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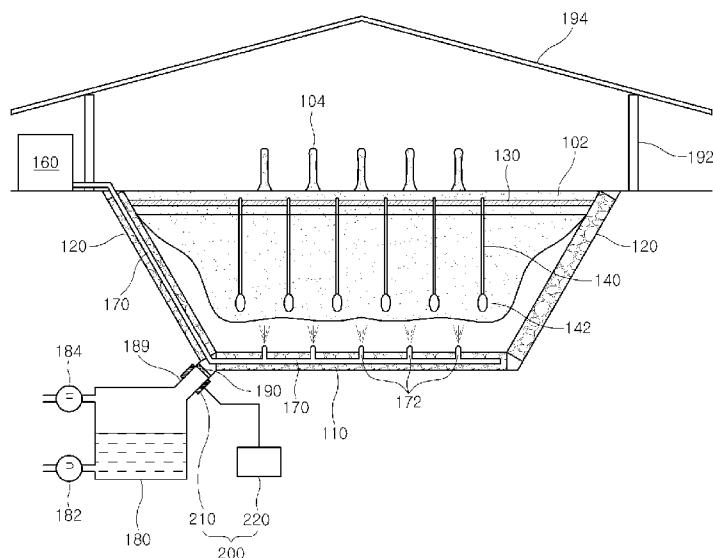
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(54) Title: APPARATUS AND METHOD FOR UNDERWATER PRODUCTION AND STORAGE OF ICE IN A RESERVOIR

[Fig. 1]



(57) **Abstract:** The invention presents an apparatus for producing ice from the water of a reservoir using the cold air of the winter season and storing the ice for a long duration of time extending into the summer season. The cold water and cold air obtained during thawing may be used for raising and storing crops. The apparatus can include a compressor (160) for compressing sub-zero cold air; a support panel (110, 120) installed on the floor and slopes of the reservoir; a transport tube (170), which is installed through the floor support panel (110) and connected with the compressor (160), for transporting the compressed cold air; a nozzle connected with the transport tube (170) for spraying the sub-zero compressed cold air into the water to produce ice; a water collector (180) for collecting the cold water and cold air created during thawing; and a discharge unit (182, 184) for discharging the cold water and cold air collected in the water collector (180).

Description

Title of Invention: APPARATUS AND METHOD FOR UNDERWATER PRODUCTION AND STORAGE OF ICE IN A RESERVOIR

Technical Field

- [1] The present invention relates to an apparatus and a method for the underwater production and storage of ice in a reservoir. More particularly, the invention relates to an apparatus and a method for producing ice from the water of a reservoir using the sub-zero cold air of the winter season and storing the ice for a long duration of time extending into the summer season. In particular, the cold water and cold air obtained during thawing may be used for raising and storing crops, while protecting water quality and maintaining an adequate water supply.

Background Art

- [2] A reservoir is an artificial facility that stores runoff and regulates the water level in response to water surpluses and water shortages, and is an important source of surface water in cases where a sufficient amount of water cannot be obtained from rivers. Reservoirs may vary in size, ranging from a small pool to a large-scale dam.
- [3] In spring, when there is a demand for both drinking water and agricultural water, a draught can be devastating to crops and can cause inconvenience to many people, who will experience a lack of household water. These situations occur every year, albeit in varying degrees.
- [4] To resolve this problem requires reserving a sufficient amount of water in reservoirs, for example by building more reservoirs or increasing the size of existing reservoirs.
- [5] However, building a new reservoir requires much time and high costs; the costs reaching astronomical numbers when building a large-scale reservoir. In addition, building a new reservoir requires careful consideration of various issues large and small, such as the effect on the surrounding environment, as well as compensation issues, damage to the scenery, possible destruction of cultural assets, etc. Such issues aside, it is inefficient to build a larger number of reservoirs in the limited area of domestic territory, and there is a limit to finding suitable sites for constructing reservoirs.
- [6] Even if the number of reservoirs were increased, the amount of water reserved in the reservoir will continuously decrease, due to the enormous amounts of water evaporated during the dry season in winter or spring, in which there is little rain and much evaporation. Because of this, reservoirs are emptied before the rainy season almost every year, and this is a problem that cannot be solved simply by increasing the

number of reservoirs or building larger dams.

[7] As a result, the limited quantity of the reservoirs may not be able to provide a sufficient amount of water in the dry season of early spring, so that the problem of shortages in agricultural and household water caused by draughts may not be resolved. Also, the rise in water temperature during the summer season can cause phytoplanktons to flourish, causing problems of pollution, etc., in the water reserve.

[8] To resolve the problems above, the patent A METHOD FOR ICE KEEPING IN RESERVOIR (Korean Reg. Pat. No. 10-829825) has previously been filed by the applicant. However, the method described in the above patent may require much energy and high cost during the process of drawing water above the water level and spraying the water for producing ice. Also, the features of the patent are mainly directed towards preventing ice evaporation and preventing water pollution, so that there is room for consideration regarding strategies for effectively utilizing the cold water and cold air obtained during thawing. In particular, there is a need for an improved means of storing the produced ice for long periods of time, as well as for an improved means of utilizing the cold water and cold air obtained during thawing.

Disclosure of Invention

Technical Problem

[9] To resolve the problems described above, an aspect of the invention aims to provide an apparatus and a method for producing and storing ice underwater in a reservoir that utilize the sub-zero cold air of the winter season to produce ice from the water of the reservoir and store the ice for a long duration of time, so that the cold water and cold air obtained during thawing in the summer season may be used for cooling and refrigeration, while at the same time protecting water quality and maintaining an adequate water supply.

Solution to Problem

[10] To achieve the above objectives, an aspect of the invention provides an apparatus for producing and storing ice underwater in a reservoir that includes: a compressor for compressing sub-zero cold air; a support panel installed on the floor and slopes of the reservoir; a transport tube, which is installed through the floor support panel and connected with the compressor, for transporting the compressed cold air; a nozzle connected with the transport tube for spraying the sub-zero compressed cold air into the water to produce ice; a water collector for collecting the cold water and cold air created during thawing; and a discharge unit for discharging the cold water and cold air collected in the water collector.

[11] Another aspect of the invention provides an apparatus for producing and storing ice underwater in a reservoir that includes: a compressor for compressing sub-zero cold

air; a support panel installed on the floor and slopes of the reservoir; a transport tube, which is installed horizontally at a particular height of the reservoir and connected with the compressor, for transporting the compressed cold air; a nozzle connected with the transport tube for spraying the sub-zero compressed cold air into the water to produce ice; a water collector for collecting the cold water and cold air created during thawing; and a discharge unit for discharging the cold water and cold air collected in the water collector.

- [12] Certain embodiments of the invention may include one or more of the following features.
- [13] For example, the apparatus can further include a delaying unit for delaying the thawing of the ice produced.
- [14] From among the support panels, those slope support panels that are opposite each other can be connected with a buoyant rod. Here, a buoyant rope or a buoyant net can be installed, which may have one end secured to the buoyant rod and the other end positioned in the water. A weight can be installed on a lower part of the buoyant rope or buoyant net.
- [15] A thawing unit can be installed on a conduit that connects the water collector and the reservoir. In this case, a valve can be installed on the conduit connecting the water collector and the reservoir.
- [16] A support panel can be a gabion that includes fillers contained in a steel mesh, where fillers can include mineral substances.
- [17] Also, the delaying unit can include a windbreak fence, which may be installed around a perimeter of the reservoir, and a sunshade, which may be installed over the reservoir.
- [18] Yet another aspect of the invention provides a method for producing and storing ice underwater in a reservoir. The method includes: installing support panels on the floor and slopes of the reservoir; installing a buoyant rod that connects two or more opposing slope support panels from among the support panels; compressing sub-zero cold air; transporting the sub-zero compressed cold air; and spraying the transported sub-zero compressed cold air into the water. In certain embodiments, the method can include delaying the thawing of the produced ice by using a delaying unit, and the method can further include: thawing the produced ice by supplying warm air to a lower part of the ice; and storing and utilizing cold water and cold air created during the thawing. The sub-zero compressed cold air can be made into microbubbles for spraying, and the amount of dissolved oxygen can be increased.
- [19] By installing a buoyant rope or a buoyant net on the buoyant rod, the ice can be prevented from falling when the ice is thawed, so that a space may be formed between the ice and the ground surface that serves as a channel for the cold water. Also, mineral

fillers can be filled in the support panels to supply minerals to the water.

[20]

[21] The sub-zero compressed cold air can be sprayed upwards from the reservoir floor to form icicles that stand on the surface of the ice. Additional aspects and advantages of the present invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention.

Advantageous Effects of Invention

[22]

As set forth above, an apparatus and a method for producing and storing ice underwater in a reservoir according to certain embodiments of the invention can be utilized to produce ice from the water of the reservoir using the sub-zero cold air of the winter season and store the ice for a long duration of time, after which the cold water and cold air obtained during thawing in the summer season may be used for cooling and refrigeration.

[23]

Also, certain embodiments of the invention can be utilized to prevent eutrophication in the water stored in the reservoir and purify the water, during the procedures of producing and thawing ice, to produce natural water having a high amount of dissolved oxygen and a high mineral content.

[24]

Moreover, the water temperature of the reservoir in summer can be lowered, to minimize water loss caused by evaporation and to protect water quality by suppressing the development of phyto-planktons.

[25]

Furthermore, the effect of volumetric expansion in the ice produced underwater in the reservoir can create upright icicles (in other word, ice spike), concentrated around the vent holes formed in the surface. The upright icicles can be utilized for aesthetic and educational purposes.

Brief Description of Drawings

[26]

Figure 1 is a schematic drawing of an apparatus for producing and storing ice underwater in a reservoir according to an embodiment of the invention.

[27]

Figure 2 is a perspective view of a support panel in an apparatus for producing and storing ice underwater in a reservoir according to an embodiment of the invention.

[28]

Figure 3 is a schematic drawing of an apparatus for producing and storing ice underwater in a reservoir according to another embodiment of the invention.

[29]

Figure 4 is a flowchart of a method for producing and storing ice underwater in a reservoir according to an embodiment of the invention.

[30]

Mode for the Invention

[31]

Certain embodiments of the present invention will be described below in more detail

with reference to the accompanying drawings. In describing the embodiments of the invention, and in rendering reference numerals to the elements represented in the drawings, like numerals refer to like elements throughout, regardless of the figure number.

- [32] Figure 1 is a schematic drawing of an apparatus for producing and storing ice underwater in a reservoir according to an embodiment of the invention, and Figure 2 is a perspective view of a support panel in an apparatus for producing and storing ice underwater in a reservoir according to an embodiment of the invention. Figure 3 is a schematic drawing of an apparatus for producing and storing ice underwater in a reservoir according to another embodiment of the invention.
- [33] As illustrated in Figure 1, support panels 110, 120 may be installed on the floor and the slopes of the reservoir. Those installed on the floor will be referred to as floor support panels 110, while those installed on the slopes will be referred to as slope support panels 120. These support panels 110, 120 may serve to prevent the ice produced in the reservoir during the winter season from touching the ground surface and being thawed by geothermal energy.
- [34] The structure of the support panels 110, 120 will be described as follows with reference to Figure 2. The structures of the floor support panels 110 and the slope support panels 120 can be substantially the same; therefore, the following descriptions will be provided using a floor support panel 110 as an example.
- [35] As illustrated in Figure 2, a support panel 110 can be structured as a gabion that has a filler 114 contained inside a steel mesh 112. It can be advantageous to use a mineral substance for the filler 114, so as to supply minerals to the water stored in the reservoir (i.e. the water before freezing) and to the thawed water flowing to the water collector 180, which will be described later in more detail. The filler can be made from a substance that provides a high insulation effect.
- [36] Among the support panels 110, 120 structured in this way, certain slope support panels 120 positioned opposite each other can be connected by buoyant rods 130. The buoyant rods 130 may serve to separate the produced ice from the support panels 110, 120, especially the floor support panels 110. By forming a space between the ice and the support panels 110, the buoyant rods 130 can cause the water created during thawing to be separated from the ice immediately, and thereby delay the thawing time, so that the ice produced in the winter season may continue frozen into the summer season.
- [37] A multiple number of buoyant ropes 140 can be installed on one buoyant rod 130, so that the heavy mass of the ice may be suspended on the buoyant rods 130 more easily. Weights 142 may be installed on the lower parts of the buoyant ropes 140 to prevent the buoyant ropes 140 from rising to the water surface or being swept by water

currents before the ice is formed.

- [38] A compressor 160 can be installed on one side of the reservoir, in which the support panels 110, 120, buoyant rods 130, and buoyant ropes 140 are installed as described above. The compressor 160 may compress the sub-zero winter air to enable ice production while maximizing the amount of dissolved oxygen in the water stored in the reservoir. Here, it can be advantageous to install the compressor 160 on the shore, as in the illustrated example of this embodiment, for easier repair and maintenance.
- [39] A transport tube 170, through which the sub-zero cold air compressed by the compressor 160 (hereinafter referred to as compressed cold air) can be transported, may be installed penetrating through the support panels 110, 120 installed on the floor and slopes of the reservoir. The transport tube 170 may branch out evenly over the entire floor of the reservoir and may include nozzles 172 at the ends to freeze the water stored in the reservoir by spraying the compressed cold air into the water. Also, if a microbubble generator (not shown) is added within the compressor 160 or along the transport tube 170, the compressed cold air sprayed by the nozzles 172 can be sprayed as microbubbles.
- [40] If the compressed cold air is sprayed as microbubbles using a microbubble generator, the amount of compressed cold air sprayed may be decreased, compared to direct spraying, but the amount of dissolved oxygen in the water before freezing can be increased. On the other hand, direct spraying, without the use of a microbubble generator can increase the amount of compressed cold air sprayed, to facilitate ice production. As such, the decision on whether or not to use the microbubble generator may vary according to the ice-producing environment and the requirements of the user.
- [41] On one side of the reservoir, a water collector 180 may be prepared in which the cold water and cold air created during thawing may be gathered. The water collector 180 may be equipped with a discharge unit 182, 184 for discharging the stored cold water and cold air to the exterior. For example, a pump 182 may be included to discharge the cold water, and a fan 184 may be included to discharge the cold air.
- [42] On a conduit 189 connecting the water collector 180 with the reservoir, a thawing unit 200 may be installed. The thawing unit 200 can include a heating pad 210 that surrounds the conduit 189 and a heater 220 that generates heat, where the heat generated by the heater 220 may be supplied to the heating pad 210 to melt ice in the conduit 189. Also, a valve 196 may be installed on the conduit 189 to regulate the flow of water to the water collector 180. The valve 196 may be such that can withstand the water pressure of the reservoir during the initial stages of ice production and may be made from a material that is resistant to the heat transferred through the thawing unit 200 during thawing.
- [43] By using this thawing unit 200, the ice in the conduit 189 can be melted, allowing the

cold water at the bottom of the reservoir to be discharged towards the water collector 180. Also, as warm air is supplied to the bottom of the reservoir by way of the fan 184 or the transport tube 170, the ice of the reservoir can be thawed, beginning from the lower part of the ice. The cold water created as the ice melts may be discharged to the water collector 180, to prevent the ice from being immersed in the water and thus thawing more quickly, so that the ice produced in winter may continue frozen into the summer. Also, since the insides of the water collector 180 and the reservoir are always filled with cold air, letting the cold air out as little as possible can help store the ice for a long duration of time.

[44] Furthermore, delaying units 192, 194 may be provided to delay the thawing of ice produced during the winter season. The delaying units 192, 194 can include one or more windbreak fences 192 installed around the perimeter the reservoir, and one or more sunshades 194 installed over the reservoir. The sunshade 194 may serve not only to block solar radiation but also to prevent rainwater, etc., from falling directly on the ice surface. It can be advantageous to use a retractable structure, so that the ice may be subjected to ultraviolet rays as necessary, for example, for disinfection purposes.

[45] Figure 3 is a schematic drawing of an apparatus for producing and storing ice underwater in a reservoir according to another embodiment of the invention. The following will describe another embodiment of the present invention, with reference to Figure 3.

[46] As illustrated in Figure 3, support panels 110, 120 may be installed on the floor and the slopes of the reservoir. Those installed on the floor will be referred to as floor support panels 110, while those installed on the slopes will be referred to as slope support panels 120. These support panels 110, 120 may serve to prevent the ice produced in the reservoir during the winter season from touching the ground surface and being thawed by geothermal energy.

[47] As illustrated in Figure 2, a support panel 110, 120 can be structured as a gabion, in which a filler 114 is contained inside a steel mesh 112. It can be advantageous to use a mineral substance for the filler 114, so as to supply minerals to the water stored in the reservoir (i.e. the water before freezing) and to the thawed water flowing to the water collector 180.

[48] Among these support panels 110, 120, certain slope support panels 120 positioned opposite each other can be connected by buoyant rods 130. The buoyant rods 130 may serve to separate the produced ice from the support panels 110, 120, especially the floor support panels 110. By forming a space between the ice and the support panels 110, the buoyant rods 130 can cause the water created during thawing to be separated from the ice immediately, and thereby delay the thawing time, so that the ice produced in the winter season may continue frozen into the summer season.

- [49] A buoyant net 150 can be installed on each buoyant rod 130, and weights 152 can be installed on the lower parts of the buoyant net 150 to prevent the buoyant net 150 from rising to the surface of the water or being swept by water currents before the ice is formed.
- [50] A compressor 160 can be installed on one side of the reservoir, in which the support panels 110, 120, buoyant rods 130, and buoyant net 150 are installed. The compressor 160 may compress the sub-zero winter air to enable ice production while maximizing the amount of dissolved oxygen in the water stored in the reservoir. Here, it can be advantageous to install the compressor 160 on the shore, as in the illustrated example of this embodiment, for easier repair and maintenance.
- [51] A transport tube 170, through which the sub-zero cold air compressed by the compressor 160 (referred to as compressed cold air) can be transported, may be installed parallel to the buoyant rods 130, and nozzles 172 may be formed along the transport tube 170 in certain intervals.
- [52] On one side of the reservoir, a water collector 180 may be provided in which the cold water and cold air created during thawing may be gathered. The water collector 180 may be equipped with a discharge unit 182, 184 for discharging the stored cold water and cold air to the exterior. For example, a pump 182 may be included to discharge the cold water, and a fan 184 may be included to discharge the cold air.
- [53] On a conduit 189 connecting the water collector 180 with the reservoir, a thawing unit 200 may be installed. The thawing unit 200 can include a heating pad 210 that surrounds the conduit 189 and a heater 220 that generates heat, and the heat generated by the heater 220 may be supplied to the heating pad 210 to melt ice in the conduit 189.
- [54] Also, a valve 196 may be installed on the conduit 189 to regulate the flow of water to the water collector 180. The valve 196 may be such that can withstand the water pressure of the reservoir during the initial stages of ice production and may be made from a material that is resistant to the heat transferred through the thawing unit 200 during thawing.
- [55] In addition, the water collector 180 can be connected to the exterior by way of an air vent 186, through which unnecessary warm air created in the water collector may be discharged, preventing any increases in temperature in the cold water and cold air stored in the water collector 180.
- [56] A damper 188 can be prepared in an upper portion inside the water collector 180, to prevent an inflow of warm air through the air vent 186 during the summer season or to prevent a backflow of warm air from within the water collector towards the reservoir. In this way, the ice produced in the winter season can be kept frozen into the summer season.

- [57] For the purpose of delaying the thawing of ice produced in the winter season, delaying units 192, 194 may be provided, which may include one or more windbreak fences 192 installed around the perimeter the reservoir, and one or more sunshades 194 installed over the reservoir. The sunshade 194 may serve not only to block solar radiation but also to prevent rainwater, etc., from falling directly on the ice surface. It can be advantageous to use a retractable structure, so that the ice may be subjected to ultraviolet rays as necessary, for example, for disinfection purposes.
- [58] The embodiment of the invention described above makes it possible to omit the support panels 110, 120 or simplify the structure of the support panels 110, 120 according to the requirements of the user.
- [59] Figure 4 is a flowchart of a method for producing and storing ice underwater in a reservoir according to an embodiment of the invention.
- [60] With reference to Figure 1 and Figure 4, the following will describe a method for producing and storing ice underwater in a reservoir using an apparatus according to an embodiment of the invention described above.
- [61] The method can include installing support panels 110, 120 on the floor and slopes of the reservoir (S10), installing buoyant rods 130 that connect opposing slope support panels 120 (S20), compressing sub-zero cold air (S30), transporting the sub-zero compressed cold air (S40), spraying the transported sub-zero compressed cold air into the water (S50), delaying the thawing of the ice produced (S60), thawing the ice by supplying warm air (S70), and storing and utilizing the cold water and cold air created during thawing (S80).
- [62] Each operation will be described below in more detail.
- [63] First, the installing of the support panels 110, 120 on the floor and slopes of the reservoir may be preceded by the fabrication of the support panels 110, 120. As already described above, the support panels 110, 120 can be structured as gabions (see Figure 2), each composed of a steel mesh 112 and a filler 114 contained inside the steel mesh 112.
- [64] As the support panels 110, 120 thus structured are installed on the floor and the slopes of the reservoir, the ice produced in the reservoir in winter can be kept from directly contacting the ground surface and therefore can be prevented from being thawed by geothermal energy. Also, if a mineral substance is used for the filler 114 contained in the steel mesh 112, it is possible to supply minerals to the water stored in the reservoir (i.e. the water before freezing) and the thawed water flowing to the water collector 180. Of course, according to another embodiment of the invention, the support panels 110, 120 can be omitted or installed as simpler structures.
- [65] When the fabrication of these support panels 110, 120 is complete, the support panels 110, 120 may be installed on the floor and slopes of the reservoir, and buoyant rods

130 may be installed that connect certain slope support panels 120 positioned opposite each other.

[66] The buoyant rod 130 may separate the produced ice from the floor support panels 110, to form a space between the ice and the floor support panels 110. Thus, by preventing the ice from being immersed in the water created during thawing, the thawing time can be delayed, and the ice produced in the winter season may continue frozen into the summer season.

[67] The heavy mass of the ice can be secured more easily if buoyant ropes 140 (Figure 1) or buoyant nets 150 (Figure 3) are installed on the buoyant rods 130. That is, the buoyant ropes 140 and buoyant nets 150 may prevent the ice from falling and may increase the contact area between ice pieces, so that the bonding between the ice pieces may be improved, and the ice may be secured more easily.

[68] The buoyant ropes 140 or buoyant nets 150 may be of a light weight and therefore may rise to the surface of the water or may be swept by water currents, but this problem may readily be solved by installing weights 142, 152 onto the lower parts.

[69] After the support panels 110, 120, buoyant rods 130, and buoyant ropes 140 or buoyant nets 150 are installed, the sub-zero cold air of the winter season may be compressed by a particular amount of pressure using the compressor 160.

[70] By spraying the cold air compressed by a compressor 160 as described above, the water stored in the reservoir may be frozen with an increased amount of dissolved oxygen. While obtaining cold air may be a simple matter in regions that have sub-zero climates in winter, this may not be the case in regions that do not often have sub-zero temperatures. In such regions, ice production may require additionally installing a freezer.

[71] The compressed cold air may be sprayed through the transport tube 170 and nozzles 172 into the water of the reservoir. If a microbubble generator (not shown) is provided in the compressor 160 or on the transport tube 170, microbubbles can be sprayed into the water to maximize the amount of dissolved oxygen in the water and also to reduce freezing time.

[72] The freezing time can further be reduced by drawing water from below the layer of ice 102 formed on the water surface and discharging the water to the outside. This method has been described in the patent A METHOD FOR ICE KEEPING IN RESERVOIR (Korean Reg. Pat. No. 10-829825) invented by the applicant.

[73] As in the embodiment of the invention illustrated in Figure 3, it is also possible to install the transport tube 170 parallel to the buoyant rods 130 and produce ice by spraying compressed cold air through nozzles 172 formed in certain intervals on the transport tube 170.

[74] A suitable apparatus and method for producing and storing ice can be selected

according to circumstances from among the various apparatuses and methods described above.

- [75] In the layer of ice 102 formed on the surface of the reservoir, a vent hole (not shown) may be formed to discharge the compressed cold air sprayed for freezing the water. When the compressed cold air is discharged through the vent hole, water may be discharged as well, due to the volumetric expansion of the ice. The water discharged through the vent hole may freeze in the sub-zero atmosphere and may undergo volumetric expansion to form upright icicles 104.
- [76] An upright icicle 104 refers to a column of ice that rises upward, similar to a stalagmite in a limestone cave. The upright icicle 104 may form more easily when the water temperature and ambient temperature are near the freezing point, and when the air is dry such that there is a greater amount of water evaporation. Thus, by creating such an environment, a large number of upright icicles 104 can be formed, which may then be used for educational and aesthetic purposes and even as a tourist attraction.
- [77] After a sufficient amount of ice is obtained, a gap can be formed between the ice and the support panels 110, 120 by melting the bottom of the ice first or by removing the water remaining under the ice. The cold air accumulated in the gap may serve as insulation. The water removed from under the ice or additional water can be sprayed over the ice to make the ice thicker, as disclosed in the patent A METHOD FOR ICE KEEPING IN RESERVOIR (Korean Reg. Pat. No. 10-829825).
- [78] If cold air is continuously supplied even after the water of the reservoir is frozen, gaps may occur between the slope support panels 120 and the ice. These gaps may serve as passages through which the cold air sprayed through the nozzles 172 may be discharged to the outside. Thus, it is possible to further solidify the ice by continuing to inject sub-zero cold air after forming gaps between the slope support panels 120 and the ice, after the water of the reservoir is frozen.
- [79] When the ambient temperature is above 0 C, the flow of warm air through the transport tube 170, etc., can be stopped, to prevent any unnecessary increases in temperature in the ice. On the contrary, the ice can be thawed more quickly by passing warm air through the transport tube 170.
- [80] If the water of the reservoir is completely frozen and the gaps are blocked, so that it is difficult to inject the compressed air, it is possible to simply wait for portions of the ice to melt and form gaps in the ice, when the temperature becomes warmer, or to inject compressed air between the slope support panels 120 and the ice to form gaps in-between. These gaps may also serve as passages for the cold water created during thawing.
- [81] The ice produced in the winter through the procedures described above may naturally thaw in the summer. To delay the thawing time, windbreak fences 192 can be installed

around the perimeter of the reservoir, or sunshades 194 can be installed over the reservoir. The sunshades 194 may be installed to prevent contact with rainwater or solar energy, and the windbreak fences 192 may be installed to prevent contact with wind so that the accumulated cold air may not be lost.

[82] Afterwards, in cases where cold water and cold air are obtained by thawing the produced ice as required, but the conduit 189 connecting the water collector 180 with the reservoir is frozen, a pre-installed thawing unit 200 can be used to thaw the frozen conduit 189. That is, the heat generated by a heater 220 can be supplied to a heating pad 210 to melt the ice in the conduit 189. The heat may be applied until the valve 196 and the conduit 189 are opened, and as such, the valve 196 and the conduit 189 can be made from a material resistant to heat, in case such heating is necessary.

[83] When a thawing unit 200 is used, the cold water at the bottom of the reservoir that is gathered as the ice in the conduit 189 is melted can be discharged to the water collector 180 (If warm air is supplied to the bottom of the reservoir using a fan 184 and/or the transport tube 170, the ice of the reservoir can also be thawed at the lower part of the ice.). In this way, the ice can be prevented from being immersed in water and thus can be prevented from thawing quickly, so that the ice produced in the winter season may continue frozen into the summer season.

[84] Finally, the cold water and cold air created during thawing may be stored in the water collector 180 provided on one side of the reservoir, and the cold water and cold air stored in the water collector 180 may be discharged to the outside by way of a discharge unit 182, 184 such as a pump 182 and a fan 184.

[85] The cold water discharged in this manner can lower the temperature of the water downstream and suppress evaporation, providing an effect of conserving the water resources. The cold water can also greatly suppress the development of planktons and can thus prevent water pollution caused by algae. Moreover, the cold water and cold air can be utilized in preserving grains, vegetables, fruits, etc., for long periods of time, as well as in growing crops that only survive at low temperatures. Thus, the energy consumed in growing and storing crops can be dramatically reduced, and the amount of carbon dioxide generation can be reduced.

[86] For example, if the cold air is utilized in storing rice, the quality of the rice can be preserved in a reliable manner, and the taste of fresh rice can be preserved for several years. The cold water and cold wind can also be utilized to grow high-quality mushrooms. Furthermore, the cold water can be utilized not only for growing and storing crops but also for farming cold-water fish that only live in areas where the yearly average temperature is 15 - 16 C or lower.

[87] While the present invention has been described with reference to particular embodiments, the embodiments are merely for illustrating the spirit of the invention.

Those skilled in the art will understand that numerous variations can be conceived without departing from the scope and spirit of the invention. Therefore, the scope of the invention is to be defined by the appended claims rather than by the foregoing description. All variations coming within the meaning and range of equivalency of the claims are embraced within their scope.

Claims

- [Claim 1] An apparatus for producing and storing ice underwater in a reservoir, the apparatus comprising:
a compressor configured to compress sub-zero cold air;
a support panel installed on a floor and slopes of the reservoir;
a transport tube installed through the floor support panel and connected with the compressor, the transport tube configured to transport compressed cold air;
a nozzle connected with the transport tube, the nozzle configured to produce ice by spraying sub-zero compressed cold air into the water;
a water collector configured to collect cold water and cold air created during thawing; and
a discharge unit configured to discharge the cold water and the cold air collected in the water collector.
- [Claim 2] The apparatus of claim 1, further comprising:
a delaying unit configured to delay the thawing of the ice produced.
- [Claim 3] The apparatus of claim 2, further comprising:
a buoyant rod connecting two or more opposing slope support panels from among the support panels.
- [Claim 4] The apparatus of claim 3, further comprising:
a buoyant rope secured to the buoyant rod and positioned in the water.
- [Claim 5] The apparatus of claim 3, further comprising:
a buoyant net secured to the buoyant rod and positioned in the water.
- [Claim 6] The apparatus according to either claim 4 or claim 5, wherein a weight is installed on a lower part of the buoyant rope or the buoyant net.
- [Claim 7] The apparatus of claim 2, wherein a thawing unit is installed on a conduit connecting the water collector and the reservoir.
- [Claim 8] The apparatus of claim 7, wherein a valve is installed on the conduit connecting the water collector and the reservoir.
- [Claim 9] The apparatus of claim 2, wherein the support panel is a gabion having fillers contained in steel mesh, the filler comprising mineral substances.
- [Claim 10] The apparatus of claim 2, wherein the delaying unit comprises a windbreak fence and a sunshade, the windbreak fence installed around a perimeter of the reservoir, and the sunshade installed over the reservoir.
- [Claim 11] An apparatus for producing and storing ice underwater in a reservoir, the apparatus comprising:

a compressor configured to compress sub-zero cold air;
a support panel installed on a floor and slopes of the reservoir;
a transport tube installed horizontally at a particular height of the reservoir and connected with the compressor, the transport tube configured to transport compressed cold air;
a nozzle connected with the transport tube, the nozzle configured to produce ice by spraying sub-zero compressed cold air into the water;
a water collector configured to collect cold water and cold air created during thawing; and
a discharge unit configured to discharge the cold water and the cold air collected in the water collector.

[Claim 12] The apparatus of claim 11, further comprising:

a delaying unit configured to delay the thawing of the ice produced.

[Claim 13] The apparatus of claim 12, further comprising:

a buoyant rod connecting two or more opposing slope support panels from among the support panels.

[Claim 14] The apparatus of claim 13, further comprising:

a buoyant rope secured to the buoyant rod and positioned in the water.

[Claim 15] The apparatus of claim 13, further comprising:

a buoyant net secured to the buoyant rod and positioned in the water.

[Claim 16] The apparatus according to either claim 14 or claim 15, wherein a weight is installed on a lower part of the buoyant rope or the buoyant net.

[Claim 17] The apparatus of claim 12, wherein a thawing unit is installed on a conduit connecting the water collector and the reservoir.

[Claim 18] The apparatus of claim 17, wherein a valve is installed on the conduit connecting the water collector and the reservoir.

[Claim 19] The apparatus of claim 12, wherein the support panel is a gabion having fillers contained in steel mesh, the filler comprising mineral substances.

[Claim 20] The apparatus of claim 12, wherein the delaying unit comprises a windbreak fence and a sunshade, the windbreak fence installed around a perimeter of the reservoir, and the sunshade installed over the reservoir.

[Claim 21] A method for producing and storing ice underwater in a reservoir, the method comprising:
installing support panels on a floor and slopes of the reservoir;
installing a buoyant rod connecting two or more opposing slope support

panels from among the support panels;
compressing sub-zero cold air;
transporting the sub-zero compressed cold air; and
spraying the transported sub-zero compressed cold air into the water.

[Claim 22] The method of claim 21, further comprising:
delaying a thawing of produced ice by using a delaying unit.

[Claim 23] The method of claim 22, further comprising:
thawing the produced ice by supplying warm air to a lower part of the
ice; and storing and utilizing cold water and cold air created during the
thawing.

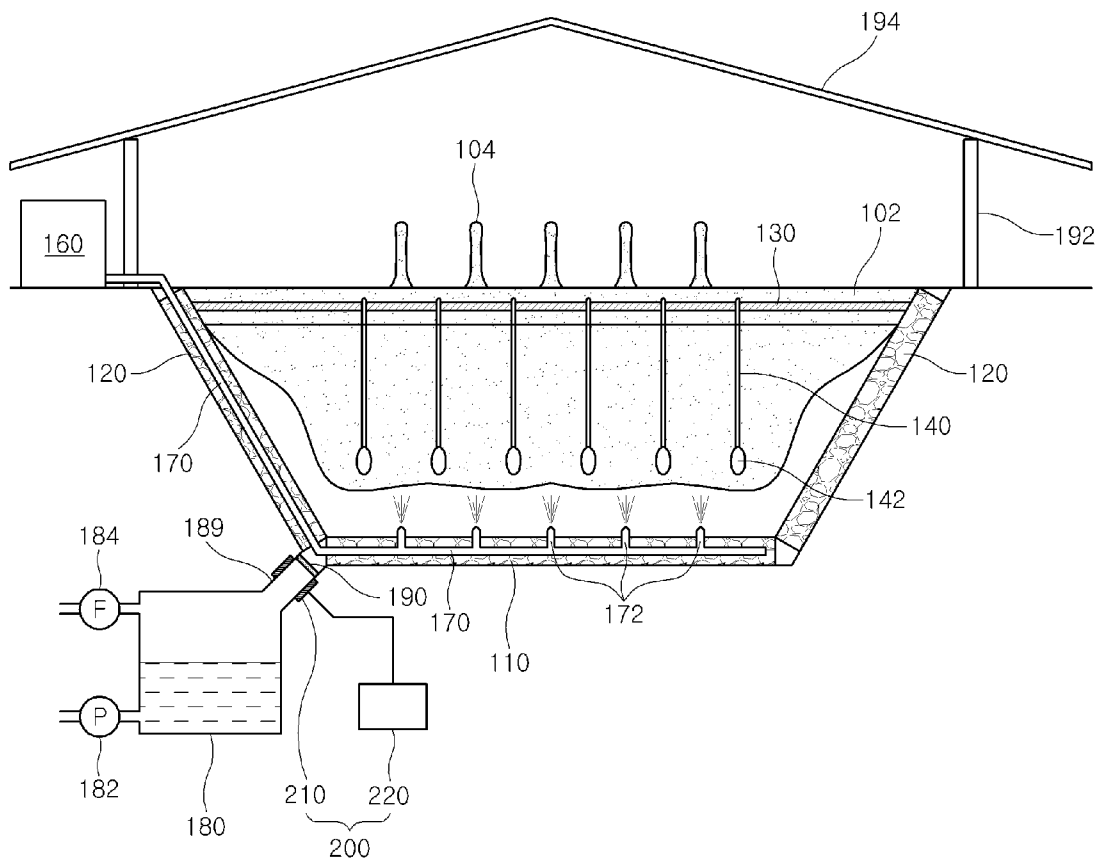
[Claim 24] The method of claim 23, wherein the sub-zero compressed cold air is
sprayed as microbubbles.

[Claim 25] The method of claim 23, wherein a buoyant rope or a buoyant net is
installed on the buoyant rod such that a space is formed between the ice
and a ground surface during the thawing.

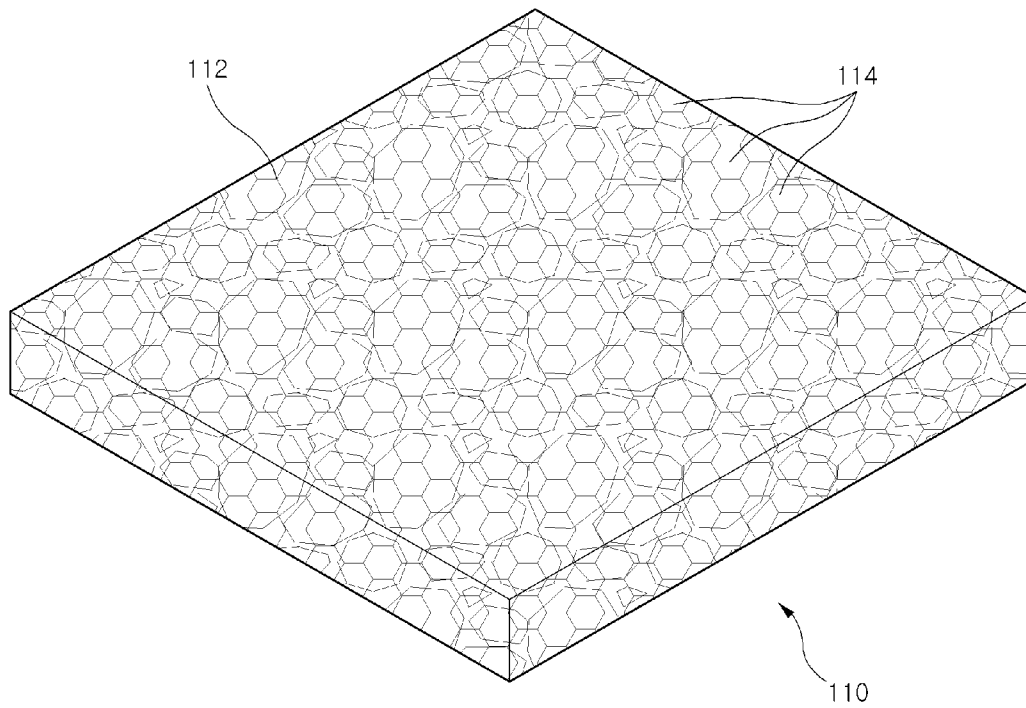
[Claim 26] The method of claim 23, wherein mineral fillers are filled in the support
panels to supply minerals to the water.

[Claim 27] The method of claim 23, wherein the sub-zero compressed cold air is
sprayed upwards from a reservoir floor to form icicles standing on a
surface of the ice.

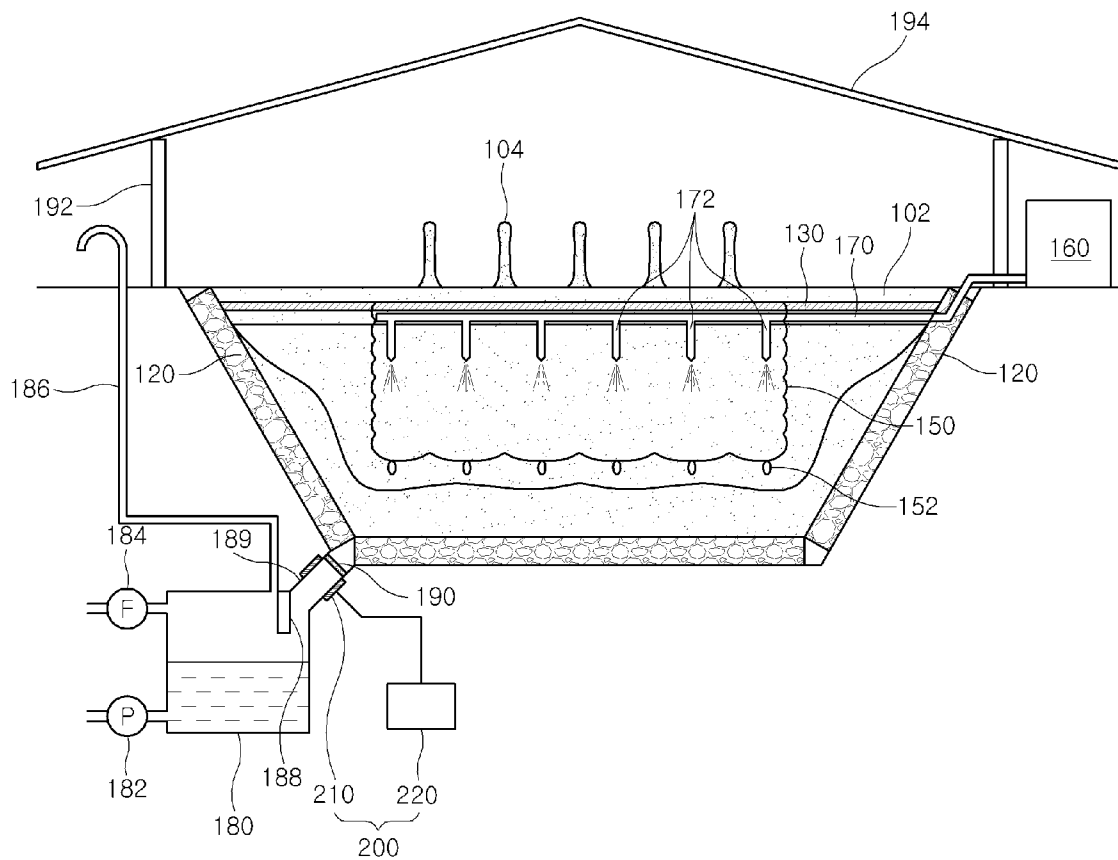
[Fig. 1]



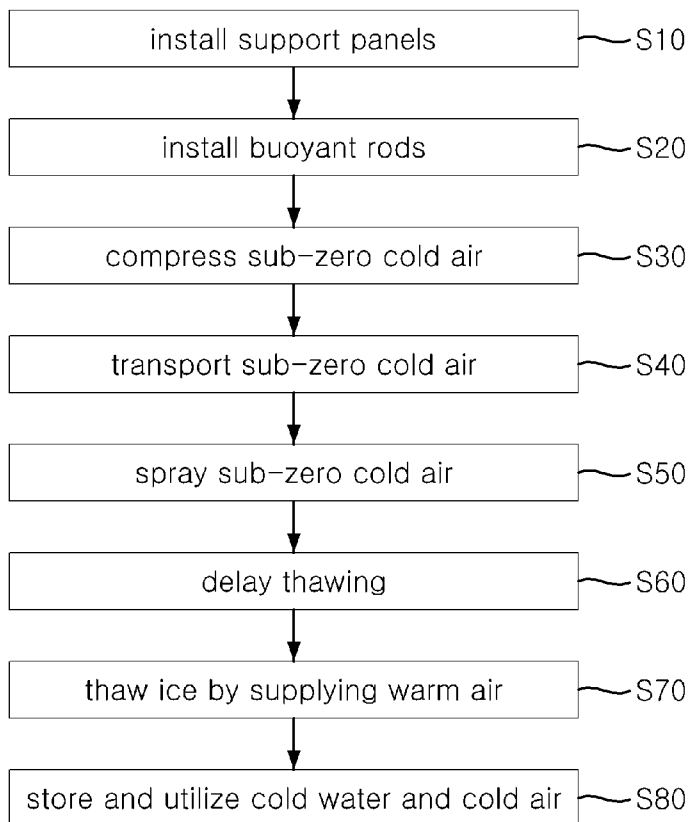
[Fig. 2]



[Fig. 3]



[Fig. 4]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 2009/005229

A. CLASSIFICATION OF SUBJECT MATTER

IPC⁸: **F25C 1/00** (2006.01); **E02B 1/00** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁸: F25C, E02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-304386 A (HITACHI) 05 November 1999 (05.11.1999) <i>fig. 9</i> --	1,11,21
A	US 3,331,207 A (MC GREW) 18 July 1967 (18.07.1967) <i>fig. 2</i> --	1,11,21
A	US 3,318,098 A (HODDINOTT) 09 May 1967 (09.05.1967) <i>description column 2, lines 5-7</i> ----	1,11,21

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
19 October 2010 (19.10.2010)Date of mailing of the international search report
02 November 2010 (02.11.2010)Name and mailing address of the ISA/ AT
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR 2009/005229

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JP	A	11304386		JP	A	11304386	1999-11-05
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