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DEVICES FOR MAINTENANCE OF COMFORTABLE WORKING CONDITIONS IN FLOATING DOCKS

ПРИСТРОЇ ДЛЯ ЗАБЕЗПЕЧЕННЯ КОМФОРТНИХ УМОВ ПРАЦІ ПРИ РЕМОНТІ СУДЕН У ПЛАВУЧИХ ДОКАХ

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Abstract. Classification of ice-retaining devices has been presented; they allow docking vessels when there is a lot of ice in the water area. Schemes of the devices designed for closing the ends of floating docks are provided. They reduce the amount of draughts on the pontoon deck, which is especially relevant throughout cold autumn, partly winter, and spring. Schemes of the staff structures of dock scaffoldings are presented; the requirements for them are also described.

Keywords: floating dock; ice-retaining device; device for closing the ends of a floating dock; dock scaffoldings; maintenance of working conditions.

Анотація. Наведена класифікація льодозатримуючих пристроїв, які дозволяють проводити докування суден при наявності великої кількості льоду в акваторії. Наведені схеми пристроїв закриття торців доків, які зменшують кількість протягів на стапель-палубі, що особливо актуально протягом усього холодного осіннього періоду, частини зими, а також навесні. Наведені схеми штатних конструкцій лісів дока та описані вимоги, які до них пред'являються.

Ключові слова: плавучий док; льодозатримуючий пристрій; пристрій закриття торців дока; докові ліси; забезпечення умов праці.

Аннотация. Приведена классификация льдозадерживающих устройств, которые позволяют проводить докование судов при наличии большого количества льда в акватории. Приведенные схемы устройств закрытия торцов доков, которые уменьшают количество сквозняков на стапель-палубе, что особенно актуально в течение всего холодного осеннего периода, части зимы, а также весной. Приведены схемы штатных конструкций лесов дока и описаны требования, которые к ним предъявляются.

Ключевые слова: плавучий док; льдозадерживающее устройство; устройство закрытия торцов дока; доковые леса; обеспечение условий труда.

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Problem statement. Every vessel operating less than 12 years needs to enter the dock for inspection and control at least once every three years and before each transportation of valuable insured cargo. In addition, docking must be conducted annually after 12 years of vessel exploitation. Each ship owner must ensure the high quality of ship repair, including maintenance of the overall strength and watertight integrity. Procedures conducted in the floating dock involve inspection of the hull, restoration of the protective coating, treatment with the protector, replacement of the outer hull, and repair or replacement of the elements of the propeller rudder system. To reduce operational costs, the ship hull needs to be cleaned from fouling in a floating dock. It is impossible to carry out maintenance without ship-lifting devices because most of vessels are heavy and a huge part of the hull is under water [5].

To receive and repair a vessel, the floating dock is submersed to a certain depth into a special foundation dug in the water area of the shipyard. The foundation is fitted with devices designed to hold the vessel-dock system over it, provide transportation links with the coast, and supply various types of energy to perform the works. All this constitutes an expensive complex of hydro-technical installations [2].

The specific features of docking works requires improving the working conditions in floating docks. For this purpose, there have been developed devices creating microclimate zones and devices protecting ship-lifting facilities from snow, rain, and ice [3].

Latest research and publications analysis. Docking of vessels often has to be conducted in the cold season, when there is ice in the water area. A lot of ice enters the pontoon deck of a dock simultaneously with the vessel, then settles there after surfacing and fills all the spaces between the vessel bottom and the pontoon deck. The ice prevents normal ship sitting on keel blocks. It is hard or even impossible to perform repair works under the vessel bottom. Ice removal requires a lot of labor and time and increases the costs of docking repair of vessels. For this reason, designing and modernization of floating docks should provide for special ice-retaining devices.

In recent years, shipyards have offered and tested numerous ice-retaining devices [1, 4, 7]. They include various containment booms and devices designed to neutralize the water streams flowing in the same direction with the vessel and capturing ice masses into the dock. Water supplied under pressure or compressed air is used for dispersion of the ice that moves with the water.

Under extreme working conditions, there are strong draughts in the pontoon deck towers. The works might be sometimes impossible because of strong winds directed towards the end of the dock. Shipyards that exploit floating docks face the necessity to close the dock ends and tower corridors [6, 8, 9].

THE ARTICLE AIM is to analyze existing devices that improve the working conditions in floating docks, as well as provide examples of ice-retaining devices and systems used for protection of floating docks from icing.

Basic material. Floating docks can be divided into repair docks (for extensive, emergency or minor ship repair, i.e. preventive docking), transfer docks, transport docks, and specialized docks (hangar docks, modular docks, base docks) [5].

Floating docks for extensive and emergency ship repair (see Fig. 1 [10]) have a sufficient height of towers and overall strength, which allows absorbing the entire or the majority of the load from uneven distribution of weight and buoyant forces of the vessel-dock system. Such floating docks are used to repair the ships that need

replacement of a significant part of the outer hull and the framing system, as well as emergency ship repair. Floating docks of this group are utilized for inspection, cleaning and painting of the vessel bottom, repair of the propeller-rudder system, and partial replacement of the outer hull.

Transport floating docks (see Fig. 2 [11]) serve for ship transportation in shallow waters and through shallow channels. Such a floating dock has a barge shape. The volume of the dock's ballast tanks is smaller than in ordinary floating docks with same cargo capacity because of the presence of waterproof gates.

Containment booms for ice protection have not been widely applied because of their bulkiness. The designer V. P. Sekisov have proposed a device which retains ice with counter water jets (Fig. 3). It must be installed at both ends of the pontoon deck. One ballast pump in the dry tank operates for the fore end, while the other one serves the aft end. The side embrasures are closed by a girder to avoid the impact of ice.

The following pneumatic ice-retaining device has acquired widespread application. It consist from a tube 90 mm in diameter lying at the very edge of the pontoon deck of a floating dock. This tube has holes 3-5 mm in diameter drilled at the distance of 80-100 mm one from another. One end of the tube is plugged, and another end is connected to the compressed air line. The air coming out of the openings forms a breaker on the water surface, which prevents ice hitting the pontoon deck.

The ice-retaining devices are installed on both ends of a floating dock. Two dock compressors (with the production capacity of 10 m^3/min) provide for their operation. A considerable experience in exploitation of this construction has shown positive results. The amount of ice coming on the pontoon deck of a floating dock is insignificant if the dock is equipped with the pneumatic ice-retention device.

The pneumatic ice-retention device designed for docks under construction (Fig. 4) consist of air tubes *1*, *2* (108 mm in diameter), which are placed along the contour of the dock's console sites (crinolines) under the fender. The bottom side of the tubes has holes *4* mm in diameter drilled at the distance of 50 mm. The device connects to the air line of the floating dock through tubes *3*, *4* (57 mm in diameter).

Considering the issue of dock protection from ice, staff devices should also be described. They are designed to support the open water space in the ice cover around a dock in the winter season. Manual ice breaking is a time-consuming and often dangerous operation.

Special pneumatic systems are used to protect hydrotechnical constructions from ice and support navigation channels. In these systems, the air supplied through tubes comes out with small bubbles and causes the movement of lower, warmer layers of water to the surface. This prevents water on the surface from freezing both in a purely mechanical way and due to the heat of the lower water layers. Besides, this principle can be used to maintain the open water space in the ice cover around the dock.

Fig. 1. Composite floating dock with the cargo capacity of 7100 tons that was built at the Kherson State Plant «Pallada».

Fig. 2. Steel transport floating dock at the Australian Marine Complex (Australia)

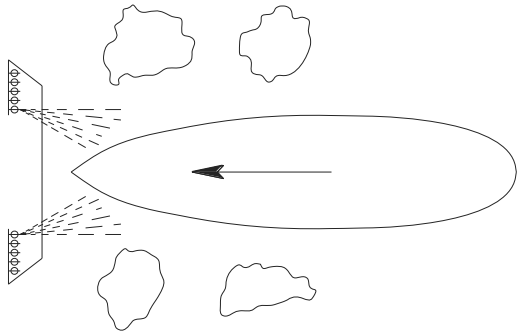

Fig. 3. Scheme of operation of the the ice-retaining device and water supply to the fore end of a floating dock

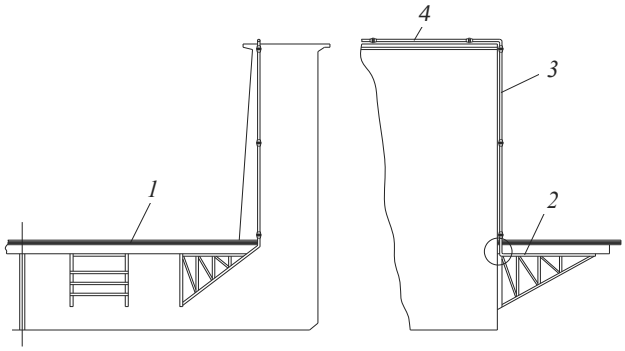

Fig. 4. Pneumatic ice-retention device on the floating dock

For this purpose, air tubes must be installed in the underwater part along the contour of the floating dock. The tubes periodically receive air from a special automatic compressor. The supplied air must be dried to avoid ice plug formation in the pipe network. The design of such a construction that protects a floating dock with the cargo capacity of 6500 tons from ice covering is presented in Fig. 5.

A compressed air line is placed along the contour of the dock under the fender. This network is connected to 40 sections (28 of them have three nozzles and 12 have two nozzles), which are submersed to the depth of 4 m under water. Every section consists of a vertical tube with its end connected to a horizontal tube with nozzles. The tubes are installed on special struts, which are fixed on the dock. This construction makes disassembling easier after the winter season. The sections are disconnected and removed from water. In addition, the pipe network is equipped with plugs.

The entire system is fed from a separate unit, which consists of 2 compressors (with the production capacity of 3 m^3/hour), an air filter, an air cooler, a water and oil separator, and a receiver with the volume of 4 m^3. The pressure necessary for efficient operation of the system after reduction is 1.4 kg/cm^2. To maintain the open water space in ice covering, the system should operate for 5–10 minutes every hour.

Floating docks are opened at the ends and often have open corridors (loaded openings) in towers. Hence, powerful draughts often appear on the pontoon deck, which may cause illness of dock workers. Strong winds blowing towards the end of a dock may disrupt the working process or even make it impossible.

The plants that exploit floating docks always face the need to close the dock ends and tower corridors. Both are most commonly planked with special barriers, which requires a lot of timber and labor. Besides, due to the complex structure and high cost of these barriers, they are installed only in the winter season after “the last docking of the year” (in freezing ports), i.e. after the dock is loaded with a vessel that requires extensive repair to be performed throughout the winter.

Thus, the ends of the dock are kept opened and the workers have to operate under constant draught conditions during the entire cold season (autumn, part of winter, and spring).

When designing new floating docks, particular attention should be paid to devices with a reliable and simple construction closing the dock ends and loaded openings. Staying in the idle position on the dock, the closing construction does not interfere with a normal working process. Closing of the dock’s loaded openings is easily accomplished with the aid of sheets, which move on rollers along the track. Fig. 6 depicts the construction of such

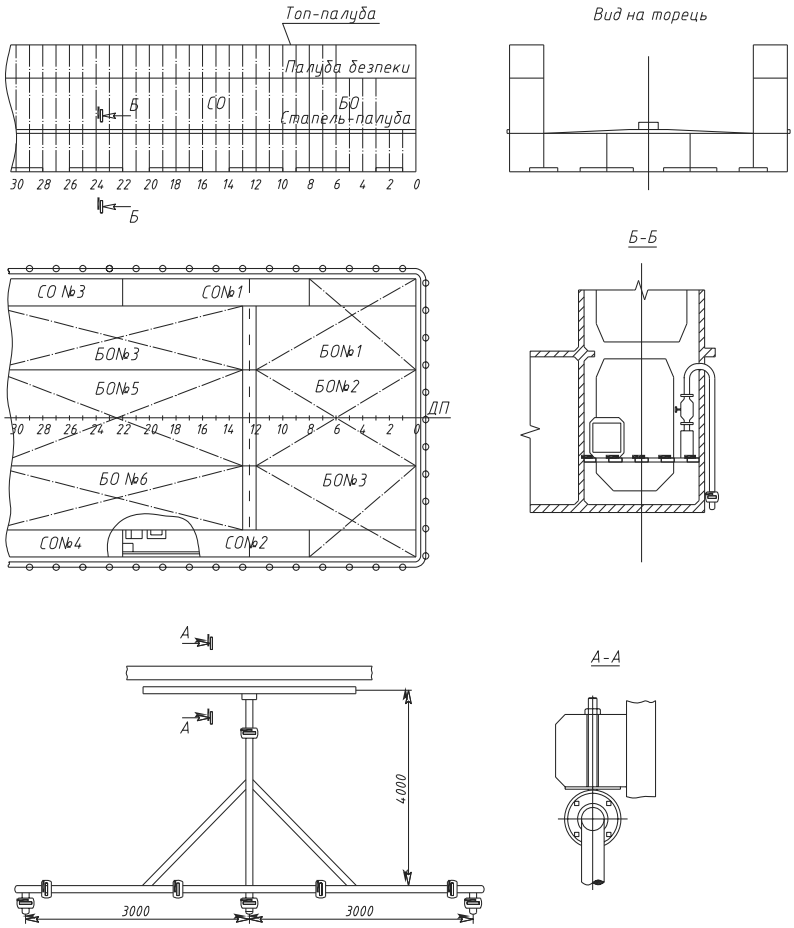

Fig. 5. Principal scheme of the pneumatic dock protection from ice covering

doors with an upper track placed on the outside of the dock. Special devices are provided for fixing doors in the open or closed position.

The dock ends can also be closed with help of canvas curtains secured with a rope on special columns that are installed in support braces placed in the side parts of the dock ends. The curtains are attached on special cranes, which are placed on the dock towers, and at the catwalk. However, the canvas closings are not widespread because the materials are rare, wear out rapidly, while their mounting and assembling are quite labor-intensive.

Various closures in the form of metal sliding folding screens or gates are not widespread either, since they reduce the slipway length and sometimes decrease the dock width. However, some of these closures are quite interesting and can be applied in some cases. A sample closure design is presented in Fig. 7. In the idle position, extendible shields are placed in the tower ends; special framework is provided for this purpose. The shields are moving with the dock spires or cranes along guided tracks with the help of ropes through the cheek blocks.

In another version, the closure is carried out by means of sliding gates, which consist of two four-section halves of the folding screen. The folding parts are assembled from metal shields and connected with one another by fittings. There are rollers at the bottom of the folding parts and tracks on the pontoon deck of the dock to direct the gate movement and make it smoother. The gate is opened and closed with the dock crane by means of ropes running along the blocks installed in the dock towers.

When designing new docks, engineers can provide for special niches to mount sliding barriers in the idle position there. Considering that vessels can be docked with overhang, there should be canvas fastening at the ends of central folding parts near the gates in order to close the space between the barriers and the ship contours.

Several variants have been designed to close the ends with folding gates and with a corrugated steel plate. In the idle position, the steel is kept in rolls, mounted vertically or horizontally at the end of the dock. The construction of described closures is wieldy. However, the idea of a permanent closure of the dock ends is attractive, especially for the cold regions of the country, as well as for the regions subject to strong winds.

The end closing structure is three-shielded steel plate hinged at the bottom part of the permanent console area of the dock (Fig. 8). In the lowered position, the steel plate is arranged like plating, and its upper part slightly overhangs from the edge. The fenders are provided to avoid damage of the overhung parts. Dock pillars serve to lift the shields. When a vessel with overhang is docked, the middle shield is not lifted, and only two outermost shields and canvas curtains between them and the vessel carry out the closure of the ends.

The construction provides for the possibility of lifting all three shields at the same time, or only two side shields, which are a little wider than average. The side shields are provided with doors for entering the console area from the pontoon deck. Those shields are made

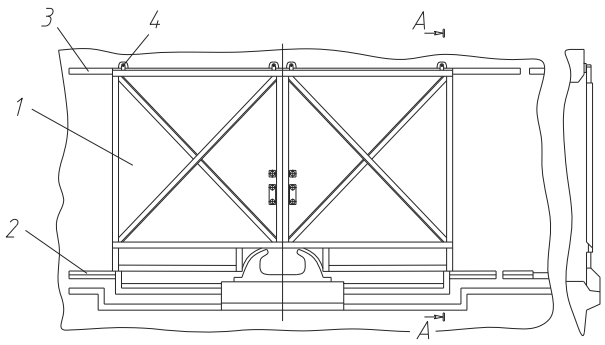

Fig. 6. Doors for closing loaded openings:
1 — doors; *2* — bottom track; *3* — upper track; *4* — roller

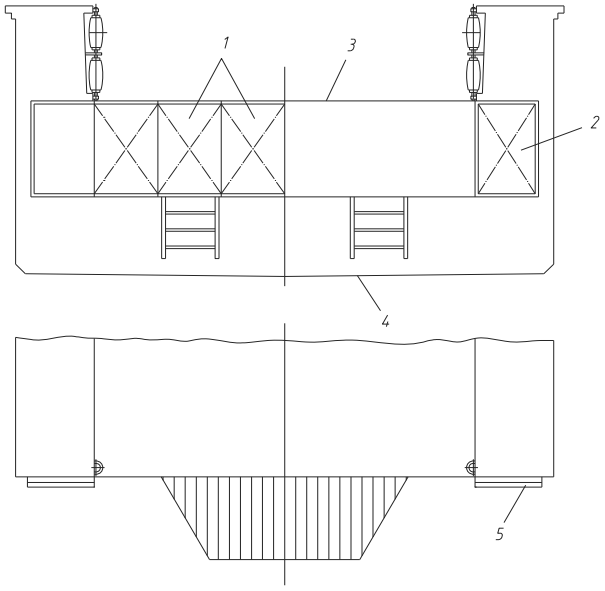

Fig. 7. Scheme of closing of the dock ends by means of extendible shields:
1 — shields in the operating position; *2* — shields in the idle position; *3* — upper guided track; *4* — bottom guided track; *5* — framework for the shield installation

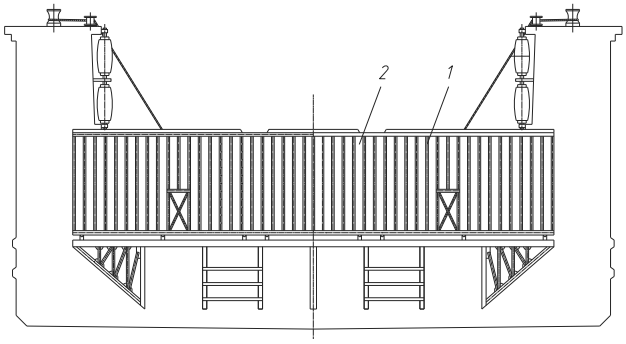

Fig. 8. Three-shielded closure of the dock ends:
1 — side shield; *2* — middle shield

from steel that is 3 mm thick, enforced with frames. The frame consists of a horizontally located H-beam and vertical stiffening ribs, which are connected at the bottom with a transverse angle. The upper launcher beam of the framing has a wedge lock connecting the shields with each other. The dimensions of the shields for docks with the cargo capacity of 6000 tons: 9.00×5.88 m for the side shield, 6.00×5.88 m for the middle shield. In general, this device is a constructional part of the dock; it does not reduce the dock's clear dimensions and is relatively easy to operate.

Reliable and serviceable docking scaffoldings are regarded as one of the primary measures to improve the working conditions in docks. Creating high-quality temporal timber scaffolds is labor-intensive and needs a lot of lumber, which often cannot be used for the second time. Assembling and disassembling of scaffoldings take up a lot of space on the dock. The temporary scaffoldings are usually built without calculations and drawings, often hastily and with a lack of necessary materials. They do not always satisfy the safety requirements.

For that matter, it has been proposed to construct permanent scaffoldings as the dock's staff equipment. A number of designs showed positive results in the operational verification.

Requirements for the dock's permanent scaffoldings can be summarized as follows:

– scaffoldings must be rugged and stable in exploitation;

– scaffolding loading must be set according to calculations and indicated on the construction;

– for calculations, the weight of a one person with instruments and a small folding device is averagely considered 100 kg.

Since replacement of side plates and some other operations are performed by whole brigades, the loading calculations should provide for the maximum number of workers (3–4 people) present on the limited area of scaffoldings. If the scaffolding stairwells are located at a considerable distance from each other, other workers should be able to go along the scaffoldings when the brigade is working there. If these loads are not taken into account, passage-prohibiting signs must be put on scaffoldings during their exploitation.

The load on scaffoldings caused by some weight placed on them (for example, steel sheets, cylinders, etc.) is not taken into account; therefore, even temporary placement of weights on scaffoldings is strictly prohibited. The snow load is taken into account only for the areas subject to heavy snowfalls. In the winter, scaffoldings must be generally cleaned of snow and ice before the beginning of works. Scaffolding calculations must allow for the wind loading, which has high values in the conditions of floating docks.

Scaffoldings are provided with fences that ensure the safety of work operations at height. The fences consist of a handrail, a middle longitudinal element, columns and panels with the height of 14–15 cm in their lower part. The handrails must be made of a smooth and solid material. The connection of the columns and the fence must be smooth. The distance between the columns (usually up to 2 m) must exclude the possibility of bending of the handrails. The distance between the stages of scaffoldings must be at least 1.9 m, while the width of the platform floor must be no less than 1–1.2 m. The clearance between the vessel being repaired and the scaffoldings in the parallel middlebody part of the vessel must not exceed 50 mm. If necessary, flaps, movable sideboards or shields should be provided for larger clearances.

The design of scaffoldings must ensure the safety of workers involved in their assemblage or installation into the working position, as well as dismantling or disassembly into the non-working position. All the works on the movement of scaffoldings must be mechanized for this purpose. Appropriate ramps are to provide the exit from scaffoldings. To avoid reducing the width of scaffoldings due to the design of the ramp hatches, it is feasible to arrange separate staircase sections. They can be portable and installed with the use of cranes. The stair sections and areas of each stage must have fencing that ensures safe access to scaffoldings.

The construction of metal scaffoldings must allow for their rapid and reliable grounding after installation in the working position. All of the dock's permanent scaffoldings, parts of which remain there when vessels enter and leave the dock, are recommended for use only in the water areas not polluted with petroleum products. In the polluted water areas, it is feasible to use scaffoldings that are removed entirely from docks at the time of ship-carrying operations.

According to their design features, dock scaffoldings can be divided into suspended (console) scaffoldings, which do not have piers on the pontoon deck, and the scaffoldings supported by piers or frames mounted on the pontoon deck of a dock.

Console scaffoldings usually consist of telescopic support brackets, which are rigidly or flexibly secured on the dock towers, floors comprising boards tightly put together and laid on the brackets, and appropriate fences. Several types of such scaffoldings have been developed, tested, and exploited. For instance, there are scaffoldings with tubular telescopic support brackets, which are secured on the tower docks and can rotate around the vertical axis within 180°. When a vessel goes in and out of the dock, the scaffolding floors and fencing are removed.

The Odessa shipyard has proposed sectional suspended platform scaffoldings able to turn around the horizontal axis within 90°. When idle, the scaffolding are folded vertically and fixed to the dock towers.

The Riga shipyard has developed scaffoldings that have floors placed on telescopic support brackets (Fig. 9); the scaffoldings can be removed when they are not operating.

The construction of suspended scaffoldings, supporting elements of which are fixed on the towers of docks, is inconvenient because they are not sturdy enough with large consoles. It restricts their extension and build-up. Therefore, their design is not versatile enough and can-

not be successfully applied for the repair of vessels of different sizes.

Another disadvantage of such scaffoldings is that they complicate the supply of materials and parts to the dock workplace by means of cranes, as they occupy the entire space between the ship and the dock towers. When using cranes to supply materials to any central part of the dock, it is necessary to disassemble scaffoldings in this area. This is inconvenient and requires extra time. Suspended scaffoldings usually provide for the possibility of supplying materials only from the ends of the dock. This leads to the need for their further transportation along the dock with the help of carts, roller beds or other equipment.

Of the above designs of suspended scaffoldings, the one proposed by the Riga shipyard can be considered the most successful. Support brackets of these scaffoldings are extended inside the open girder construction of the towers of the steel dock pontoon, which allowed making them massive (with box-shaped cross-section) and fitting them closely in rather long welded support boxes that provide sturdiness of the supporting elements of the scaffoldings. According to the Riga shipyard, the scaffoldings are placed around the ship within half an hour. Their disassembling takes about the same amount of time.

The design of versatile metal dock scaffoldings was proposed by a group of engineers and technicians of the Riga shipyard and has been successfully exploited at the plant up to the present day (Fig. 10). These scaffoldings consist of lightweight framed metal stairs that are hinged to the ends of steel brackets, which are also hinged to the dock towers. The hinge connection facilitates moving the entire device to the tower dock, as well as installing the scaffolding close to the vessel regardless of its width and distance between the dock towers and the vessel. This is accomplished by changing the angle of the mounting bracket relative to the dock tower in the range from 20° to 90°. When docking narrow vessels, the angle of rotation of the brackets approaches 90°.

Wooden planks are laid on the girder ladders. Horizontal elements of the girders are placed every 0.5 m, which makes it possible to use the scaffolding for any height necessary for the works. Straps are installed on the longitudinal elements of the girders to secure the fence. In order for the girder not to hang on the brackets in the working position of the scaffoldings, its lower ends are supplied with special telescopic tips. With their help, the girder in the working position is tightly supported by the pontoon deck, and the necessary clearance is created when it is pulled into the non-working position. The scaffoldings can be installed on the docks where the scaffolding brackets can be securely fixed in the towers.

For composite docks, there has been developed a system of scaffoldings based on this design with a reduced number of brackets on towers. The reduction is achieved through suspending each bracket on special traverses, each carrying 3 vertical girders. The girders are attached to panhard rods with permanent floor plates mounted on them. As a result, a complete section of scaffoldings is suspended to each bracket (Fig. 11). For the purpose of mounting the brackets, the dock hull is supplied with special embedded parts. For example, a dock with the cargo capacity of 6000 tons is fitted with twenty sections of scaffoldings, with ten sections on each tower, which ensures that scaffoldings are installed at the distance around 90 m from each board.

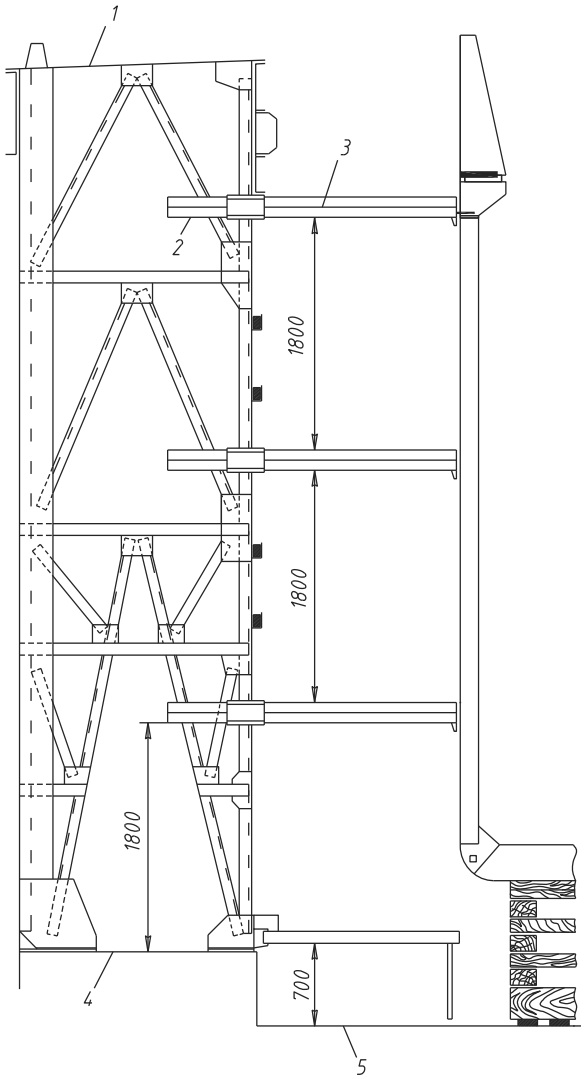

Fig. 9. Scaffoldings with telescopic support brackets:
1 — pontoon tower; *2* — support «box» of the pontoon proposed by the Riga shipyard; *3* — extendible pillars of the scaffoldings; *4* — deck of the side tanks; *5* — pontoon deck

In the working position, sections of the scaffoldings are interconnected with special locks. On the plank shields, rotary brackets of the scaffoldings are made of L-steel, while traverses and vertical girders are made of tubes. There are openings for special fastenings every 0.5 m of the girder pillars, which secure the height of installation of the stages of the scaffolding (i.e. arrangement of horizontal rods, on which plank shields are suspended).

Due to the hinged connection of the brackets, traverses, girders and plank shields, the scaffoldings are easily mounted into the working and idle position. Be-

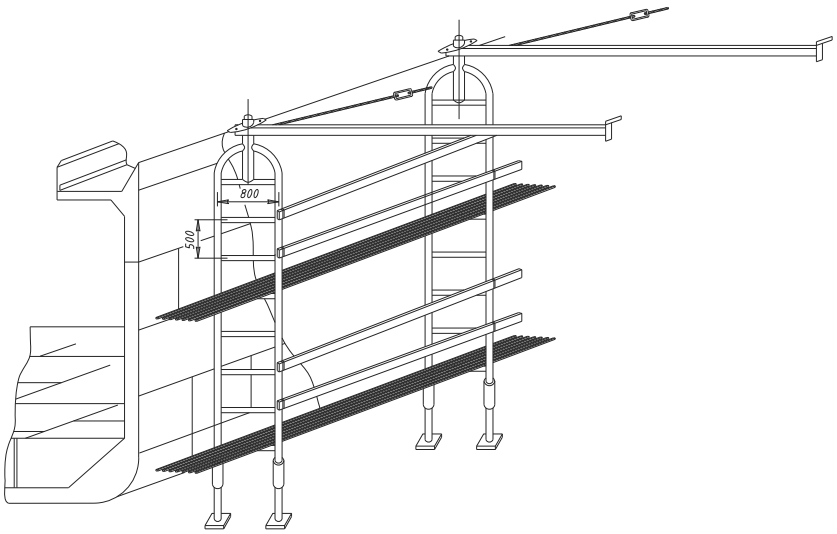

Fig. 10. Versatile metal scaffoldings

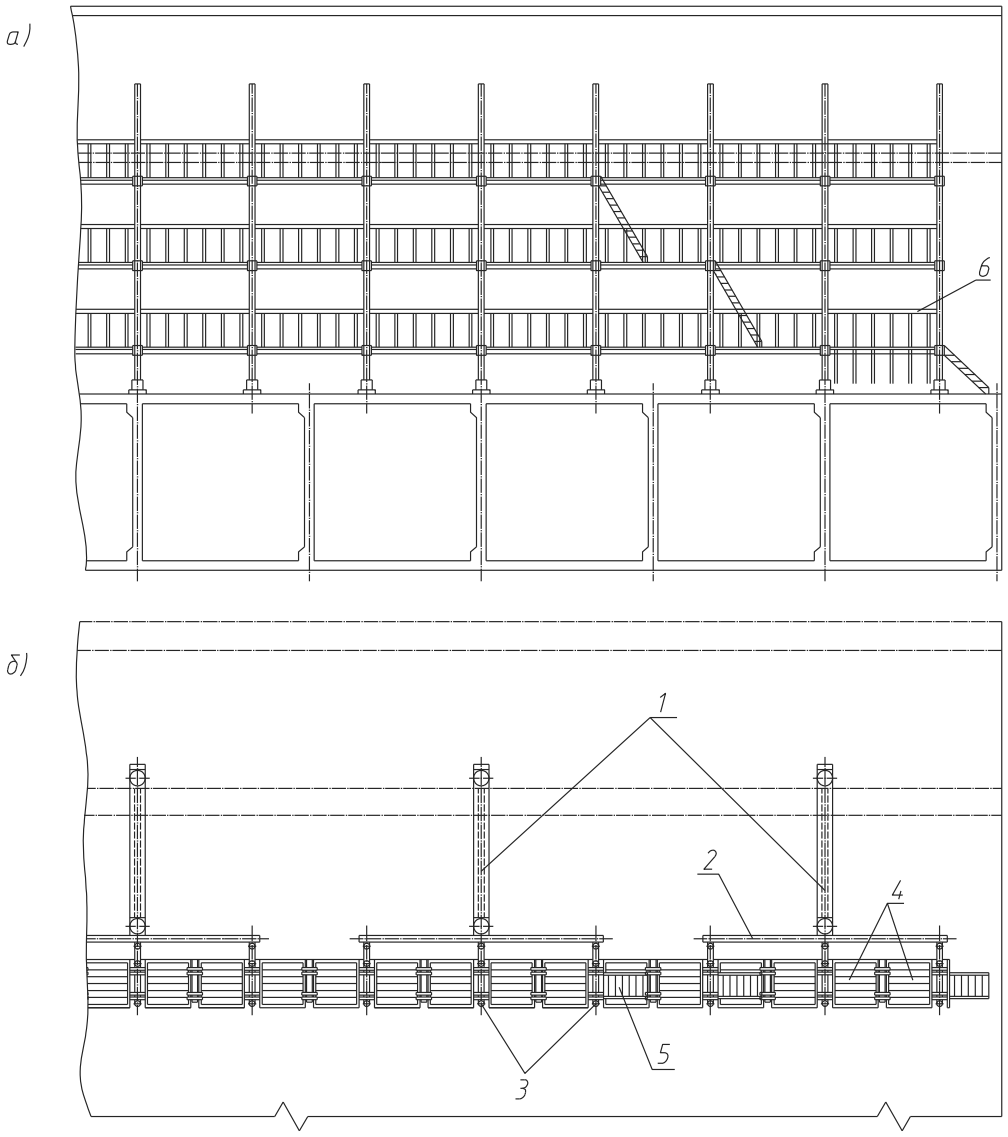

Fig. 11. Scaffoldings for composite docks:

a — view of the inner side of the dock tower; *b* — plan;

1 — bracket; *2* — traverses; *3* — support girders of the scaffoldings; *4* — plank shields; *5* — ladder; *6* — fencing

fore a ship enters or leaves the dock, the scaffoldings are moved to the dock tower and secured with set-in pins.

The experience of operation of the dock scaffoldings described above leads to a conclusion that they are quite efficient for repairing the parallel middlebody of vessels. Meanwhile, the situation is much worse with the scaffoldings used to repair the ship edges. For this purpose, design organizations and manufacturing enterprises have only offered scaffoldings that are assembled from individual elements or sections (much alike those used in construction). Exploitation of such scaffoldings has not shown positive results because the scaffoldings are not sufficiently strong when made from lightweight elements, while the elements bend and lose their original shape. When made of heavy elements, the scaffoldings require more physical effort during assembly.

The Kanonersky plant has offered an original design of the scaffoldings intended for repairing the ship edges, which is presented in Fig. 12.

The mobile gantry serves as the basis of the scaffoldings. It is connected with girder pillars, where working areas of the scaffoldings are placed each 2.1 m on horizontal guides. Hence, these areas can be moved horizontally. The ends of the working areas have additional folding planks for a closer attachment of the floor to the ship. The length of scaffoldings is 3.2 m; the ladder to enter them is also provided. The scaffoldings have a fence ensuring the safety of works at height. Successful exploitation of such scaffoldings allows recommending them as a standard for repairing the ship edges.

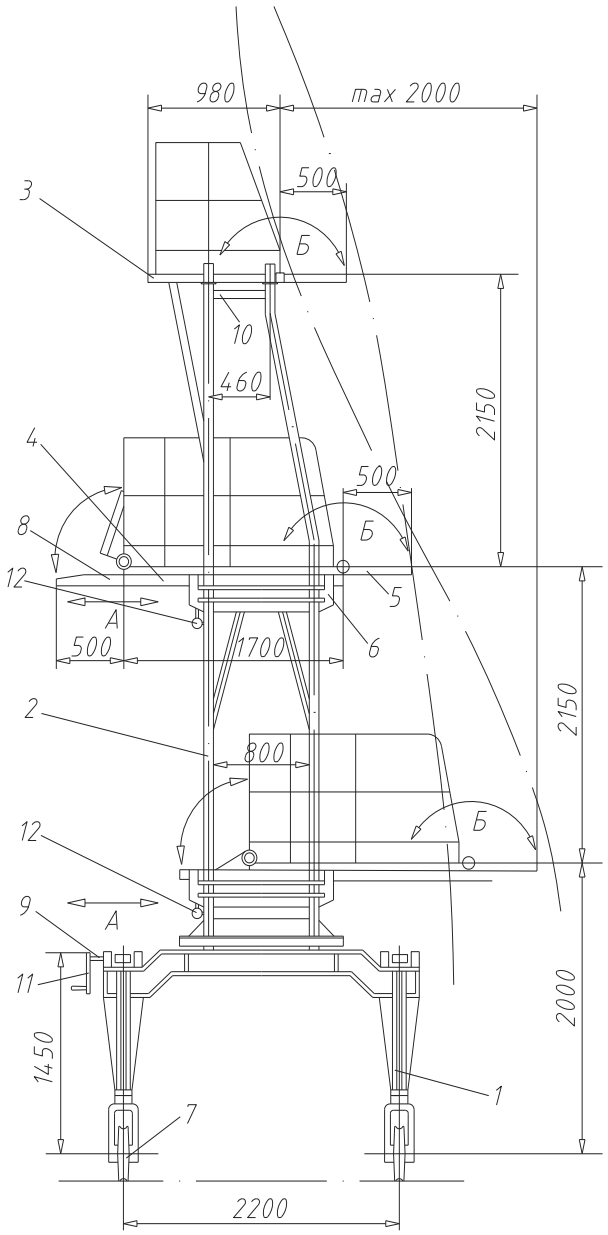

Fig. 12. Scaffoldings for repairing the ship edges:

1 — gantry; *2* — girder made of pipes; *3* — upper stationary area; *4* — lower and intermediate extendable areas; *5* — foldable areas; *6* — guided roller blocks; *7* — rotating wheels; *8* — foldable guiding tracks; *9* — worm-type steering gear; *10* — connected solid girder angles; *11* — handles; *12* — screw-type stoppers

CONCLUSIONS. The article presents a classification of ice-retaining devices which allow ensuring a normal ship sitting on keel blocks and reduce the labor and time input for ice removal. It provides the schemes of devices closing the ends of docks, which allow reducing draughts directed towards the dock end. There is also a classification of staff constructions of dock scaffoldings; the requirements for the scaffoldings are given as well.

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