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Bennett et al.

[11] **3,841,252**

[45] **Oct. 15, 1974**

[54] **METHOD OF BREAKING ICE**

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[73] Assignee: **Sun Oil Company (Delaware)**, Dallas, Tex.

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[52] **U.S. Cl.** **114/40**

[51] **Int. Cl.** **B63b 35/08**

[58] **Field of Search** 114/40–42; 61/1

[56] **References Cited**

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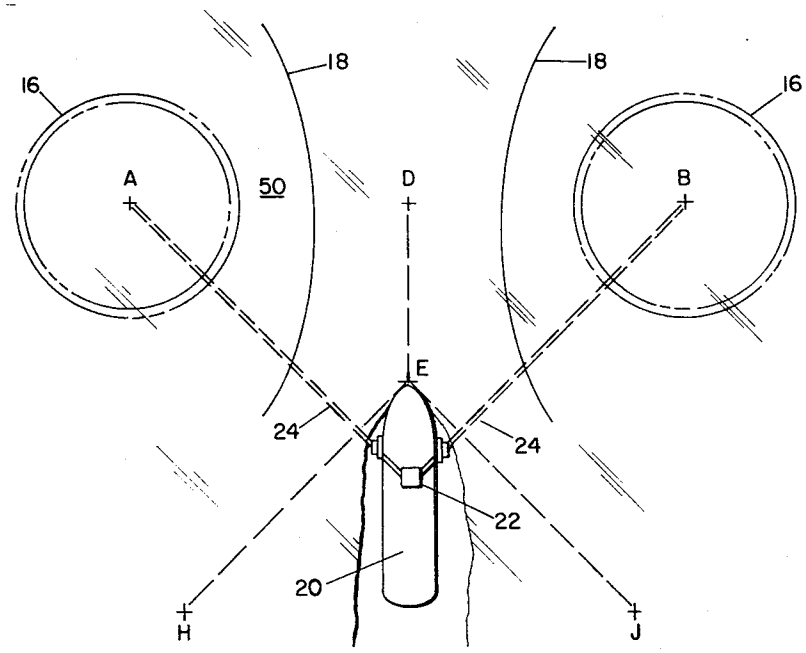
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Assistant Examiner—Jesus D. Sotelo
Attorney, Agent, or Firm—George L. Church; Donald R. Johnson; John E. Holder

[57] **ABSTRACT**

Injection of gas beneath ice sheets located in frigid waters to lift portions of the ice to place a stress on an area of ice for easier breaking by a vessel or marine structure. The gas conduits can be fixed as with a marine structure, or a movable flexible conduit for use with a vessel. Two mounds of ice can be created by injecting air at two locations to create a trough therebetween which is in stress for easier failure when contacted by the vessel or marine structure. An air motor or turbine can be used in the ends of the flexible conduits for moving the conduits outwardly from the vessel or the exhaust end of the conduit can be directed toward the vessel to utilize jetting action to push the conduit from the vessel. Connected bridles or hydraulic line actuated rudders can control direction so the conduits exhaust ends will properly position.

9 Claims, 5 Drawing Figures



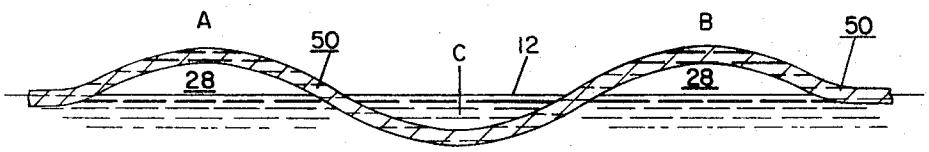


FIG. 2

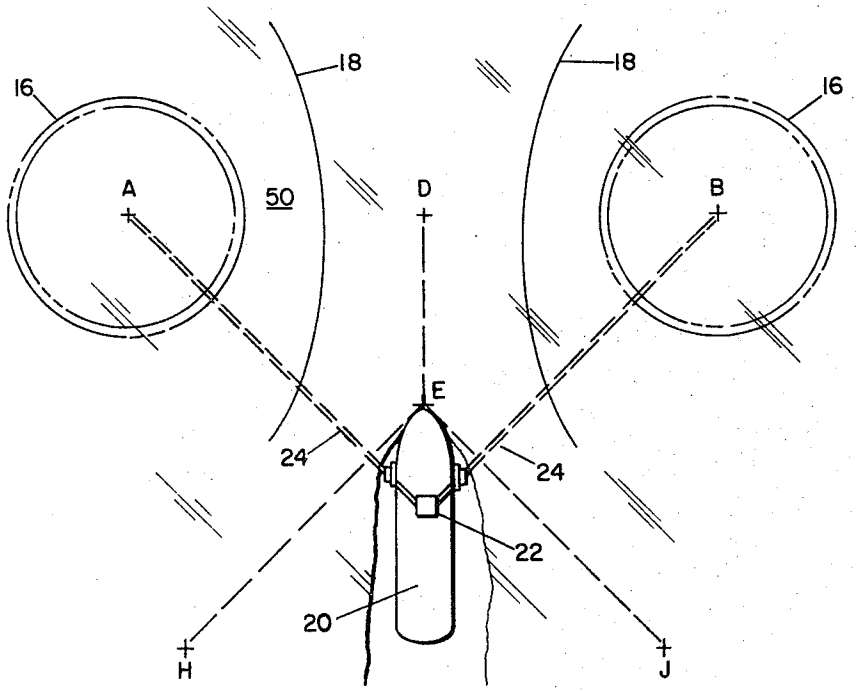


FIG. 1

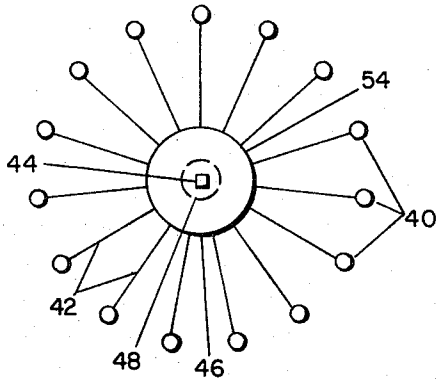


FIG. 4

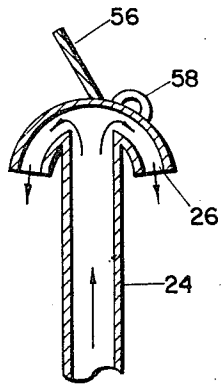


FIG. 3A

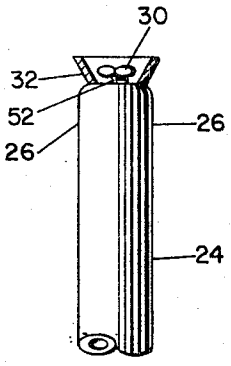


FIG. 3B

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METHOD OF BREAKING ICE

BACKGROUND OF THE INVENTION

This invention deals with the problems caused by ice floating in frigid waters such as the Arctic Islands area. Currently there is high interest in exploring for and developing natural resources in such areas. In the search for and development of petroleum from offshore areas, platforms have been used which are supported on the floor of a body of water by rigid upright members. 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 and propelled at such a speed that the platform support members would be subjected to damage or destruction from the severe pressures. Additionally, the specially equipped SS Manhattan recently made a voyage through the Northwest Passage to determine if a vessel could be used for transportation of hydrocarbons from areas in Alaska and encountered difficulty in penetrating the ice. Other vessels will be attempting to serve both the offshore drilling structures and storage facilities in these areas and must be able to penetrate through ice floes in order to reach these locations.

The Arctic Ocean adjacent the North Slope area of Alaska is typical of conditions a vessel or marine structure might encounter. This area is characterized by its shallow depth and gradual slope to deep water. Air temperatures usually range from −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 – 15 mph, with a maximum of 50 to 60 knots, however, 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 in the Arctic Ocean.

The main ice form in the Arctic Ocean is the ice sheet, which is generally uniform and 6 to 10 feet in thickness. Another form of ice encountered is "rafted" ice, which is the term used to describe 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 one or two 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, and is not as strong because of poor bonding between its layers.

Other forms of ice in the Arctic Ocean are the icebergs and pressure ridges. Icebergs do not occur, except in waters over 120 feet in depth. Since these icebergs can be several square miles in area, and can be up to 160 feet thick, in those areas where icebergs may be encountered, an above water surface platform would not appear to be feasible. Pressure ridges occur when two sheets of ice impinge upon each other. Crushing occurs and the ice is broken and piles up above and below the general ice level. Pressure ridges may be encountered which are some 150 feet thick. These ridges should also be avoided.

Thus, it can be seen that offshore platforms located in shallow water will encounter ice sheets from 6 to 10 feet thick when located in the Arctic Ocean, 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 foot thick ice sheets having diameters of several thousand feet, being moved by winds of 15 mph. This ice has a shear strength of 60 psi and a crushing stregth of 300 psi.

Regarding ice which a vessel will encounter while attempting to service drilling platforms located in the Arctic Ocean as well as storage facilities located in such areas as Cook Inlet and Prudhoe Bay, it is presumed that ice would not be encountered beyond the same 10 or 15 foot thick sections. It is therefore an object of the present invention to provide a method and apparatus for aiding vessels to penetrate, and marine structures to withstand, ice floes.

SUMMARY OF THE INVENTION

With these and other objects in view, the present invention contemplates injecting a fluid such as a gas underneath an ice sheet to raise portions thereof in order to place an area of the ice sheet in stress. The gas is injected at locations which will provide a stressed area in the ice sheet in the path of a vessel for easier breaking of the ice or to provide a stressed ice area which contacts a marine structure. The gas is injected by conduits which are in fixed locations for marine structures, and are flexible, positionable conduits for use with vessels. The conduits may be motivated by gas propulsion and maneuvered by hydraulic actuated vanes, connected bridles, or other known control mechanisms.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a vessel having apparatus for introducing a gas beneath an ice sheet;

FIG. **2** is a cross-sectional view of the sheet of ice deformed by the introduced gas;

FIGS. **3A** and **3B** are cross-sectional and plan views respectively of the discharge ends of gas conduits which incorporate propulsion systems for positioning the conduits; and

FIG. **4** is a plan view of a marine structure encircled by gas conduits.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. **1**, there is seen a vessel **20** located in the midst of an ice sheet **50.** Extending from the vessel **20** are a pair of conduits **24** which are shown to be laterally spaced from one another. These conduits **24** are connected to pump **22** and extend through guides **36.** When the vessel **20** first encountered the ice sheet **50,** these conduits **24** were extended from the vessel **20** and positioned in a manner which will hereinafter be discussed. Once the conduits are positioned, gas is pumped through the conduits **24** by pump **22** to elevate ice portions **16** and points A and B are approximately the center of such elevated ice portions. Located between elevated ice portions **16** is a depressed area generally defined by lines **18.** The area between lines **18** has been forced downward in reaction to the upward movement of the ice portions **16.** As the vessel **20** moves forward, and contacts the ice sheet **50,** a portion of the weight of the vessel is applied to the ice sheet at point E which tends to split the ice down the

middle along the line D-E. As the ice sheet **50** is forced downward, the edge of the ice sheet along the lines E-H and E-J would be forced downward since the load on the ice sheet **50** is greater along the side of the ice sheet adjacent the vessel **20,** than it is on the opposite side of the elevated ice portion **16.** Thus, these elevated portions should continue to move forward with the same velocity that the vessel **20** moves along the line D-E. Therefore, as a vessel encounters ice sheets in Arctic regions, conduits are extended from the vessel and laterally spaced in front of the vessel under the ice sheet. Gas is pumped through the conduits to elevate two mounds in the ice with a resultant stressed depressed area therebetween. This area is then contacted by the vessel, whose weight more easily breaks the ice sheet because of its weakened condition due to the stressing caused by the air bubble. The conduits can be retracted for operation of the vessel in clear water or waters having thin ice sheets.

FIG. **2** illustrates the deformity of the ice sheet **50** relative to the normal water level **12.** As gas is injected through the conduits **24** as shown in FIG. **1,** it raises the ice sheet **50** and occupies the area **28** below points A and B. As points A and B are elevated, point C located between A and B is depressed. This deformation of the ice sheet **50** places point C in stress and enables the vessel **20** shown in FIG. **1** to more easily break the ice sheet **50** when the weight and moving force of the vessel bow is applied to point C.

FIGS. **3A** and **3B** show alternative embodiments for moving the conduit discharge ends outwardly from the vessel **20.** FIG. **3A** illustrates a conduit **24** terminating such that the discharge openings are directed toward the vessel. Thus, when air or other fluid mediums are injected through conduits **24** and exit the discharge opening **26,** the jetting action of the medium forces the discharge end of the conduit away from the vessel. Assuming the conduit is a telescoping member, made of a flexible material or the like, such force will move the discharge end of the conduit away from the vessel. Fixed vane member **56** is located on the terminal end of the conduit **24** so that water moving relative to the vane member will force the conduit discharge end in a counter clockwise direction. Attachment loop **58,** preferably made of metal, as is the discharge end of conduit **24,** is positioned adjacent the vane member **56** and in operation is attached to a flexible connector member which has not been shown. The co-action between the vane member **56** and connector member attached to loop **58** operates to position the discharge end of the conduit **24** as will be explained hereinafter.

FIG. **3B** illustrates conduit **24** with a fluid motor located in the end thereof. As fluid proceeds through conduit **24,** it contacts vanes located in the conduit which rotate shaft **52** on the end of which is propeller **30.** The shaft **52** rotates on bearings and the propeller **30** is guarded by shroud **32** so as not to be fouled by floating objects. After the fluid medium proceeds through the vanes it exits apertures located on each side of the conduit and located generally at **26.** The propeller **30** is operated to pull the conduit **24** away from the vessel.

Several methods can be utilized for directionally controlling the conduit discharge ends so that they will be located under an ice sheet so as to provide a stressed trough between elevated portions of the ice sheet. One such system is the use of a hydraulic line located inside the conduit **24** which acts on a vane member located at the discharge end of the conduit. Pressure applied through the hydraulic line controls the vane member such that the discharge end of the conduit **24** can readily be positioned. Sound sensors can be used to determine the location of the conduit discharge ends when it is hidden by the ice sheet, or water. This system of positioning has not been shown in the drawings. Another method of positioning the conduit discharge ends is to tie two conduits **24** with a flexible connection of such length as to provide the proper lateral distance for the purposes of ice sheet elevation in FIG. **3A.** Vanes attached to the discharge ends of the conduits **24** can be arranged to pull the discharge end in an outward direction to keep the flexible connection in tension. The flexible connectors are attached to each conduit at attachment loops **58.** Upwardly directed vents at the discharge end of the conduis **24** could be used to force the ends of the conduits downward so that the flexible connecting element would not become fouled on an anomaly on the underside of the ice sheet. This upwardly directed vent should be constructed to operate only when extremely high injection rates of gas are used so that the conduit discharging ends would dive only at such times as are desired.

FIG. **4** illustrates an offshore marine structure **54** atop a support member **48.** Extending away from the marine structure **54** are fixed conduits **42** which extend outwardly to upwardly directed pipes **40.** Pump and control panel **44** communicates with the fixed conduits **42.** In operation, sensors and/or visual observations can be used to determine the direction of an encroaching ice floe. Once this is determined, a pair of directed pipes **40** are selected to emit a gaseous element for the purpose of creating elevated portions of the ice. These upwardly directed pipes **40** are selected so that the lateral distance therebetween will provide a trough area in the ice floe which will impinge against the marine structure support member **48.** Since this depressed area of the ice floe is under tension, it becomes very easy to shear by the support member **48.** The fixed conduits **42** may be rigid pipe members and the upwardly directed pipes **40** may be placed so that they extend upward so that they are fairly close to the ice floe, or may be dispensed with entirely, and an aperture in the fixed conduits **42** may be used instead.

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. Method of breaking ice sheets floating on a body of water comprising the steps of: injecting a gas under the ice sheet at two locations to create two spaced raised portions of the ice sheet and a resultant stressed depressed ice area therebetween; and applying a force to the stressed depressed area of ice to fracture the ice sheet.

2. The method of claim **1** wherein the gas is injected from a vessel and the ice sheet is in the path of the vessel, and wherein the stressed depressed ice area is created in the path of the vessel and the ice sheet is fractured by moving the vessel against the stressed depressed ice area.

3. The method of claim 2 wherein the gas is injected through flexible conduits attached to the vessel having gas motors in the discharge ends of the flexible conduits and including the step of passing a gas from the vessel through the flexible conduits and the gas motors so as to position the discharge ends of the conduits laterally and forward of the vessel.

4. The method of claim 3 including the steps of monitoring the location of the discharge ends of the flexible conduits and controlling movement of the conduit to position the discharge ends at a desired location.

5. In a method of breaking ice in the path of a vessel from a larger ice mass by applying the weight of the vessel to the ice mass to force it downwardly and thereby break a section of ice therefrom, the improvement comprising: injecting a gas beneath the ice mass to create two mounds in the ice mass spaced laterally and forward of the vessel, thereby creating a stressed depressed area between said mounds; and thereafter applying the weight of the vessel to the stressed depressed area.

6. A method of breaking ice from an ice mass in the path of a vessel comprising the steps of: extending a pair of conduits from the vessel so that the discharge ends are spaced laterally beneath the ice mass and are forward of the vessel; pumping a gas through and out the discharge end of the conduit thereby elevating two areas of the ice mass into mounds thereby stressing and depressing the area between the mounds; and moving the vessel forward against the depressed area to fracture the ice mass.

7. The method of claim 6 wherein conduits are constructed so that gas forced through the conduit will act as a force to move the conduit discharge end away from the vessel.

8. Apparatus for breaking ice floating on a body of water adjacent a marine structure including: a pump mounted on the marine structure; a plurality of elongated conduit means extending from said structure and spaced completely around said structure and having laterally spaced terminal ends; discharge means on said terminal ends arranged to pass a gas from said conduits; and means for directing a gas through a selected pair of conduit means.

9. Apparatus for breaking ice floating on a body of water including: a pump mounted on a self-propelled vehicle; at least two elongated conduits, made of a flexible material, extending from said vessel having laterally spaced terminal ends, which terminal ends includes means for moving the terminal ends of the conduits relative to the vessel, which terminal ends moving means comprises propulsion means activated by a gas operated motor means; and discharge means on said terminal ends arranged to pass a gas from said conduits, wherein said pump supplies gas under pressure to said conduits.

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