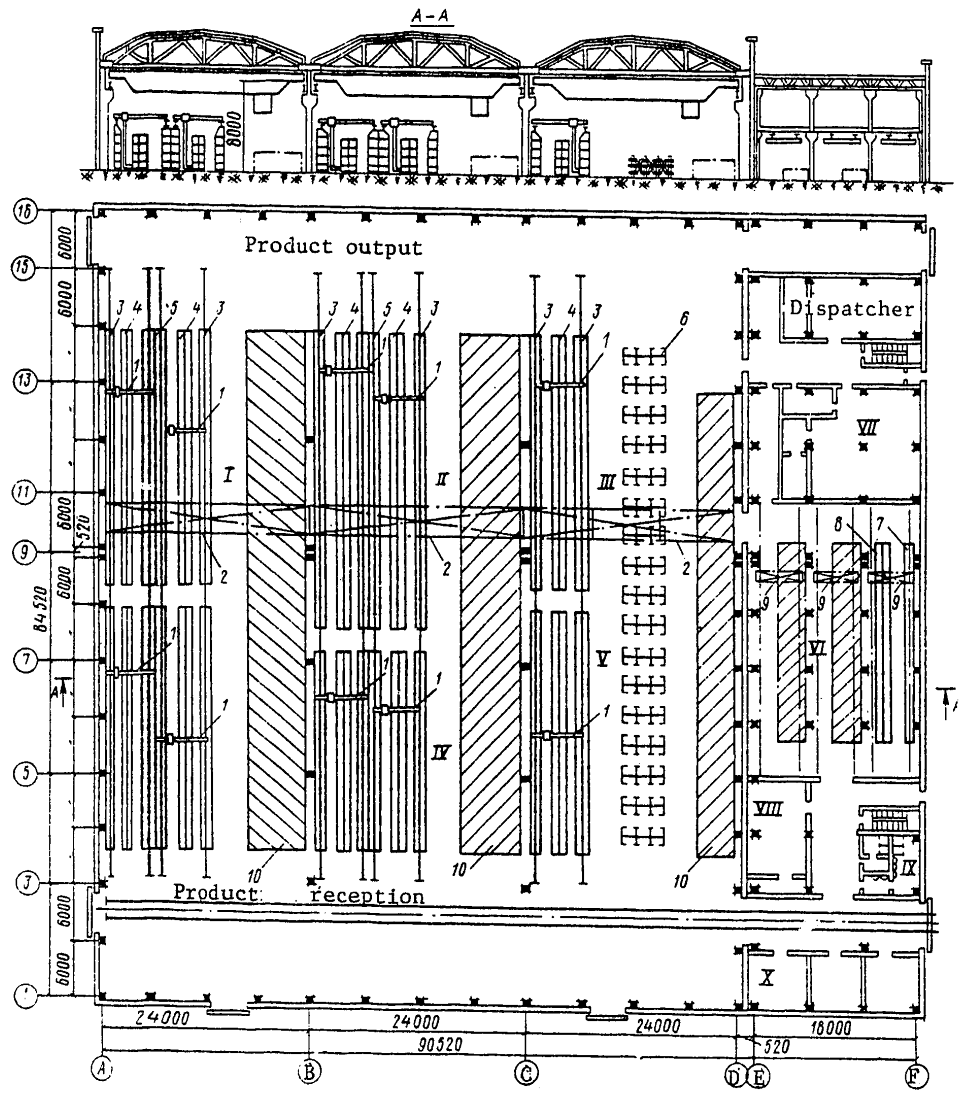


Figure 75. Floor plan of the central makeup warehouse. I -- machine building products; II -- products from the hull fittings shop; III -- products from the pipe preparation shops; IV -- products from the galvanizing shops; V -- products from the rigging and sail shops; VI -- products of the woodworking shops; VII -- men's dressing room; VIII -- women's dressing room; IX -- bathroom and laundry; X -- administrative and general services facility. 1 -- stacking crane; 2 -- electric bridge crane, Q = 10 tons, H = 8 meters; 3 -- one-way shelves with rails for the stacking crane; 4 -- two-way bin and shelf rack; 5--two-way rack with crane rails for the stacking crane; 6 -- cantilevered rack for pipe; 7 -- one-way shelf rack; 8 -- two-way shelf rack; 9 -- overhead single-boom electric crane, Q = 1 ton; 10 -- areas for storing products on the floor.

The warehousing and makeup area S_{wh} is defined by the formula

$$S_{wh} = Q_{wh}T/365\rho_{wh}K_{u.a},$$

where Q_{wh} is the total weight of the parts and products going through the central makeup warehouse for the annual program, tons; T is the duration of simultaneous storage of parts and products, calendar days; ρ_{wh} is the load of the parts and products per m^2 of usable warehousing and packaged product area, tons/m^2; 365 is the number of calendar days per year; $K_{u.a}$ is the area use factor (the ratio of the usable area to the total area).

The receiving S_{rec} and dispatch S_{dis} areas of the warehouse are calculated analogously considering the coefficient of nonuniformity of arrival and dispatch of parts and products by the following formulas:

$$S_{rec} = \frac{Q_{rec}K_{rec}t_{rec}}{365\rho_{rec}K_{u.a}};$$

$$S_{dis} = \frac{Q_{dis}K_{dis}t_{dis}}{365\rho_{dis}K_{u.a}},$$

where Q_{rec} is the total weight of parts and products received at the warehouse in the annual program, tons; Q_{dis} is the total weight of parts and products dispatched from the warehouse in the annual program, tons; K_{rec} is the coefficient of nonuniformity of receiving parts and products, K_{rec} = 1.2 to 1.5; K_{dis} is the coefficient of nonuniformity of dispatch in parts and products, K_{dis} = 1.1 to 1.2; t_{rec} is the time the parts and products spend in the receiving area, calendar days; t_{dis} is the time the parts and products spend in the dispatch area, calendar days; ρ_{rec} is the load of the parts and products per square meter of usable receiving area, tons/m^2; ρ_{dis} is the load of the parts and products per square meter of usable dispatch area, tons/m^2.

An example calculation of the areas of the central makeup warehouse is presented in tabular form (Tables 90, 91) in accordance with the formulas.

The layout of the central makeup warehouse is illustrated in Figure 75.

The central makeup warehouse is equipped with the corresponding equipment.

Table 91. Calculation of Storage Area for Receiving and Distributing Products

Warehousing objects	Weight of parts and products in the annual program, tons	Average weight of parts and products simultaneously in the area, tons	Coefficient of nonuniformity of arrival of parts and products	Coefficient of nonuniformity of dispatch of parts and products	Load per square meter of usable area, tons/m^2	Use coefficient of the area	Load per square meter of total area, tons/m^2	Area for receiving products, m^2	Area for dispatching products, m^2
Parts and Products:									
Hull fitting shop									
Pipe preparation shop									
Woodworking shop									
Rigging workshop									
Galvanizing shop									
Machinebuilding section									
Total									

CHAPTER XVIII. ENGINEERING ASSIGNMENTS FOR THE DEVELOPMENT OF ADJACENT PARTS OF THE DESIGN

The assignments for the development of adjacent parts of the design developed and published by the process engineers, along with the initial data on the area or the rebuilt shipyard (project) are the basis for developing adjacent parts of the design. The engineering assignments for the development of adjacent parts of a design are issued by the established forms which have the proper content and volume providing for quality and completeness of the development of these parts of the design.

The development and publication of the indicated assignments constitute one of the basic phases of engineering design.

A brief content of the engineering assignments for the development of adjacent parts of the contract design is discussed below.

§ 55. Assignments to Calculate the Cost of Production, the Financial Estimate Calculation for Equipment and Installation Work. Master Plan and Internal Transportation of the Shipyard

When calculating the production cost in the technical-economic part of the design, the engineers defending the project develope and distribute the following documents:

The consolidated list of production output, the number of employees and the size of the areas in which the total labor consumption of the shop operations, the average time available of one worker and the number of employees with subdivision into production and auxiliary workers, engineering-technical workers, office-accounting and junior service personnel, the distribution of workers by shifts, the production output with indication of unit of measure and quantity, and the total shop area are indicated with respect to each shop of the shipyard;

The consolidated list of labor consumption for the calculated program in which the labor consumption per unit and for the annual program with respect to the entire nomenclature of production of the calculated shipyard program is presented by individual shipyard shops;

The materials consumption list, in which the nomenclature of all basic forms of materials with indication of the unit of measure, quantity and percentage waste are presented with respect to each designed ship. The weight of the materials must correspond to the weight load of the ship. It is possible to combine materials with respect to individual groups considering the settlement principle, that is, under the condition of small deviations in their cost;

The deliveries list with respect to interplant cooperation and contractors.

In the list for each designed ship both with respect to deliveries by interplant cooperation and by contracted deliveries, the name of the products, the units of measure, the quantity and type of products for one ship and their total weight are presented. The deliveries with respect to intershop cooperation can be combined into uniform groups by the settlement attribute (waterproof covers, light doors, and so on). The contract deliveries are given with respect to each product individually.

As the assignments are compiling the financial estimate for equipment and installation operations, as a rule, the production engineers distribute the specifications for the production equipment for subdivision of it into new and existing equipment and with indications of the performance of the dismantling and installation work with respect to rearrangement of the existing equipment.

When developing a design for rebuilding or expansion of a shipyard (facility), an assignment is distributed for calculating the cost of the unused equipment (according to the plant inventory cards accounting for the basic means) with indication of the name of the equipment, shop, inventory number, date put into service, initial cost and total wear in rubles.

The production engineers develop and distribute a schematic diagram of the arrangement of the basic production facilities and hydroengineering structures in the shipyard area considering the planned methods of building ships and organization of production for the master plan and internal shipyard transportation design assignment. The indicated diagram is coordinated with the developments of the hydroengineering part. As a rule, this diagram is developed in several versions, and the final decision with regard to the master plan is made only after comprehensive technical-economic analysis of the versions.

In the assignment for the planning of internal transportation of the shipyard, data are presented on each shop about the received and shipped materials. In the "shop receiving" section, the name of the material, where it comes from, the amount in tons and type of transportation are indicated; in the "shop dispatch" section, the name of the material, where the material is to be sent, the amount in tons and form of transportation are indicated (see Table 69).

§ 56. Assignments for Construction Design and the Design of Hydroengineering Structures

In the construction design assignment the following are presented:

The purpose of the facility and a brief description of the production process;

The features of the building (new or rebuilt);

The nature and degree of precision of operations performed in the facilities;

Nature of production from the point of view of fire hazard (with indication of category);

Air parameters inside the facilities -- temperature (°C) and relative humidity (%);

Facilities with aggressive media (acids, gases, dust);

Facilities in which clean, wet wiping or washing of the walls and floors is required;

List of units with high temperatures (siting is indicated on the plan);

Data for planning noise-suppression measures, including the name of the facilities (or the floor axes), the name of the machines (installations), the numbers of their positions on the plan, the table noise levels from individual machines (decibels), the mean geometric frequencies of the octave bands (hertz) and the sound pressure levels on them (decibels);

Data on uniformly distributed, concentrated and dynamic (inertial) loads on the floors of the first floor and multistory floors;

Data on the crane equipment, overhead transportation and elevators, including the All-Union State Standard numbers, operating conditions and lifting capacity, and for the crane equipment and overhead transportation, the span of the bridge crane or the total length of the overhead crane and height from the floor to the crane rail;

Door and gate sizes;

Basic requirements on partitions;

Location and sizes of the sections of the facilities the floors of which are subject to mechanical effects (impacts), the effect of fluids, acids, alkali, oil and emulsions with indication of concentration (%) and nature of effect (systematic, periodic or accidental). In addition, the traffic sections and the type of floor rail transportation and also the recommended floor coverings and data on the staffs for designing the administrative and general services facilities are indicated.

The construction design assignment includes the following: the layout of the facility with bay dimensions, the names of all facilities and siting of equipment and cranes; characteristic sections; entrance of railroad tracks to the buildings (a copy of the master plan is attached); the nomenclature of the administrative and office personnel and engineering servicesfacilities.

In the hydroengineering part of the design, as a rule, lines for the assembly and installation of modules, building slips or building slip lines, launching facilities, outfitting quays, water area and water lanes to it are developed.

In the engineering assignment for designing hydroengineering structures, in addition to their locations in the shop buildings and on the master plan, the following data are indicated:

For designing lines to assemble modules, the basic dimensions and weight of the modules (especially the weight of the modules when testing their tanks with water), the calculated and prospective ships, the dimensions of the lines, the gage and type of rails, the calculated characteristics of the foundation for the rail track, the planned basic transport and towing equipment, the flow diagram and production path of movement of the modules, and special requirements on the module assembly lines;

For designing the building slips (lines) and launching structures the following are indicated: the basic dimensions and launch weight of the program and future ships with inclusion of the maximum possible specific load, diagrams of versions of the building slips and launching facilities (with basic data), planned crane, towing and launching equipment, recommendations and special requirements on the building slips and launching facilities;

For the outfitting quays and water area, the basic dimensions of the ships (especially the draft of future ships), their location on the outfitting quay (also the location for trials when working on the propeller), planned quay dimensions, considering access routes, loads on the quay cordon and its crane equipment, gage and type of rails, nomenclature of planned industrial service lines; basic requirements on the outfitting quay, water area and approach water lanes.

All of the basic solutions with respect to hydroengineering structures are agreed on with the production engineers and developers of the master plan; the optimal version is taken only after predesign developments, including the technical-economic substantiations.

§ 57. Assignments for Power Supply Planning

Electric Power Supply. The set of assignments developed by the production engineers for planning the electric power supply for the shipyard include the following:

The assignment for designing electrical equipment and electric lighting of the shops and facilities;

The assignment for trolley line design.

The assignments for designing the electrical equipment and electric lighting of the shops and facilities include a text and layout of the location of equipment with indication of the position number with respect to the plan and the type of electric user, type of current, voltage, frequency, installed capacity and quantity of like equipment with indication of the amount and the installed power of the equipment -- new, used in place and used after rearrangement, the number of operating shifts of the equipment and basic requirements. Sometimes instead of the discussed data, a schematic plan and specifications for the equipment are distributed if the data on the electrical equipment are presented (power, type of current, voltage, frequency).

On the equipment siting plan, the category of explosion and fire hazardous facilities, the locations for connecting welding and other equipment, the special current feeds, and so on, the location of transformer and converter substations, panel and other similar facilities are indicated. By the consolidated indices, the latter are determined in advance together with the designers of the electrical equipment and the electric lighting of the shops and facilities.

When reserve equipment is used by the engineering design, the data on this equipment are reflected in the distributed assignment.

Data are also presented in the assignment on the machinery and electric users requiring uninterrupted electric power supply, the equipment requiring blocking with a fan or other equipment, the number of simultaneously operating welders and tack welders. The facilities are indicated in which it is necessary to provide increased lighting.

The assignment for designing crane trolley lines includes the following: the name of the materials handling means with indication of the number on the proposed shop or facility layout, the number of like cranes, their lifting capacity, the length of the crane tracks, the power of the main and auxiliary lift, trolley and bridge moving engines. The necessity for the application of direct current is indicated in the remarks.

Compressed Air Supply. As a rule, low and high pressure air is used at the shipyards. The low pressure air (5-6 kg/cm^2) is primarily needed for the operation of various pneumatic tools and devices, for mechanization of the labor consuming production processes in the various shops when building the ships. The high pressure compressed air is used when checking out the individual systems of ships under construction.

The assignment for planning the compressed air supply is developed with indication of the types and the number of tools and equipment for each shop, the operation of them by shifts, maximum possible number of operating tools and equipment per shift, the mean use coefficient of them with respect to time, the required pressure and purity of the air.

A layout of the shop or facility with indication of users and locations of air connection points is appended to the design.

Gas Supply. Acetylene-oxygen cutting of steel and gas-electric cutting of primarily aluminum and its alloys in a mixture of argon and hydrogen are widely used in shipbuilding; in individual cases, gas-electric cutting of stainless steel, copper and its alloys in technical nitrogen is used. Semiautomatic carbon dioxide shielded welding of the hull steel, argon arc welding and also helium arc welding of aluminum alloys are widely used. When making small products with a thickness, as a rule, of no more than 10 mm from aluminum alloys, gas (acetylene-oxygen) welding is used.

In the assignment for planning the supply of the shipyard shops with these gases, the types of operation for which the gas feed is required, the annual shop program with respect to production output in tons, the average thickness of the machined metal, the type of gas, the average number of operating tools or welding arcs with subdivision by shifts and by mechanical and manual operations, the maximum possible number of operating tools and arcs in one shift, both with respect to mechanical and manual operations, the specific gas consumption per tool or arc (with subdivision into mechanical and manual operations), the average use coefficient of the tools and arcs with respect to time (also with subdivision into mechanical and manual operations) are presented.

The gas users (or gas connection points) are indicated on the shop or facility layout appended to the assignment.

Steam Supply. In the shipyards the production users of steam are primarily the galvanizing shops and the anodic oxidation sections in the shops for making aluminum-magnesium alloy structural elements, the drying chambers, and the impregnating woodworking shops, individual benches for demothballing and preparing machinery for installation, the primed and painted products drying chambers, and so on. Steam is also required for heating ships under construction in the uncovered building slips and on the outfitting quays in the winter.

The assignments for planning the production steam supply with respect to individual shops and facilities includes the name, the basic characteristic and quantity of steam user equipment, the required steam pressure, the equipment shift loading time factor, maximum, average hourly and annual consumption of steam.

A layout of the shop or facility with indication of the steam users is appended to the assignment.

Oil Supply. At modern shipyards petroleum products, fuel and oil for production needs are primarily concerned during the mooring, sea and acceptance trials of ships under construction. Therefore the types of calculated ship users of petroleum products, the type of petroleum products, their quantity per ship and for the annual calculated program with subdivision into mooring, sea and acceptance trials and also the expected maximum monthly consumption during the ship trial periods are indicated in the assignment for planning the oil supply. The petroleum products consumption for trials of individual ships are taken by the design data of the design offices -- the persons submitting the designs for these ships. The maximum consumption of petroleum products per month is determined by the shipbuilding schedule.

§ 58. Assignments for Designing Heating, Ventilation and Air Conditioning, Inside and Outside Water Lines and Sewage, Purification Works and Environmental Protection

Heating and Ventilation. The requirements on the heating and ventilation of industrial buildings are growing in connection with the application of new types of steel and electrodes, new production processes (chemical cleaning and shot blasting of steel, inert gas shielded and submerged arc welding, and so on), new synthetic painting and other materials in shipbuilding. This requires more careful and complete development of the assignments for designing heating and ventilation on the part of the production engineers, in particular, with respect to such sections as the basic data: the data on the equipment operations; data on welding, gas cutting and heating operations.

In the "Basic Specifications" the following are presented with respect to each shop: name of facility, a brief description of the production process, indication of the presence of the release of toxic gases, dust and liquids, the entrance opening conditions (duration and frequency), the amount of material hauled into the shop, the installed power of equipment (including equipment operating with cooling), the amount of equipment and number of workers in the largest shift;

In the "Equipment Operation Specifications" the following are indicated:

The shop equipment layout;

Name, model, trademark or type of equipment, a brief description of the equipment and installations releasing toxic gases, dust, liquids and other harmful substances with indication of the number on the plan;

Dimensions of the working bays, the type and size of shelters;

The amount of equipment, the load factor and simultaneousness of equipment operation;

Description of harmful emissions (heat, steam, gases, and so on);

The surface area of the equipment emitting heat;

Inside or outside temperatures of the devices and the material of surfaces emitting heat;

Type of fuel and its heat of combustion;

Average hourly fuel consumption;

Liquid evaporation surface with indication of the area;

Names of harmful liquids;

Recommended devices for removal of harmful substances;

Amount of air collected from the facilities for blowing, drying, and so on;

Nature of the forced ventilation air;

Operating time of equipment during the day;

Installed power;

Cooling of installed equipment (air, water, and so on);

Amount of air used to cool machinery;

Air parameters for which normal operation of the equipment is insured;

Number of workers in the largest shift.

"Data on welding, gas cutting and painting operations" by shipyard shops and facilities contains materials on the following basic types of operations:

Manual welding, electric tac welding, manual argon-shielded welding with consumable and nonconsumable electrode;

Semiautomatic submerged arc welding, carbon dioxide shielded and argon shielded welding;

Automatic submerged arc welding, argon-shielded welding;

Manual gas cutting of carbon and high-manganese steels;

Mechanical gas cutting with indication of type of machines;

Arc-air gouging;

Painting operations, and so on.

The number of employees working simultaneously in the shop in each shift is indicated with respect to each type of operation (with indication of the number of employees in the covered sections); the consumption of electrodes, welding wire, acetylene, paint per station or tool; type of electrodes, welding wire and paint; type and thickness of machined material; average output capacity of the gas cutting stations and tools; number of shifts.

The composition of the paint and the solvent is indicated with respect to painting operations, and the percentage ratio of electrodes of different types is indicated with respect to manual welding and tac welding.

Air Conditioning. Air conditioning is provided in the mold loft operations department of the hull platers shop, the welding materials stores, and so on.

In the assignment for the air conditioning design, the name of the facility in which air conditioning is needed, the air parameters, including data on the temperature and its admissible fluctuations, dust content and mobility of the air, number of employees and installed power of the welding equipment are presented.

Inside and Outside Water Lines and Sewage. The basic production users of water in the shipyard include the following: the assembly-welding shop, the shop for making structural elements from aluminum-magnesium alloys and synthetic materials, the module assembly shop, shipbuilding shed with building subways, the outfitting quay, hull fitting and pipe preparation shops and the galvanizing shop.

Water is used to cool the equipment (for example, the resistance welders and welding torches) and, primarily, to test the structural elements and products, individual compartments, pipelines and systems of the ships under construction. In the galvanizing shop and in the anodic oxidations section in the shop for making structural elements from aluminum-magnesium alloys, in the chemical cleaning section, hot galvanizing and pipe priming sections in the pipe fabrication shop water is used to fill the baths and wash the parts and products.

In the assignment for designing the inside water lines and sewage with respect to each shop or facility the following are presented:

The name of the equipment, units and devices consuming water and the number of them;

The mean diurnal and maximum production consumptions per hour per unit of equipment, and the consumption conditions;

Water quality (fresh, salt, and so on);

Required head;

Coefficient of simultaneousness of use;

Description of waste water with indication of the composition of the used water, temperature, the possibility of repeated use;

Name of pollutants (acids, alkalis, oil, and so on) and their percentage content;

Recommended method and location of discharging the water into the sewage.

In the assignment for designing the outside power plant and sewage the following are indicated:

The name of the shops and facilities, annual, diurnal and maximum hourly consumption of production water in each shop;

Conditions of using water, required free head at the unit;

Water quality (fresh, salt), composition of used water;

Calculated hourly output of used water;

Number of employees (total and in the largest shift), of them, the number taking a shower (total and on the largest shift).

Industrial Waste Purification Works. In the assignment for designing the industrial waste purification works of the galvanizing shops, the anodic oxidation sections in the shops for making structural components from aluminum-magnesium alloys, the sections for repairing mastics and washing containers in the shops for making structural components from synthetic materials and the sections of chemical cleaning of pipe in the pipe preparation shops with respect to each shop or section discharging industrial waste and spent solutions, the following are discussed:

The total output capacity with respect to industrial waste with subdivision into acid-alkali, chromium-containing, cyanide-containing and other industrial waste;

The heavy metals (in acid-alkaline waste), chromium and cyanide contents in the industrial waste;

The volume of spent acid-alkali, chromium-containing and cyanide-containing solutions discharge simultaneously and during the course of a month, the heavy metals, chromium and cyanide contents in the spent solutions;

The coefficient of simultaneousness of arrival of industrial waste;

The operating conditions (number of hours a day);

The siting of the purification works on the master plan (in a shop or in an independent building);

Recommended purification technique.

Assignment for Planning Environmental Protection Measures. These assignments contain the following data with respect to each shop of the shipyard:

In the assignment for planning the protection of the atmosphere from industrial waste, a list of harmful substances, the amount of them, chemical formula with indication of state in which the harmful agents are found (steam, gas, aerosol, dust) are presented; in the assignment for protection of water areas from pollution by wastewater, the volume of waste water is indicated with naming of the harmful pollutants present in the waste water (chemical and mechanical admixtures) and their percentage content are presented.

Note. In design practice, the materials of the assignments are also used as the initial data for developing environmental protection measures: with respect to protection of the atmosphere from the industrial waste, assignments for designing heating and ventilation; with respect to protection of water areas from pollution, assignments for designing sewage and purification structures.

§ 59. Assignments for Designing Automation, Process Control Devices and Means, Control Communications and Signaling Hardware and Also Launching and Transport Equipment

In the assignment for designing the automation of equipment, units, sections and shops, the names of the equipment and units subject to automation in the recommended method of controlling the production processes and units (local, semiautomatic, program), the requirements in the electrical blocking of the individual mechanisms, units, sections and other systems entering into the line, and the types of signals (precautionary, warning, emergency) are presented.

The following are appended to the assignment: a layout diagram of the equipment and transport means with indication of the locations and facilities for boards, panels and other devices; the diagrams of the production, hydraulic, pneumatic and other systems entering into the process regulation and control complex; the production process flow diagrams with a brief discussion of the process.

In the assignment for designing the automation of the galvanizing processes the following are discussed:

The name and numbers of the baths according to plan;

The number of like baths;

The rated voltage and current of the bath;

The maintenance time of the current polarity in the bath on the parts (cathode and anode);

Limits of adjustment of the current density and temperature;

Coating cycle time;

Feed sources and method of controlling the rectifiers.

A layout diagram of the shop (section) is appended to the assignment with indication of the location of baths, the placement of the rectifiers (generators) and the location for installing the panels.

In the assignments for designing the process control units of the shops or facilities the following are presented:

The name of the measured variable and the description of the environment;

The name of identically measured variables;

The value and the dimensionality of the measured variables with subdivision into minimum, rated and maximum;

The required accuracy of the measurements in percentages of the rated values;

The requirements on the monitoring and measuring devices (KIP) with indication of their location and also indices, recordings, reports and signals.

A layout diagram of the shop or facility with indication of the locations of the KIP is appended to the assignment.

The production control hardware is being continuously improved and changed. At the present time the engineering assignments for the design of the production control hardware of the shops, sections and services have the following:

Operative communications (number of subscribers) with subdivision into director communications, chief engineer's communications, chief power engineer's, chief dispatcher's and intrashop dispatch communications;

Search signaling with indication of who is wanted and by what signal, light or sound;

Call signaling, with indication of who is called and by what signal;

Information signaling about deviations from the schedule for mutual deliveries by the shops of parts and products with respect to the process makeups with indication of the shop (warehouse) of the supplier and the number of supplied process makeups;

The accounting for materials by process makeups, put into production -- with indication of the name of the material, in what form it was delivered (packages, containers, and so on), units of measure, total amount of material delivered per hour or in a shift;

Accounting for annual production -- with indication of the name, units of measure and amount;

Accounting of equipment operation -- with indication of the name of equipment and its number by the shop plan and also the descriptions of monitoring (with respect to machine time, intake power, idle time) and auxiliary services of the shop for calling;

Teletype communications with indication of the purpose and the number of teletypes;

Phototelegraph communications with indication of its purpose and the number of receivers and transmitters;

Television for production purposes with indication of the name and number of transmitting chambers.

In the assignment for designing communications and signals by units and facilities, in addition to the ones provided in the production control hardware, the number of telephone sets of the city telephone office and administrative-service communications, the number of internal and external electric clocks with subdivision into one-way or two-way, the number of security and fire sirens with indication of their operation, the number of dispatch communication sets for water transportation, motor transportation, railroads, operative communications for process control, communications of the crane operator with the sling operators, are presented.

In cases where the plan calls for developing automatic fire signaling or automatic fire extinguishing hardware, the category of fire and explosion hazard (according to the PUE), the area, height, basic fuels and explosive materials and the amount of them and also the fire hazardous equipment are indicated in the assignment in accordance with the classification of the facilities by fire and explosion hazard with respect to each facility of the shop, in addition to its layout diagram.

In the assignment for designing special launching equipment the following are indicated: the basic dimensions and launching weight of the ships in the calculated and future programs; proposed launching facility and its slope; layout of the launching facility; the amount of transport equipment and its location under the ship with indication of weight loads on each trolley or support; the speed of launching and pulling the ships; gage and type of rails for end and sideway launching; basic requirements on the launching facility.

The special transport and tow equipment are basically used in the assembly-welding shops for moving sections on flow lines; in the module assembly shops for moving modules to the various positions and feeding them to the shipbuilding ways; in the shipbuilding sheds for joining the modules on the shipbuilding ways, movement of the ship as a whole along the building positions and to the launching facility.

The process engineerings develop and distribute an assignment for the design of transport and towing equipment with respect to each of the indicated shops, which contains the following data:

Maximum and minimum size and weight of sections, modules and ships in the calculated and future programs;

The amount for the annual calculated program;

Brief instructions with respect to the assembly and fitting processes; width of the ship carriage gage, desired form of transport means for moving sections, modules and ships and joining modules;

Location of the center of gravity of sections, modules and ships with respect to the axis of symmetry of the transport unit;

Side and frontal sailing capacity of the load;

Wind load;

Displacement steps;

The placement diagram of the transport means under the object and load on the transport means;

Train Speed;

Calculated data on the railroad track foundation;

Basic requirements imposed on transport, towing and joining equipment;

Siting diagrams for the flow lines for manufacturing sections in the assembly-welding shops, the lines for assembly and fitting of modules in the module assembly shops, the shipbuilding lines for joining the modules and building the ships as a whole in the shipbuilding sheds.

In the assignment for designing the transporter, the required capacity of the transporter, the desired type, the location of the trolleys under the ship (module, section) and the load on each trolley, the location of the center of gravity with respect to the axis of symmetry of the transporter, the overall dimensions of the transporter and length of the transporter well, the speed of the transporter, the calculated characteristics of the foundation, the choice of tracks and transporter well, the gage of the railroad tracks on the transporter and the basic requirements are presented.

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