United States Patent

Holder

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[54] **ICE BREAKER FOR MARINE STRUCTURES**

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[51] **Int. Cl.**.....**E02b 15/02,** B63b 35/12

[58] **Field of Search** 61/46, 46.5, 1, 5, 6; 114/41, 114/42, 40; 299/24, 25, 26, 27

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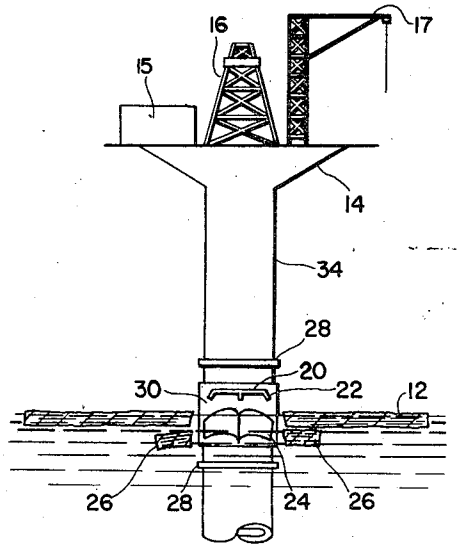
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[57] **ABSTRACT**

An ice breaker for marine structures comprising a rotatably mounted plow member on an offshore platform and utilizing a vane member to position the plow member in the path of encroaching ice floes. Buoyant chambers vertically position the plow member so that the leading edge will be under or above the ice floe. High pressure fluids or mechanical saws can be used as cutting members to cut sections in the ice floe and allow the plow member to break the ice sections from the ice floe and force them above or below the remaining ice floe. High pressure jets may be located in apertures in the face of the plow member and/or located between the ice floe and the plow member. The cutting members are arranged to cut sections of ice resembling the vertical section of a truncated pyramid.

10 Claims, 5 Drawing Figures



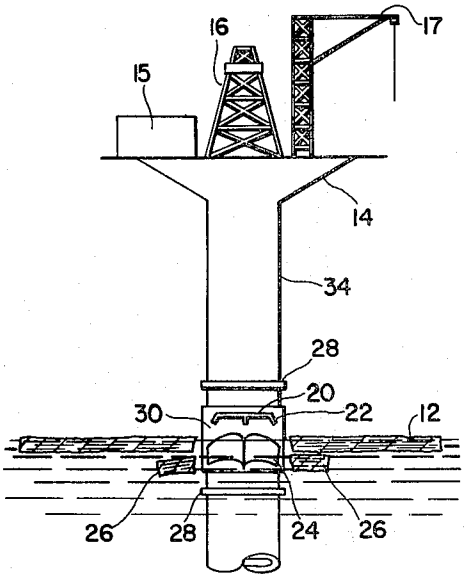


FIG. 1

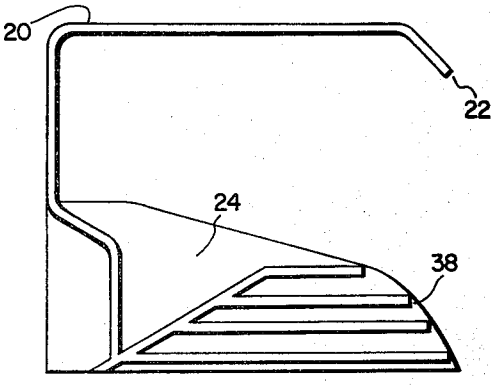


FIG. 4A

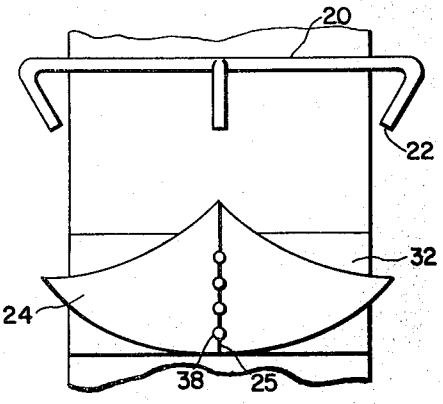


FIG. 4B

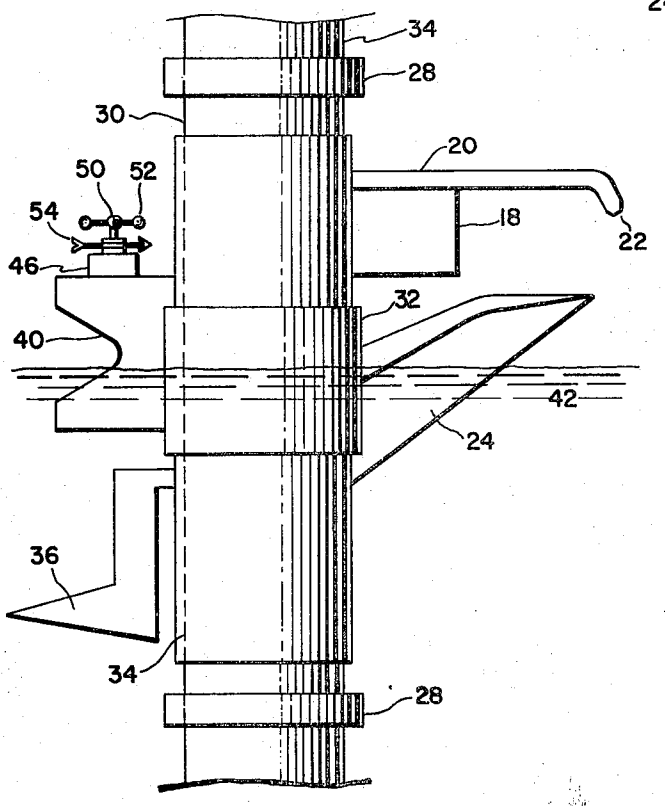


FIG. 3

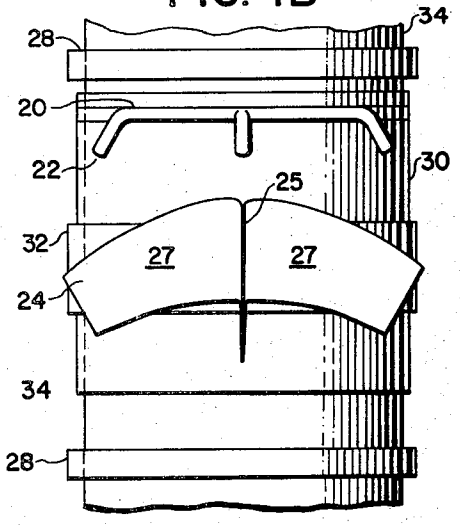


FIG. 2

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ICE BREAKER FOR MARINE STRUCTURES

BACKGROUND OF THE INVENTION

This application relates to an application filed of even date herewith by John D. Bennett entitled "-METHOD AND APPARATUS FOR CUTTING ICE" which describes cutting ice in a manner to facilitate vertical movement of an ice section in an ice floe. The invention disclosed herein deals with the problem of floating ice encountered in frigid waters such as the Arctic Ocean, where there currently is high interest in locating and developing natural resources. In the search for and development of petroleum from other offshore areas, platforms have been used which are supported on the floor of a body of water. Such platforms if located in the Arctic Islands area would be exposed to ice floes which float freely in the water, and may be of such a size that the platform support would be susceptible to damage or destruction by the severe pressures of such an encroaching ice floe. The environment to which a platform might be exposed if located in the Arctic region could well resemble that of the Arctic Ocean adjacent the North Slope.

The arctic Ocean adjacent the North Slope area of Alaska is characterized by its shallow depth and gradual slope to deep water. Air temperatures usually range from -31 40° F. to +50° F. The water is very uniform in temperature, from +28° F. to +30° F., and very saline except in the lagoons opposite the rivers. Winds are predominantly from the East 10 to 15 mph, with a maximum of 50 to 60 knots. Waves are not usually more than 5 feet high. In the months of November through April, large masses of ice are in continuous movement by the effects of wind in the Arctic Ocean. Ice fields measuring thousands of feet in diameter are propelled in many directions by the winds and are generally unaffected by the minor currents present.

The main ice form in the Arctic Ocean is the ice sheet, which is generally 6 to 10 feet in thickness. Another form of ice encountered is "rafted" ice, which is the term used to described the overlapping of ice sheets as one sheet rides up over another sheet, resulting in an ice floe made up of two or more distinct layers. In open locations, the rafting does not generally take place between sheets of more than 1 or 2 feet in thickness since thick sheets cannot withstand the deflection necessary for one sheet to ride over the other. Rafted ice has a much smaller surface area than that of the more prevalent ice sheets.

Thus, it can be seen that offshore platforms located in relatively shallow water in the Arctic Ocean will encounter ice sheets from 6 to 10 feet thick, and occasionally rafted or sheet ice up to 15 feet thick. Generally speaking, then, an offshore platform should be able to routinely withstand at least 15 feet thick ice floes having diameters of several thousand feet being moved by winds of 15 mph.

Drilling platforms may also be located in the lagoons and among the islands. Here pile-up can occur from the ice sheets impinging on long vertical surfaces. Thus in order to locate platforms in these areas, special equipment other than the equipment disclosed herein may be necessary.

It is desirable to use offshore platforms rather than subsea systems because of their availability and low cost. It is therefore an object of the present invention to provide methods and apparatus for equipping offshore platforms for use in areas where ice floes are encountered.

SUMMARY OF THE INVENTION

With these and other subjects in view, the present invention contemplates rotatably mounting a plow-like member on an offshore platform support member and locating it relative to the water surface by buoyant chambers so that the leading edge of the plow member is above or below the ice floe. Cutting apparatus such as mechanical saws or high pressure jet nozzles emitting liquids are used to cut the ice in advance of its reaching the plow member. A series of cuts can be made to define ice sections having bottom and top surfaces of different cross-sectional areas to facilitate vertical movement of the ice section. A vane member, which also may act as a counterweight for the plow member as well as a wind direction and velocity detector are used to orient the plow-like member in the path of the encroaching ice floe.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of an offshore platform equipped with a plow member and cutting nozzles;

FIG. 2 is an enlarged view of the plow member and cutting nozzle shown in FIG. 1;

FIG. 3 is an elevational side view of the plow member and cutting nozzles shown in FIG. 2; and

FIGS. 4A and 4B illustrate an elevational front view and sectional elevational side view of a plow member having cutting nozzles located in the face of the plow member.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates an offshore platform **14** supported by a single support member **34**. The support member **34** is a hollow cylindrical member which extends from the floor of a body of water to a point above the water surface. The support member **34** also serves as a conduit for well pipe, and is of sufficient strength to support the platform and customary storage and housing facilities **15**, derrick **16**, and crane **17** located on the top of the platform. Sleeve **30** is rotatably mounted on support member **34**. Mounted on sleeve **30** are plow member **24** and nozzle assembly **20**. Plow member **24** has a center rib portion which slants downwardly toward the support member **34**, and concave side members which flare outwardly from the center rib portion. The nozzle assembly **20** includes three nozzles laterally spaced with the outside nozzles directed angularly outward from the middle of the nozzle assembly **20**. Stops **28** positioned above and below the sleeve **30** extend about and may be welded to support member **34** and are spaced so that sleeve **30** has room to move a short distance in a vertical direction. These stops **28** are constructed of heavy metal and describe a shoulder. A high pressure fluid is emitted and directed by the nozzles in nozzle assembly **20**. When this fluid impinges on ice sheet **12**, the abrasive effect causes the cutting of such ice sheet.

As depicted in FIG. 1, ice sheet 12 is shown by passing platform 14. Plow member 24, together with nozzle assembly 20, separates two sections of ice 26 from the ice sheet 12. The plow member 24 is shown in an inverted position so that the leading edge of the plow member 24 is over the ice sheet 12, and as the ice sheet 12 moves toward the platform 14, the ice sections 26 are forced downward and sideways underneath the ice sheet 12 by the flared concave side members of the plow member 24. Before and during the ice sheet contact with the plow member 24, a fluid emitted by nozzle assembly 20 cuts the ice by the fluid impinging the ice sheet 12 at a high velocity and pressure. As shown herein, the nozzle assembly 20 has nozzles 22 directed so as to cut the ice in two sections. The outside nozzles 22 are angled so that the sections being cut have a larger bottom surface than a top surface to facilitate downward movement of the ice sections 26.

FIG. 2 more clearly illustrates the section shown in FIG. 1 between the stops 28, as well as showing floatation chamber 32. Flotation chamber 32 is a hollow water-tight metallic member which is buoyant in water. As shown here, inverted plow member 24 is made up of a center portion 25 which first contacts the ice sheet 12 of FIG. 1. This center portion 25 has a leading edge higher than its trailing edge. This forces an ice sheet downwardly as it moves from the leading edge to the trailing edge of the center portion 25. This downward force stresses the ice sheet until such ice sheet is split. Concave surfaces 27 of plow member 24 force the broken ice sections to the side of sleeve 30 and platform support member 34. To aid the function of inverted plow member 24 in its task of breaking the ice sheet, nozzle assembly 20 with nozzles 22 are placed so that an eroding fluid exiting the nozzles 22 will contact the ice sheet immediately prior to the ice sheet encountering inverted plow member 24. Both the plow member 24 and nozzle assembly 20 are mounted on sleeve 30 which rotates on platform support member 34. The sleeve 30 is limited in its vertical movement by stops 28 located above and below sleeve 30. Flotation chamber 32 should be positioned so that the leading edge of the center portion 25 of the plow member 24 is located above an encroaching ice sheet. In this regard, several methods can be used to determine the relationship between the inverted plow member 24 and an encroaching ice sheet. Sensors for automatically determining the height of an ice sheet could automatically activate a chain hoist, hydraulic system, or a ballast system flow control. Additionally, visual observations can be relied upon to determine how and when to activate equipment for raising or lowering the position of the inverted plow member 24.

Referring next to FIG. 3, a side view of the apparatus shown in FIG. 2 is illustrated. Here it can be seen that the inverted plow member 24 has a leading edge higher than its trailing edge. The leading edge projects above water level 42 high enough to ride over an encroaching ice sheet. The inverted plow member 24 is attached to sleeve 30 which is raised and lowered relative to the water surface by flotation chamber 32. Sleeve 30 is slidably arranged on platform support member 34. Vane member 36 also attached to sleeve 30, is responsive to the directional flow of water 42 and therefore orients the inverted plow member 24 so that it is in the path of encroaching ice sheets which are propelled by the sea currents. Because of the mass of the plow member necessary to force ice sheets up to 15 feet thick downwardly, the vane member 36 probably would need to be connected to a motorized system for rotating the sleeve 30. Such rotation can be done in any conventional manner, such as for example, by transmittal of a directional signal from the vane member 36 to a unit located on the platform for rotating the plow member 24. The unit for rotating the plow member 24 might comprise a motorized tracked pulling unit wherein the track defines a circular path above the platform support member 34. This pulling unit can be linked to the ice breaker by flexible or rigid members. Alternatively, a pinion and shaft may be used for rotating the plow member 24. For ease of movement of sleeve 30, counterweight 40 is used to offset the weight of inverted plow member 24 and nozzle assembly 20 so that sleeve 30 can freely move.

A wind velocity and direction detector 56 is shown mounted on counterweight 40. Wind velocity and direction detector 56 comprises direction vane 54 and wind velocity gauge 50 comprising a plurality of cups 52. The velocity gauge and direction detector are independently rotatable and are connected to plow member rotational means. Like the vane member 36, information obtained from the detector 56 is transmitted as a signal to actuate the plow member rotating means. Since wind often is the primary moving force in propelling ice floes, the detector 56 might be used exclusively in such areas of minor currents. Where both sea current and wind affect ice floe movement, a composite signal might be used to activate means for rotating the plow member 24.

Locking devices can be used which are responsive to forces being applied against inverted plow member 24 so that the plow member will not be pushed sideways by an encroaching ice sheet. A typical locking device could consist of a reinforced ribbed metal cover immovably mounted between the platform support member 34 and the sleeve 30. The ribbed cover would extend around and completely encircle the support member 34 and the vertical ribs would be closely spaced so that the sleeve 30 could freely rotate thereon. Several pivotable metal rods hydraulically actuated and attached in slots in the sleeves 30 could be pivoted to engage the ribs for locking the plow member 24 into position. Such a locking device has not been shown. Stops 28 prevent excessive vertical movement caused by the ice sheet forcing the inverted plow member 24 up too high to be operational. Also, lower stop 28 prevents the loss of sleeve 30 and related inverted plow member 24, nozzle assembly 20, etc. if the flotation chamber 32 was damaged and no longer operational. Alternatively or additionally, cables attached to the platform and ice breaker assembly could be used to prevent the loss of the ice breaker assembly. Nozzle assembly 20 has nozzles 22 located above and in advance of inverted plow member 24 so that its cutting action is utilized in advance of the ice sheet reaching inverted plow member 24. Pump assembly means 18 is shown adjacent to the nozzle assembly 20, but can be placed in any appropriate location, and is used to pump fluid to the nozzles.

FIG. 4 illustrates an alternative embodiment of the plow member and nozzle assembly. FIG. 4A is a side view of a plow member **24** and related nozzle assembly **20**. Here, as in FIGS. **2** and **3**, the nozzles **22** are located above the plow member **24**. Additionally, nozzles **38** are located in the face of the plow member **24**. As illustrated here, the plow member is in an upright position rather than inverted. This is better illustrated in FIG. **4B**. There the nozzles **22** include a pair of outside nozzles angled inwardly rather than outwardly as previously illustrated in FIG. **2**. Because of the upright position of the plow member **24**, the ice sheet will ride up on the center portion **25** of the plow member **24** to facilitate movement of a broken ice section in an upward direction; the outside nozzles **22** are directed inwardly so that the ice sections will have a larger top surface than a bottom surface. Flotation chamber **32** maintains the plow member **24** in appropriate position relative to an encroaching ice sheet. As illustrated here, there is a nozzle shown between outside inwardly directed nozzles **22** which may be eliminated because of nozzles **38** located in the face of plow member **24** on the mid-portion **25**. Alternatively, the nozzles can be eliminated altogether or used singly or in multiples.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects, and therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Apparatus for protecting an offshore platform supported on a substructure from encroaching ice floes, comprising: an inverted plow member having a central ridge portion and concave shoulders rotatably mounted on the offshore platform substructure and positioned such that the leading edge of the plow member is located above the ice floe; and at least one cutting member attached to the offshore platform and positioned relative to said plow member so that the cutting member contacts the ice floe adjacent the plow member.

2. The apparatus of claim **1** including means for rotating the plow member and cutting member which is responsive to elements responsible for the direction of movement of the ice floes.

3. Apparatus for protecting a platform located in water from ice floes in said water, comprising: a plow member having a central ridge portion and concave shoulders which is rotatably mounted on the offshore platform and located adjacent the water surface; and cutting means located adjacent the plow member, including high pressure liquid nozzles directed toward the ice floe.

4. The apparatus of claim **3** wherein the plow member is in an inverted position, having the leading edge positioned above the trailing edge so that ice contacting the plow member is deflected downwardly.

5. The apparatus of claim **3** including means for orienting the plow member which is responsive to direction of movement of the ice floes.

6. The apparatus of claim **3** wherein the cutting means includes means for forcing a liquid at high pressure through said nozzles.

7. The apparatus of claim **3** wherein said cutting means is arranged to cut the ice floe so that the cutting planes define ice sections having a top and bottom surface of substantially different cross-sectional surface areas.

8. The apparatus of claim **3** wherein the ice cutting means are jet nozzles directed through apertures in the face of the plow member.

9. The apparatus of claim **3** including buoyant members attached to said plow member for maintaining the plow member adjacent the water surface.

10. Method of protecting an offshore structure from encroaching ice floes comprising the steps of: locating a plow member between the structure and the encroaching ice floe; directing high pressure streams of liquid against said ice floe, at various angles to provide cutting planes which define ice sections having top and bottom surfaces of different cross-sectional areas; and removing the ice sections from the ice floe.

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