Oct. 18, 1938. R. WUSSOW ET AL 2,133,521

ICE MAKING APPARATUS

Filed May 14, 1934 2 Sheets-Sheet 1

Fig. 1

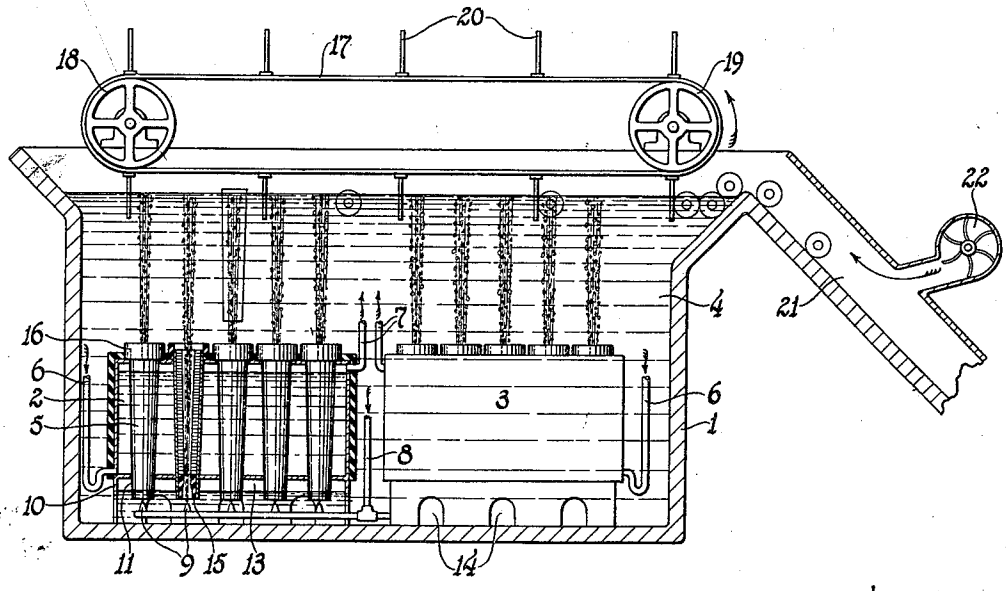


Fig. 2

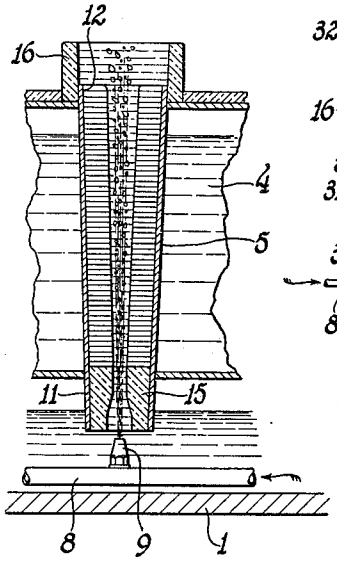
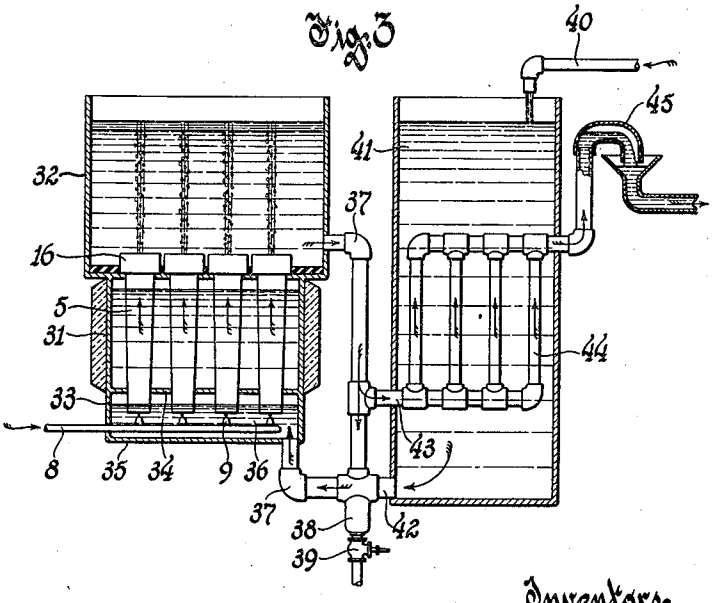


Fig. 3



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ICE MAKING APPARATUS

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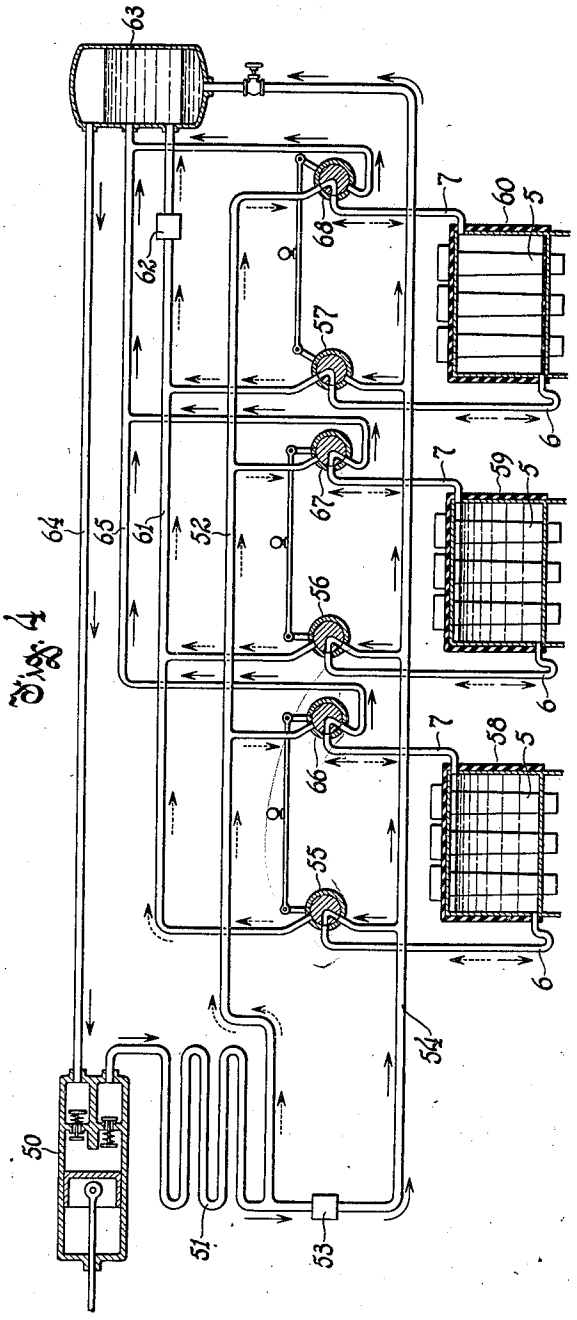


Fig. 4

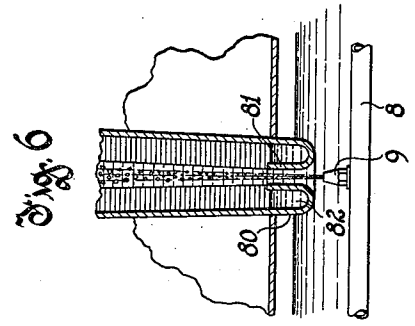


Fig. 6

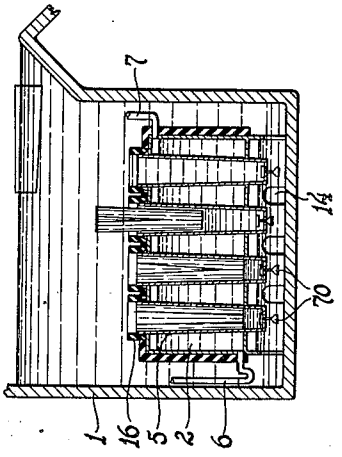


Fig. 5

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UNITED STATES PATENT OFFICE

2,133,521

ICE MAKING APPARATUS

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Application May 14, 1934, Serial No. 725,508
In Germany May 15, 1933

24 Claims. (Cl. 62—164)

This invention relates to improvements in the method of congealing liquids by refrigeration and to the apparatus employed for that purpose.

An object of the invention is to provide an improved method and apparatus for producing bodies of ice in the form of columns by direct contact of the liquid which is to be frozen with the freezing surface of an evaporator or boiler containing an evaporative freezing agent or refrigerant.

Another object is to provide an improved method and improved means for producing an ice body of convenient shape and increased utility.

Another object is to provide a more efficient system for producing and harvesting ice bodies.

Another object is to provide a novel apparatus for separating during the refrigeration process from the liquid which is to be frozen, foreign bodies and substances which are contained therein, so as to prevent them from contaminating the ice which is produced.

Another object is to provide improved methods and means for periodic removal of the ice bodies which have formed in the freezing tubes during the freezing period.

Another object is to provide an improved freezing container which is specially adapted for the ready removal of the ice bodies therefrom.

In carrying out our invention we provide a refrigerant boiler or evaporator, which is equipped with vertical tapered ducts or tubes, whose cross section gradually increases towards the top, and connect both ends of said tubes with the body of the freezing liquid in such a manner, that the latter produces a pressure head on both ends of the tubes. The body of said liquid is preferably so confined that it extends some distance vertically above the upper end of the tubes as will hereinafter be explained. Thus, when a tube is filled with an ice body, the removal of the latter is simply accomplished by causing it to separate from the surface of the tube, whereupon it floats to the surface of the liquid and may be removed from there to a storage container by simple conveying means. The removal of the ice body which adheres on the freezing surface of the tube may be accomplished by temporarily heating the latter by passing high pressure refrigerant through the evaporator, or by the pressure produced by the expanding ice in the lower extension of the tube.

If it is desired to manufacture a clear ice which is free from occluded air and solid impurities, we provide a stream of air which is passed through the center of the tubes, while the ice is forming to cause the separation of air and other impurities in a well understood manner.

With one modification of our invention it is desirable, as aforementioned, to apply heat to the tube surface after the ice body has formed, in order to loosen the latter from the former. In that case means are provided for the efficient application of such heat and for a high efficiency of the refrigerating process, by preferably employing a multiplicity of evaporators and connecting them alternately so as to be flooded by low pressure, low temperature refrigerant, or to be supplied with high pressure, high temperature refrigerant from a refrigerating system. In the latter case the evaporators act as condensers for the refrigerant as will be explained.

The accompanying drawings are illustrative of several embodiments of the invention.

In the drawings,

Fig. 1 illustrates, partly in section, a freezing tank having two evaporators which may be separately supplied with refrigerant;

Fig. 2 illustrates the details of construction of a tube as employed in the evaporators of Fig. 1 and Fig. 3;

Fig. 3 illustrates a modified form of the freezing tank shown in Fig. 1 and which is particularly suited to liquids which contain foreign matter, such as salt, which is to be kept out of the ice body;

Fig. 4 illustrates a complete refrigerating system in accordance with our invention and especially applicable to the freezing apparatus of Figs. 1 to 3, consisting of several evaporators which may be connected alternately to the pressure and expansion side of the refrigerating system.

Fig. 5 illustrates a modification of the freezing tube shown in Fig. 2 with alternative means for the removal of the ice columns, while

Fig. 6 illustrates another modification of the tubes shown in Figs. 2 and 5.

Referring to Figs. 1 and 2, a tank 1 contains two evaporators 2 and 3 for the refrigerant. These evaporators are completely immersed in the body of water 4 which is to be converted into ice. The evaporators are insulated from the surrounding water in any suitable manner. Each evaporator is provided with a number of vertical tubes or ice containers 5. Pipes 6 and 7 are inlet and outlet respectively and provide for connection of the evaporators to a refrigerating system as will hereinafter be explained. A conduit 8 is provided with branches which terminate in nozzles 9 below the lower end of the tubes and serves to supply compressed air to said nozzles for a pur-

pose which will be explained hereinafter. The tubes 5 have the shape of inverted frustrated cones or pyramids, and both ends of their walls 11 and 12, respectively, extend beyond the wall of the evaporator, while the outer lower edge of the latter is provided with a skirt 10, which with the lower tube extensions 11 forms an air trap 13, which latter prevents the water in the tank from contacting with the bottom surface of the evaporator, thus insulating the latter from the surrounding water body. Suitable passages 14 permit water from the tank to enter the space inside of the skirt 10.

Experiments have shown that after the water in the tubes between the upper and lower wall of the evaporator has frozen, it may also freeze on the inside of the tube extensions 11 and 12 due to the heat conductivity of the ice body and of the metal of the tubes. To prevent this freezing, which may interfere with the removal of the ice column, a ring shaped plug 15 preferably of redwood or other low conducting material is inserted in the bottom of the tube extending upward to a point slightly above the top of the bottom plate of the evaporator, so that ice can only form above the top of the plug. Similarly the top extension 12 is surrounded by a ring 16 of redwood or other suitable insulating material to prevent the formation of ice around the upper outside edge of the tube.

If it is desired to freeze ice bodies in the tubes 5, the evaporator is flooded with low pressure refrigerant through the pipe 6. The heat absorbed by the refrigerant from the water causes the latter to boil and the resulting vapor escapes through pipe 7 to the suction side of the refrigerating system. As a result a gradually increasing layer of ice forms on the walls of the tubes 2. During the freezing process compressed air is supplied by the nozzles 9, and this causes a rapid upward circulation of the water through the tubes, which prevents the occlusion of air and impurities in the ice. As the layer of ice grows thicker, the lower end of the tube is closed up, but if desired the freezing period may be prolonged until the tube is completely filled with a solid body of ice. However, the cycle may also be interrupted at any stage, for instance, when the ice body has still the shape of a hollow cone, such hollow cones of ice being desirable for certain cooling purposes, such as cooling of a current of air, as they have a relatively large exposed surface for a given weight.

When it is desired to remove the ice column from the tubes, the evaporator 2 is emptied of low pressure refrigerant and supplied for a short time with high pressure refrigerant vapor, the temperature of which is above the freezing temperature of the liquid. The vapor is condensed on the tube wall and thereby gives up heat energy which heats said wall. As a result of the heating of the tube wall the ice body quickly melts free therefrom and by its buoyancy is floated to the surface of the liquid in the tank. As only an infinitely thin layer of ice needs to melt to free the ice body, and fresh water enters quickly from the bottom of the tube, the heating needs to be carried on only for a short time.

The tank may be provided with an endless belt 17, the lower part of which is guided parallel to and above the water surface by two pulleys 18 and 19, one of which may be driven by any suitable means. The belt may be provided with fingers or rakes 20 which extend to or below the water line. They catch the floating ice bodies and convey them to chute 21, by which they are carried to a storage place. The chute may be closed as indicated, to confine a stream of cold, dry air to pass therethrough and over the ice bodies in order to thoroughly dry them before reaching the storage and to prevent their freezing together. A blower 22 may be provided to convey precooled and dried air to the duct as aforementioned. Other gathering means may of course be substituted for those illustrated and described.

The apparatus illustrated in Fig. 3, is particularly suitable when it is desired to manufacture clear ice from sea or other salty water. In this case the evaporator 31 is mounted below a water tank 32 and its outside is suitably insulated as indicated. The evaporator is provided at its lower end with a skirt 33 which extends below its bottom 34 and the space inside of said skirt and below said bottom plate 34 is closed by a second plate 35. The skirt 33 and the plates 34 and 35 thus form a lower compartment 36 for the reception of water, as will be further explained. The evaporator is provided with tubes 5, which are similar in construction and operation to the tubes, explained in connection with Figs. 1 and 2; said tubes extending from the compartment 36 to the tank 32. The evaporator may also be provided with a compressed air line 8, having nozzles 9, similar to those aforedescribed.

A pipe connection 37 provides for circulation of water between the bottom of the tank 32 and the compartment 36. The connection 37 is provided at its lower end with a sump 38 in which salt and heavy impurities which are precipitated from the freezing water may collect, and from which they may be discharged through a drainage cock 39.

Fresh water is admitted from a suitable supply 40 to the outside space 41 of a heat exchanger from the bottom of which it passes through a pipe 42, through a connection to the lower end of pipe 37, then through the pipe 37 into the compartment 36. The surplus water from tank 32 which is partly cooled, passes through the upper half of pipe 37 and the branch conduit 43 connected to the former, into the bottom of the heat exchanger coils 44, upward through the latter. The water thereby absorbs heat from the warmer water in the outer space 40 and in cooling the latter water recovers some of the cooling energy expended in cooling the water in the tank 32. The surplus water after leaving the heat exchanger coils is conducted away through the syphon 45. It is obvious that the waste water may carry away a certain amount of salt and other impurities, as it has a higher content of such impurities than the fresh water, due to the separation which takes place during the freezing process in the tubes 5. Some of the impurities and salt crystals are deposited by gravity in the sump aforementioned.

It is to be understood that the apparatus illustrated in Fig. 3 may be provided with a multiplicity of evaporators and may also be equipped with ice gathering and drying means, such as illustrated in Fig. 1. It is further to be understood that the tank 41 and/or the heat exchanger 44 may be omitted from the apparatus illustrated in Fig. 3.

Fig. 4 illustrates a complete refrigerating system for the continuous production of ice bodies by means of the freezing apparatus illustrated in Figs. 1 and 3. A compressor 50 has its exhaust or compression side connected to a condenser 51 of well known construction. The outlet of the

condenser is connected to a header 52. Said outlet also communicates through a float valve 53 which is in series with a header 54 with 3-way valves 55, 56 and 57 by means of which the header 54 may be connected to the inlet pipes of the evaporators 58, 59 and 60 respectively. Alternately the valves 55, 56 and 57 are adapted to connect the inlet pipe of their respective evaporators to a header 61. A drainage float valve 62 connects the header 61 with a liquid header or separator 63 near the bottom of the latter. The header 52 is also connected to the bottom of the separator 63, while the top of the latter is connected by pipe 64 to the suction side of the compressor 50. A header 65 is connected to the separator 63 intermediate of its top and bottom. 3-way valves 66, 67 and 68 are adapted to connect the header 65 to the outlet pipes of the evaporators 58, 59 and 60 respectively. Said last mentioned 3-way valves are also adapted to alternately connect said outlet pipes of the evaporators to the header 52.

With the valves in the position shown in the drawing the evaporators 58 and 59 are producing ice, while the evaporator 60 is connected to thaw the ice bodies which have been formed and to discharge them. The arrows in full lines indicate the flow of the refrigerant for freezing, while the arrows with dotted shafts indicate the refrigerant flow for causing discharge of the ice bodies. The liquid refrigerant which is under pressure flows from the compressor 50 to the condenser 51, where it is cooled, thence through the float valve 53 where its pressure is reduced and from there through header 54 and valves 55 and 56 to the evaporators 58 and 59 respectively and floods the latter. The heat from the water causes boiling of the refrigerant in these evaporators and the refrigerant vapor escapes through valves 66 and 67 respectively to header 65 and into the receiver 63 to return to the compressor 50 by the pipe 64, while liquid refrigerant which may be carried along with the vapor is separated in the separator 63 and returns to the header 54. The boiling of the refrigerant causes absorption of heat from the water in the tubes and results in the gradual formation of ice bodies.

As shown the valves 57 and 68 are positioned to cause discharge of the ice which has previously been formed in evaporator 60. The inlet pipe of evaporator 60 is connected to header 61, while the outlet pipe is connected to header 52. Hence the relatively hot liquid refrigerant under pressure from the compressor now enters the evaporator 60 through its outlet pipe on top and the cooler low pressure liquid in the evaporator from the previous freezing period is forced out through the bottom inlet pipe into the header 61 and past the float valve 62 into the separator 63. The relatively hot refrigerant which enters the evaporator 60 as vapor forces out the liquid refrigerant and is condensed on the cool surfaces of the tubes and thereby gives up heat which quickly thaws off the ice bodies and floats them to the surface. The condensed vapor is forced back into header 61 and separator 63. Thereafter the valves 57 and 68 are reversed again, and the condenser 60 again produces new ice bodies. The two other evaporators 58 and 59 may be operated in a manner similar to that aforedescribed in connection with evaporator 60, and the system may obviously be provided with any desired number of evaporators, which may be connected alternately to freeze ice and to discharge it.

Fig. 5 illustrates another method of ejecting the ice bodies from the tubes after their completion, which makes use of the pressure developed by the ice itself. The evaporator is constructed similar to that shown in Fig. 1. The tubes are similar to those illustrated in Fig. 2, except that the lower wood ring 15 is omitted and the lower end of the tube 5 is provided with a gravity closed check valve 70, which is of such proportions that due to its own head water may pass through it into the tube. As the water in the tube freezes the wall of the ice body ultimately attains such a thickness that the lower part of the tube is completely closed. Due to the heat conduction through the lower end of the ice body, the stagnant water, which is trapped above the valve begins to freeze in the tube extension, while the valve opposes the escape of the water which the expanding ice tends to compress. The pressure therefore reacts on the frozen ice body and when it is high enough it raises the latter and permits water to enter from above into the space between the tube and the ice body. Thus the ice body is floated to the surface of the water in the tank. At the same time the downward pressure on the valve is released, and the pressure of the water from below lifts said valve again and admits water from below. This assists in the flotation of the ice body to the surface and fills the tube again with fresh water. The newly admitted water due to its higher temperature melts any ice which may have formed on the wall of the tube extension and prevents further accumulation thereon until a new ice body is formed, whereupon the cycle is repeated as aforedescribed. The four tubes shown in Fig. 5 illustrate from left to right four stages in the cycle beginning with the partially formed ice body to the moment when the tube is again filled with fresh water after expulsion of the ice body.

It is of course to be understood that if desired, air may be supplied to the freezing tubes of Fig. 5 as illustrated in Fig. 1, and that the ice may be gathered as aforedescribed. It is also possible to use the tubes of Fig. 5 in connection with the tank arrangement of Fig. 3, as will be obvious.

If it is desired to manufacture hollow ice bodies by a method similar to that illustrated in Fig. 5, the modification illustrated in Fig. 6 may be employed. In this modification the lower extension 80 of the tube is closed by a trough or hollow ring 82 of approximately semi-circular cross section, the outer rim of the trough forming a continuation of the tube, while the inner rim 81 extends into and is concentric with said tube and ends preferably slightly above the freezing zone of the tube.

The ice freezes on the side of the tube, while air and water are passed through the center by means of nozzles 9 as aforedescribed. The ice body ultimately becomes thick enough to confine the water in the sump 82 and as the ice body due to the heat conduction of the ice, aforedescribed in connection with Fig. 5, extends into this confined water filled space, its expansion raises the pressure therein, so as to ultimately force the ice body upward to release it and float it to the surface of the water in the tank as aforedescribed. The fresh water entering through the bottom orifice then again fills the freezing tube and the cycle is repeated.

The tubes illustrated in Fig. 6 may be used in connection with tanks as illustrated in Figs. 1 or 3, and the gathering and drying means illustrated

in Fig. 1 may also be employed in connection therewith.

Having thus set forth the nature of the invention what is claimed herein is:

1. The process of producing ice bodies from a body of liquid which comprises the steps of confining a part of said liquid in a vertical column surrounded by a freezing surface, while maintaining contact between the top and bottom of said column and said body of liquid, surrounding said surface with an evaporable refrigerant to cause transfer of heat energy from the column to the refrigerant and thereby freeze the former and cause the latter to evaporate, and releasing said column from said surface and thereby permit it to rise to the surface of the liquid by flotation.

2. The process of producing ice bodies from a body of liquid which comprises the steps of confining a part of said liquid in a vertical column surrounded by a freezing surface, while maintaining contact between the top and bottom of said column and said body of liquid, surrounding said surface with an evaporable refrigerant to cause transfer of heat energy from the column to the refrigerant and thereby freeze the former and cause the latter to evaporate, circulating air through said column, and releasing said column from said freezing surface and thereby permit it to rise to the surface of the liquid by flotation.

3. The process of producing ice bodies from a body of liquid which comprises the steps of confining a part of said liquid in a vertical column surrounded by a freezing surface, while maintaining contact between the top and bottom of said column and said body of liquid, surrounding said surface with an evaporable refrigerant of relatively low temperature and pressure to transfer heat from the column to the refrigerant and freeze the former, thereafter surrounding said surface with refrigerant of relatively high temperature and pressure to induce heat flow from the latter refrigerant to the column to thereby release the latter from said surface and float it to the surface of the liquid.

4. The process of producing ice bodies from a body of liquid which comprises the steps of confining a part of said liquid in a vertical column surrounded by a freezing surface, while maintaining contact between the top and bottom of said column and said body of liquid, surrounding said surface with an evaporable refrigerant of relatively low temperature and pressure to transfer heat from the column to the refrigerant and freeze the former, circulating air through the column while it is freezing, thereafter surrounding said surface with refrigerant of relatively high temperature and pressure to induce heat flow from the latter refrigerant to the column to thereby release said column from said surface and float it to the surface of the liquid.

5. Apparatus for the production of ice bodies from a liquid, comprising, a tank for the liquid, an evaporator adapted to be supplied with a vaporizable refrigerant and provided with vertical tubes extending through the interior of said evaporator and having open ends exterior of the same, said evaporator being arranged below the liquid level in said tank, connections between said tubes and said tank adapted to permit free circulation of liquid therebetween, and means for causing a refrigerant to release the ice bodies formed in said tubes from the liquid and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process.

6. Apparatus for the production of ice bodies from a liquid, comprising, a tank for the liquid, an evaporator adapted to be supplied with a vaporizable refrigerant and provided with vertical tubes extending through the interior of said evaporator and having open ends exterior of the same, said evaporator being arranged below the liquid level in said tank, connections between said tubes and said tank adapted to permit free circulation of liquid therebetween, means for causing a refrigerant to release the ice bodies formed in said tubes from the liquid and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process and means to gather said bodies from the surface of said liquid and to remove them to storage.

7. Apparatus for the production of ice bodies from a liquid, comprising, a tank for the liquid, an evaporator adapted to be supplied with a vaporizable refrigerant and provided with vertical tubes extending through the interior of said evaporator and having open ends exterior of the same, said evaporator being arranged below the liquid level in said tank, connections between said tubes and said tank adapted to permit free circulation of liquid therebetween, means for causing a refrigerant to release the ice bodies formed in said tubes from the liquid and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process, means to gather said bodies from the surface of said liquid and to remove them to storage and means to conduct a current of dry cold air over said bodies on their passage to storage to thereby dry them.

8. Apparatus for the production of ice bodies from a liquid, comprising a tank for the liquid, an evaporator adapted to be supplied with a vaporizable refrigerant and provided with vertical tubes extending through the interior of said evaporator and having open ends exterior of the same, said evaporator being arranged below the liquid level in said tank, connections between said tubes and said tank adapted to permit free circulation of liquid therebetween, means to circulate air through the liquid in the tubes, and means for causing a refrigerant to release the ice bodies formed in said tubes from the liquid and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process.

9. Apparatus for the production of ice bodies from a liquid, comprising, a tank for the liquid, an evaporator adapted to receive a vaporizable refrigerant and provided with vertical tubes extending through the interior of said evaporator and having open ends exterior of same, said evaporator being arranged below the liquid level in said tank, connections between said tubes and said tank adapted to permit free circulation of liquid therebetween, means to supply a vaporizable refrigerant to said evaporator to freeze the liquid in said tubes, and means for causing a refrigerant to release the ice bodies formed in said tubes and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process.

10. Apparatus for the production of ice bodies from a liquid, comprising, a tank for the liquid, an evaporator adapted to receive a vaporizable refrigerant and provided with vertical tubes extending through the interior of said evaporator and having open ends exterior of same, said evaporator being arranged below the liquid level in said tank, connections between said tubes and

said tank adapted to permit free circulation of liquid therebetween, means to supply a vaporizable refrigerant to said evaporator to freeze the liquid in said tubes, means for circulating air through said tubes, and means for causing a refrigerant to release the ice bodies formed in said tubes and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process.

11. Apparatus for the production of ice bodies from a liquid, comprising, a refrigerating system including a vaporizable refrigerant, a tank for the liquid, an evaporator adapted to be connected to said refrigerating system and provided with vertical tubes extending through the interior thereof and having open ends exterior of said evaporator, said evaporator being arranged below the liquid level of said tank, connections between said tubes and said tank adapted to permit free circulation of liquid between said tank and said tubes, means to supply air to said tubes, means adapted to flood said evaporator with low temperature refrigerant from said system and to cause said refrigerant in said evaporator to absorb heat and thereby cause formation of ice bodies in said tubes, and means for causing a refrigerant to release said ice bodies and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process.

12. Apparatus for the production of ice bodies from a liquid, comprising, a tank for the liquid, an evaporator adapted to receive a vaporizable refrigerant and provided with vertical tubes extending through the interior of said evaporator and having open ends exterior of same, said evaporator being arranged below the liquid level in said tank, connections between said tubes and said tank adapted to permit free circulation of liquid therebetween, means providing a fresh liquid supply and an overflow for said liquid, a heat exchanger connected in series with said supply and said overflow respectively, means to supply a vaporizable refrigerant to said evaporator to freeze the liquid in said tubes and means for causing a refrigerant to release the ice bodies formed in said tubes and thereby permit them to rise to the surface of the liquid by flotation, upon their completion.

13. Apparatus for the production of ice bodies from a liquid, comprising, a refrigerating system adapted to contain a vaporizable refrigerant, a tank for the liquid, an evaporator adapted to be connected to said refrigerant system and provided with vertical tubes extending through the interior thereof and having open ends exterior of said evaporator, said evaporator being arranged below the liquid level of said tank, connections between said tubes and said tank adapted to permit free circulation of liquid between said tank and said tubes, means adapted to flood said evaporator with low temperature refrigerant from said system and to cause said refrigerant in said evaporator to absorb heat and thereby cause formation of ice bodies in said tubes, and means for causing a refrigerant to release said ice bodies and thereby permit them to rise to the surface of the liquid by flotation, upon completion of the refrigerating process.

14. Apparatus for the production of ice bodies from a liquid, comprising, a refrigerating system adapted to contain a vaporizable refrigerant, a tank for the liquid, an evaporator adapted to be connected to said refrigerating system and being provided with vertical tubes extending through the interior thereof and having open ends exterior of said evaporator, said evaporator being arranged below the liquid level of said tank, connections between said tubes and said tank adapted to permit free circulation of liquid between said tank and said tubes, means adapted to flood said evaporator with low temperature refrigerant from said system and to cause said refrigerant in said evaporator to absorb heat and thereby cause formation of ice bodies in said tubes, and alternately to admit to said evaporator high temperature refrigerant from said system and to cause said refrigerant in said evaporator to release heat to thereby release said ice bodies and to cause them to rise to the surface of the liquid.

15. Apparatus for the production of ice bodies from a liquid, comprising, a refrigerating system adapted to contain a vaporizable refrigerant, a tank for the liquid, a plurality of evaporators adapted to be connected to said refrigerating system and provided with vertical tubes through the interior thereof and having open ends exterior of said evaporators, said evaporators being arranged below the liquid level of said tank, connections between said tubes and said tank adapted to permit free circulation of liquid between said tank and said tubes, means adapted to selectively flood said several evaporators with low temperature refrigerant from said system and to cause said refrigerant in the respective evaporators to absorb heat and thereby cause formation of ice bodies in said tubes and alternately to admit to the respective evaporators high temperature refrigerant from said system and to cause said refrigerant in the respective evaporators to release heat to thereby release said ice bodies and to permit them to rise to the surface of the liquid by flotation.

16. Apparatus for the production of ice from a liquid by the use of a vaporizable refrigerant, comprising, a compressor for said refrigerant, a condenser connected to the delivery side of said compressor, a plurality of evaporators, each having an inlet and an outlet, an expansion valve, a separator connected to the suction side of said compressor, means for selectively connecting the inlet of any of said evaporators to said condensers in series with said expansion valve, while their respective outlet is connected to said separator and for alternately connecting said outlet directly to said condenser exclusive of said expansion valve and said inlet to said separator.

17. A vertical ice freezing tube for immersion in a body of liquid to be frozen and having a bottom extension outside of direct contact with the freezing agent, said extension being provided at its lower end with a check-valve adapted to permit said liquid to enter said tube from the bottom and to prevent escape thereof when trapped by an ice body formed in the tube, so as to exert an upward pressure upon said body for freeing it from the tube.

18. Apparatus for the production of ice from a liquid by the use of a vaporizable refrigerant, comprising a compressor for said refrigerant, a condenser connected to the delivery side of said compressor, a plurality of evaporators each having an inlet and an outlet and provided with vertical freezing tubes passing through the interior thereof and having open ends exterior of said evaporator, an expansion valve, means for selectively connecting the inlet of the respective evaporators to said condenser in series with said expansion valve and alternatively directly to said

condenser, a separator connected to the suction side of said compressor, means for selectively connecting the outlet of an evaporator to said separator when its inlet is connected to said condenser through said expansion valve and for connecting said outlet directly to said condenser when its inlet is connected to said evaporator, and means for blowing air through said tubes while the respective evaporator is connected to the condenser in series with said expansion valve.

19. Apparatus for the production of ice bodies from a liquid, comprising, a tank for the liquid, an evaporator adapted to be supplied with a vaporizable refrigerant and provided with vertical freezing tubes extending through the interior of said evaporator and having open ends exterior thereof, said evaporator being arranged below the liquid level of said tank, connections between said tubes and said tank adapted to permit free circulation of liquid therebetween, a ring of heat insulating material surrounding the exterior upper extension of said tube and a heat insulating ring lining the interior of the lower tube extension to prevent the formation of ice on the surfaces of said tubes so insulated.

20. A freezing tube for producing hollow ice bodies, comprising, a vertical freezing tube in the shape of an inverted truncated cone and having a freezing zone which is adapted to be cooled by a refrigerant, the lower end of said cone being contiguous with the outer rim of a ring-shaped trough, the inner rim of said trough being approximately coplanar with the lower end of the freezing zone of said tube.

21. In an ice making apparatus, the combination of a water tank, a sealed freezing and thawing tank in said water tank adapted to be entirely immersed in the body of water in said water tank, open ended molds mounted in said freezing and thawing tank with their ends opening through opposite walls of the latter, and means for conducting freezing and thawing agents through said freezing and thawing tank.

22. In an ice making apparatus, the combination of a water tank, a sealed freezing and thawing tank in said water tank adapted to be entirely immersed in the body of water in said water tank, substantially vertical open-ended tubular molds mounted in said freezing and thawing tank with their ends opening through the top and bottom walls of the latter, and means for conducting freezing and thawing agents through said freezing and thawing tank.

23. The process of producing ice bodies from a body of liquid which comprises the steps of confining a part of said liquid in a vertical column surrounded by a freezing surface, while maintaining contact between the top and bottom of said column and said body of liquid, surrounding said surface with a refrigerant to cause transfer of heat energy from the column to the refrigerant and thereby freeze the former, and releasing said column from said surface and thereby permit it to rise to the surface of the liquid by flotation.

24. The process of producing ice bodies from a body of liquid which comprises the steps of confining a part of said liquid in a vertical column surrounded by a freezing surface, while maintaining contact between the top and bottom of said column and said body of liquid, surrounding said surface with a refrigerant to cause transfer of heat energy from the column to the refrigerant and thereby freeze the former, thereafter surrounding said surface with a thawing agent to induce heat flow from said agent to said column to thereby release the latter from said surface and permit it to rise to the surface of the liquid by flotation.

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