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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) COLLISION-RESISTANT STRUCTURE

(57) A collision-resistant structure for a side of a ship's hull is disclosed, the structure comprising an outer shell having an inner surface and an outer surface, an array of web frames extending broadwise substantially perpendicular to, and lengthwise transversely across, the inner surface of the outer shell, wherein the web frames are mutually spaced along the inner surface, wherein the structure further comprises an array of longitudinal stiffening profiles that extend lengthwise longitudinally along, and are mutually spaced across, at least part of the inner surface of the outer shell, and an array of intermediate transverse stiffening profiles that extend lengthwise transversely across, and are mutually spaced along, at least part of the inner surface of the outer shell, wherein the web frames and the intermediate transverse profiles are arranged in such an alternating manner that, between neighbouring web frames in the array, at least one of the transverse profiles is positioned, wherein the longitudinal profiles cross the web frames and the intermediate transverse profiles such that the arrays together form a net-like structure, wherein the net-like structure of the arrays is attached to the inner surface of the outer shell.

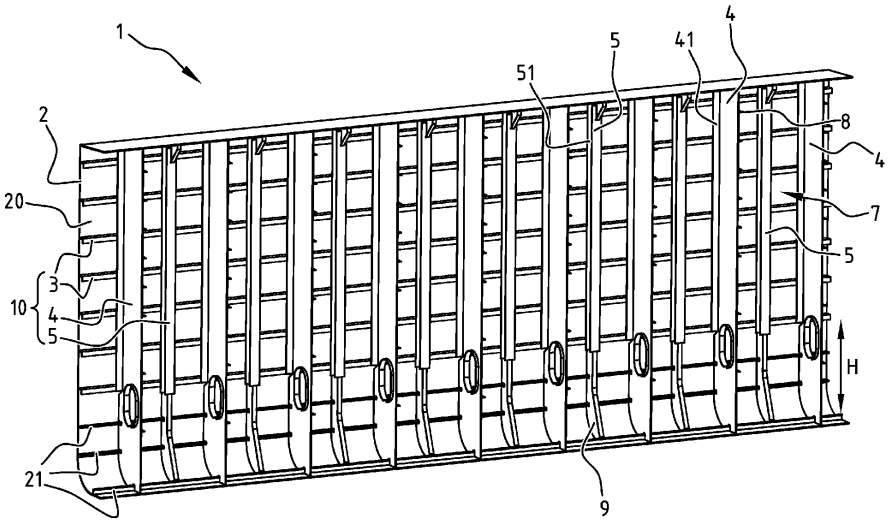

FIG. 1

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Description

[0001] The present invention relates to a collision-resistant structure for a side of a ship's hull. Furthermore, the present invention relates to a ship's hull provided with such a collision-resistant structure, and a ship comprising such a hull. The present invention further comprises a method of configuring the collision-resistant structure.

[0002] In recent decades, inland navigation ships particularly in Europe, in particular chemical tankers and gas carriers, have overall increased in size due to an overall increase of cargo tank sizes for commercial and operational reasons. If such a large ship is involved in a collision, which can especially occur on inland waterways and in ports, the hull and cargo tanks could be heavily damaged and, as a consequence, the environment could be severely polluted or even, in some cases, an explosion risk could arise. A considerable risk arises notably in the event of a side collision, e.g., when another ship collides frontally with a lateral side of the hull. Therefore, the safety of ships with increased cargo tank sizes in the case of side collisions was to be increased. In particular, the impact resistance of shell structures of ships had to be improved.

[0003] Lapsed European patent No. 1 137 571 discloses a collision-resistant structure comprising a series of ducted sections positioned above one another and attached to the inner surface of the outer wall. The known collision-resistant structure has been applied in many ships with cargo tanks having an increased capacity, with the purpose of providing a sufficient safety when absorbing the impact from a side collision by another ship. An applied embodiment of the structure comprises a so-called HAT-profile, wherein the ducted sections are strengthened by means of built-up T-profiles, wherein these ducted, built-up structures are welded to the inner surface of the outer wall.

[0004] The known collision-resistant structure nonetheless has numerous drawbacks. Overall, the structure is relatively complex and adds considerable weight to the construction of the ship. More specifically, the series of ducted profiles are relatively heavy and complex to be constructed and to be welded to the wall such that the construction time is increased considerably. Furthermore, once constructed and installed, the ducted profiles complicate coating of the structure. The same applies to the repair of such a construction after a collision, which repair is thus more expensive. Moreover, the ducted profiles require to be tested for weathertightness after installation, as the inside of the ducted profiles may be prone to corrosion. Testing each ducted profile along the ship's cargo tank area at both port side and starboard side extends the building time of the ship significantly.

[0005] It is therefore an object of the present invention, amongst other objects, to provide an improved collision-resistant structure, in particular a collision-resistant structure wherein at least one of the aforenoted drawbacks is at least partially alleviated, preferably while providing the structure with a sufficient capability to absorb the impact of a collision with another ship.

[0006] To that end, a collision-resistant structure for a side of a ship's hull is provided, wherein the structure comprises:

- an outer shell having an inner surface and an outer surface;
- an array of web frames extending broadwise substantially perpendicular to the inner surface of the outer shell and lengthwise transversely across the inner surface of the outer shell, wherein the web frames are mutually spaced along the inner surface;
- an array of longitudinal stiffening profiles that extend lengthwise longitudinally along at least part of the inner surface of the outer shell and are mutually spaced across at least part of the inner surface of the outer shell;
- an array of intermediate transverse stiffening profiles that extend lengthwise transversely across at least part of the inner surface of the outer shell and are mutually spaced along at least part of the inner surface of the outer shell, wherein the web frames and the intermediate transverse profiles are arranged in such an alternating manner that, between neighbouring web frames in the array, at least one of the transverse profiles is positioned, wherein the longitudinal profiles cross the web frames and the intermediate transverse profiles such that the arrays together form a net-like structure, wherein the net-like structure of the arrays is attached to the inner surface of the outer shell.

[0007] Compared to the known collision-resistant ducted structure, the net-like structure provides a more progressive resistance to the impact of a collision, which increases the absorption capacity of the structure in case of a collision. The term "collision-resistant" can be defined as, e.g., compliant with the regulations of the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN).

[0008] Furthermore, by forming a net-like structure, the construction can be significantly simplified, and the weight and material use can be reduced, especially when the structure essentially consists of only the outer shell, the web frames, the profiles and, optionally, an inner shell as described further below. Preferably, between neighbouring web frames in the array, only one transverse profile is positioned. In general, web frames for a hull are substantially plate-like. The web frames extend further inwards, i.e., further away from the outer shell, than the stiffening profiles, in particular the intermediate transverse profiles. Such web frames as such are a well-known structural component in naval architecture and, in a further embodiment as described further below, may be adjusted to allow the longitudinal profiles to cross.

[0009] Moreover, the structure can be made using relatively standard profiles as opposed to the specific duct-

ed profiles that have been used previously. For example, the intermediate transverse profiles are preferably H-profiles or I-profiles, or alternatively T-profiles or L-profiles, or the array of intermediate transverse profiles may comprise a combination of such profiles. Similarly, the longitudinal profiles are preferably L-profiles or T-profiles, or alternatively flat bars or Holland profiles, or the array of longitudinal profiles may comprise a combination of such profiles. Each or at least one of the longitudinal profiles is preferably fixed lengthwise, via an outer edge thereof, to the inner surface of the outer shell. The outer edge of the longitudinal profile may be directly fixed to the inner surface of the outer shell.

[0010] A further advantage of the structure is that the coating of the profiles can be maintained more easily such that corrosion risks can be reduced, and the structure may even be suitable for corrosive conditions as in the case of ballast tanks.

[0011] As such, by providing any one of the above advantages, an improved collision-resistant structure can be obtained for single-walled and double-walled ships. Furthermore, applying the net-like structure instead of the known ducted structure can lower the carbon footprint of the ship. In the net-like structure, it is preferred if the longitudinal profiles cross the web frames and the transverse profiles perpendicularly, wherein it is further preferred if the web frames and the transverse profiles are mutually parallel, such that a substantially grid-like or raster-like structure is obtained for an optimal impact absorption capacity of the structure. As such, the web frames and the transverse profiles can be substantially vertical, while the longitudinal profiles are substantially horizontal.

[0012] It is to be appreciated that the term "ship" is particularly understood to refer to, inter alia, an inland navigation vessel or a sea-going ship, such as a tanker, but may also refer to a pontoon or a tug-pushed barge. The term "transverse", as in transverse profiles, relates herein to a direction perpendicular to the longitudinal direction, or the direction of movement, of the ship.

[0013] According to a preferred embodiment of the collision-resistant structure, neighbouring web frames and transverse profiles are arranged at equal mutual distances. This way, an even more evenly configured grid-like or raster-like structure can be obtained, such that the impact absorption capacity is substantially even across and along the structure.

[0014] To obtain a responsive collision-resistant structure, the transverse profiles and the longitudinal profiles are particularly made of a ductile material, preferably steel, particularly shipbuilding-quality steel.

[0015] In case the longitudinal profiles are fixed to the inner surface of the outer shell, it is preferred if the web frames and the transverse profiles are fixed to and across the longitudinal profiles in an overlapping manner. Such an overlapping configuration simplifies the construction of the collision-resistant structure since, conveniently, the longitudinal profiles can be mounted to the outer shell first and the web frames and the transverse profiles can be affixed in a subsequent step. The mounting, connecting and attaching of the profiles is preferably done by means of welding. The overlapping configuration may enhance the ability of the structure to progressively resist the impact of a collision.

[0016] In the overlapping configuration, it is further preferred if each or at least one transverse profile comprises a flange, wherein the transverse profile is fixed to the longitudinal profiles via an outer face of the flange. For example, the transverse profile may be an H-profile, an I-profile, a T-profile or an L-profile, each of which comprises such a flange. Additionally, or alternatively, it is preferred if each or at least one web frame is provided, preferably lengthwise along an outer edge thereof, with a face bar, wherein the web frame is fixed to the longitudinal profiles via an outer face of the face bar.

[0017] By fixing the transverse profile or the web frame to the longitudinal profiles via a flange or a face bar, the respective member is affixed over a larger connection area such that a sturdier connection can be obtained. Moreover, a larger connection area may further enhance the impact absorption capacity of the structure, as the connection enables the longitudinal profiles to push against the web frames and the transverse profiles for an improved response of the structure to the impact of a collision.

[0018] It is then further preferred if each or at least one longitudinal profile comprises a flange, wherein the longitudinal profile is fixed to the web frames and the transverse profiles via an outer face of the flange. As such, the flange of the longitudinal profile may be fixed to the flange of the transverse profile and to the face bar of the web frame. This further enlarges each connection area. For example, the longitudinal profile may be an L-profile, a T-profile, an I-profile or an H-profile, each of which comprises such a flange.

[0019] According to a further preferred embodiment of the collision-resistant structure, the web frames extend to a bottom of the outer shell, wherein the transverse profiles are spaced from the bottom of the outer shell. When another ship collides into the side of the hull, the impact area is generally above the waterline. Hence, it may generally suffice to arrange the net-like structure over only a part of the height of the outer shell, specifically the part near the top of the outer shell. Therefore, to further simplify the net-like structure, the lower ends of the transverse profiles preferably do not extend all the way to the bottom of the outer shell but are located at a distance above the bottom of the outer shell. In that case, it is preferred if each or at least one transverse profile is provided with a bottom bracket arranged to connect the transverse profile to the bottom of the outer shell.

[0020] A specific embodiment of the collision-resistant structure, more specifically a double-walled structure, further comprises an inner shell spaced from the outer shell. The web frames are arranged between the shells. Preferably, the web frames are connected to the inner

shell, wherein the inner shell is preferably spaced from the intermediate transverse profiles. Such double-walled structures may be particularly applied in chemical tankers and cryogen gas tankers. The outer surface of the inner shell, which faces the outer shell, may be provided with an array of longitudinal stiffening profiles that extend lengthwise longitudinally along, and are mutually spaced across, at least part of the outer surface of the inner shell. These longitudinal profiles on the inner shell may be L-profiles, T-profiles, flat bars or Holland profiles, or the array of longitudinal profiles on the inner shell may comprise a combination of such profiles.

[0021] As such, according to a further aspect, a ship's hull is provided, wherein a side of the hull, preferably a lateral side such as port side or starboard side, is provided with a collision-resistant structure according to any of the embodiments described above. Further provided is a ship, in particular a chemical tanker or a gas carrier, wherein the ship comprises said hull. The ship preferably further comprises at least one cargo tank. Each or at least one cargo tank may have a capacity volume exceeding 380 cubic metres, for instance a capacity volume of between 380 and 1000 cubic metres. A risk can arise particularly in the event of a collision into the hull at the location of the cargo tank. It is therefore preferred if the collision-resistant structure is provided alongside of the cargo hold area, specifically the cargo tank, more preferably along the entire cargo hold area.

[0022] According to yet another aspect, a method of configuring a collision-resistant structure according to any of the embodiments described above is provided, wherein the method comprises the step of determining distances between neighbouring web frames and transverse profiles in dependence of the degree to which the web frames, the transverse profiles and the longitudinal profiles absorb an impact on the outer surface of the outer shell.

[0023] The step of determining said distances may comprise the steps of:

- providing a finite element model of the collision-resistant structure, wherein the model includes a cell length parameter representative for distances between neighbouring web frames and transverse profiles in the array;
- simulating, for various values for the cell length parameter, an impact on the outer surface of the outer shell;
- determining, for each simulated impact, an impact absorption parameter representative for the degree to which the web frames, the transverse profiles and the longitudinal profiles absorb the impact;
- selecting, from the various values for the cell length parameter, an optimal value that maximises the impact absorption parameter.

[0024] The structure is hereinafter further elucidated with reference to the attached drawings, wherein:

- Figure 1 represents an isometric view of a single-walled structure for a side of a ship hull;
- Figure 2 represents a side view of the single-walled embodiment seen from inside the hull;
- Figures 3 and 4 represent different cross-sectional views of a double-walled embodiment.

[0025] In Figures 1 and 2, a collision-resistant single-walled structure 1 for a side of a hull of a ship, in particular a non-cryogenic gas carrier, is shown. The structure 1 comprises an outer shell 2 for forming part of the outer surface of the hull, and a net-like structure 10 of arrays of stiffening members 3, 4, 5.

[0026] In Figures 3 and 4, a double-walled variant of the collision-resistant structure 1, in particular for a chemical tanker or a cryogenic gas carrier, is shown in cross-section, which further comprises an inner shell 6. Throughout the drawings, corresponding elements are indicated by corresponding reference signs.

[0027] The net-like structure 10 includes a vertical array of horizontal L-profiles 3 positioned above one another. The horizontal L-profiles 3 form impact rows and are fixed lengthwise, via an outer edge thereof, directly to the inner surface 20 of the outer shell 2. Seen in cross-section, the opposite leg 31 of each L-profile 3 extends downwards from the leg 32 that is fixed to the inner surface 20.

[0028] The net-like structure 10 further includes a horizontal array of vertical plate-like web frames 4 for the hull, and of intermediate vertical H-profiles 5. The vertical web frames 4 and H-profiles 5 form, respectively, primary and secondary impact columns and are arranged in the array in such an alternating manner that, between neighbouring web frames 4, one H-profile 5 is positioned. The profiles 3, 5 and the web frames 4 define cell-like spaces 7 therebetween. It has been found that the impact energy absorption capacity of the structure 1 is particularly governed by the selected length L of the cell-like spaces 7, which is thus preferably to be optimised for each design. The cell-like spaces 7 are uniform.

[0029] Specifically, Figure 3 represents a cross-section at the location of a web frame 4, whereas Figure 4 represents a cross-section at the location of an H-profile 5. For the horizontal L-profiles 3 to cross the vertical web frames 4 and H-profiles 5, each web frame 4 is provided with a passage 40 therethrough, whereas each vertical H-profile 5 overlaps the horizontal L-profiles 3. Each web frame 4 and H-profile 5 is attached, via a respective face bar 41 or flange 51 thereof, onto the leg 31 of each L-profile 3 that is spaced from the inner surface 20 of the outer shell 2. Such flange-to-flange connections enable the L-profiles 3 to push against the web frames 4 and the H-profiles 5 in the event of a collision for an improved response of the structure 1 to the impact of the collision. Each web frame 4 is furthermore provided with a vertical array of horizontal flat bars 8 (indicated in Figures 1 and 2) extending lengthwise transversely across the width of the web frame 4.

[0030] The part of the net-like structure 10 that includes the L-profiles 3 and the H-profiles 5 covers only an upper part of the inner surface 20 of the outer shell 2. This upper part essentially corresponds to a potential impact zone in the event of a collision by a cross-sectionally U- or V-shaped hull of another vessel as indicated by dashed lines in Figure 2. The lower ends of the vertical H-profiles 5 are located at a height H from the bottom of the outer shell 2 and are connected thereto by respective bilge brackets 9. A lower part of the inner surface 20 of the outer shell 2, i.e., below the horizontal L-profiles 3 of the net-like structure 10, is provided with horizontal Holland profiles 21, also known as bulb profiles, extending lengthwise longitudinally along the lower part of the inner surface 20. Similarly, in the double-walled structure shown in Figures 3 and 4, the outer surface 60 of the inner shell 6 is provided with horizontal L-profiles 61, extending lengthwise longitudinally along the outer surface 60 of the inner shell 6 in a similar manner as the L-profiles 3 along the inner surface 20 of the outer shell 2. These Holland profiles 21 and L-profiles 61 extend through the web frames 4. The Holland profiles 21 furthermore extend through the bilge brackets 9.

[0031] The figures and the above description serve to illustrate specific embodiments of the invention and do not limit the scope of protection defined by the following claims.

Claims

1. Collision-resistant structure for a side of a ship's hull, the structure comprising:

   - an outer shell having an inner surface and an outer surface;
   - an array of web frames extending broadwise substantially perpendicular to the inner surface of the outer shell and lengthwise transversely across the inner surface of the outer shell, wherein the web frames are mutually spaced along the inner surface;
   - an array of longitudinal stiffening profiles that extend lengthwise longitudinally along at least part of the inner surface of the outer shell and are mutually spaced across at least part of the inner surface of the outer shell;
   - an array of intermediate transverse stiffening profiles that extend lengthwise transversely across at least part of the inner surface of the outer shell and are mutually spaced along at least part of the inner surface of the outer shell, wherein the web frames and the intermediate transverse profiles are arranged in such an alternating manner that, between neighbouring web frames in the array, at least one of the transverse profiles is positioned,

   wherein the longitudinal profiles cross the web frames and the intermediate transverse profiles such that the arrays together form a net-like structure, wherein the net-like structure of the arrays is attached to the inner surface of the outer shell.

2. Collision-resistant structure according to claim 1, wherein neighbouring web frames and transverse profiles are arranged at equal mutual distances.

3. Collision-resistant structure according to claim 1 or 2, wherein the transverse profiles are H-profiles, I-profiles, T-profiles or L-profiles.

4. Collision-resistant structure according to claim 1, 2 or 3, wherein the longitudinal profiles are L-profiles, T-profiles, flat bars or Holland profiles, wherein each longitudinal profile is fixed lengthwise, via an outer edge thereof, to the inner surface of the outer shell.

5. Collision-resistant structure according to any of the preceding claims, wherein the longitudinal profiles are fixed to the inner surface of the outer shell, wherein the web frames and the transverse profiles are fixed to and across the longitudinal profiles in an overlapping manner.

6. Collision-resistant structure according to claim 5, wherein each transverse profile comprises a flange, wherein the transverse profile is fixed to the longitudinal profiles via an outer face of the flange, and wherein each web frame is lengthwise along an outer edge thereof provided with a face bar, wherein the web frame is fixed to the longitudinal profiles via an outer face of the face bar.

7. Collision-resistant structure according to claim 5 or 6, wherein each longitudinal profile comprises a flange, wherein the longitudinal profile is fixed to the web frames and the transverse profiles via an outer face of the flange.

8. Collision-resistant structure according to any of the preceding claims, wherein the web frames extend to a bottom of the outer shell, wherein the transverse profiles are spaced from the bottom of the outer shell.

9. Collision-resistant structure according to claim 8, wherein each transverse profile is provided with a bottom bracket arranged to connect the transverse profile to the bottom of the outer shell.

10. Collision-resistant structure according to any of the preceding claims, further comprising an inner shell spaced from the outer shell, wherein the web frames are connected to the inner shell.

11. Ship's hull, wherein a lateral side of the hull is pro-

vided with a collision-resistant structure according to any of the preceding claims.

12. Ship, in particular a chemical tanker or a gas carrier, wherein the ship comprises a hull according to claim 11 and at least one cargo tank with a capacity volume exceeding 380 cubic metres, wherein the collision-resistant structure is provided alongside of the cargo tank.

13. Method of configuring a collision-resistant structure according to any of the preceding claims 1-10, wherein the method comprises the step of determining distances between neighbouring web frames and transverse profiles in dependence of the degree to which the web frames, the transverse profiles and the longitudinal profiles absorb an impact on the outer surface of the outer shell.

14. Method according to claim 13, wherein the step of determining said distances comprises the steps of:

- providing a finite element model of the collision-resistant structure, wherein the model includes a cell length parameter representative for distances between neighbouring web frames and transverse profiles in the array;
- simulating, for various values for the cell length parameter, an impact on the outer surface of the outer shell;
- determining, for each simulated impact, an impact absorption parameter representative for the degree to which the web frames, the transverse profiles and the longitudinal profiles absorb the impact;
- selecting, from the various values for the cell length parameter, an optimal value that maximises the impact absorption parameter.

Amended claims in accordance with Rule 137(2) EPC.

1. Collision-resistant structure (1) for a side of a ship's hull, the structure (1) comprising:

- an outer shell (2) having an inner surface (20) and an outer surface;
- an array of web frames (4) extending broadwise substantially perpendicular to the inner surface (20) of the outer shell (2) and lengthwise transversely across the inner surface (20) of the outer shell (2), wherein the web frames (4) are mutually spaced along the inner surface (20);
- an array of longitudinal stiffening profiles (3) that extend lengthwise longitudinally along at least part of the inner surface (20) of the outer shell (2) and are mutually spaced across at least part of the inner surface (20) of the outer shell (2);
- an array of intermediate transverse stiffening profiles (5) that extend lengthwise transversely across at least part of the inner surface (20) of the outer shell (2) and are mutually spaced along at least part of the inner surface (20) of the outer shell (2), wherein the web frames (4) and the intermediate transverse profiles (5) are arranged in such an alternating manner that, between neighbouring web frames (4) in the array, at least one of the transverse profiles (5) is positioned, wherein the longitudinal profiles (3) cross the web frames (4) and the intermediate transverse profiles (5) such that the arrays together form a net-like structure (10), wherein the net-like structure (10) of the arrays is attached to the inner surface (20) of the outer shell (2), wherein the longitudinal profiles (3) are fixed to the inner surface (20) of the outer shell (2), wherein the web frames (4) and the transverse profiles (5) are fixed to and across the longitudinal profiles (3) in an overlapping manner.

2. Collision-resistant structure according to claim 1, wherein neighbouring web frames (4) and transverse profiles (5) are arranged at equal mutual distances (L).

3. Collision-resistant structure according to claim 1 or 2, wherein the transverse profiles (5) are H-profiles, I-profiles, T-profiles or L-profiles.

4. Collision-resistant structure according to claim 1, 2 or 3, wherein the longitudinal profiles (3) are L-profiles, T-profiles, flat bars or Holland profiles, wherein each longitudinal profile (3) is fixed lengthwise, via an outer edge thereof, to the inner surface (20) of the outer shell (2).

5. Collision-resistant structure according to any of the preceding claims, wherein each transverse profile (5) comprises a flange (51), wherein the transverse profile (5) is fixed to the longitudinal profiles (3) via an outer face of the flange (51), and wherein each web frame (4) is lengthwise along an outer edge thereof provided with a face bar (41), wherein the web frame (4) is fixed to the longitudinal profiles (3) via an outer face of the face bar (41).

6. Collision-resistant structure according to any of the preceding claims, wherein each longitudinal profile (3) comprises a flange (31), wherein the longitudinal profile (3) is fixed to the web frames (4) and the transverse profiles (5) via an outer face of the flange (31).

7. Collision-resistant structure according to any of the preceding claims, wherein the web frames (4) extend

to a bottom of the outer shell (2), wherein the transverse profiles (5) are spaced from the bottom of the outer shell (2), wherein the part of the net-like structure (10) that includes the longitudinal profiles (3) and the transverse profiles (5) covers only an upper part of the inner surface (20) of the outer shell (2).

8. Collision-resistant structure according to claim 7, wherein each transverse profile (5) is provided with a bottom bracket (9) arranged to connect the transverse profile (5) to the bottom of the outer shell (5).

9. Collision-resistant structure according to any of the preceding claims, further comprising an inner shell (6) spaced from the outer shell (2), wherein the web frames (4) are connected to the inner shell (6).

10. Ship's hull, wherein a lateral side of the hull is provided with a collision-resistant structure (1) according to any of the preceding claims.

11. Ship, in particular a chemical tanker or a gas carrier, wherein the ship comprises a hull according to claim 10 and at least one cargo tank with a capacity volume exceeding 380 cubic metres, wherein the collision-resistant structure (1) is provided alongside of the cargo tank.

12. Method of configuring a collision-resistant structure (1) for a side of a ship's hull, the structure (1) comprising:

- an outer shell (2) having an inner surface (20) and an outer surface;
- an array of web frames (4) extending broadwise substantially perpendicular to the inner surface (20) of the outer shell (2) and lengthwise transversely across the inner surface (20) of the outer shell (2), wherein the web frames (4) are mutually spaced along the inner surface (20);
- an array of longitudinal stiffening profiles (3) that extend lengthwise longitudinally along at least part of the inner surface (20) of the outer shell (2) and are mutually spaced across at least part of the inner surface (20) of the outer shell (2);
- an array of intermediate transverse stiffening profiles (5) that extend lengthwise transversely across at least part of the inner surface (20) of the outer shell (2) and are mutually spaced along at least part of the inner surface (20) of the outer shell (2),

wherein the web frames (4) and the intermediate transverse profiles (5) are arranged in such an alternating manner that, between neighbouring web frames (4) in the array, at least one of the transverse profiles (5) is positioned, wherein the longitudinal profiles (3) cross the web frames (4) and the intermediate transverse profiles (5) such that the arrays together form a net-like structure (10), wherein the net-like structure (10) of the arrays is attached to the inner surface (20) of the outer shell (2), wherein the method comprises the step of determining distances (L) between neighbouring web frames (4) and transverse profiles (5) in dependence of the degree to which the web frames (4), the transverse profiles (5) and the longitudinal profiles (3) absorb an impact on the outer surface of the outer shell (2).

13. Method according to claim 12, wherein the step of determining said distances (L) comprises the steps of:

- providing a finite element model of the collision-resistant structure (1), wherein the model includes a cell length parameter representative for distances (L) between neighbouring web frames (4) and transverse profiles (5) in the array;
- simulating, for various values for the cell length parameter, an impact on the outer surface of the outer shell (2);
- determining, for each simulated impact, an impact absorption parameter representative for the degree to which the web frames (4), the transverse profiles (5) and the longitudinal profiles (3) absorb the impact;
- selecting, from the various values for the cell length parameter, an optimal value that maximises the impact absorption parameter.

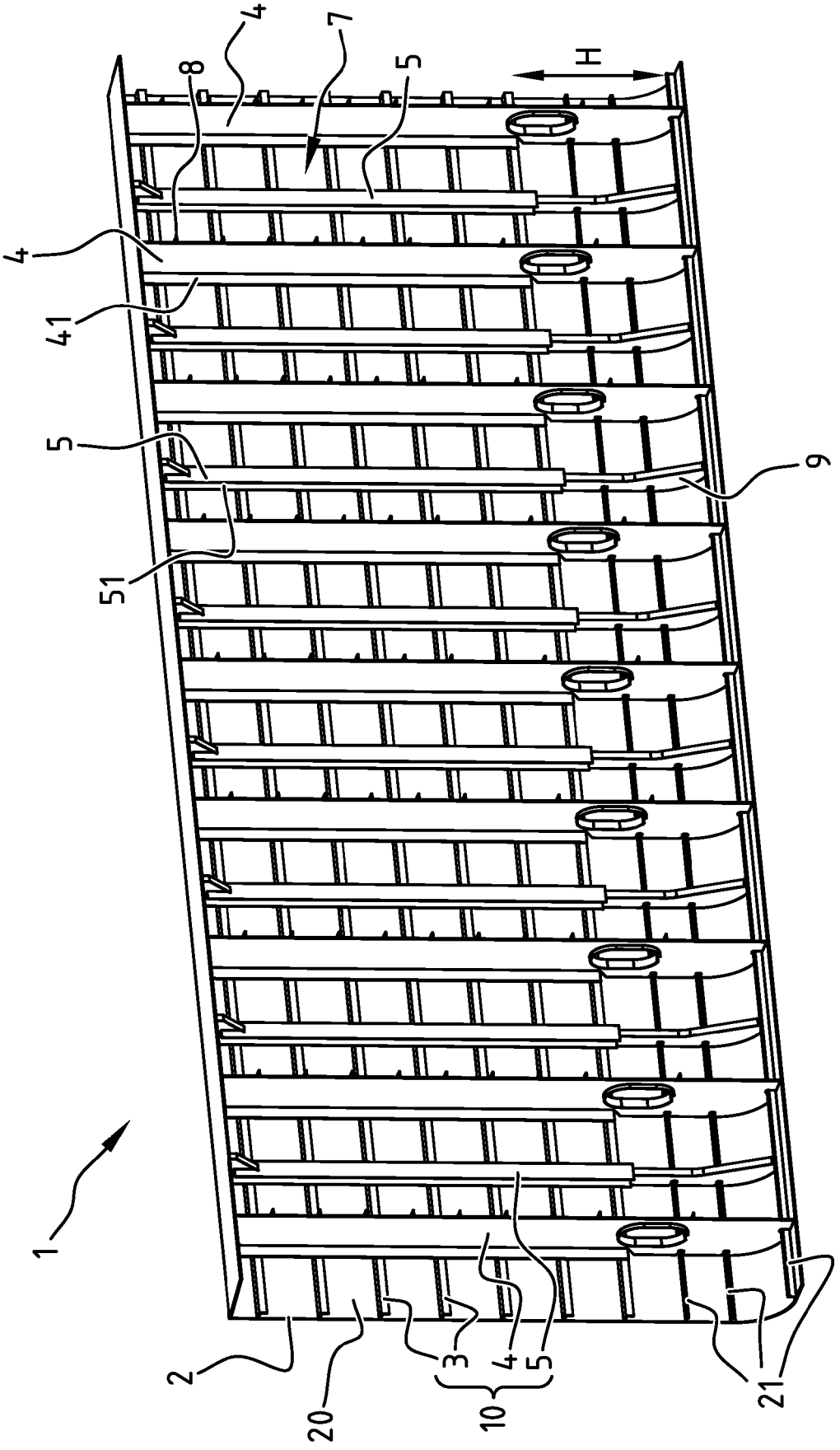

FIG. 1

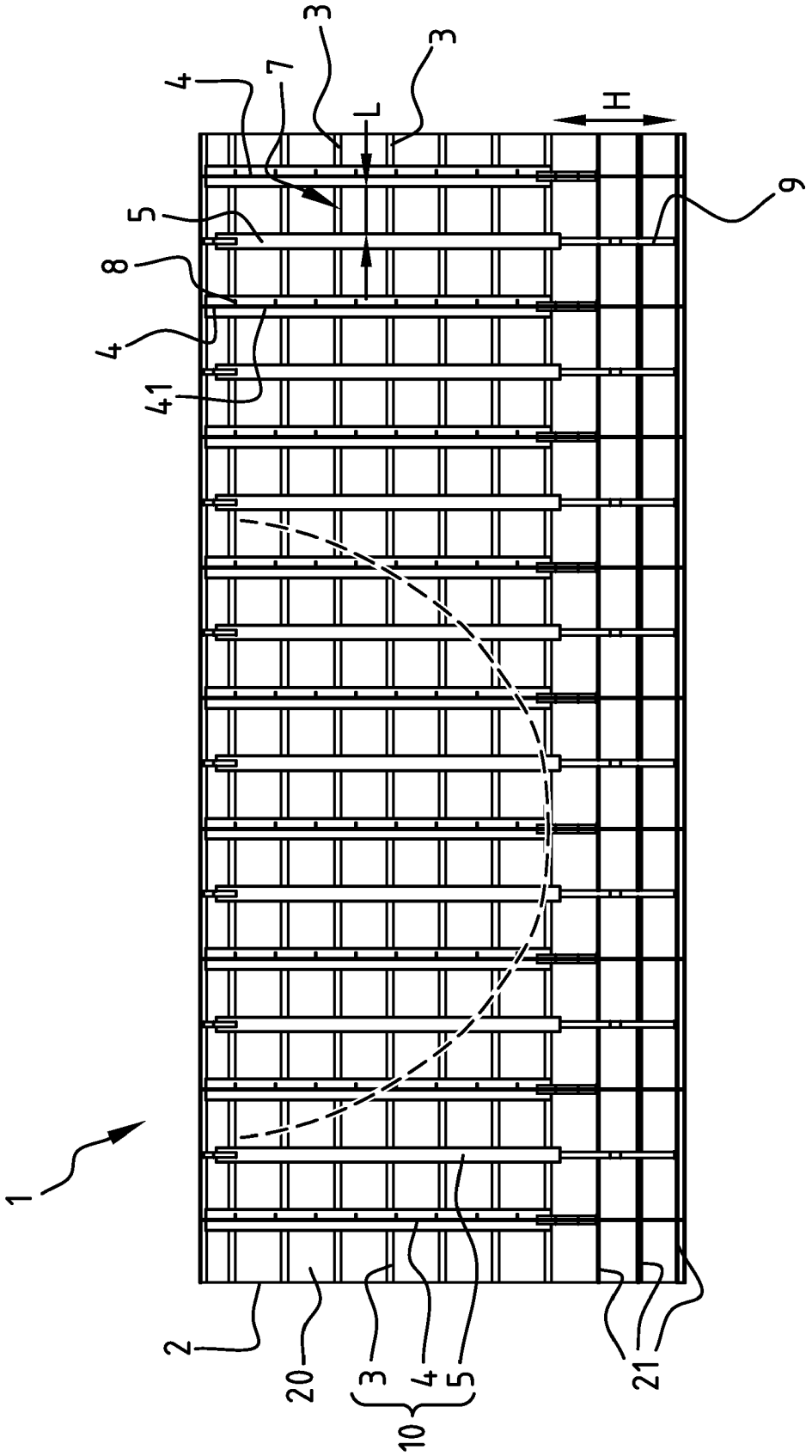

FIG. 2

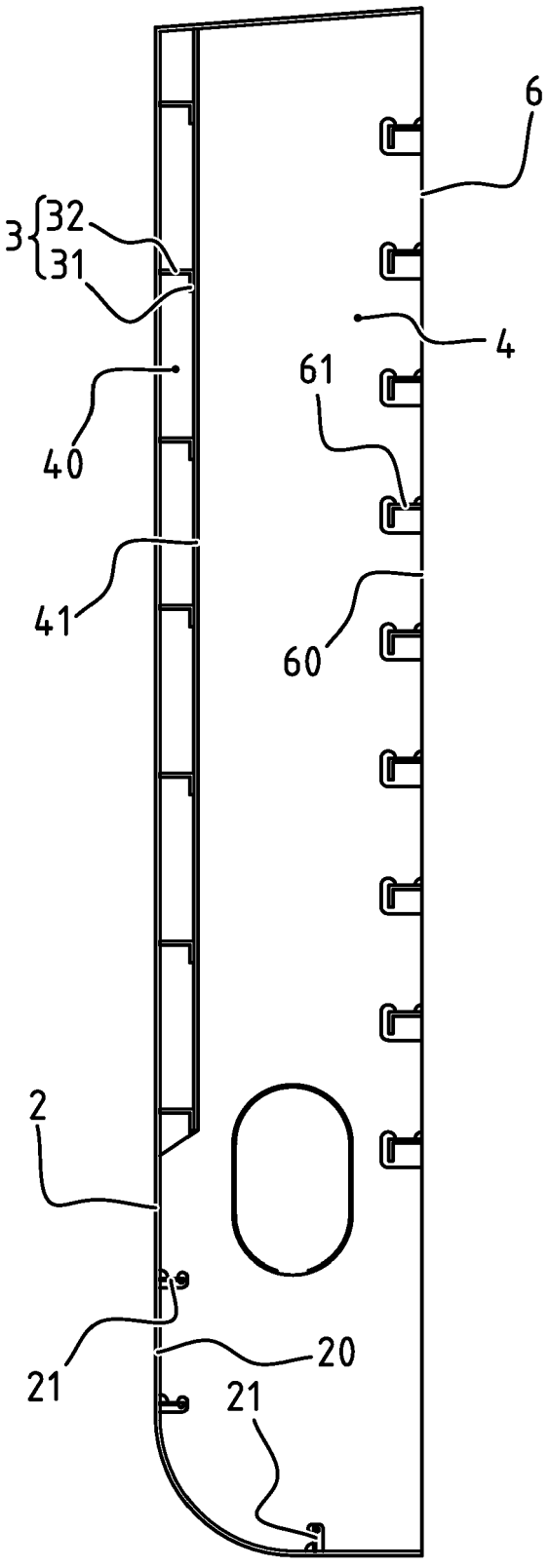

FIG. 3

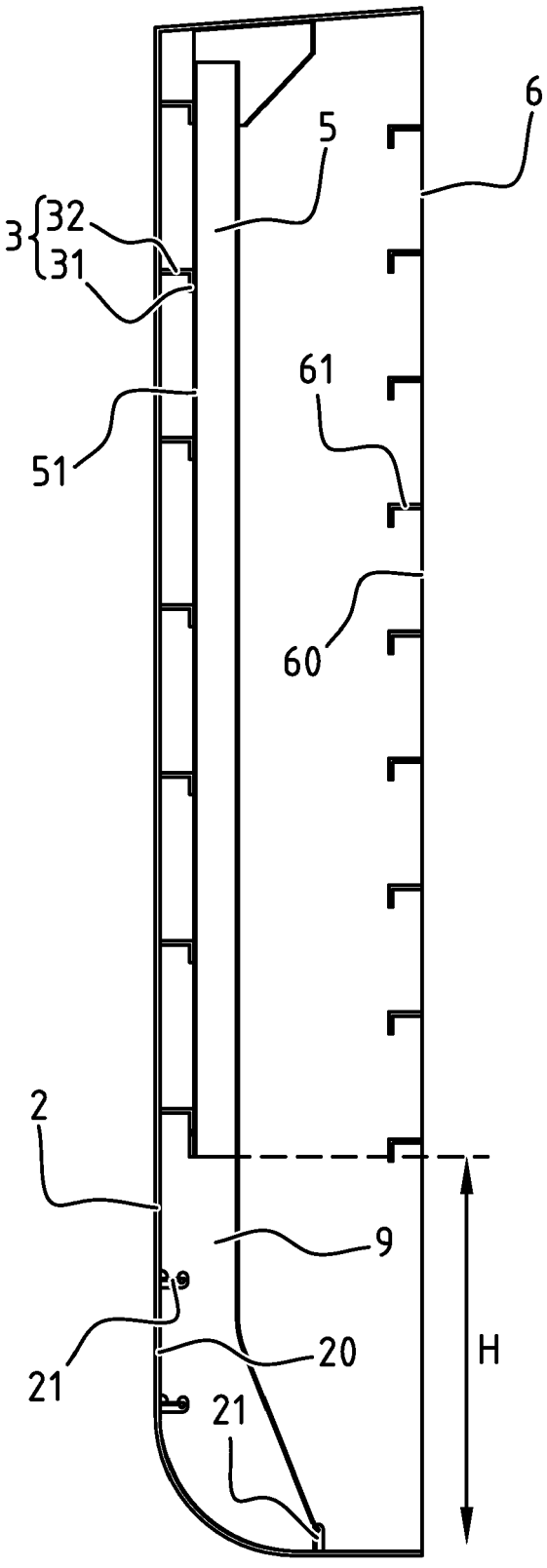

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 4870

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 1 674 471 A (ISHERWOOD JOSEPH W) 19 June 1928 (1928-06-19) * page 4, lines 20-23 * * figures * -----	1-4,8,9, 11-14 5-7,10	INV. B63B3/20 B63B3/32 B63B3/36
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Place of search	Date of completion of the search	Examiner
The Hague	10 November 2023	Gardel, Antony

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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