July 21, 1970 J. GERMAN ET AL 3,521,590

SHIP'S BOW CONSTRUCTION

Filed Aug. 6, 1968 5 Sheets-Sheet 1

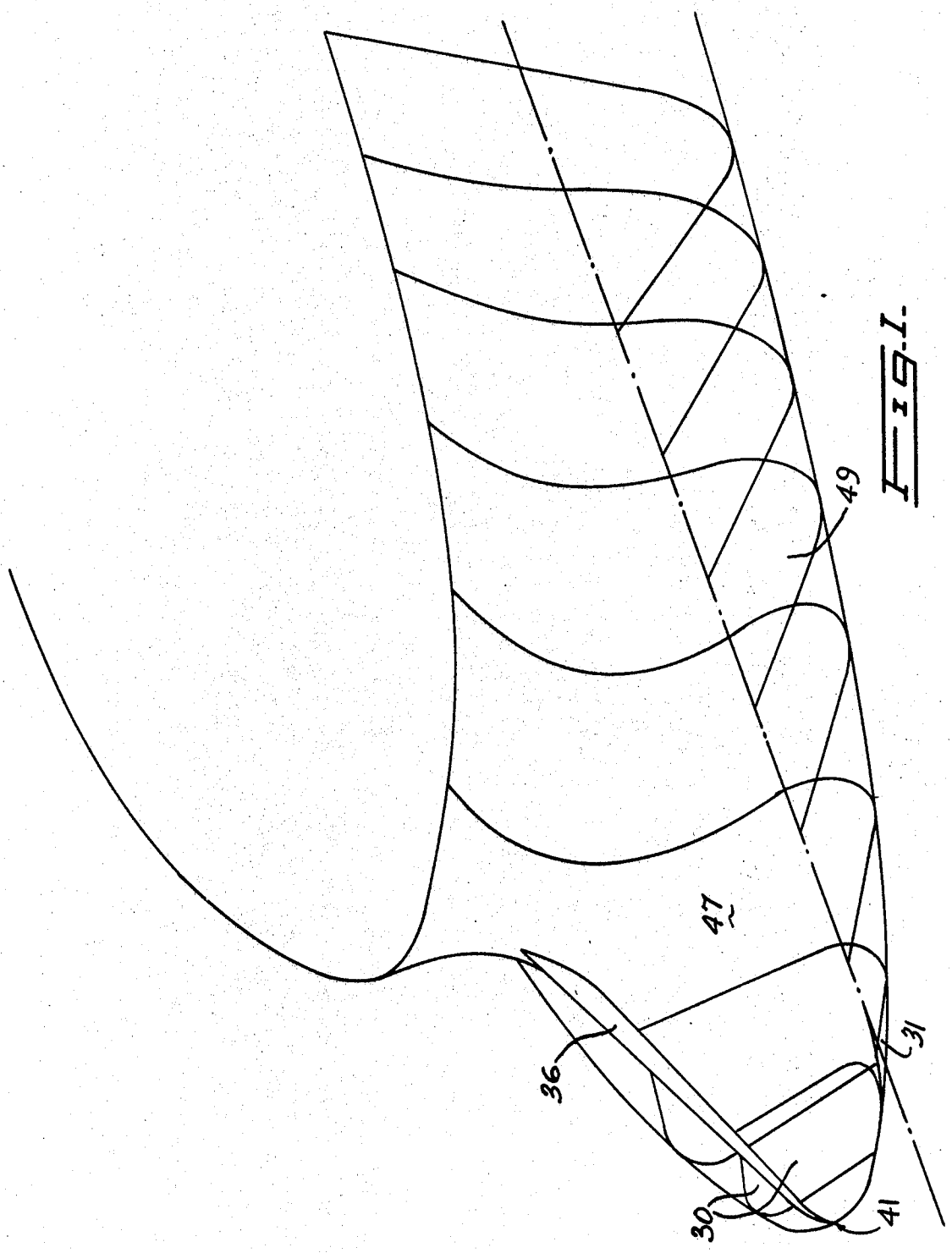

FIG. 1.

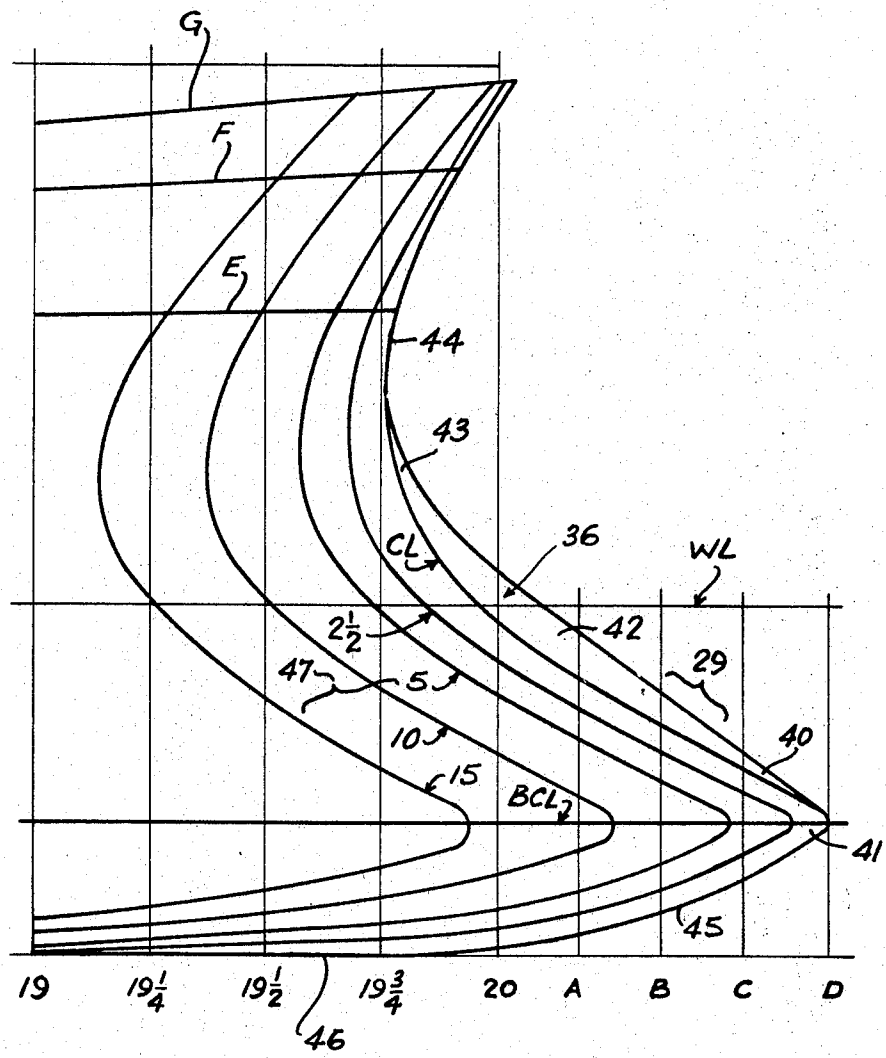
G
F
E
44
43
CL
36
WL
2½
42
47
5
29
10
40
15
BCL
41
45
19
19¼
19½
19¾
20
A
B
C
D
46

Fig. 2.

SHIP'S BOW CONSTRUCTION

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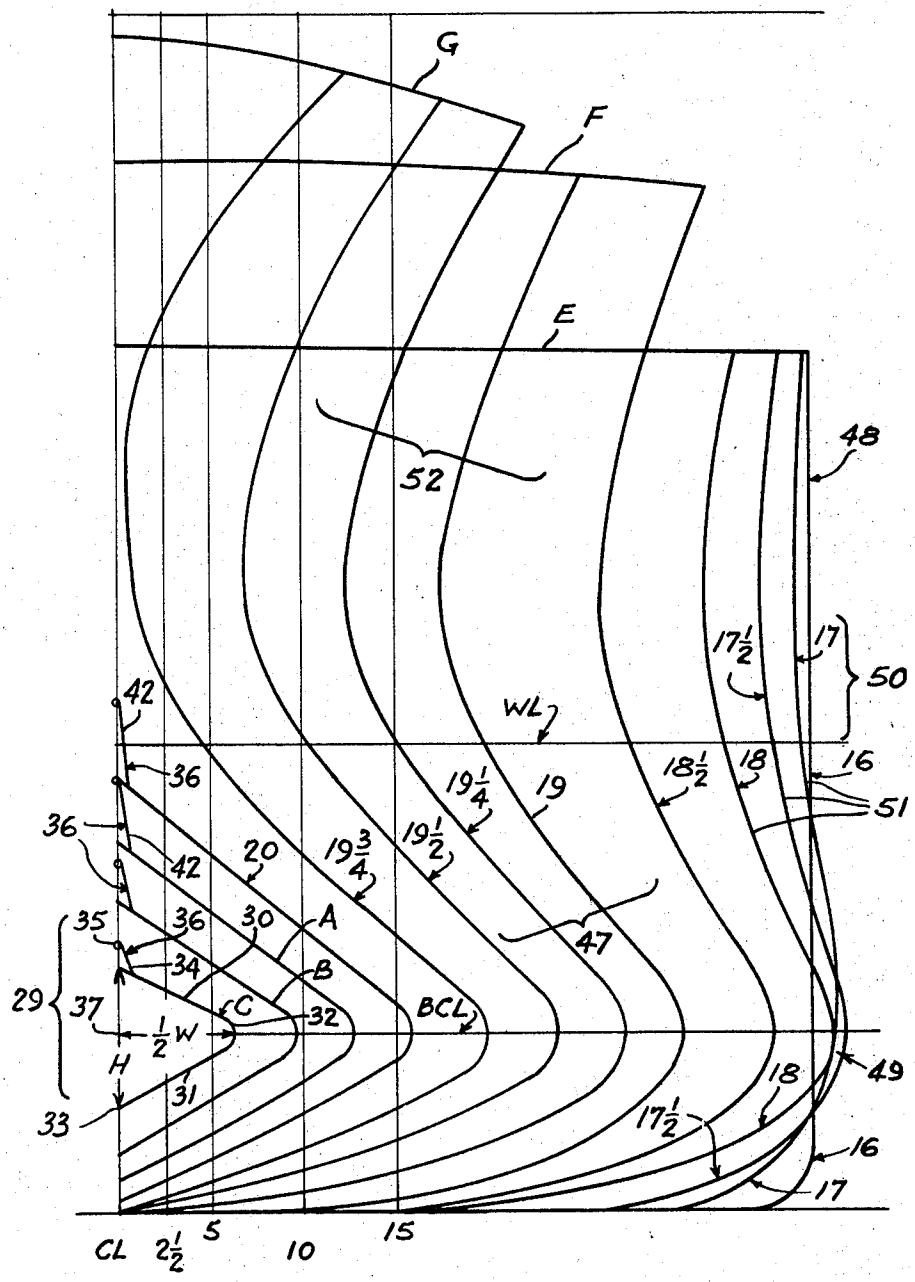

Fig. 3.

SHIP'S BOW CONSTRUCTION

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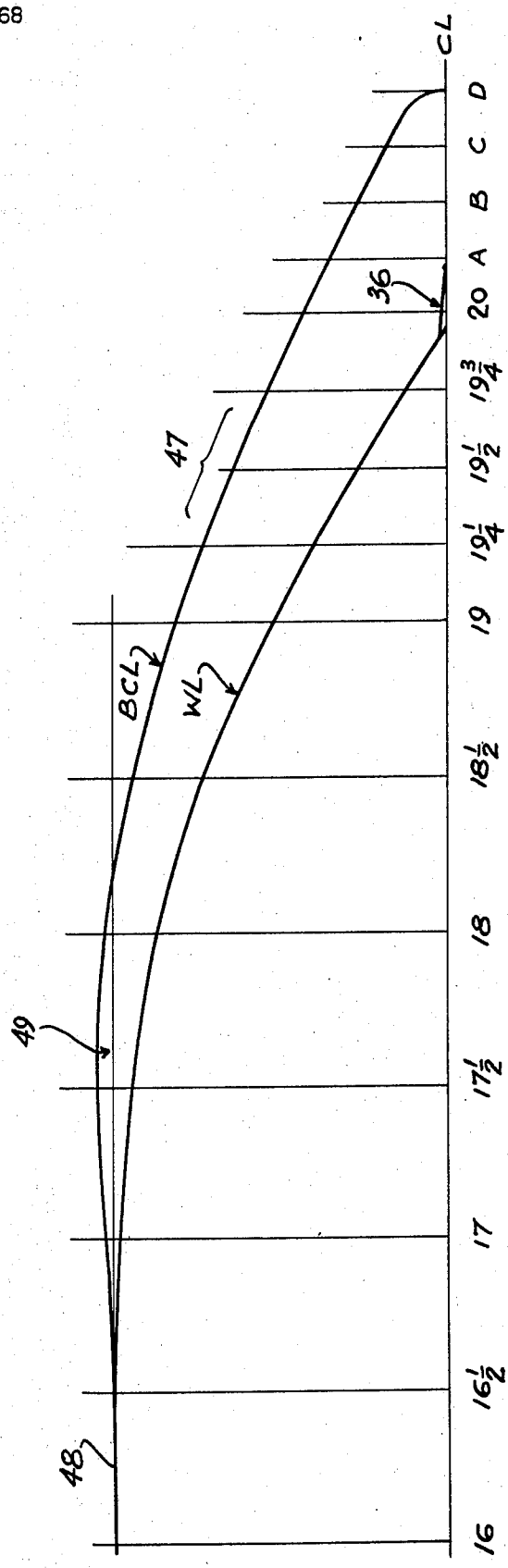

Fig. 4.

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SHIP'S BOW CONSTRUCTION

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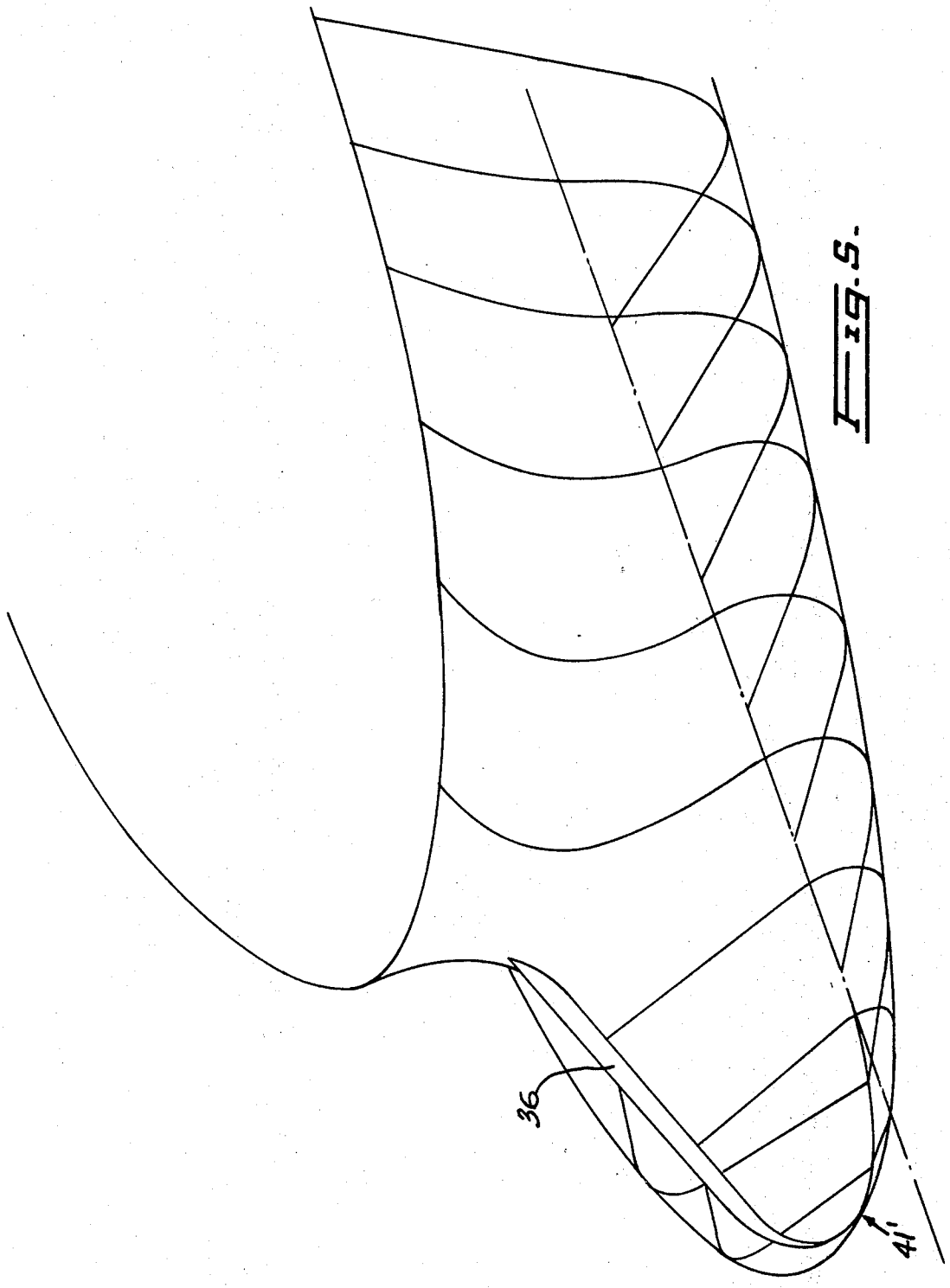

Fig. 5.

United States Patent Office 3,521,590 Patented July 21, 1970

3,521,590

SHIP'S BOW CONSTRUCTION

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Filed Aug. 6, 1968, Ser. No. 750,582
Claims priority, application Canada, Aug. 15, 1967, 997,888
Int. Cl. B63b *1/00, 35/08*
U.S. Cl. 114—41 18 Claims

ABSTRACT OF THE DISCLOSURE

A bow for use in both ice breaking and normal seagoing service takes the form of a bulbous bow projecting forward below the waterline, the cross-section of the bow being relatively flat, i.e. generally having a greater horizontal than vertical dimension. An upstanding blade projects upwardly to a relatively sharp edge along the upper central region of the bulbous bow. The surfaces extending rearwardly and outwardly of the bow are shaped for elevating pieces of ice cut by the bow and for moving these pieces outwardly for stacking on pack ice beside the ship.

This invention relates to improvements in the construction of a ship's bow to render it suitable for ice breaking service. The invention embodies certain of the features of the known bulbous type of bow, but with the addition of various novel features that render the bow especially suited for ice breaking service.

The so-called bulbous bow was developed for incorporation into the design of the hulls of ocean going ships to provide certain deep sea advantages that are now well known, principally good seakeeping qualities combined with a relatively low fluid resistance to travel through the water. A bulbous bow consists of a portion of the ship's hull that projects forwardly below the waterline. This projection is generally circular or may be pear-shaped in transverse cross-section, the area of this cross-section diminishing as the bow tapers forwardly towards a curved, bulbous (roughly semi-spherical) nose portion. This bulbous nose portion generates a wave system, when the ship is underway, that sets up an interference pattern with the wave system produced by the remainder of the bow, the overall results being a diminution in the total fluid resistance experienced by the ship.

Until the present time, however, bulbous bows have been relatively ineffectual in breaking any ice that ships fitted with such bows have encountered, and, for this reason, this particular form of bow construction has not generally been favoured for ships likely to encounter ice in significant amounts. Most assuredly, such a construction would not suggest itself as a form of bow suitable for incorporation into a vessel specifically designed as an ice breaker.

It has now been discovered that, contrary to these indications of prior experience, the bulbous type of bow construction can be made to be especially well suited to ice breaking duty by the adoption of certain essential dimensional changes in the bow's construction.

More specifically, the major change required to render the bow suitable for the performance of an ice-breaking function is to modify its cross-sectional shape (at least in the forward portion of the bulbous bow) such that the horizontal distance in the plane of the centerline of the bulb as measured from one side edge to the other of the bulbous bow is greater than the vertical distance in such vertical centreline plane from the top to the bottom surface of the bulbous bow. In less exact, but more readily visualisable terms, the bulbous bow can be said to be flattened somewhat, that is to be made wider than it is high, at least in the area that projects forward of the stem. By contrast, prior art bulbous bows have generally been made higher than they are wide, or, in some instances, of the same height as width (i.e. circular in cross-section).

In the present construction, the preferred ratio of width to height (as defined above) is of the order of 1½:1, although in some circumstances this ratio may go as low as approximately 1¼:1, or as high as approximately 2:1.

Other important features of the changes to be made to the bow's shape to render it suitable for ice-breaking service are set out more fully below.

Another feature of the preferred embodiment of the present invention is the provision of an addition to the main bulbous bow portion in the form of an upstanding blade projecting upwardly to a sharp top edge, this blade extending along the central upper part of the main portion of the bulbous bow to perform an ice splitting function. In connection with use of the term "sharp" throughout this specification, it is to be appreciated that this term is to be interpreted in the light of the function that is to be performed by the part in question and in the light of typical ship surfaces. For example, the so-called sharp top edges of this blade will typically be formed of a round bar of say 1" diameter, or greater or less depending on the size of the ship. While such a surface in itself would hardly be considered sharp in the normal sense of the word, in comparison to the typical, gently curved, merging surfaces of ship's hulls, it is effectively very sharp. Even a typical ship's stem having a radius of curvature of perhaps six inches or so is sharp in terms of its ability to cut through the water and in comparison with most of the other hull curvatures.

Other features of the present construction reside in the provision of a V form for both the lower and upper faces of the bulbous bow, i.e. tumblehome upper bow surfaces and lower bow surfaces with significant deadrise; and the provision of further upwardly and outwardly sloping deflecting tumblehome surfaces extending rearwardly from the bow tumblehome surfaces for receiving and temporarily supporting ice thereon while deflecting it outwardly onto the ice pack through which the ship is cutting a channel. These and other features will be more fully explained below.

One form of bow construction according to the invention is illustrated diagrammatically in the accompanying drawings. It is to be understood that these drawings and the specific description that follows are provided by way of example only, and not by way of limitation of the broad scope of the invention, which latter is defined in the appended claims.

In the drawings:

FIG. 1 is a general front perspective view of the bow, this view being furnished more as an artist's impression to provide a general pictorial appreciation of the shape of the bow and not to attempt to represent accurately the relative dimension of the various parts;

FIG. 2 is a typical ship's hull diagram of buttock lines of the bow construction in FIG. 1, that is, a series of sections taken on vertical fore-and-aft planes starting from the ship's centre line and progressing to one side;

FIG. 3 is a set of body sections of the bow construction, i.e. sections taken on transverse vertical planes;

FIG. 4 is a pair of waterlines of the construction, i.e. sections taken on two horizontal planes; and

FIG. 5 is a variant of FIG. 1.

In accordance with conventional ship drawing practice, the body sections shown by the curved lines in FIG. 3 are taken on transverse sections known respectively as **16**; **16½**; **17**; **17½**; **18**; **18½**; **19**; **19¼**; **19½**; **19¾**; **20**; and three additional sections forward of the hull proper, designated A, B and C, the lines along which section **19**

and those sections forward of it are taken being shown in FIG. 2, and all the section lines being shown in FIG. 4. These body sections have thus been identified in FIG. 3 by corresponding reference numerals. By the same token, the buttock lines shown by the curved lines of FIG. 2 are appropriately labelled as having been taken on the planes CL (the vertical ship's centreline plane); 2½; 5; 10 and 15, the lateral displacement of these latter planes being shown in FIG. 3. Finally, the waterlines of FIG. 4 are labelled as having been taken on horizontal planes identified respectively as BCL (bulb centreline plane) and WL (the normal load waterline plane).

Various features of the construction will be apparent from these diagrams.

Firstly, it will be noted from FIG. 3 that the cross-sectional shape of the bulbous bow **29**, that is the portion forward of the body section **20**, is not circular. Taking section C as representative, this cross-section will be seen to comprise, on each side of the centreline CL, a relatively flat main upper face **30** and a relatively flat lower face **31**, these faces joining one another at a curved edge **32**. Faces **30** constitute bow tumblehome surfaces. At the underside, the faces **31** on each side of the centreline CL meet each other in a sharp ridge **33** and are so inclined outwardly and upwardly as to exhibit substantial deadrise. Alternatively, these faces **30** and **31** and more particularly the lower faces **31** may be formed with some curvature which will normally be a convex curvature, except perhaps in parts of the upper faces **30** where some concave curvature may be used, even as far forward as section C. On the upperside, the face **30** on each side of the centreline CL merges into an almost vertically upstanding wall **34**, the two walls **34** being joined together along their tops by a strong bar **35** to provide a sharp top edge and thus define a so-called splitter blade **36**. The blade **36** will be seen to form an additional portion of the cross-sectional shape of the bulbous bow, the main portion of which is essentially symmetrical about the bulb centreline plane BCL, at least at a location as far forward as section C. While inclusion of the blade **36** is preferred, this part is optional, since it is not essential to the basic bow design.

A second feature of section C (and to a large extent also of sections B and A and even **20**, although to a lesser degree as the cross-sectional shape moves aft) resides in the fact that the width dimension W taken from one edge to the other on the plane BCL is significantly greater than the height dimension H taken vertically along the centreline CL between the ridge **33** and the point **38** where the upper faces **30** intersect one another, i.e. ignoring for these considerations the added splitter blade **36** and considering only the cross-sectional shape of the main portion of the bulbous bow.

In side view (FIG. 2), the splitter blade **36** will be seen to taper in height from a front portion **40**, where it merges into a sharp nose portion **41** of the bow (at line D), up to a central portion **42** having a maximum height between sections A and **20**. A rearmost portion **43** merges into the stem **44**. It will be seen from FIG. 2 that the stem **44** has a negative rake angle, i.e. slopes upwardly and rearwardly, at the load waterline WL and for some substantial distance above this waterline.

Below the bulb centreline plane BCL, a bow portion **45** sweeps smoothly downward and rearwardly to a bottom line **46**.

Returning consideration again to FIG. 3, it will be noted that, rearward of the bulbous bow **29**, there is on each side of the ship's hull a so-called "tumblehome" surface **47** that represents a rearward extension of the upper face or bow tumblehome surface **30** and extends rearwardly and outwardly ot merge into the ship's hull surface **48**. This surface **47**, which functions as an ice deflecting surface for displacing sideways ice that has been broken by the bulbous bow **29**, faces upwardly and outwardly so as to be able temporarily to support the ice that it is deflecting as the ship moves forward and cuts a channel. The surface **47** retains this upward facing inclination all the way to the hull surface **48** (in the vicinity of body section **16** and aft thereof), which latter surface **48** represents the maximum width of the hull, for all the parts thereof, except for projecting sponson portions **49** that are provided one on each side of the ship below the waterline and are centered on the bulb centreline plane BCL (see FIGS. 3 and 4). The latter figure also shows how, at about body section **16½**, the sponson **49** disappears by merging into the hull surface **48**. The sponson portions **49** may, however, be omitted, depending on requirements.

In addition to the tumblehome surfaces **47**, the bow has, on each side, a flared surface **52**, i.e. a surface that faces outwardly and downwardly.

Lines E, F and G, respectively, indicate the upper deck, the fo'c's'le and the bulwark.

It is also noteworthy that, in horizontal section at the load waterline WL (as seen in FIG. 4), the merging tumblehome surfaces **30** and **47** define a profile that is comparatively pointed in the forward direction (apart from the splitter blade **36**), and rather more sharply pointed than the horizontal profile at the bulb centerline BCL.

In operation, the bulbous bow performs under normal deep sea conditions essentially in the same manner as prior constructions of bulbous bow, that is to say it will help to provide good seakeeping qualities, good behaviour in rough seas, a relatively low fluid resistance to travel through the water and an incremental increase to the total buoyancy of the vessel. In addition, due principally to its "flat" nature, i.e. the fact that the ratio $W:H$ is greater than unity, preferably of the order of 1½:1, and due also to the general cross-sectional shape of the bow, to the continuously expanding tumblehome surfaces and to the various profiles, as well as to the existence of the splitter blade, the bow has excellent ice-breaking characteristics. For thicknesses of sheet ice up to about a third of the load draft of the vessel, the bow **29** will pass under the ice and the latter will be broken by the combined action of the splitter blade **36** and the upper bow faces **30**. This blade *per se* is the subject of copending United States patent application Ser. No. 750,583 filed concurrently herewith by Scott E. Alexander, and reference may be made to such other application for a detailed description of the specific mechanism whereby the splitter blade achieves shattering of the ice.

Broken ice is deflected outwards and upwards along the continuously expanding tumblehome surfaces **30** and **47** and subsequently outwardly and downwardly by the flared surfaces **52**. These surfaces extend outwardly to the area shown at **50** in FIG. 3, which area is above the waterline WL. The result is that broken ice deflected upwardly and outwardly along the surfaces **47** and finally downwardly by the surfaces **52** tends to be piled up on top of the sheet ice beside the vessel, rather than being pushed under to reappear in its wake. This effect tends to have the result of producing a cleaner channel behind the ship, freer from pieces of floating ice than has been customary heretofore with conventional ice-breakers.

If the ship encounters ridges or areas of ice that are so thick as to extend down below the bulb centreline BCL, then the underside of the bow portion defined by the faces **31** will tend to act in the manner of a conventional ice-breaker, i.e. to press down on the ice and break it by downward pressure, and then deflect the broken pieces of ice laterally outwardly by virtue of the deadrise built into the inclination of the faces **31**. But normally the bow will penetrate below the ice, so that the principal breaking and deflecting action will be upwards. In any event, in both directions the bow has sharp ice-cutting surfaces, i.e. the ridge **33** below and the blade **36** above. The V form of the underside of the bow portion is also useful in minimising slamming in open water.

By virtue of the sponson portions **49** it is possible to form the hull with surfaces **51** of significant tumblehome nearer to the maximum breadth of the main hull than is possible without the sponson portions. This feature results in a channel being broken through the ice, that is wider than the maximum breadth of the main hull, before entry of such maximum breadth into the channel, thus minimising jamming and facilitating turning.

Notwithstanding the numerous differences between the present construction and conventional bulbous bows, which differences render the present construction practicable for ice-breaking service, the present construction nevertheless essentially retains at least some of the favourable deep sea characteristics for which bulbous bows are well known.

FIG. 5 shows an alternative construction in which the nose portion **41'** at the bulb center line BCL is less sharp than the nose portion **41** of FIGS. 1 to 4. Subject to changes to the other surface shapes consequent upon the blunter nose portion **41'**, the bow of FIG. 5 embodies all the main features of the bow of FIG. 1, especially the greater than unity ratio of W to H and the provision of the splitter blade **36.**

We claim:

1. A ship's bow construction for both ice breaking and normal seagoing service, comprising a stem and a bulbous bow projecting forwardly of the stem below the load waterline, said stem having a negative rake angle at and above said load waterline and said bulbous bow defining a horizontally and forwardly extending bulb centreline plane, said bulbous bow being symmetrical about the main vertical centreline plane of the ship and having a cross-sectional width and height that expand continuously from a nose portion to surfaces merging outwardly and rearwardly into the hull of the ship,

(a) said cross-section being of such a shape, at least in the forward parts of a main portion of said bulbous bow, that

(i) the horizontal distance in said bulb centreline plane from one side edge to the other of the bulbous bow is greater than the vertical distance in said vertical centreline plane from the top surface of the main portion of the bulbous bow to the bottom surface thereof, and

(ii) upper faces partly defining said cross-section slope upwardly towards said vertical centreline plane to form bow tumblehome surfaces, while lower faces further defining said cross-section slope downwardly towards said vertical centreline plane to exhibit a substantial deadrise,

(b) said merging surfaces being such as to define a forwardly pointed profile as seen in horizontal section at the load waterline and including further tumblehome surfaces forming rearward continuations of said bow tumblehome surfaces and extending up to the load waterline for receiving, temporarily supporting and deflecting ice in an outward direction as the ship moves forward.

2. A construction according to claim **1**, wherein the ratio between said horizontal and vertical distances lies within the range of approximately 1¼:1 and approximately 2:1.

3. A construction according to claim **2**, wherein said ratio is approximately 1½:1.

4. A construction according to claim **1**, wherein said main portion of the bulbous bow, at least in the forward parts thereof, is substantially symmetrical about said bulb, centreline plane.

5. A construction according to claim **4**, wherein said bulbous bow includes an additional portion comprising an upstanding blade projecting upwardly to a sharp top edge from the central upper part of said main portion.

6. A construction according to claim **5**, wherein said blade tapers in height forwardly to merge into said nose portion and rearwardly to merge into the stem.

7. A construction according to claim **5**, wherein said cross-sectional shape is such as to include substantially flat underside faces sloping downwardly and inwardly towards each other to define said bottom surface as a sharp ridge.

8. A construction according to claim **7**, wherein said cross-sectional shape is such as to include substantially flat upper faces sloping upwardly and inwardly towards said blade.

9. A construction according to claim **1**, wherein said merging surfaces include deflecting surfaces rearward of said bulbous bow portion that extend rearwardly and outwardly to merge into the ship's hull, said deflecting surfaces including surfaces facing upwardly and outwardly to receive and temporarily support ice and deflect it in an outward direction as the ship moves forward.

10. A construction according to claim **9**, wherein said deflecting surfaces include flared surfaces above the waterline facing outwardly and downwardly to deflect ice outwardly and downwardly onto sheet ice beside the ship as it moves forward.

11. A construction according to claim **8**, wherein said merging surfaces include deflecting surfaces rearward of said bulbous bow, said surfaces comprising smooth continuations of said substantially flat upper faces and extending rearwardly and outwardly to merge into the ship's hull, said deflecting surfaces including "tumblehome" surfaces facing upwardly and outwardly to receive and temporarily support ice and deflect it in an outward direction as the ship moves forward and flared surfaces above said tumblehome surfaces facing downwardly and outwardly.

12. A construction according to claim **11**, wherein said deflecting surfaces extend rearwardly to the maximum width of the ship's hull.

13. A construction according to claim **11**, wherein said deflecting surfaces extend rearwardly into sponson portions projecting laterally beyond the maximum width of the remainder of the ship's hull below said load waterline, said sponson portions subsequently extending rearwardly and inwardly to merge with the ship's hull.

14. A construction according to claim **1**, wherein said lower faces of the bulbous bow slope rearwardly and downwardly to merge into further rearwardly and downwardly sloping continuations thereof that retain said deadrise for a substantial distance rearward of said bulbous bow, said continuations ultimately merging into the ship's bottom at a level substantially below said bulb centreline plane.

15. A ship's bow construction for both ice breaking and normal seagoing service, comprising a stem and a bulbous bow projecting forwardly of the stem below the load waterline, said bulbous bow defining a horizontally and forwardly extending bulb centreline plane, said bulbous bow being symmetrical about the main vertical centreline plane of the ship and having a cross-section that expands from a nose portion to merge rearwardly into the hull of the ship, characterized by said cross-section being of such a shape, at least in the forward parts of a main portion of said bulbous bow, that the horizontal distance in said bulb centreline plane from one side edge to the other of the bulbous bow is greater than the vertical distance in said vertical centreline plane from the top surface of the main portion of the bulbous bow to the bottom surface thereof, wherein said bulbous bow includes an additional portion comprising an upstanding blade projecting upwardly to a sharp top edge from the central upper part of said main portion.

16. A construction according to claim **15**, wherein said blade tapers in height forwardly to merge into said nose portion and rearwardly to merge into the stem.

17. A construction according to claim 15, wherein said cross-sectional shape is such as to include substantially flat underside faces sloping downwardly and inwardly towards each other to define said bottom surface as a sharp ridge.

18. A construction according to claim 17, wherein said cross-sectional shape is such as to include substantially flat upper faces sloping upwardly and inwardly towards said blade.

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TRYGVE M. BLIX, Primary Examiner

U.S. Cl. X.R.

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