United States Patent

Fioravanti et al.

[15] **3,667,416**

[45] **June 6, 1972**

[54] **DEVICES FOR CUTTING A CHANNEL IN A LAYER OF ICE, AND AN ICE-BREAKER SHIP EQUIPPED WITH SAID DEVICES**

[72] Inventors: **Jean Fioravanti,** 3 Allee du Cedre, Chatenay-Malabry, Hautes de Seine; **Robert Lucien Carriere,** 28 Avenue Daniells Casanova, Saint-Gratien, Val d'**Oise; Paul Thibault,** 30 Avenue de Ceinture, Enghien-les-Bains, Val d'**Oise; Alain J. F. R. Fioravanti,** 3 Allee du Cedre, Chatenay-Malabry, Hauts de Seine, all of France

[22] Filed: **July 27, 1970**

[21] Appl. No.: **58,246**

[30] **Foreign Application Priority Data**

Dec. 24, 1969 France 6944891

[52] **U.S. Cl.** **114/42**

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

[58] **Field of Search** 114/40, 41, 42

[56] **References Cited**

UNITED STATES PATENTS

3,521,592	7/1970	Rosner et al.	114/42
2,665,655	1/1954	Brown et al.	114/42
3,335,686	8/1967	Pontbriand et al.	114/42

Primary Examiner—Trygve M. Blix

Attorney—Wilkinson, Mawhinney & Theibault

[57] **ABSTRACT**

The invention relates to a method of and devices for cutting a channel in a layer of ice covering the surface of an expanse of water, said method utilizing a rotary cutting device actuated from an independent source of power, the cutting force being directed in a substantially horizontal plane and being applied over a limited ice-cutting front. The broken pieces of ice are given a lateral vertical direction, upwards or downwards, and are ejected outside the edges of the cut channel. The rotary cutting device comprises two sets of spiral-blade cutters with inserted knives, one set on each side of the longitudinal axis, the cutters of each set rotating in opposite direction. An ice-breaker ship incorporating the invention has conveyor means for transferring the cut ice away from the channel, auxiliary screws on each side of the front portion and auxiliary devices at the sides of the stern for varying the direction of the cut channel.

16 Claims, 8 Drawing Figures

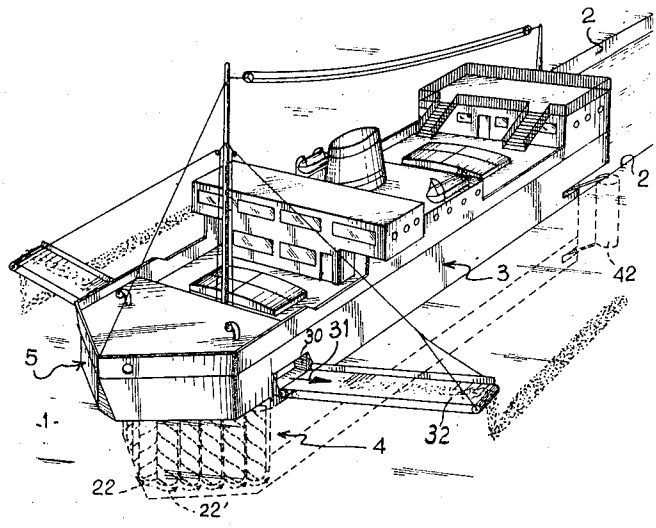
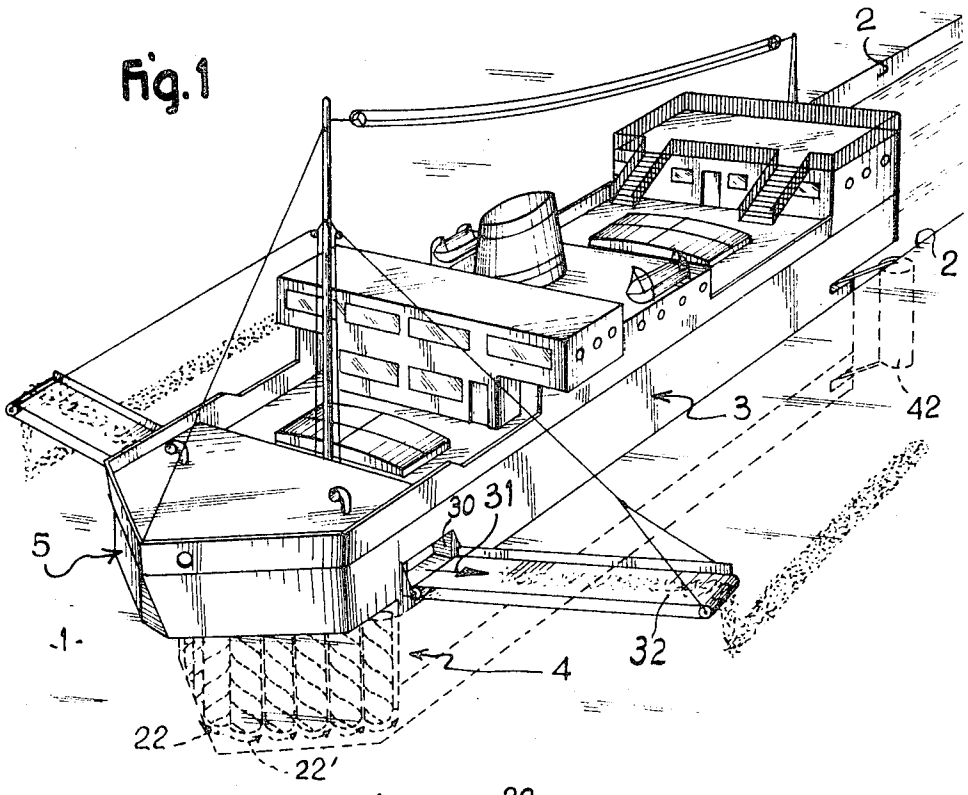


Fig.1


2
2
3
42
30
31
5
1
4
32
22
22'

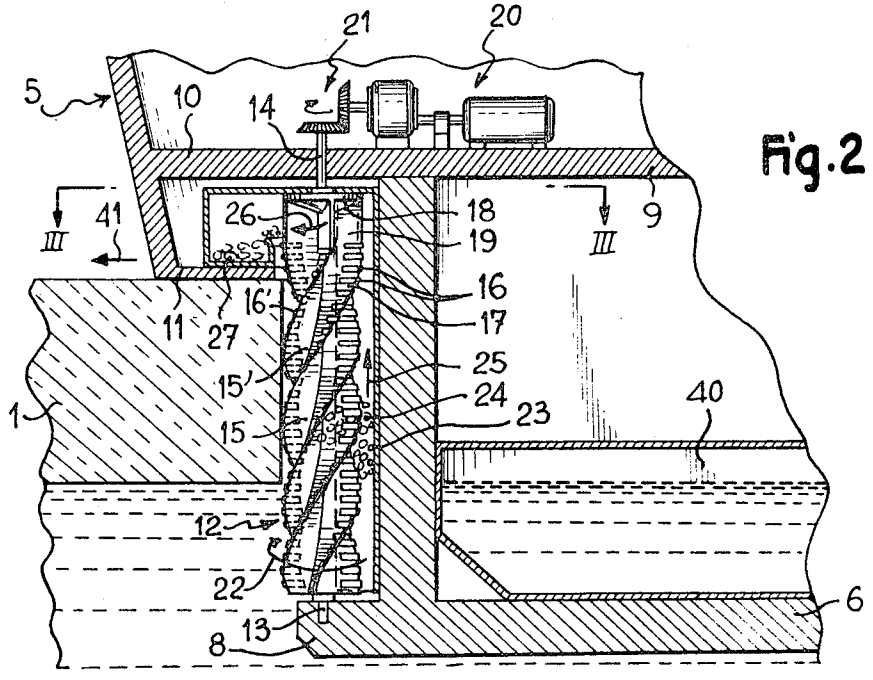

21
20
5
10
14
9
III
41
26
18
19
III
16'
16
11
27
17
15'
25
24
23
40
1
15
12
22
6
13
8

Fig.2

Fig.1a

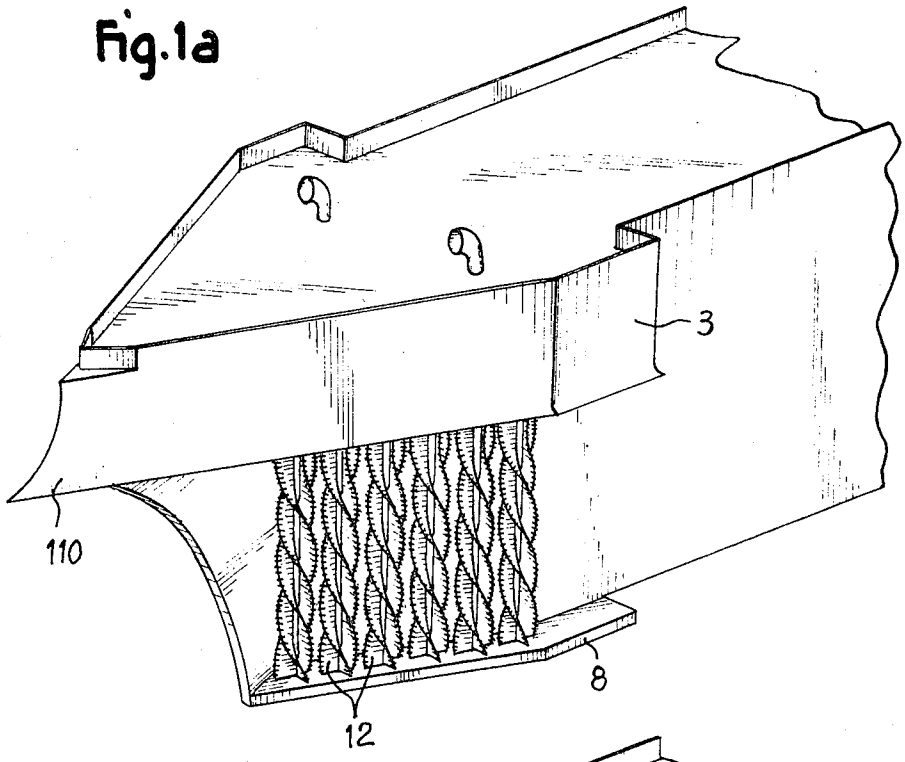


Fig.1b

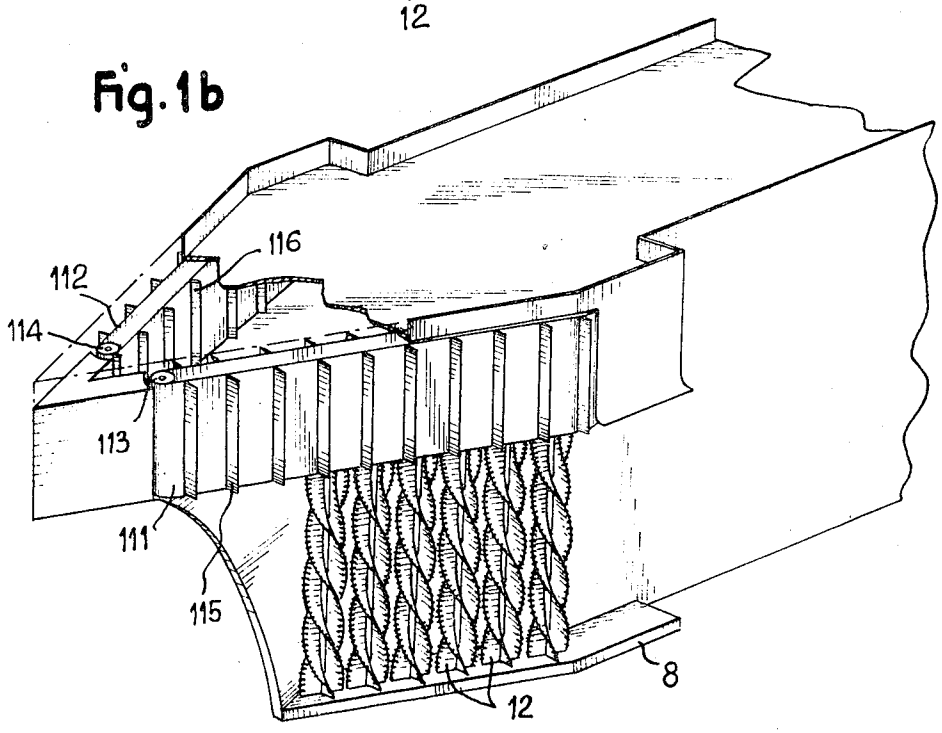


Fig.3

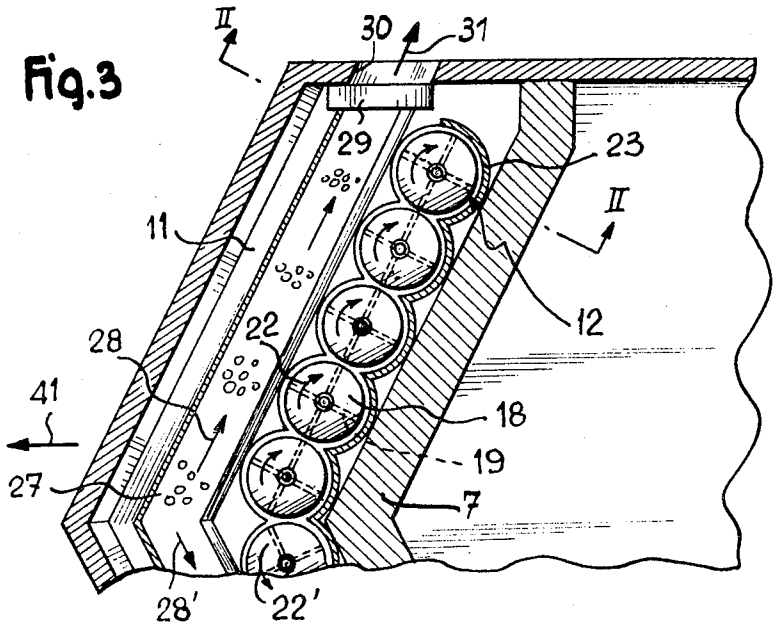


Fig.4

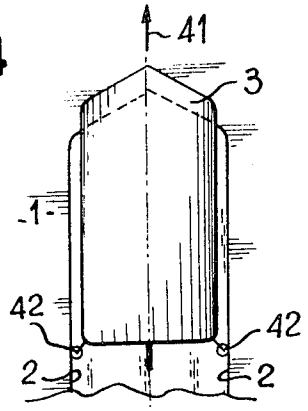


Fig.5

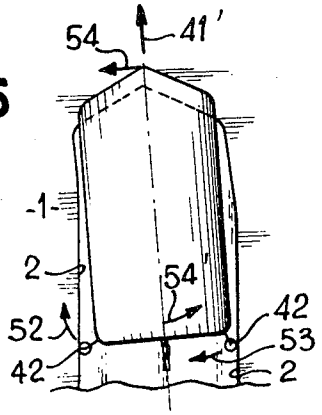
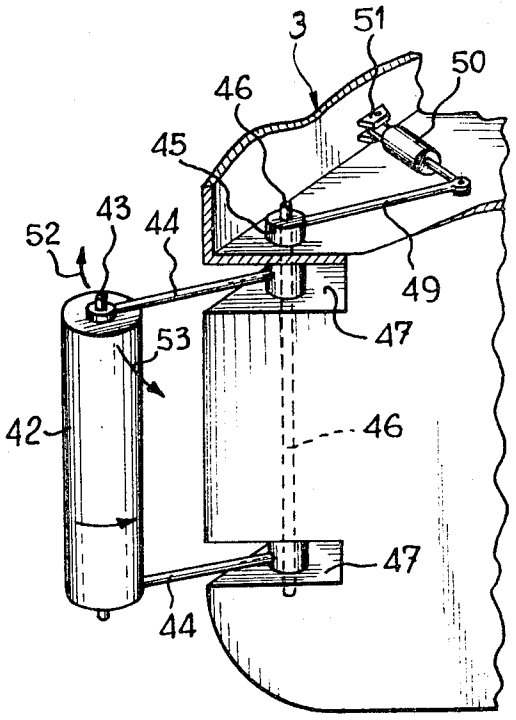


Fig.6



DEVICES FOR CUTTING A CHANNEL IN A LAYER OF ICE, AND AN ICE-BREAKER SHIP EQUIPPED WITH SAID DEVICES

The present invention relates in the first place to a method of cutting a channel in a layer of ice covering the surface of an expanse of water.

At the present time, the operation of forming a channel in a layer of ice is carried out by cutting-up or breaking the ice over a limited front, by means of a mechanical breaking force.

Ice-breakers designed for working in an ice-floe in particular, work in this way. These ice-breakers can be classified in two groups.

A first group of ships of this kind utilizes only the propulsive force of the ship for the operation of breaking the ice. These ships have a stem of special shape, carefully designed and robust.

In this group, there are found:

a. Ships having a stem in the form of a wedge with a very strong vertical edge which cuts the ice in the manner of a ploughshare by the action of the horizontal thrust of the propulsion screws;

b. Ships having a stem with a pronounced slope from the front to the rear, which permits the bow of the ship, again by the action of the propulsive force, to mount on the ice which is broken by the effect of the weight of the ship.

Ships of this first group having a number of major disadvantages: very high consumption of power; necessity of using hulls having very high mechanical strength which are thus costly and particularly heavy, this increased weight requiring a still further increase in the propulsive power of the ship's engines; In addition, the operation of these ships is considerably hindered, not only by the resistance of the ice, but also and especially by the blocks of broken ice which have a tendency to become agglomerated along the hull and to re-form into a layer which is liable to imprison the ship. The operation of ballast weights provided in these ships permits the center of gravity of the ship to be rapidly varied during the course of working, by creating rolling and pitching movements so as to prevent the ice from re-forming along the hull, but this involves conditions of working which are particularly arduous for the crew.

Efforts have been made to overcome these drawbacks in ships of the second group which are provided at the front with a breaking device, the action of which on the ice is independent of the propulsion of the ship. These mechanical devices work by "pick-axing," that is to way, the mechanical breaking force is applied vertically on the ice, from the bottom to the top or from the top to the bottom. In addition, in order to prevent the pieces of ice from re-forming round the ship, auxiliary installations are provided to enable the blocks of broken ice to be rejected outside the zone of the channel formed, on each side of the ship.

However, ships of this second group also have disadvantages: relative fragility of the breaking devices; large expenditure of power, not only for the propulsion of the ship but also for actuating the breaking devices; irregularity of the stresses to which the breaking devices and the structure of the ship are subjected, due to the vertical method of attack on the ice, which first of all offers a large resistance and then breaks abruptly. This constitutes bad working conditions for the mechanical equipments and may result in their rapid deterioration.

In addition, it will be understood that the breaking force directed vertically hinders the forward movement of the ship to a certain extent, and in any case prevents even a fraction of the propulsive force from being utilized to assist in the mechanical breaking work.

The present invention has for its object to remedy these drawbacks by providing a method of forming a channel in a layer of ice by means of a rotary breaking device driven from a source of power, this method consisting of breaking-up the ice over a front of the layer of ice and of transferring the blocks of ice outside the zone of the channel.

The said method is characterized in that:

The breaking force of the device is directed into a substantially horizontal plane;

This force is applied over the whole surface of the ice-front;

and the blocks of ice are given a lateral movement practically in a vertical direction and in the vicinity of the said device.

Thus, the reactions of the layer of ice to the breaking action will be directed almost horizontally, that is to say practically along the axis of forward movement of the ship, and the propulsive force of this latter can therefore assist in overcoming them.

Furthermore, the fact of attacking the ice along the whole surface of a vertical front enables the rotating device to be worked under good conditions, without jerks liable to have an adverse effect on the equipment and the driving installation.

It will be understood that under these conditions, the power necessary for breaking the ice may be relatively small, and that in addition the life of the equipment will be increased.

The invention also relates to a device for carrying the above method into effect, the said device being constituted by:

a helicoidal member having a continuous thread with an axis of rotation forming an angle with the horizontal plane of the layer of ice, this helicoidal member being driven in rotation by driving means;

and means for guiding the blocks of ice, said means partly enclosing the helicoidal member so as to form with this latter and the ice-cutting front a passage for carrying away the blocks of ice in a vertical movement of translation.

The helicoidal member preferably comprises a plurality of continuous threads of the same pitch, uniformly arranged around the axis of rotation.

In addition, the edge of each thread can be provided with inserted knives arranged along the generator lines of the helical thread, these knives having a profile suitable for cutting and breaking-up the ice. According to a preferred arrangement, two consecutive knives of the same thread are spaced apart by the width of a knife, and this space between two knives is at the same level as a knife of one of the adjacent threads.

In addition, at least one of the extremities of each thread terminates in the form of a blade so as to permit the projection outside the device of the pieces of ice reaching the end of their vertical movement along the device; these blades may have any desired shape provided that they enable the blocks of ice to be expelled perpendicularly to the axis of the helicoidal member. According to the case, this shape may be flat, concave, etc., these blades having the function devolving for example on the blades of rotary pumps.

A device of this kind may of course equip any type of carrying vehicle capable of giving this device a propulsive movement of translation.

It is however particularly adapted for operation on an ice-breaker ship.

In consequence, the invention also relates to an ice-breaker ship equipped with the device according to the invention and having its own propulsion means. The said ice-breaker ship comprises at least two sets of helicoidal members having a substantially vertical or inclined axis of rotation, these sets being arranged symmetrically with respect to the longitudinal axis of the ship and being driven by driving means; and at least two sets of guiding means for the blocks of ice, each of these guiding means co-operating with one of the helicoidal members and being arranged behind the associated helicoidal member.

All the members of the same set preferably rotate in the same direction, but the members of one of the sets rotate in the opposite direction to the members of the other set.

This arrangement makes it possible to maintain a symmetry of the breaking force on the ice on each side of the ship and in consequence permits suitable handling of this latter.

In order to facilitate the penetration of the ship into the layer of ice, a preferential direction of rotation is employed for the helicoidal members, namely the clockwise direction for the set located on the right-hand side with respect to the forward direction of the ship, and the anti-clockwise direction for the left-hand set.

It should finally be noted that depending on whether a right-hand or left-hand thread is adopted for the helicoidal members, a vertical translation movement of the blocks of ice will be obtained, either upwards or downwards, together with the lateral ejection of the blocks outside the channel.

There will now be described, simply by way of non-limitative example, a preferred form of embodiment of the invention, reference being made to the accompanying drawings, in which:

FIG. 1 is a diagrammatic view in perspective of an ice-breaker ship according to the invention;

FIG. 1*a* shows a perspective view of a ship's bow profiled so as to facilitate the breaking-up of the ice ;

FIG. 1*b* also shows a perspective view, with parts broken away, of a ship's bow equipped with lateral aprons for breaking-up the ice ;

FIG. 2 shows a partial longitudinal section to a larger scale of the front of the ship of FIG. 1, taken along the line II—II of FIG. 3, the helicoidal member being shown in an external view for the purpose of clearness ;

FIG. 3 is a partial horizontal section taken along the line III—III of FIG. 2 ;

FIGS. 4 and 5 are diagrams showing how the direction of forward movement of the ship can be modified by means of a directing mechanism provided at the rear of the ship,

FIG. 6 is a diagrammatic view in perspective to a larger scale, showing one form of construction of the mechanism for directing the ship.

In the drawings, there has been shown at 1 a layer of ice in which an ice-breaker ship 3 is required to cut a channel the sides of which have been indicated at 2. The bow of the ship 3 is equipped with a device according to the invention, indicated by the general reference 4, housed in the lower part of the bow of the ship which is set back with respect to an upper portion 5 which overhangs, and the function of which will be explained later.

FIG. 2 shows the profile of the bow of the ship in vertical cross-section. The bottom 6 is provided with a forwardly projecting portion 8 with respect to the vertical front wall 7, and similarly an intermediate deck 9 is extended by a platform 10 to the front of the wall 7. Finally the front of the overhanging bow 5 is rigidly fixed to a flooring 11 parallel to the platform 10 and extending towards the wall 7.

In plan view (see FIG. 3) the front of the ship, symmetrical with respect to its longitudinal axis, has the general shape of a V and in consequence the rotating helicoidal members indicated by the general reference 12 are arranged along the arms of the V. This arrangement enables the ship to be easily kept in a preferred direction while permitting controlled changes in direction as will be described later in a more detailed manner.

It will however be understood that this arrangement is not limitative, and that the members 12 could be placed otherwise, depending on the object desired (for example, the arms of the V may be curved). As can be seen from FIG. 3, the helicoidal members 12 are arranged in two sets respectively forming one of the arms of the V. All the members of the same set rotate in the same direction, but the members of one set rotate in the opposite direction to that of the members of the other set, the directions of rotation being preferably chosen so that they facilitate the forward movement of the ship and its penetration into the ice.

As can be seen from FIG. 2, which shows a helicoidal member 12 of the starboard side, the helicoidal members 12 are mounted parallel to the wall 7 between the forward projection 8 of the ship's bottom and the platform 10 of the intermediate deck. In the example shown these members 12 are almost vertical, but it will be understood that they may be more or less inclined, the essential being that they make an angle with the horizontal plane of the layer of ice. Each member 12 is provided at its lower extremity with a shaft 13 rotatably mounted in the projecting bottom 8, and at its upper extremity with a shaft 14 which passes rotatably through the platform 10.

Between the shafts 13 and 14, the helicoidal member is formed, in the example shown, of four threads 15 arranged in a spiral and displaced from each other by 90°. The number of threads may of course be different provided that they have the same axis, the same pitch, the same form and the same angle, and that the member 12 is both statically and dynamically balanced.

Each thread is provided with knives 16 inserted along the edge of the thread and extending along the generator lines of the helical thread. These knives, similar to the cutting tools used for working metals, may be made for example of tungsten carbide and are ground suitably for breaking-up and pulverizing ice. The fixing of these knives along the edges of the threads can be carried out by any conventional means (not shown).

The knives 16 inserted on the same thread are preferably spaced apart from each other, the space 17 between two consecutive knives 16 being equal to the width of a knife.

In addition, the knives of one thread are alternated with the knives of the two adjacent threads, that is to say for example, a knife 16′ of a thread 15′ is located at the same level as the space 17 between two consecutive knives 16 of the thread 15. By means of this arrangement it is possible to break-up the ice over the entire height of the ice front.

It should be observed that, contrary to what might appear, the utilization of a system of this kind is entirely economic, due to the very low resistance of the ice to the milling forces.

In fact, studies carried out on a model have shown that the power necessary for breaking-up ice in fresh water is of the order of 1 HP per centimeter of depth of the ice when the linear speed of the knives is in the vicinity of 15 meters per second and the speed of forward movement of the device, that is to say of the ship, is 1 meter per second.

The helicoidal member 12 is terminated at the top by a horizontal circular deflector 18 of the same diameter as the member 12, and the upper extremities of the thread 15 are fixed on this deflector. Over a certain height, the upper extremities of the thread 15 may change from the helicoidal shape in order to form blades 19 or vanes without knives having a profile which enables the pieces of ice which have risen towards the top along the threads, to be expelled from the helicoidal member. In FIG. 2, these blades 19 are flat, but is will be understood that they may be curved or may have any other appropriate shape.

In the example shown in FIG. 3, the starboard members 12 with a right-hand pitch are driven in rotation in the clockwise direction shown by the arrow 22, by a driving set 20 which gives the shaft 14 a movement of rotation through the intermediary of an installation comprising a clutch, speed-varying and speed-reduction gear shown diagrammatically at 21 and which it is not necessary to describe in detail since it is of a conventional type.

On the other hand, the port members 12, which have a left-hand pitch, are driven in the anti-clockwise direction 22′.

It will be noted that there may be provided :

either a motor driving set for each member 12 ;

or a common driving set for all the members 12. In this case, the transmission of the movement between the various members will be obtained for example by conventional gear-trains.

The choice between these two solutions will depend on specific economic and technical considerations.

Each helicoidal member 12 is surrounded over its entire height and over part of its periphery by a gutter 23 consisting of a fraction of tube fixed behind the associated member 12 against the wall 7 of the ship, this gutter being coaxial with the member 12 and having a slightly larger diameter.

This gutter 23 enables the pieces of ice 24 caused by the breacking action of the members 12 to be guided an carried away in a vertical translation movement by the effect of the rotating threads 15. The gutter and the ice-front in contact with the members 12 thus form a continuous channel which forces the pieces of ice to move vertically.

In the example shown in FIG. 2, the pieces of ice 24 move upwards in the direction of the arrow 25, due to the direction of rotation of the member 12 and the orientation of the pitch of its threads. When the pieces of ice 24 reach the level of the blades 19, the latter drive them forward in the direction of the arrow 26 into a conduit 27 closed on all its sides except on that adjacent to the helicoidal members. The conduit 27 is made-up of two sections (see FIG. 3) passing respectively along one of the sets of members 12, and it permits the evacuation (for example by means of a slight selope) of the pieces of ice towards each of the sides of the ship, in the direction of the arrows 28 and 28 .

In the vicinity of each of the sides of the ship, the speed of the pieces of ice is accelerated, for example by a pump and compressor set shown diagrammatically at 29, permitting the pieces of ice to be ejected from the ship through a lateral orifice 30 in the hull, in the direction of the arrow 31. In order to permit the pieces of ice to be carried away as far as possible from the ship, there may furthermore be provided, in the extension of the conduits 27 and the orifices 30 but outside the hull, conveyors 32 (see FIG. 1) preferably of the metal strip type, so as to withstand atmospheric conditions, supported on the sides of the ship and held in an overhanging position by a system of cables. These conveyors may advantageously be folded back vertically against the ship when they are not in use.

It is of course also possible to employ means for evacuating the ice other than those shown, such as rotary brushes, etc., for example. In certain cases, it is also possible by a suitable arrangement to eliminate the use of subsidiary evacuation means for the pieces of ice.

In addition, instead of evacuating the broken ice from the top, the evacuation may be provided from the bottom. The above installation would thus be simplified, in particular by the elimination of the conduit 27, evacuation pumps and compressor, without thereby changing the scope of the invention.

In fact, the volume of ice worked on by the helicoidal members 12 is very small as compared with that of the free water covered by the ice. If the pieces of ice are put into contact directly with the free water, they will melt very rapidly. In order to effect the evacuation towards the bottom of the ice, it would naturally be necessary to provide, for the same direction of rotation of the helicoidal members 12, a left-hand pitch for the starboard members and a right-hand pitch for the port members, and to arrange the knives 16 in such manner that they can break-up the ice.

With an ice-breaker ship as shown, that is to say with evacuation of the ice from the top, it is necessary that the upper level of the working portion of the threads (that is to say the first knives 16, taken from the top) should be flush with the upper level of the layer of ice 1. It is to maintain the ship constantly in this favorable position during working that the upper portion 5 of the ship is overhung. In addition, in the bottom of the ship, there may be arranged ballast tanks 40 which may be filled or emptied at will in the same way as the ballast tanks of submarines.

The level of the draught of the ship with respect to the layer of ice can be regulated by arranging that the flooring or platform 11 at the front of the ship is practically level with the layer of ice, as shown in FIG. 2. In addition, the overhung bows of the ship provide the latter with a forward supporting point which enables the reaction of the ice and the action of the helicoidal members which tend to force the front of the ship downwards, to be counterbalanced.

In the contrary case, in which the evacuation of the ice is effected downwards, it will not be useful for the upper portion 5 of the ship to be overhung, since the reaction of the ice on the ship and the action of the helicoidal members 12 will have a tendency to cause the front of the ship to rise. In order to overcome this drawback, it will only be necessary to ballast the bow of the ship in a suitable manner by means of ballast-tanks.

In order to free the accumulations of ice which are formed in certain places above the free surface of the water (hummocks) as a result of the various relative movements and local pressures produced in the layers of ice, the part of the bow which overhangs the mean level of these layers of ice must be able to take part in the breaking-up action of the device. To this end, two solutions are proposed :

If the hardness of the surface ice so permits, the bow will be given the general shape of an elongated and cutting dihedron 110 (FIG. 1*a*) which, during the forward movement of the ship, acts like a double ploughshare, that is to say breaks-up the hummocks and then throws them back on each side of the ship. The bow then has a static action.

If the hardness of the surface ice is high, a bow with a dynamic action can be obtained by fixing symmetrically with respect to the longitudinal axis of the ship, two devices each constituted for example, by two endless chains 111 and 112 of the same dimensions, driven by one or more drums 113, 114 and fitted with plates 115, 116 suitably dimensioned and orientated so as to break-up the ice and expel it laterally (FIG. 1*b*).

For guiding the ship, a conventional rudder may not prove very effective. In order to facilitate changing the direction of travel of the ship, there has therefore been provided, in addition to the rudder, an orientation device mounted at the rear of the ship.

This device (see FIGS. 4, 5 and 6) is constituted by two independent vertical rollers 42 mounted so as to be freely rotatable on vertical shafts 43 arranged on the side and to the rear of the ship. The shaft 43 of each roller is mounted at the end of two crank-arms 44 located in the same vertical plane, one above the other and rigidly fixed on a sleeve 45 which is articulated on a vertical shaft 46 arranged in the vicinity of one of the rear angles of the ship. The crank-arms 44 are housed in cavities 47 in the structure 3 of the ship so as to permit their displacement in a horizontal plane.

The displacement of the rollers 42 in the direction of the arrows 52 or 43 about their respective shaft 46 is effected by the operation of an arm 49 rigidly fixed to the sleeve 45 of the crankarms 44. The arm 49 pivots about the shaft 46 under the action for example of a jack 50, the rod of which is articulated on the end of the arm 49, the jack body being itself articulated at 51 on a support fixed to the structure 3 of the ship.

When the ship moves in a straight line in the channel (see FIG. 4) the crank arms 44 are equally inclined with respect to the plane of symmetry of the ship so that the rollers 42 project to an equal extent beyond the sides. In this position, the rollers are in contact and roll one on the right-hand side, the other on the left, against the vertical walls of the channel, thus helping to keep the ship in line.

When a change in direction becomes necessary, for example due to the presence of a large obstacle, such as an iceberg for example, the jack 50 is actuated so as to cause pivotal movement of the roller 42 which is closer to the center of gyration of the ship (for example in the direction of the arrow 52, see FIG. 5) in order to displace this roller from the plane of symmetry of the ship by applying it strongly against the wall 2 of the corresponding channel. Simultaneously, the retraction of the second roller 42, located at the exterior, is effected by actuating its corresponding jack 50 in order to displace this roller in the direction of the arrow 53 (see FIG. 5).

Thus, the rear portion of the ship which is the farthest from the center of gyration is brought nearer to the corresponding wall 2 of the channel.

It will be observed however that the rear of the ship does not come into contact with the wall 2 of the channel, since the roller 42 is retracted in such manner that it remains slightly projecting from the side of the ship, which is effected for example by an abutment system for the crank-arms 44 or for the arm 49 of the roller or alternatively for the jack 50. It will be noted that this abutment system is provided for each of the rollers 42.

All the movements described, conjugated with the displacement of the ship, result in the desired change of direction. The structure 3 of the ship is only in contact with the ice through

the intermediary of the rollers **42** and in consequence it is not subjected to the friction or deformation which could result from this contact.

The operation of the jacks **50**, which may be mechanical, hydraulic, pneumatic or the like, is effected by a servo-mechanism associated with the device which causes the movements of the steering rudder.

This installation is of course only described by way of indication and a different control of the pivotal movement of the rollers could be provided.

The change of direction of forward movement of the ship is shown diagrammatically in FIGS. **4** and **5**. The ship **3** of FIG. **4** moves forward in the direction of the arrow **41** and cuts a straight channel. The rollers **42** project from the sides of the ship **3**. If it is desired to turn the ship towards the left in the direction of the arrow **41'** (FIG. **5**), it is only necessary to cause the rollers **42** to pivot in the direction of the arrows **52** and **53** respectively. The port roller **42** accentuating its pressure against the wall of the channel tends to push away the left-hand side of the ship, while the retraction of the starboard roller permits the corresponding side to come closer to the wall of the channel.

The bow of the ship then pivots towards the left in the direction of the arrow **54** and the stern moves towards the right, as shown by the arrow **54'** until the rear of the starboard side of the ship comes into close proximity, but without touching, to the right-hand edge **2** of the channel. The V-shape of the breaking devices enables the ice to be attacked laterally and the ship may then be directed in the direction of the arrow **41'**.

It will be noted that in order to assist a lateral attack on the ice, for example when the ship is in the position shown in FIG. **5** or still more inclined, there may be provided the setting to work of an auxiliary screw mounted on the side of the bow of the ship opposite to the side in contact with the ice. In this way, any slipping of the members **12** against the ice would be avoided. A lateral screw of this kind would naturally be provided on each side of the bow of the ship.

It will be understood that additions and modifications may be made to the present description without thereby departing from the scope of the invention, which should be considered in its widest aspect.

What we claim is:

1. A shipboard device for breaking-up ice, driven in rotation by a source of power, comprising

a. a helicoidal member with continuous thread having an axis of rotation having a vertical vector relative to the horizontal plane of the layer of ice,

b. means for driving said helicoidal member in rotation,

c. guiding means for pieces of broken ice, said means partially enclosing said helical member so as to form with the member and the ice front, a passage for carrying away the pieces of ice in a movement of vertical translation, and

d. lateral conveying means positioned to receive the pieces of broken ice from said guiding means to deposit the ice at a point laterally spaced from the channel occupied by the ship.

2. An ice-breaking device as claimed in claim **1**, in which each helicoidal member comprises a plurality of continuous threads having the same pitch, said threads being spaced apart along the periphery coaxial with the axis of rotation, by the same angle with respect to each other.

3. An ice-breaking device as claimed in claim **1**, in which the edge of the apex of each thread is provided with knives arranged along the generator lines of the helical thread.

4. An ice-breaking device as claimed in claim **3**, in which two consecutive knives of the same thread are spaced apart from each other by the width of a knife, said space between two consecutive knives of the same thread being at the same level as a knife of one of the adjacent threads.

5. For use with an ice-breaker ship having its own propulsion means for its displacement comprising at its extremity in contact with said ice front

a. at least two sets of helicoidal members with substantially vertical axes of rotation, said sets being arranged symmetrically with respect to the longitudinal axis of the ship,

b. means for driving said helicoidal members in rotation, and

c. at least two sets of guiding means for the broken pieces of ice, each of said guiding means being adapted to co-operate with one of said helicoidal members, said guiding means being arranged at the rear of said helicoidal members.

6. An ice-breaker ship as claimed in claim **5**, in which the helicoidal members of the same set rotate in the same direction, the members of one of the sets rotating in the opposite direction to that of the members of the other set.

7. An ice-breaker ship as claimed in claim **5**, in which the co-operation of the helicoidal members with their associated guiding means and said ice-front cause the pieces of ice to be carried away downwards in a movement of translation.

8. An ice-breaker ship as claimed in claim **5**, in which the co-operation of said helicoidal members with their associated guiding means and said ice-front causes the pieces of ice to be carried away in an upward movement of translation.

9. An ice-breaker ship as claimed in claim **8**, in which each of the threads of said helicoidal members terminates at its upper extremity in a substantially vertical blade.

10. An ice-breaker ship as claimed in claim **9**, in which at the end of their upward movement, the pieces of ice come into contact with the blades of said helicoidal members and are ejected laterally by centrifugal force.

11. An ice-breaker ship as claimed in claim **10**, and further comprising, in the vicinity of the upper parts of said helicoidal members, conveyor means for the pieces of ice in order to project said pieces laterally outside the ship.

12. An ice-breaker ship as claimed in claim **5**, in which the bow of said ship has a portion located above said ice-breaking members and extending in front of said members in the direction of forward movement of said ship.

13. An ice-breaker ship as claimed in claim **5**, in which said ship is provided at the rear with moving means adapted to be forced selectively into contact with one or the other of the lateral edges of said channel in order to vary the direction of movement of said ship.

14. An ice-breaker ship as claimed in claim **13**, in which said moving means are constituted by two vertical rollers mounted on each side of the ship on a deformable articulated structure and actuated by driving means, the deformation of said structure effecting the change in position of the stern of said ship with respect to the channel.

15. An ice-breaker ship as claimed in claim **5**, and further comprising supplementary conveyor devices extending laterally from each of the sides of the ship and adapted to complete the ejection action of the pieces of ice outside the channel.

16. An ice-breaker ship as claimed in claim **5**, and further comprising auxiliary screws on each side of the front ice-cutting device, said auxiliary screws facilitating the lateral displacement of the ship in the ice.

* * * * *