A composite sandwich construction for hulls of water-going vessels and the like wherein a strong but lightweight structure is required. The hull can take compound curvatures without deterioration of structural properties. The sandwich construction comprises a core of oppositely disposed nodular elements forming generally hyperbolic paraboloidal or interrupted hyperbolic paraboloidal structures between the nodular elements, the skins being adhered to the nodular elements.

10 Claims, 5 Drawing Figures
HULL CONSTRUCTION FOR VESSELS AND THE LIKE

DESCRIPTION OF THE INVENTION

Naval and other water-going vessels or the like for either surface or submerged use require great strength to withstand stresses imposed by pounding waves or deep submergence. An additional consideration is the vessel's weight, whether the vessel be a power or sailing craft, and especially if it is a pleasure or light commercial and limited military use craft or one used for deep sea exploration.

A sandwich type construction is highly desirable because it can give the desired strength with the least weight. It has been discovered that a strong, light weight sandwich structure including a core formed of a dimpled like sheet having oppositely disposed nodes or nodular elements with generally hyperbolic paraboloidal and/or interrupted hyperbolic paraboloidal saddles between the nodes is particularly effective. Accordingly, it is among the objects of the present invention to form lightweight vessel constructions which can take considerable pressure and stresses and be formed into configurations involving complex curvatures.

It is additionally within the concepts of the present invention to employ a hull construction which will prevent leakage through the outer shell from reaching the inner hull. Any such leakage would flow to the lowest point in the vessel and could be pumped out from that spot without entering the hold of the ship.

On the other hand, if the vessel were to be scuttled, this invention permits filling of the hull structure and vessel hold with water by simple puncturing.

Additionally, if there was a need for thermal insulation such as in refrigeration ships, the voids within the hull structure could be filled with a suitable insulation material.

Furthermore, compartments can be formed between the inner and outer shells by spot locations of foam between the shells so as to create baffles where desired.

Briefly, the invention involves forming a water-going vessel hull of a sandwich construction comprised of inner and outer hull skins or shells attached to a core structure having oppositely disposed nodular elements or nodes. The nodes form part of a continuous sheet giving it a dimpled effect, the areas between the nodes being generally in the shape of hyperbolic paraboloidal saddles or interrupted hyperbolic paraboloidal saddles. Voids between the skin and the saddles can be filled with foam to achieve certain desirable effects as above indicated.

Yet additional objects and advantages of the present invention are even more apparent when taken in conjunction with the accompanying drawing in which like characters of reference designate corresponding material and parts throughout the several views thereof, in which:

FIG. 1 is a fragmentary isometric view of a composite hull construction of a water-going vessel or the like wherein the hull of the vessel has a compound curvature;

FIG. 2 is a greatly enlarged cross-sectional view thereof taken along reference line 2-2 in FIG. 1;

FIG. 3 is a greatly enlarged cross-sectional view thereof taken along reference line 3-3 of FIG. 1;

FIG. 4 is a greatly enlarged side fragmentary view of the hull structure with portions of the outer hull skin and the core removed to show the layer elements of the composite structure; and

FIG. 5 is a view like FIG. 2 only showing a modified composite hull construction taken along reference line 5-5 of FIG. 4, only without removal of the skin and core portions and the insulation.

Referring more particularly to FIGS. 1-3 there is shown a vessel 10 comprising a deck 12 and a fragmentary composite hull construction or hull 14. The hull 14 has a compound curvature of a generally S-shaped configuration from the deck to the vessel bottom generally along the line 2-2 of FIG. 1. As seen in FIG. 2 the cross-sectional view, the composite construction involves an inner hull shell or skin 16 and outer hull shell or skin 18, with a core 20 located therebetween. A single more gentle curvature is found in the transverse (horizontal) direction as illustrated in FIG. 3. Thus the hull structure has a double curvature through its vertical section while it has a single curvature through its transverse section which curvatures together provide for a compound curvature which is not readily obtainable with ordinary core structures.

The materials forming the skins 16 and 18 and the core 20 can vary considerably depending on the most desirable materials for a particular vessel. It can be formed of lightweight materials such as aluminum or from reinforced plastics such as glass impregnated epoxy or polyester resins. These materials would be preferable to wood because wood does not generally have the resiliency to take compound curvatures as do the metal materials and reinforced plastics.

The particular configuration of the core 20 is like that shown for example in U.S. Pat. No. 3,227,598 the subject matter of which is hereby incorporated fully by reference. Briefly the core 20 comprises sheet-like structures having oppositely disposed nodular elements 24 and 26 and, located therebetween, saddles 28. The skins 16 and 18 can be spot welded where they are metal and can be adhesively bound such as by epoxy resins or by means disclosed in the aforesaid patent to form the desired sandwich construction.

The spacing of the nodular elements 24 and 26 might be varied as illustrated in FIG. 4 wherein they are staggered to interrupt hyperbolic paraboloidal saddles as at section 29 and thus minimize the effect of lines of bending weakness in the core sheet itself, in the event this is needed or desirable. Such a core is described in some detail in U. S. Pat. application Ser. No. 729,195, filed Dec. 18, 1968, now abandoned, and assigned to the same assignee as the present invention.

More specifically, core 21 in this modified embodiment is comprised of a sheet having nodular elements 24 and 26 oppositely disposed from one another in a square array, each element having one dimension thereof longer than the other and directed at about a 90° angle with respect to the longer dimension of an oppositely disposed nodular element, elements of the same disposition being located in parallel rows, adjacent rows being staggered from one another so that the center of each nodular element is about mid-way between the nodular element of the next adjacent parallel row, the oppositely disposed nodular elements being spacedly interdigitated with one another,
whereby no straight lines of bending weakness are present in the sheet. Core 21 could alternately have oppositely disposed nodular elements in a triangular array with each of the nodular elements presenting directional portions spaced about 120° from one another and extending outwardly and in a direction reversely parallel with that of a like directional portion in each of its adjacent oppositely disposed nodular elements, whereby no straight lines of weakness exist within the tringular array portion of the sheet, each nodular element being spaced a given distance from the other.

In any event, whether the core structure is core 20 as taught in the aforesaid patent or core 21 as taught in the aforesaid patent application, the concept is generally the same and the advantageous features of this invention are readily accomplished with either. For example, the core 20 can be made from various combinations of materials to fit the particular requirements of the vessel. The same core can be essentially flat or in single, double or multiple curvatures without deterioration of the core's physical properties. It could also be used in combination with other like cores or cores having varying heights of nodular elements as described in U.S. Pat. No. 3,388,522 assigned to the same assignee as is the present invention. Likewise, properly installed and sealed, a core 20 would prevent leakage through the outer hull from reaching the inner hull. Such leakage would flow to the lowest point in the vessel and could be pumped out from the spot without entering the hold of the ship. To scuttle the vessel one single puncture through the hull structure would fill the entire area between the skins as well as the hold of the vessel.

Referring more particularly to FIG. 5 this shows a structure having skins 16 and 18 and a core 21 similar to that described with respect to FIG. 4 and in the aforesaid U.S. Pat. application, Ser. No. 792,125 core 20 could likewise have been employed. Here, however, the void between the core and the skins has been filled with an insulating plastic foam material 30 such as expanded polystyrene beads, expanded polyethylene foam or expanded polyurethane foam. It is particularly advantageous that the foam be closed cell so as to give the benefit of the greater thermal insulation as is desired. If it is necessary to compartment off the areas between the inner and outer shells, foam could be used intermittently in the hull structure to create baffles.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope of the invention.

Accordingly, what is claimed as new is:

1. A hull structure for water-going vessels and the like comprising a composite sandwich construction which in at least part of said hull structure includes a double curvature through one of its sections and a single curvature through a transverse section, said sandwich construction including a core and skins on opposite sides of said core, said core being formed of a dimpled-like continuous sheet having oppositely disposed nodular elements, said skin being adhered to said nodular elements, said core and skins being sealed about their peripheries to prevent any leakage through the outer skin from filling substantially no more than one-half said hull structure or from entering the hold of the vessel.

2. The hull structure of claim 1 wherein said sheet is comprised of a joined series of substantially saddleshaped areas, each said area including a mid-level portion and alternate upwardly and downwardly curved projections radiating from a common center located at each mid-level portion.

3. The hull structure of claim 1 wherein said sheet is formed of even-sided polygonal areas each having curved projections equal to the number of said sides spaced radially around a common center on each of said areas, said projections radiating from said common center and ending at said nodular elements, one series of alternate projections extending in one direction and the other series of alternate projections extending in the opposite direction towards oppositely disposed nodular elements.

4. The hull structure of claim 1 wherein generally hyperbolic paraboloidal saddles are located between the nodular elements.

5. The hull structure of claim 1 wherein generally interrupted hyperbolic paraboloidal saddles are located between the nodular elements.

6. The hull structure of claim 1 wherein said nodular elements oppositely disposed from one another are in square array, each of said nodular elements having one dimension thereof longer than the other and directed at about a 90° angle with respect to the longer dimension of an oppositely disposed nodular element, nodular elements of the same disposition being located in parallel rows, adjacent rows being staggered from one another so that the center of each nodular element is about mid-way between the nodular element of the next adjacent parallel row, the oppositely disposed nodular elements being spacedly interdigitated with one another, whereby no straight lines of bending weakness are present in the sheet.

7. The hull structure of claim 5, wherein said oppositely disposed nodular elements are in a triangular array with each of the nodular elements presenting directional portions spaced about 120° from one another and extending outwardly and in a direction reversely parallel with that of a like directional portion in each of its adjacent oppositely disposed nodular elements, whereby no straight lines of weakness exist within the tringular array portion of the sheet, each nodular element being spaced a given distance from the other.

8. The hull structure of claim 1 wherein insulation material is located at least between portions of said skins and said core to form an insulated hull.

9. The hull structure of claim 1 wherein material divides off sections between the inner and outer skins to provide baffles.

10. The hull structure of claim 1 wherein the materials forming said skins and said core are sufficiently resilient to accept compound curvatures.

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