The invention applies to shipbuilding dealing with the construction of Arctic heavy-tonnage carriers. The Arctic heavy-tonnage carrier comprises an underwater cargo hull and above-water body in the form of the main deck with a superstructure. The underwater hull is connected to the main deck with an ice-resistant pylon along which the ship load waterline passes and which is located in the fore body of the underwater hull directly behind the forepeak symmetrically related to the center plane of the ship hull. The upper deck of the underwater ship hull has in the area of the pylon a strengthened construction. The pylon structure is a bearing one for the main deck. The underwater hull can be made in the cross-sectional view to the shape of a round-angled rectangle the height of which is 10-12 m and a height-breadth ratio does not exceed 1:6. The underwater hull of said ship has along each side the aft arranged retractable mooring bollard. The ice-resistant pylon for connecting the ship underwater hull to above-water body is executed in the form of a strength longitudinally and transversely framed hull having in the plan view a long and symmetrical shape. The pylon breadth or diameter is significantly less than that of the ship load hull as well as the practical width of channel to be laid by the icebreaker. The pylon height provides the movement of the main deck above the ice surface and underwater hull—beneath the lower ice edge. The invention enables to increase the ship heavy ice-breaking capabilities when going after the icebreaker in the Arctic shelf areas with shallow waters as well as to decrease the ship navigation resistance in broken ice and decrease the height of ship underwater hull.
ARCTIC HEAVY-TONNAGE CARRIER AND ICE-RESISTANT PYLON FOR CONNECTING THE SHIP UNDERWATER AND ABOVE-WATER BODIES

FIELD OF THE INVENTION

[0001] The invention relates to sea-going heavy-tonnage carrier intended for operation simultaneously with the icebreaker in Arctic ice fields, including the shallow depths conditions in Arctic shelf.

BACKGROUND OF THE INVENTION

[0002] For economic efficiency of heavy-tonnage carriers they are constructed presently of rather large capacity and consequently with large principal dimensions, viz length, breadth, depth and draft. Such ships are intended mainly for navigation in ice-free water areas.

[0003] Delivery of cargoes to Arctic regions in autumn and spring seasons is affected, when floating after the icebreaker, by surface ice-class ships with a displacement from 10 to 20 thou tons. In ice of small thickness (up to 1 m) such method of ice-breaking assistance, regardless of ship’s slow speed, is considered as effective. However, when going after the ice-breaker in ice of larger thickness such method of ice-breaking assistance becomes ineffective as the carrier is nipped by arctic ice in the ice belt reducing thus significantly ship’s speed down to her stop. This factor signifies particularly in cargo transportation by large-capacity ships with the enlarged principal dimensions.

[0004] It is well-known the General Dynamics Corp. project of supersize tanker for cargo transportation beneath the surface of arctic ice (“Problems of underwater shipping in the foreign Arctic”, V. F. Burkanov et al., Collected Articles on Foreign Shipbuilding, issue 126, 1965). This ship is a submersible tanker having a large operating submersible depth of 120 m and consequently a strength hull. Similar projects of submersible tankers appeared in the last time in Russia too. However, caused by the economic efficiency of transporting, the main dimensions of such tankers, for instance, height (hull diameter) of 25-30 m, require the construction of deep-water ports or equipped underwater offshore storage and terminals. This reduces the choice of ways of cargo transportation and makes impossible the operation of such tankers in shallow depths conditions of Arctic shelf.

There are well-known methods and means to increase the ice-breaking capability of ice-class ships based on engineering solutions of navigation of such ships in ice field, e.g.:

[0005] by means of installation in the forward part of the ship of ice-cutting roller (SU i.e. No. 92014097);
[0006] owing to increase of ship hull pneumatic washing efficiency (SU i.e. No. 3021772);
[0007] It is also well-known a semi-submersible cargo-and-passenger tanker (RU patent No. 2043261) accepted as a prototype comprising an underwater cargo hull and a superstructure topside connected with the hollow streamlined stanchions in the forward part of which the inclined ice-crushing devices installed.

[0008] The prototype ship, however, can be used for breaking of relatively light ice. For arctic 2-3 m thick ice fields the ship ice-crushing devices will not be able to replace the high-power nuclear icebreaker. Furthermore, when ship is floating after the icebreaker, the heavy arctic field ice bits will be found between the ship stanchions thus impeding the ship floating. And in case of freezing of such ship in the ice field her release with the ice-breaker becomes impossible as the ship construction does not envisage the icebreaker approach so as to release the ship from the ice inside of her stanchions.

SUMMARY OF THE INVENTION

[0009] The present invention is focused into the solving a task of constructing the heavy-tonnage carrier with high ice-going qualities in heavy ice when going after the ice-breaker including the areas of shallow depth of the Russian Arctic shelf.

[0010] The major engineering result achieved at realization of invention consists in the reduction of area of ice belt of the carrier and decrease of resistance to ship navigation in broken ice, as well as reduction in underwater hull height.

[0011] The major engineering result is achieved due to the fact that similarly to prototype the carrier comprises an underwater cargo hull as well as above-water body in the form of the main deck with a superstructure. However, in the proposed solution its underwater hull having a precise height is connected to the main deck with an ice-resistant pylon along which the ship load waterline passes and which is located in the fore body of the underwater hull directly behind the foep’s peak symmetrically in relation to the center plane of the ship hull. In this case the upper deck of the underwater ship hull has in the area of pylon a strengthened structure and the pylon structure is a bearing one for the main deck.

[0012] The required height of the underwater hull is obtained due to the fact that in the instance of proposed engineering solution an underwater hull of said ship is made in the cross-sectional view to the shape of a round-angled rectangle the height of which is not more than 10 m and a height-breadth ratio does not exceed 1:6.

[0013] In another case an underwater hull of said ship has along each side the aft arranged retractable mooring bollards.

[0014] In order to connect the ship underwater hull to above-water body an ice-resistant pylon executed in the form of strength longitudinally and transversely framed hull is proposed. This hull has in the plan view a long and symmetrical shape, its breadth being less than that of ship’s load hull as well as the practical width of channel to be laid by the icebreaker and a height of said pylon providing the main deck movement above the ice surface while the underwater hull— beneath the lower ice edge.

[0015] In the case of proposed engineering solution the pylon length does not exceed the ¼ of the ship underwater hull length, the pylon breadth is not more than ¼ of the ship underwater hull breadth and the pylon height is not more than 20 m from the ship underwater hull upper deck to the main deck of above-water body. Due to such pylon solution a minimum possible area of the ship ice belt and increased ice-breaking capability of the ship is ensured.

[0016] In another case of engineering solution of ice-resistant pylon ensuring reduction in broken ice navigation resistance, the pylon fore body, which is length is not less than ½ of the total pylon length, is executed with constructed lines. These lines are formed in height by waterlines of variable fullness having the shape of a directed-forward nonlinear-sided wedge, the maximum fullness of waterlines is at the level of 0.5-1.5 m above the load waterline below which the fullness goes gradually down to the minimal one at a height corresponding to the middle of the calculated thickness of ice field after which the fullness of waterlines grows up again to the maximum one at the upper deck of the underwater hull.
Then the hull aft is executed in the form of an elongated in the plan view trapezoid with its larger base being a fore end, and its smaller base—a transom bulkhead the upper part of which is inclined towards the bow, and furthermore, in the cross-sectional view the hull is also made in the form of a trapezoid with its smaller base upwards.

[0017] In the next case of the claimed engineering solution of ice-resistant pylon the contours of waterline in the pylon fore body are changed from the convex-concave at the waterline of minimal fullness to the convex ones at the waterline of minimal fullness being determined by a half-breath of points lying on a plotted curve described near the ray drawn from the center plane of the hull at an angle $\alpha$ in a plane of any waterline within its fullness change in height of said pylon and conjugated with a line of its total breadth. For the least fullness waterline an angle $\alpha$ equal to 30°, the fullness of each subsequent waterline (symmetrically up and down) is determined by a 5° increase of angle $\alpha$, and the change in numerical value of half-breath for all waterlines is determined by $tg\alpha$ which is the value of which is within $tg\alpha=0.5+1.5$, the position of all angle $\alpha$ vertices in the center plane is changed from the stem with a step of 0.3 m, the corresponding position of half-breath in height of said pylon is changed with a step of 1 m towards the stem from the middle of the length of the pylon fore body.

[0018] In still another case the pylon fore body is enveloped in the ice-separating means arranged in the center plane at the upper part of the constructed lines of maximum fullness at a height of 0.5±1.5 m above the load waterline, being installed with a free edge upwards at an angle of 30°±50° with the waterline and at a 5±10° slope aft passing along each side up to the intersection with the load waterline. The means is executed in the form of a strengthened plate bent in the fore body in the cross-sectional view over cylindrical surface with a convexity outwards to the bow and then towards the stern smoothly reversing the direction of cylindrical bending, its free edge as a helical line closing on said means end cross edge deviated below the waterline plane by 5±10°.

[0019] The above and other features of the invention including various novel details of construction and combinations of parts, and other advantages, will now be more particularly described with reference to the accompanying drawings and pointed out in the claims. It will be understood that the particular method and device embodying the invention are shown by way of illustration and not as a limitation of the invention. The principles and features of this invention may be employed in various and numerous embodiments without departing from the scope of the invention.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0020] In the accompanying drawings, reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale; emphasis has instead been placed upon illustrating the principles of the invention. Of the drawings:

[0021] FIG. 1 shows three projections of the claimed carrier structure and a pylon to connect the ship underwater hull to above-water body.

[0022] FIG. 2 shows a side view of the pylon pylon.

[0023] FIG. 3 shows the form of the pylon fore body waterline sections.

[0024] FIG. 4 shows ice-selecting means.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

[0025] The Arctic heavy-tonnage carrier is a triple-hulled structure (FIG. 1), the principal particulars of which are forepeak 1, main deck 2, superstructure 3, pylon 4, upper deck of underwater hull 5, ice field (broken ice) 6, machinery compartment 7, steering gear 8, cargo-fuel tanks 9 and retractable bollards 10; $L$, $B$, $H$—length, breadth and height of underwater hull.

[0026] For the claimed ship the cargo to be carried is stowed in underwater hull 5 having dimensions providing the requisite carrying capacity and capability for navigating in the restricted depth conditions of Arctic shelf. Owing to shallow operating depth of the ship the underwater hull does not require a strengthened version except the area of upper underwater hull deck to be connected with the pylon.

[0027] The pylon height must be sufficient to provide navigation of underwater hull 5 beneath the ice and above-water body 2—above the ice surface. In case of freezing the pylon 4 in the ice field its height and trapezoidal sides should be sufficient so as to provide some technological submergence of the ship ensuring thus the icebreaker approach for ice chipping.

[0028] A side view of the pylon 4, its relative dimensions as well as practical arrangement in relation to ice field is seen from FIG. 2 where an ice-separating means 11 and its spiral surface 12 are shown.

[0029] Furthermore, $h$, as shown in FIG. 2 is a height of the main deck above the ice-separating means, $h_{1}=$—is the distance above the upper edge of the ice field, $h_{2}$—is the calculated thickness of ice field, $h_{3}$—is the distance from the upper deck of the underwater hull to the lower ice edge, $a$—are the maximum fullness waterline cross-sections in the pylon fore body, $B$—is the decreasing fullness waterline section, $c$—is the minimal fullness waterlines section, $L_{1}$—is the pylon length.

[0030] A form of the pylon fore body sections in the plan view is seen from FIG. 3, where $a$, $d$—is the view of waterlines of maximal fullness, $B$—is the view of waterlines of intermediate fullness, $c$—is the view of waterlines of minimal fullness, $1/3$ $L_{1}$—is the pylon fore body length.

[0031] A form of waterlines depending on their position in height of the pylon (FIG. 3) is determined by a plotted curve described near the ray from point An at an angle $\alpha$ with the center plane. For waterline of the least fullness, i.e., optimal wedge sharpness, an angle $\alpha$ is recommended to be 30 degrees. From this level the fullness of each subsequent waterline (up and down) is determined by recommended increase of angle $\alpha$ by 5 degrees from vertex An.

[0032] The position of points An in the center plane from the stem (within the change of its concavity in the pylon length) is changed with a step of 0.3 m towards the stem. The corresponding position of points Mn is changed with a step of 1 m towards the stem from the middle of the fore pylon length (i.e., from the middle of length of 1/3 $L_{1}$, FIG. 3).

[0033] By setting angle $\alpha$ from vertex An with the ray An-Mn the change in half-breath of all waterlines will be determined using function $tg\alpha$ which will be within the limits of $tg\alpha=0.5+1.5$.

[0034] The plotted curve, described near the ray passing through point Mn with half-breath $PnMn$ and conjugated with a line of the pylon total breadth, going from the conver-
The position of ice-separating means in relation to the pylon and load waterline is shown in FIG. 4 when 3—is a pylon, 11—is in ice-separating means, 12—is the bending direction of the ice-separating means surfaces, 13—is a line of joining of ice-separating means to the pylon, 14—is a free edge, n— is the ice-separating means aft edge section.

The extreme breadth of the pylon is not more than ¼ of B, where B—is the underwater hull breadth and its recommended length is not more than ¼ of L (length of underwater hull).

A height of the pylon (h₁+ h₂+ h₃+ h₄+ hₛ) provides the navigation of underwater hull beneath the ice surface and above-water body—above the ice surface. The above-ice height of the pylon (h₁+ h₂) and its trapezoidal form, in case the pylon is frozen in the ice filled, must provide the possibility for technological ship submergence required for approaching the icebreaker and chipping of ice. Those factors as well as the maximum thickness of ice field h₃+ h₄ and a safe distance of the upper underwater deck from the lower ice edge h₂, have stipulated selection of pylon height being not more than 20 m from the upper deck of the underwater hull to the main deck of above-water body of the ship.

The claimed engineering solutions of said carrier and ice-resistant pylon shall provide the minimum heavy-tonnage carrier pylon ice belt area which will be at least 3 times less than that of the same carrying capacity surface ship; decrease of ship nipping in ice as well as the reduction in ship navigation resistance in broken ice due to:

1. Location of pylon in the fore body of the underwater hull for navigation after the icebreaker before narrowing of the channel starts;
2. The pylon lines shape as the nonlinear-sided wedge reducing the navigation resistance when separating the ice;
3. Trapezoidal in the plan view of pylon hull structure and special form of ice-separating means reducing the friction resistance on the ploting even when turning and sinking the ice floes.

The application of claimed engineering solution offers the way of more efficient use of Northern Sea Route with the operation of existing nuclear icebreakers.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

What is claimed is:

1. An arctic heavy-tonnage carrier comprising an underwater cargo hull and above-water body as the superstructure main deck distinctive in the underwater hull connected to the main deck with an ice-resistant pylon along which a load waterline is passed and which is located in the fore body of the underwater hull directly behind the forepeak symmetrically relative to the center plane of said carrier hull, said underwater hull upper deck in said pylon area having a strengthened structure and said pylon structure being a load-bearing one for the main deck.

2. The ship under claim 1 wherein its underwater hull is shaped in the cross sectional view as a round-angled rectangle which height is 10+12 m and a height-to-breadth ratio does not exceed 1:6.

3. The ship under claim 1 wherein its underwater hull has along each side the aft arranged retractable mooring bollards.

4. The ice-resistant pylon for connecting the ship (claim 1) underwater hull with above-water body is performed as a strength transversally and longitudinally framed hull having symmetrically elongated in the plan view shape, said pylon breadth being less than the ship cargo hull breadth as well as the practical breadth of channel to be laid by icebreaker and said pylon height providing the movement of ship main deck above the ice surface and the underwater hull—beneath the lower ice edge.

5. The pylon under claim 4 wherein said pylon length does not exceed the ¼ of ship underwater hull length said pylon breadth is not more than ¼ of ship underwater hull breadth and said pylon maximum height is not more than 20 m from the ship underwater hull upper deck to the above-water body main deck.

6. The pylon under claim 4 wherein said pylon forebody having a length of not less than ½ of said pylon hull length is performed with the constructed lines, said lines being formed in height by waterlines of variable fullness have the shape of directed-forward nonlinear-sided wedge, the maximum fullness of waterlines being at the level of 0.5+1.5 m above the load waterline below which the fullness goes gradually down to the minimal one at a height corresponding to the middle of the calculated thickness of ice field after which the fullness of waterlines grows up again to the maximum one at the upper deck of the underwater hull; then the hull aft is executed in the form of an elongated in the plan view trapezoid with larger base being a fore end, and its smaller base—a transom bulkhead the upper part of which is inclined towards the bow, and furthermore, in the cross-sectional view the hull is also made in the form of a trapezoid with its smaller base upwards.

7. The pylon under claim 6 wherein the contours of waterline in the fore body of said pylon are changed from the convexo-concave at the waterline of minimal fullness to the convex ones at the waterline of minimal fullness being determined by a half-breadth of points lying on a plotted curve described near the ray drawn from the center plane of the hull at an angle α in a plane of any waterline within its fullness change in height of said pylon and conjugated with a line of its total breadth, for the least fullness waterline an angle α being equal to 50°, the fullness of each subsequent waterline (up and down) is determined by a 5° increase of angle α, and the change in numerical value of half-breadth for all waterlines is determined by tₐα the value of which is within tₐα = 0.5+1.5, the position of all angle α vertices in the center plane is changed from the stem with a step of 0.5 m, the corresponding position of half-breadth in said pylon height is changed with a step of 1 m towards the stem from the middle of the length of the forebody of said pylon hull.

8. The pylon under claim 4 wherein said pylon fore body is enveloped in the ice-separating means beginning from the center plane at the upper part of the constructed lines of maximum fullness at a height of 0.5+1.5 m above the load waterline, being installed with a free edge upwards at an angle of 30+50° with the waterline plane and at a 5+10° slope aft passing along each side up to the intersection with the load waterline, being executed in the form of a strengthened plate bent in the fore body in the cross-sectional view over cylindrical surface with a convexity outwards to the bow and then towards the stern smoothly reversing the direction of cylindrical bending, its free edge as a helical line closing on said means end cross edge deviated below the waterline plane by 5+10°.