

# United States Patent

**[11] 3,632,172**

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| [45] | Patented  | <b>Jan. 4, 1972</b>                                                  |
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- [54] METHOD OF AND APPARATUS FOR WEAKENING  
ICE FOR ASSISTING AN ICEBREAKER  
21 Claims, 4 Drawing Figs.**
- [52] U.S. Cl.**..... **299/13,**  
61/72.5, 102/23, 114/42, 299/27
- [51] Int. Cl.**..... **B63b 35/08**
- [50] Field of Search**..... 114/40, 41,  
42; 102/22, 23; 61/72.5, 72.6; 299/13, 24-28;  
172/1

[56] **References Cited**  
**UNITED STATES PATENTS**

- |                 |         |                 |         |
|-----------------|---------|-----------------|---------|
| 2,551,967       | 5/1951  | Pouliot .....   | 114/42  |
| 3,130,701       | 4/1964  | Langballe ..... | 114/40  |
| 3,201,948       | 8/1965  | Schramm .....   | 61/72.6 |
| FOREIGN PATENTS |         |                 |         |
| 675,716         | 12/1963 | Canada .....    | 102/23  |

**ABSTRACT:** A self-powered vehicle is disclosed for moving across the ice ahead of an icebreaker and carrying trench-cutting means for cutting a trench along the path of travel of the icebreaker and carrying means for placing an explosive cord in the trench which can be exploded for weakening the ice. An air cushion vehicle carries a rotary saw and means for removing ice cuttings from the trench made by the saw with means for melting part of the ice cuttings for backfilling along the trench after inserting an explosive cord therein. Drill means are carried by the air cushion vehicle for drilling spaced holes along the ice for additional explosive charges. An elongate pipe has at least one opening in the wall or bottom end thereof for insertion into spaced drilling holes adjacent the trench with seal means normally covering the openings and an air supply means carried by the vehicle and connected to the pipe for building up pressure therein for rupturing the seal means and creating an airblast adjacent the trench. A buoyant fish is adapted to float under the ice and tow a length of buoyant explosive cord connected thereto with control and/or motivation means carried by the vehicle for controlling the direction of movement of the fish thereby towing the explosive cord beneath the ice in the desired direction. Additional floating explosive charges are connected along the explosive cord.

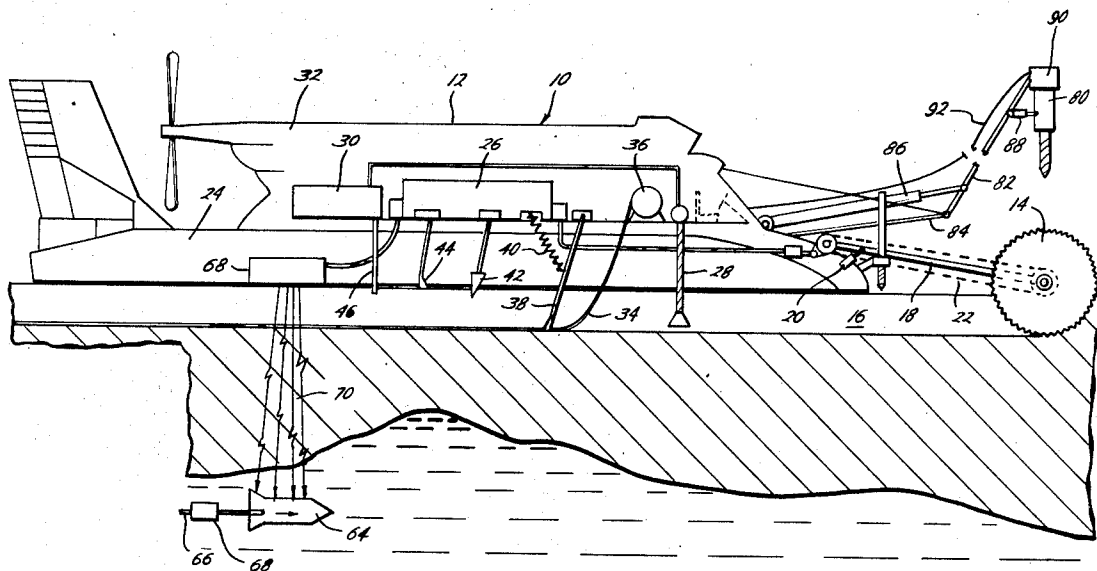
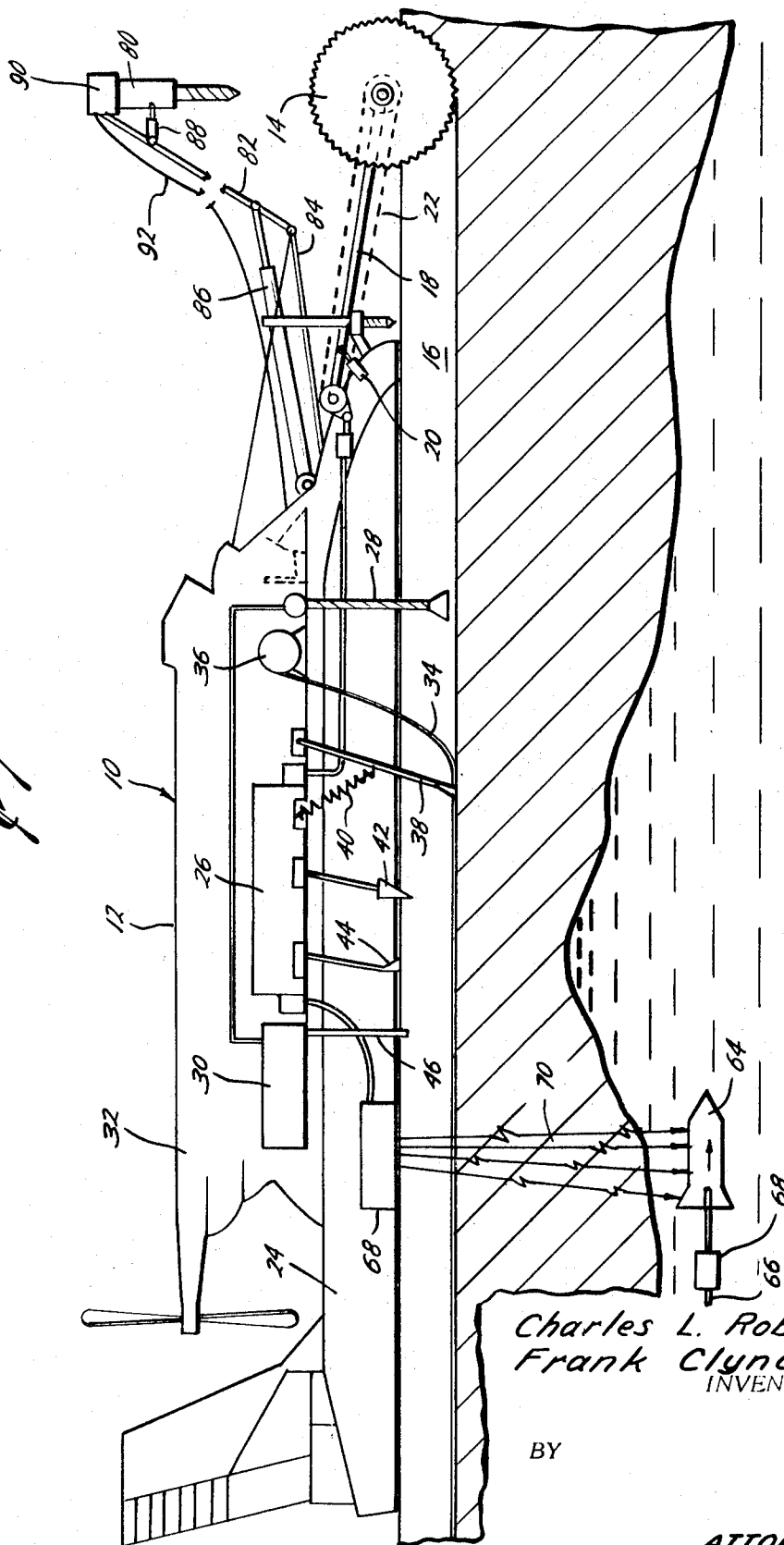


*Fig. 1*



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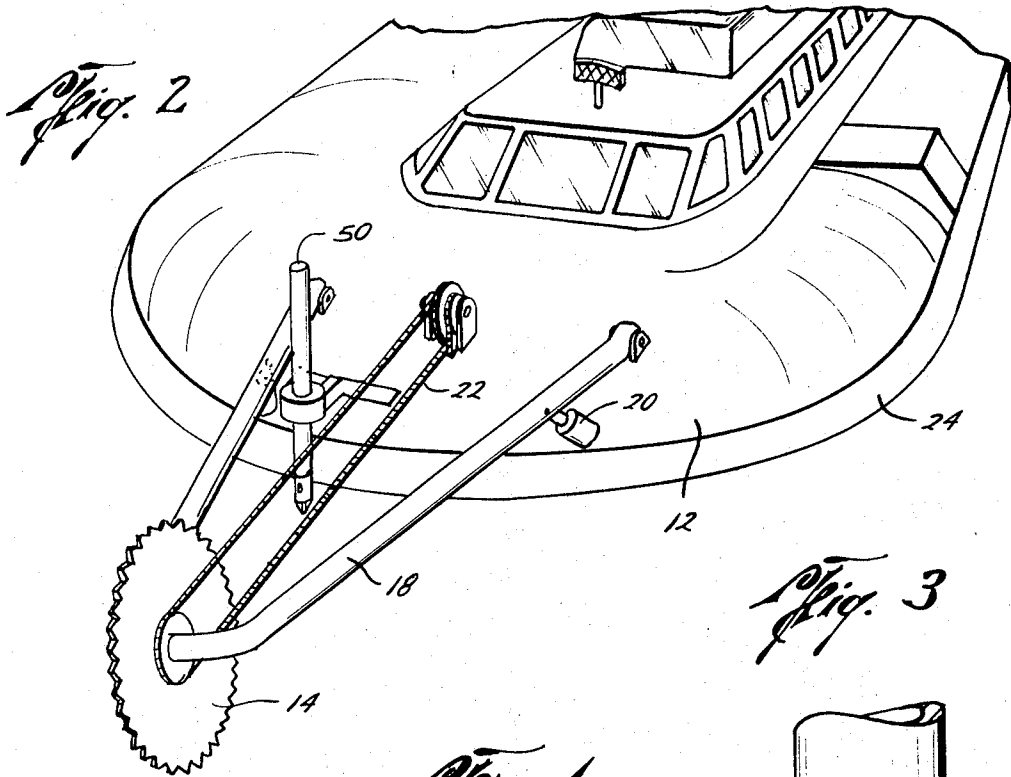


*Fig. 3*

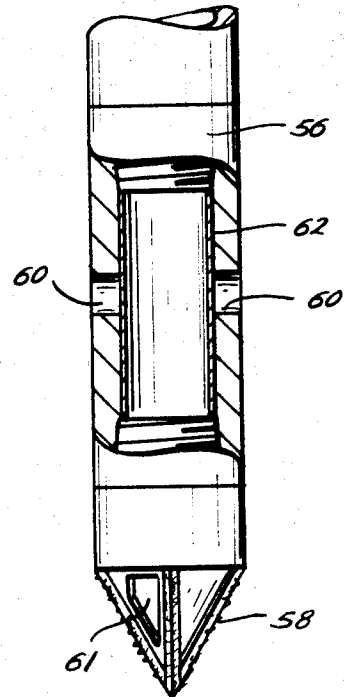
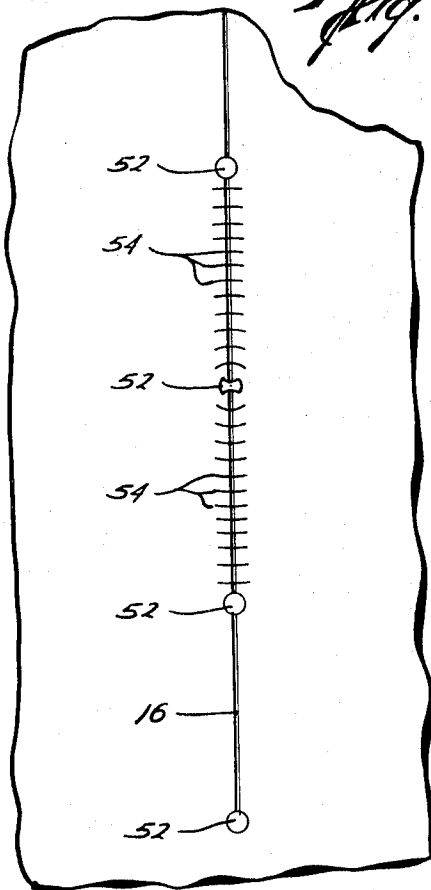


*Fig. 4*



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## METHOD OF AND APPARATUS FOR WEAKENING ICE FOR ASSISTING AN ICEBREAKER

### BACKGROUND OF THE INVENTION

The discovery of oil on the northern slope of Alaska has increased the commercial incentive for improving icebreaking methods since the cost of moving oil by tanker as compared to the cost of moving oil by pipeline over land would result in significant savings. At the present time the general principle for breaking ice is to use an icebreaker and propel the ship forward towards the ice to be broken, drive the ship upon the top of the ice, and allow the weight of the ship to push the ice downwardly and break the ice by sheer weight. In addition, icebreakers sometimes use a special bow similar to a plow which is driven under the ice, lifting the ice up causing it to break. Breaking ice in this fashion is in a sense a brute force approach using very high horsepower and very large and heavily reinforced and strengthened icebreakers.

The present invention is directed to providing a method and means to make the operation of the present icebreakers considerably more efficient. The present invention is directed to creating zones of weakness or fractures or ruptures in the ice ahead of the proposed path of the icebreaker so that the icebreaker will be able to make faster progress through the ice while breaking ice and/or will require a lesser amount of horsepower to achieve a given rate of progress through the ice than is required by present day icebreaking methods.

### SUMMARY

The present invention is directed to providing a method of and apparatus for weakening ice for assisting an icebreaker by providing a self-powered vehicle moving across the ice ahead of the icebreaker and provided with a trench-cutting means for cutting a trench along the path of travel of the icebreaker and carrying means for placing an explosive cord along the trench which can be exploded for weakening the ice.

Preferably, an air cushion vehicle is utilized since it can operate when visibility is practically zero because of fog and other weather conditions, is in no danger of breaking through thin places in the ice, and provides a stable platform from which the necessary operations can be performed, and yet can fly at high speeds to return to the icebreaker ship for refueling, supplies, crew changes or repairs.

Suitable trench-cutting means, such as a rotary saw may be carried by the vehicle for cutting a trench in the ice. The vehicle also carries means for implanting an explosive cord in the trench which can be exploded to fracture and weaken the ice. Preferably, the cuttings from the saw are removed from the trench for placing the point of explosion as low as possible, and preferably the cuttings would be at least partially melted and used to backfill the trench in order to more fully utilize the explosive force by causing it to be directed downwardly and laterally rather than having a part of the explosion wasted by blowing out of the top of the trench.

A further feature of the present invention is the provision of an ice drill carried by the vehicle for drilling spaced holes adjacent the trench in which can be placed dynamite charges of airblasts which would be preferably directed along the longitudinal axis of the trench for additionally fracturing the ice. Airblasts can be utilized in the drilled holes in place of dynamite by inserting an elongate pipe having at least one opening in the wall and/or the bottom end thereof for insertion in the drilling holes with or without sealing means normally closing the opening but rupturing on a predetermined pressure whereby an air supply means carried by the vehicle and connected to the pipe can build up pressure in the pipe and rupture the seal means for creating an airblast along the trench thereby avoiding logistic and safety problems involved in carrying dynamite.

A further feature of the present invention is the utilization of a buoyant fish adapted to float under the ice and tow a length of explosive cord, preferably buoyant, in which control means carried by the vehicle controls the direction of movement of the fish and/or provides the motivating force to propel

the fish forward under the ice to tow the cord in the desired direction for creating an explosive force acting along the bottom of the ice. Additionally, attached dynamite charges to the towed explosive cord can be provided at desired intervals to rupture the ice and also to create an opening to assist in recovering the fish so that it can be used again.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view, partly schematic and partly in cross section, illustrating the apparatus of the present invention,

FIG. 2 is a fragmentary perspective view of the apparatus of FIG. 1 but omitting the extending drill,

FIG. 3 is a fragmentary elevational view, partly in cross section, illustrating part of the apparatus for creating an airblast, and

FIG. 4 is a schematic elevational view illustrating the placement of the drilled holes relative to the trench for weakening the ice.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and particularly to FIG. 1, the reference numeral 10 generally indicates an apparatus for weakening ice for assisting an icebreaker and generally includes a self-powered vehicle 12 for moving across the ice ahead of the icebreaker. Obviously, it is easier to break a block of ice or to break through ice with an icebreaker if there is a zone of weakness. It is known that currents or tides sometime cause natural cracks to develop in the ice, and icebreakers will often use and follow these cracks or zones of weakness rather than try to break their way through more difficult solid ice where cracks are not present. The method and apparatus of the present invention are directed to creating zones of weakness along a particular desired path of travel of the icebreaker.

While various types of vehicles may be used such as helicopters or tractors, an air-cushioned vehicle is preferably utilized as the vehicle for providing the support base for carrying the equipment for creating ruptures or cracks ahead of the icebreaker. For instance, the vehicle used must be able to operate a high percentage of days during which visibility is practically zero due to fog and other weather conditions and must be able to operate over and on the ice without the danger of breaking through in thin places in the ice which would be particularly advantageous for the path of travel of the icebreaker. A helicopter, for example, is extremely limited in the number of days which it can operate during certain periods of the year and does not provide a stable operating platform. A track vehicle could also be used to crawl over the ice, but it has the danger of breaking through the thin places in the ice, which would be the ideal path of travel, and is also extremely slow. The air cushion vehicle or hovercraft, such as a conventional SRN-6 manufactured by British Hovercraft Corporation, is preferred since it can fly in all types of weather, is equipped with radar so that fog does not present a serious drawback and the radar can also scan the path ahead for obstacles on the ice such as, for example, ice ridges. The air cushion vehicle 12 flies at a fixed distance off of the surface of the ice, such as 4 feet, and is therefore a safe vehicle from the standpoint of engine failure and provides a stable platform for operations. In addition, if the ice is thin, the vehicle 12 can fly over water and in fact can land on water since it has buoyancy tanks which will keep it afloat. Further, the vehicle 12 can fly at dead slow speeds forward or sideways and can fly at speeds as high as 50 or 60 knots which is useful for returning to the icebreaker for refueling, supplies, and crew changes as well as searching at high speeds along high ice ridges for a low place which provides an easier crossing point for the hovercraft 12 to cross the ice ridge.

Suitable means 14 are provided for cutting a trench 16 in the ice, such as 2 or 3 feet deep or deeper. Such means 14 may preferably be a rotary saw supported from supports 18 from

the vehicle 12 which can be raised or lowered by suitable piston and cylinder assemblies 20, preferably hydraulic, and driven by a chain 22 from auxiliary power in the vehicle 12. The auxiliary power package 26 on the hovercraft 12 may suitably include a diesel engine driving an air compressor, electric generator, and of course the power driving the chain 22 and saw 14 may be either mechanical, electrical, hydraulic or compressed air.

The hovercraft 12 maintains a relatively constant distance above the ice, for example in the SRN-6 model, the height which is controlled by the skirt 24 height, is 4 feet. Upon reaching a starting point, the ice saw 14 will be lowered to the surface of the ice and started into rotation cutting a narrow trench 16 in the ice and the hovercraft would then be started in motion forward cutting a trench as it proceeded forward along the desired path of travel in front of the icebreaker. Preferably, it is desirable to clean the ice shavings from the trench 16 in order to place the explosive cord as deep in the trench as possible. While the ice shavings or cuttings may be blown out of the trench by the air from the air compressor (part of the auxiliary power equipment 26), it is advantageous to remove the ice cuttings from the trench 16 by a suction line 28 and deposit them in a tank 30 where the ice shavings would at least be partly melted by the surplus exhausted heat from the main engine 32 of the hovercraft 12 or from the diesel engine in the auxiliary power supply 26.

An explosive cord 34, such as Primacord, is preferably stored on a reel 36, and is reeled off as the craft 12 moves forward and is pushed down to the bottom of the trench 16 by guide means 38, preferably a long arm which is spring loaded by spring 40 in order to push the explosive cord 34 as deep as possible into the trench. Positioned to the rear of the guide means 38 may be ice scrapers 42 and 44. Scraper 42 is preferably triangular in shape and sharp at the edges to scrape ice shavings from the edge of the trench 16 onto the top of the laid cord 34. Scraper 44 is generally plow shaped to scrape all of the shavings and cuttings and chips of ice into the trench so as to fall in on top of the cord 34.

Rearwardly positioned from the scrapers is a hose 46 connected to the water tank 30 for supplying additional backfill in the trench 16 above the cord 34. The water in the tank 30 is maintained at a temperature only barely above freezing so that as it is applied to the ice scrapings on top of the cord it will provide a tamping and backfill action and will normally freeze soon after it is applied. Thus, the frozen backfill on top of the cord 34 will have the effect of causing the explosive force from the cord 34 to be directed downwardly and laterally instead of wasting part of the explosive force by simply blowing air out of the top of the trench 16.

After a suitable length, for example 1 mile of cord 34 is set in the trench, the explosive cord is detonated by conventional means to cause a rupture or crack in the ice to provide a zone of weakness downwardly and below the level of the trench. The depth of penetration of the crack or rupture will depend upon the strength of the explosive cord. Of course, if a strength greater than that normally commercially available is desired, several strands of the explosive cord 34 may be twisted together to form a larger cable prior to rolling on the reel 36.

Referring now to FIGS. 1 and 2, an ice drill 50 is provided carried by the hovercraft 12, preferably, in the plane of and behind the saw 14 which may be suitably powered by any of the auxiliary equipment and is used to drill holes in or adjacent the trench 16, as best seen in FIG. 4, such as at spaced positions 52 in the trench 16. Dynamite charges may be placed in the holes 52 and exploded either separately or in combination with the explosive cord 34. Preferably, the dynamite placed in the holes is in the form of conventional-shaped charges with the dynamite positioned in the holes 52 so that the explosive force is generated longitudinally along the trench whereby the combined effect of the explosive cord 34 shock waves and the shock waves created by the explosion of the dynamite in the holes 52 will increase the rupture or fracturing force to a force

level greater than the shock wave created by firing the Primacord 34 and dynamite separately. The dynamite in the holes 52 by being directed longitudinally along the trench 16 will create shock waves 54 which travel along the trench 16 to increase the fracturing effect on the ice.

As an alternative to the use of a shaped dynamite charge in the holes 52, an airblast may be used to create a shock blast in the holes 52. Referring now to FIG. 3, the drill may consist of an elongate pipe 56 having a suitable drill force 58 on the bottom thereof and having one or more openings 60 in the sidewall and/or, if desired, an opening 61 in the bottom. Seal means 62 such as a disk or thin cylinder for instance, of aluminum, which is replaceable, is, preferably, but not necessarily, inserted into the pipe 56 covering the openings 60. After drilling the holes 52 an air supply, such as from the air compressor of the auxiliary equipment 26 is introduced into the pipe 56 to increase the pressure therein. Upon a predetermined pressure, for example 300 to 1,000 p.s.i., the disk 62 will rupture causing a pressure wave to travel through the ice which will crack or rupture the ice. Preferably, the openings 60 are aligned with the longitudinal axis of the trench 16 causing the shock wave to travel up and down the trench helping to create a crack or zone of weakness along the trench. If the seal means 62 are omitted, a sufficient airblast may be transmitted to the pipe 56 to create shock waves through the openings 60 and/or 61.

One limitation of the hovercraft 12 is that there may be an ice ridge along the route of travel which would be too steep for the craft 12. By the use of the ice saw 46 and/or drill 50, and/or a separate drill mounted on extendable hydraulic arms to reach way out in front of the saw and the hovercraft, a path of travel for the craft 12 may be blasted through an ice ridge by using either explosive cord, dynamite charges or airblast. Additionally, an extendable drill 80 may be provided supported by extension arm 82 which in turn is pivotally connected to support 84. A cylinder and piston assembly 86 is connected to arm 82 for extending and retracting the arm 82 and drill 80. A cylinder and piston assembly 88 is connected between arm 82 and drill 80 for rotating the drill 80 for suitable drilling in an ice ridge. Preferably, the drill 80 is similar to that shown in FIG. 3, and is operated by an air motor 90 through an air line 92 which can also supply an airblast for blasting an ice ridge.

Still another operation that may be performed with the present apparatus 10 to create a zone of weakness in the ice is to blast a hole through the ice such as by using the drill 50 and dynamite charges through which a buoyant ferromagnetic fish 64 could be inserted under the icecap. A length of explosive cord would be attached to the end of the fish 64 and the fish could be motivated and/or directed or maneuvered under the ice by the hovercraft 12 flying over the surface of the ice by means of an electromagnet 68 creating electromagnetic field 70 as it flew along the desired path of flow causing the fish 64 to follow. The explosive cord could then be towed under the ice either under the trench 16 or under ice with no trench cut. The cord could also be embedded in or encased in some conventional type of flotation material so that it would be buoyant and float up against the underside of the bottom surface of the ice. When exploded, the Primacord would then cause a rupture or crack in the bottom of the ice. Additionally, dynamite charges 68 could be attached to the cord 66 that is being towed under the water to increase the rupture force. If desired, a dynamite charge could be attached a short distance, perhaps as little as 15 feet behind the fish 64 to rupture the ice all the way to the surface for access in recovering the fish 64 for reuse.

In use, one or more of the air cushion vehicles 12 could be used aboard the icebreaker to search out thin zones in the ice or zones where cracks have started to develop due to natural forces or reasons in order to provide the most desired path that the icebreaker would travel through the ice. In addition, the apparatus 10 could then create additional zones of weakness along the particular desired path of travel to make the

work of a standard icebreaker considerably more efficient. After being furnished with the proper supplies, the apparatus 10 would leave the icebreaker and proceed to a point ahead of the icebreaker in the desired direction of travel. Upon reaching the desired starting point, the hovercraft 12 would come to a stop at the starting point, the ice saw 14 would be lowered to the surface of the ice and started into rotation cutting a narrow trench 16 in the ice, for example, 2 or 3 feet or ore. The hovercraft 12 would then be started in forward motion cutting a trench 16 in the ice as it proceeded along the desired path of travel. The cuttings from the trench may be blown out, but preferably are sucked up by an ice suction hose 28 and deposited in a tank 30 where the ice shavings would be partially melted by the exhaust heat from the engines in the craft 12. Thus the trench 16 would be cleaned out leaving it in condition for placing the explosive cord 34 as deep in the trench as possible. The cord 34 would be reeled off of the reel 36 and pushed down into the bottom of the trench by the guide means 38. The ice scrapers 42 and 44 would scrape ice shavings from the top of the trench and onto the cord 34 to provide suitable backfill. Water from the water tank 30 would flow into the trench and would quickly freeze the ice scrapings on top of the cord 34 thereby providing a solid backfill. Thus, when the cord 34 was exploded the explosive force would be more effective in a downward and lateral direction. Obviously, one or more hovercrafts 12 could work simultaneously with one scouting the desired path of the icebreaker out ahead of the regular operation, locating the ice ridges, and blasting a way therethrough for another working craft 12.

Additionally, if desired, the ice drill 50 may be utilized to create an explosive force by means of dynamite charges or by air shock waves as described. Furthermore, and for the purpose of creating an additional or a separate explosive action if necessary on the ice, the buoyant fish 64 may be used to tow cord 66 on the undersurface of the ice which can be exploded, with or without additional dynamite charges 68, to create a force underneath the surface of the ice to weaken the ice to make a path of the icebreaker more easily accomplished.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein.

What is claimed is:

1. An apparatus for weakening ice for assisting an icebreaker comprising,

a self-powered vehicle for moving across the ice ahead of the icebreaker,

trench-cutting means carried by the vehicle for cutting a trench along the path of travel,

means carried by the vehicle for placing an explosive cord in the trench which can be exploded for weakening the ice, and

means carried by the vehicle for at least partially backfilling the trench after placement of the explosive cord,

wherein said means for backfilling includes,

means carried by the vehicle for the melting of the ice for use as backfill.

2. An apparatus for weakening ice for assisting an icebreaker comprising,

a self-powered vehicle for moving across the ice ahead of the icebreaker,

trench-cutting means carried by the vehicle for cutting a trench along the path of travel,

means carried by the vehicle for placing an explosive cord in the trench which can be exploded for weakening the ice, and

drilling means carried by the vehicle for drilling spaced holes near the trench for additional explosive charges.

3. The apparatus of claim 2 including,

an elongate pipe having at least one opening in the wall thereof for insertion into said spaced drilling holes, and air supply means carried by the vehicle connected to said pipe for building up pressure therein for creating an airblast therethrough.

4. The apparatus of claim 3 including,

sealing means normally closing said openings, but rupturing upon a predetermined pressure.

5. An apparatus for weakening ice for assisting an icebreaker comprising,

a self-powered vehicle for moving across the ice ahead of the icebreaker,

trench-cutting means carried by the vehicle for cutting a trench along the path of travel,

means carried by the vehicle for placing an explosive cord in the trench which can be exploded for weakening the ice, and

an extendable arm carried by the vehicle for extension in front of the vehicle, and

a drill carried by the drill for drilling holes for clearing barriers.

6. The apparatus of claim 5 wherein the drill is rotatable relative to the extendable arm.

7. An apparatus for weakening ice for assisting an icebreaker comprising,

a self-powered vehicle for moving across the ice ahead of the icebreaker,

trench-cutting means carried by the vehicle for cutting a trench along the path of travel,

means carried by the vehicle for placing an explosive cord in the trench which can be exploded for weakening the ice, and

a buoyant fish adapted to float under the ice,

a length of explosive cord connected to the fish, and

control means carried by the vehicle for controlling the direction of movement of the fish thereby towing the cord beneath the ice in the desired direction.

8. The apparatus of claim 7 wherein the cord is buoyant.

9. The apparatus of claim 7 including,

floating explosive dynamite charges connected along the cord.

10. An apparatus for weakening ice for assisting an icebreaker comprising,

a self-powered hovercraft for moving across the ice ahead of the icebreaker,

a rotary saw carried by the hovercraft for cutting a trench along the path of travel,

means carried by the vehicle for placing an explosive cord in the trench which can be exploded for weakening the ice, and

means for at least partially melting ice, and inserting the melted ice into the trench for backfill.

11. An apparatus for weakening ice for assisting an icebreaker comprising,

a self-powered hovercraft for moving across the ice ahead of the icebreaker,

a rotary saw carried by the hovercraft for cutting a trench along the path of travel,

means carried by the vehicle for placing an explosive cord in the trench which can be exploded for weakening the ice, and

drilling means carried by the hovercraft for drilling holes near the trench for receiving additional explosive charges.

12. The apparatus of claim 11 wherein the drilling means includes

an elongate pipe for insertion into the spaced drilling holes and having openings in the wall thereof adapted to be aligned with the trench, and

air supply means carried by the hovercraft and connected to said pipe for building up pressure therein for creating an airblast therethrough.

13. The apparatus of claim 12 including,

sealing means normally closing said openings, but rupturing upon a predetermined pressure.

14. An apparatus for weakening ice for assisting an icebreaker comprising,

a self-powered hovercraft for moving across the ice ahead of the icebreaker,

a rotary saw carried by the hovercraft for cutting a trench along the path of travel,

- means carried by the vehicle for placing an explosive cord in the trench which can be exploded for weakening the ice, and a buoyant fish adapted to float under the ice, a length of explosive cord connected to the fish, control means carried by the vehicle for controlling the direction of movement of the fish thereby towing the cord beneath the ice in the desired direction.
15. The method of weakening ice for assisting an icebreaker comprising,
- cutting a trench in the ice in front of and along the proposed path of travel of the icebreaker,
- placing an explosive cord in the trench,
- exploding the cord, and
- backfilling the trench with partially melted ice after placing the cord in the trench and waiting until the backfill freezes before exploding the cord.
16. The method of weakening ice for assisting an icebreaker comprising,
- cutting a trench in the ice in front of and along the proposed path of travel of the icebreaker,
- placing an explosive cord in the trench,
- exploding the cord, and
- drilling spaced holes along the trench,
- placing dynamite charges in the drilled holes,
- exploding the dynamite charges.
17. The method of claim 16 wherein the charges are directional exploding charges, and positioning the charges in the drilled holes to direct the explosion longitudinally along the trench.
18. The method of claim 16 including, drilling spaced holes along the trench, creating a directional airblast in the drilled holes along the longitudinal axis of the trench.
19. The method of weakening ice for assisting an icebreaker comprising,
- cutting a trench in the ice in front of and along the proposed path of travel of the icebreaker,
- placing an explosive cord in the trench,
- exploding the cord, and
- placing a buoyant fish under the ice,
- attaching a length of explosive cord to the fish,
- moving the fish in the desired direction, and
- exploding the cord to weaken the ice.
20. The method of weakening ice for assisting an icebreaker comprising,
- placing a buoyant fish under the ice,
- attaching a length of explosive cord to the fish, and
- exploding the cord.
21. The method of claim 20 including, controlling the fish from an air cushion vehicle traveling over the ice.
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