Aug. 26, 1941. F. W. FECHNER ET AL 2,253,512

APPARATUS FOR THE PRODUCTION OF ICE

Filed Dec. 15, 1938

Fig. 1.

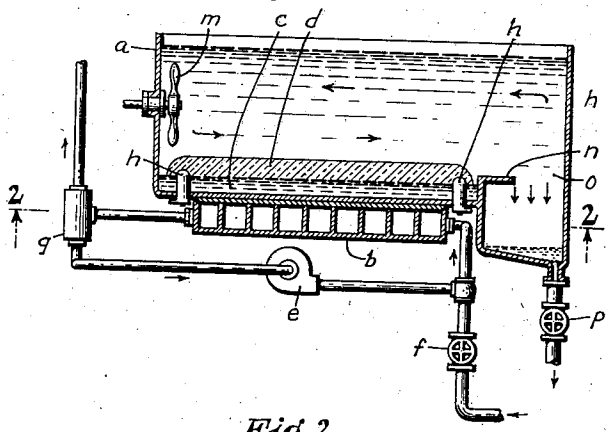


Fig. 2.

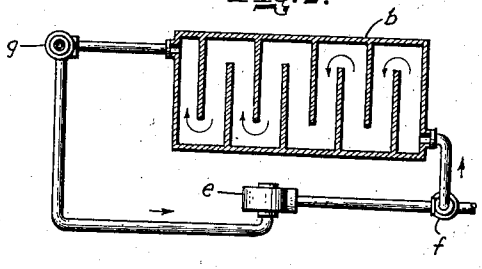


Fig. 3.

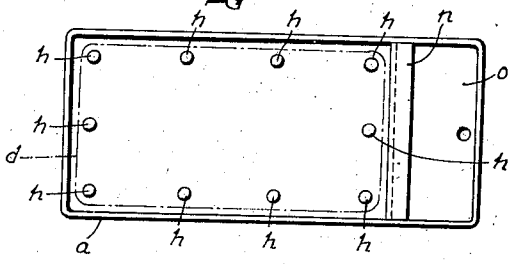


Fig. 5.

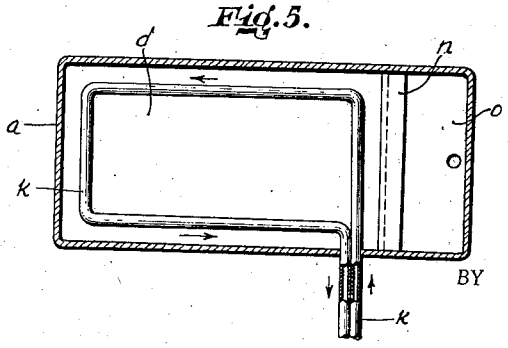


Fig. 4.

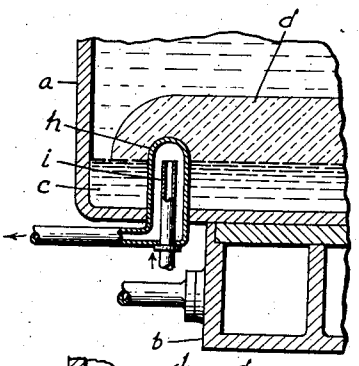


Fig. 6.

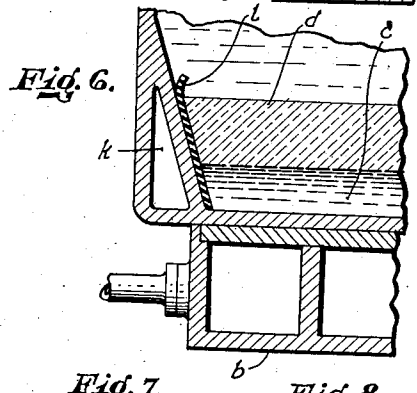


Fig. 7.

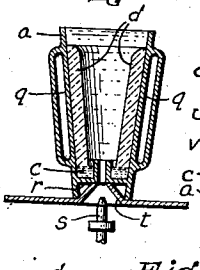


Fig. 8

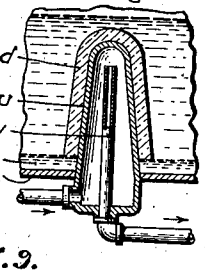
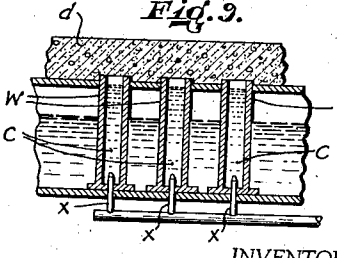


Fig. 9.



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APPARATUS FOR THE PRODUCTION OF ICE

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Application December 15, 1938, Serial No. 245,812
In Germany November 28, 1936

1 Claim. (Cl. 62—106)

This invention relates to an apparatus for the production of ice in which heat is directly withdrawn from liquid by means of a source of cold, for example an evaporator or the like. According to the invention, in order to prevent the liquid from freezing on to the heat exchange walls of the source of cold, an intermediate layer of a liquid which does not freeze easily, for example mercury, is introduced between the surface through which the heat is abstracted and the liquid to be frozen.

It has previously been proposed to produce artificial plates of ice by means of a cooling apparatus, by allowing the cooling liquid to flow through a vessel open on top and supplying the water to be frozen to the surface formed by the cooling liquid. In this known process therefore the cooling liquid is conducted, as the carrier of the cold, through the freezing vessel; this process however gives rise to certain difficulties. Either the cooling liquid is conducted at high speed through the freezing vessel in which case the surface of the cooling liquid cannot be level or it is conducted at a low speed in which case the transfer of cold and therefore the output of ice is only small. In any case, however, owing to fluid friction, the surface of the cooling liquid will, on its passage through the vessel, move the layer of liquid to be frozen in contact with it, or the ice which is in the process of formation at this place to the outlet end of the vessel, where the thin sheets of ice formed collect in layers one upon another and separate from the cooling liquid and rise at the surface where they arrest the circulation of the water and make a return movement to the side on which the cooling liquid enters. Since, however, owing to their lighter weight, the particles of ice cannot sink down again to the boundary surface between the two liquids they become superimposed in layers at this place. The formation of a uniformly clear plate of ice is therefore not possible in this way. It has also been proposed in this case to provide a layer of liquid between the cooling liquid and the liquid to be frozen. If this be done a similar phenomena also of course occurs, since this layer of liquid is carried along by the cooling liquid and the liquid to be frozen is again carried along by the former.

These disadvantages are obviated by the apparatus of the present invention since the liquid which does not freeze lies in a thin layer above the cooling device, for example an evaporator, cooling coil or the like, arranged in the vessel containing the water to be frozen, so that a clear and smooth block of ice can be formed and there is no interference with the transfer of heat. However, the task of the liquid which does not freeze is rather to prevent ice from freezing on to the cooling device, than to act as a medium for transmitting cold.

The apparatus in accordance with the invention can be used both for the production of ice and also for the separation of dissolved substances from solutions by freezing them out, for example for the separation of paraffin from crude oil or the like. For the sake of simplicity, however, reference is hereinafter made only to the production of ice.

In order that the invention may be readily understood and carried into effect, various forms of freezing apparatus in accordance with the invention will now be described by way of example with the aid of the accompanying drawing, in which

Figure 1 is a vertical section through an apparatus constructed in accordance with the invention for the production of ice.

Figure 2 is a horizontal section through the evaporator arranged at the bottom of the apparatus of Fig. 1.

Figures 3–6 are detail view of three different modifications.

Figures 7 and 8 are views illustrating the application of the invention to freezing cells of a known type, and finally

Figure 9 illustrates how granulated ice or snow can be produced with the apparatus.

Referring to Figures 1 and 2, the reference *a* represents a vessel which contains water to be frozen and *b* is an evaporator arranged at the bottom of the vessel *a*. Figure 2 shows a section through the evaporator taken on the line 2—2 in Figure 1. The bottom of the vessel *a* or the evaporator *b* is covered by a thin layer of mercury *c*. When the apparatus is operated the cold produced in the evaporator *b* is first transferred to the layer of mercury *c* and from this to the water contained in the vessel *a*. A layer of ice is therefore formed on the surface of the mercury.

In the apparatus of the invention it is necessary that the evaporator should be horizontal and without upstanding projections, and therefore a free circulation of the refrigerant cannot be obtained directly as the result of the evaporation process. It is therefore necessary to provide for an artificial circulation of the refrigerant which is effected by means of pump *e*. The reference *f* designates a pressure reducing valve

by which the pressure on the condensate from the condenser is reduced. The reference *g* designates a liquid separator. The mixture of liquid and vapour is drawn by the pump *e* from the evaporator *b* through the liquid separator *g* in which the vapour is separated and from which it is drawn off by the compressor which is not illustrated in the drawing. The liquid which is drawn in by the pump is injected into the injection pipe behind the pressure reducing valve *f* and a closed circuit is thereby formed. In some cases the circulating pump *e* may be omitted, namely by arranging the liquid separator *g* in an elevated position outside the vessel *a* and arranging, instead of the pump circuit, a downwardly extending, siphon-like return pipe from the liquid separator *g* to the injection pipe. In this case, however, care should be taken that the lowest point of the siphon-like return pipe is sufficiently far below the point of connection to the injection pipe.

The ice which is formed on the surface of the mercury will grow to form a block of ice of greater or less thickness according to the external conditions, such as the stagnancy or movement of the water and so forth, and then owing to its buoyancy will separate from the surface of the mercury and rise upwards without the production of cold being interrupted. If precautions are not taken and if, for example, the water above the surface of the mercury be in rapid movement, the ice formed will separate very quickly or in the form of a thin layer, so that a snow-like ice will be produced, which can be removed from the surface of the water, whereas, if the water in the vessel is stationary, relatively thicker layers of ice can be formed through the thickness of the ice which is obtainable in this manner still remains relatively small.

According also to the present invention, plates of ice of greater thickness are obtained by the provision in the region where the ice is formed of fixed, separate or continuous parts or surfaces which are good conductors of heat and project above the surface of the mercury; preferably these parts are so disposed that they enclose the area over which evaporation and freezing takes place.

Since these parts are good conductors of heat their temperature soon becomes the same as that of the mercury and the ice freezes fast on to these projecting parts. The plate of ice which is formed is therefore as it were adhered to the surface of the mercury and the plate of ice can consequently grow to any desired thickness. In order now to release the plate after it has attained the thickness desired, it is only necessary to heat these projecting parts by a warm medium, for example water, so that the plate of ice is thawed off from the points at which it is held. The plate of ice which is thus freed then rises to the surface owing to its buoyancy.

Figure 3 is a plan of an apparatus of the kind illustrated in Figure 1 having a number of such projections *h* by which the ice is held distributed around the periphery of the freezing zone of the evaporator. Figure 4 illustrates on a larger scale and by way of example how a device of this nature is combined with the parts shown in Figure 1. The references *a*, *b* and *c* designate, in this figure, the same parts as in Figure 1. An injection nozzle *i* is arranged centrally in the projecting sleeve *h* to which the ice adheres. Normally, however, no medium is injected into the sleeve *h*. Owing to the conduction of heat by the material of the sleeve, which is made for example of iron, the temperature of this sleeve becomes approximately the same as that of the layer of mercury and the water freezes in the same manner as on the surface of the mercury to the iron cup which projects from the surface from the mercury whereby the entire plate of ice which is formed is held coherently together. When the plate is to be released, after the ice has reached a desired thickness, a warmer medium, for example brine, which may be in heat exchange relationship with the cooling water for the condenser, is injected through the injection nozzle against the upper cup-shaped end of this sleeve, whereby this end is heated and the adhering ice is thawed off. The thawing agent which is injected flows away in the direction of the arrow indicated in the drawing. Instead of a number of separate points of adherence, a continuous pipe or passage can be arranged around the periphery of the evaporator at the level of the mercury, as is indicated in Figure 5. The method of operation is then exactly the same as previously described, that is to say in order to release the plate of ice which is formed, a thawing agent, for example warm brine, is passed in the direction of the arrows through the pipe *k*.

Figure 6 shows on a larger scale a particularly advantageous form of construction of a passage of this kind. The references *a*—*d* designate the same parts as previously. The peripheral passage *k* to which the ice adheres is formed in this case by the lower corner of the vessel *a* in which the water to be frozen is contained. The passage is of narrow, wedge-like shape and its height corresponds to the thickness of the plates of ice to be formed. With the apparatus the edges of the plates of ice formed are even and the space inside the vessel is well utilised for the production of ice. In this case also for thawing off the block of ice formed a warm medium need only be passed through the passage *k*. On the other hand, in order to be able to use this passage as a protection from the outside, the vessel is provided, preferably at the end, with an outlet in the bottom, so that after the supply of thawing medium ceases the passage can be emptied. With this latter form of construction there is a relatively large surface to which the ice adheres and further owing to the conduction of cold through the walls of the passage a ridge-like formation of ice can take place on these walls. In order to avoid difficulties arising therefrom, such as too firm adhesion and consequent delay in thawing, this surface of the passage which is in contact with the ice can be lined with a material which on the one hand is a poor conductor of heat and, on the other hand, only adheres weakly to the ice, for example, with the layer of rubber *l*.

Ice making apparatus of this kind can be used for many different freezing purposes. If, for example, a homogeneous salt water ice is to be manufactured, the water can simply be allowed to freeze in a stationary condition, the evaporator temperature being as low as possible. Since any salts or constituents of the solution which may separate are heavier than the water above them which contains less salt, the salt accumulates at the place of separation on the smooth under surface of the ice. The salt must be frozen-in because equilibrium of the solution with the upper layers of water by diffusion only proceeds very slowly at these low temperatures. This is still more the case as the temperatures of evaporation become lower, that is to say when the speed of

freezing is greater and in particular when the speed of freezing exceeds the speed of diffusion. Then the salty constituents must be frozen-in in a state of fine sub-division so that a homogeneous ice is obtained.

Conversely if fresh water ice is to be produced from salty water, then the water is circulated with as high a velocity as possible above the freezing surface. This is illustrated in Figure 1. In this figure *m* denotes a stirrer which circulates the water to be frozen with greater or less velocity above the freezing surface. In consequence of the smooth surface of the ice the materials which separate are washed away very effectively from the freezing surface. At the opposite end of the vessel, for the purpose of retaining the layer of mercury, there is arranged an edge *n* which projects only a small distance above the level of the mercury. Behind this there is a settlement vessel *o* in which the heavier constituents of the solution sink down during the circulation. Since the liquid in this settlement chamber does not take part in the circulating movements of the liquid in the vessel *a* but remains stationary therein, the heavier constituents collect in the settlement chamber *o* to an increasingly great extent during the course of operation and can be drawn off from time to time as they accumulate through the outlet valve *p*. In this way therefore an ice which is relatively poor in or free from salt can be produced from salt water.

Two further forms of construction which can also be employed are illustrated by way of example in Figures 7 and 8 respectively. Both figures show freezing cells which are flooded by the water to be frozen. Figure 7 shows a freezing cell *q* which is open on top and in which the ice is formed in the interior of the cell. The formation of ice is limited at the lower end of the cell by a transverse plate or bottom *r* which is, in the cell illustrated, provided in the middle with an opening having a tubular extension which projects a short distance upwards and through which air is blown in through the nozzle *s* for the purpose of clarifying the ice. In the annular chamber which is thereby formed at the bottom of the cell, a layer of mercury *c* is again introduced. The body of ice which is formed is therefore again in contact at the bottom with this layer of mercury at the surface of which, owing to the conduction of cold by the mercury, ice is formed without however adhering so firmly to the bottom of the cell as to cause difficulty in thawing off the ice formed. In order to prevent ice from being formed also at the under side of the bottom surface *r*, the central opening is connected to an extension of the wall of the cell by a wall *t* so that a protective air chamber is formed at the under side of the bottom *r*.

Figure 8 shows a freezing cell *u* which is also of a known kind and is closed on top. In this cell the formation of ice takes place on the outside around the cell whereas the cooling medium flows through the cell during the freezing periods in the direction indicated by the arrows and leaves through the central pipe *v*, whereas for the purpose of thawing off the ice formed the direction of flow of the cooling medium is reversed in known manner. In this case also the bottom space is covered by a layer of mercury *c* and, similarly as in the construction according to Figure 7, this mercury layer is used not only for the actual transmission of cold but also for preventing the body of ice from adhering to the bottom of the cell and to any extension thereof.

Finally, Figure 9 illustrates a further form of construction which is intended to enable ice to be produced in a finely divided form or to cool down liquid very suddenly. For these reasons this apparatus is particularly suitable for the production of ice from salt water in which case the ice which is obtained in a finely divided condition can be compressed into the form of briquettes if it is not desired to use it in this finely divided condition.

In Figure 9 the reference *w* denotes pipes which contain mercury and are closed at the bottom and assembled in a common evaporator. Instead of this, individual pipes can each be surrounded by a double pipe, as shown in Figure 7, in which case the surrounding space acts as an evaporator. Into the bottom of these pipes containing the mercury are introduced injection nozzles through which the water to be frozen is injected under pressure into the mercury which is cooled down by the evaporator. Consequently, owing to the fine state of division of the water and the direct contact with the cold mercury, the injected liquid freezes at once, which may be of importance for various other presses. Owing to its great buoyancy in the heavy mercury the finely divided ice rises rapidly to the surface and collects there from which it can then be removed by suitable conveying devices.

We claim:

Apparatus for the production of ice comprising an evaporator, at least one mercury-filled tube in said evaporator, at least one injection nozzle at the bottom of each tube, and means for injecting liquid to be frozen through said nozzle into the mercury in the tube.

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