Jan. 8, 1924. 1,480,382

C. FIELD

METHOD OF CRYSTALLIZING FLUIDS

Filed Jan. 24, 1922

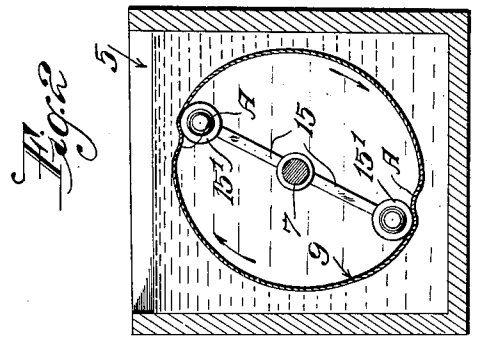


Fig. 2

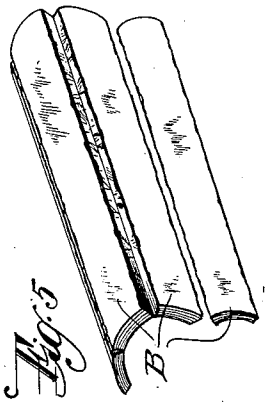


Fig. 5

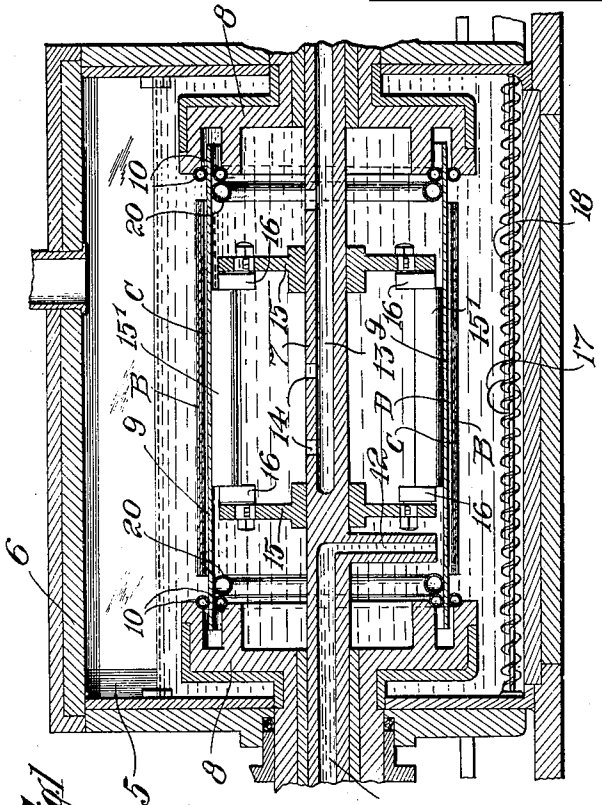


Fig. 1

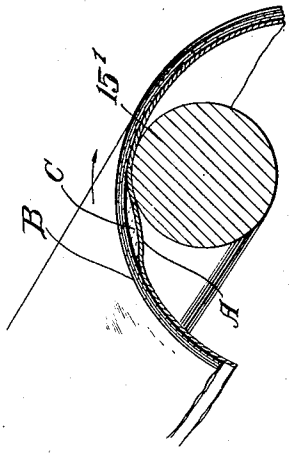


Fig. 3

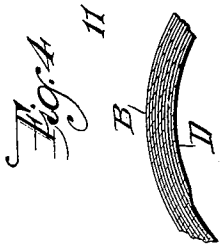


Fig. 4

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UNITED STATES PATENT OFFICE.

CROSBY FIELD, OF YONKERS, NEW YORK.

METHOD OF CRYSTALLIZING FLUIDS.

Application filed January 24, 1922. Serial No. 531,502.

To all whom it may concern:

Be it known that I, CROSBY FIELD, a citizen of the United States, and a resident of Yonkers, in the county of Westchester and State of New York, have invented a certain new and useful Improvement in Methods of Crystallizing Fluids, of which the following is a specification.

This invention relates to an improved method of crystallizing fluids and more particularly for manufacturing ice and in its generic aspect comprehends the provision of a very simple method whereby the refrigeration of the liquid and the formation of the ice crystals may be greatly expedited.

The fundamental or underlying principle of my present invention is predicated upon differences in the flexibility of a heat transfer wall and of the elastic limit of an ice film formed upon one surface of this wall by the transfer of heat from the liquid through the medium of a suitable heat transfer agent contacting with the opposite surface of said wall. I have found that by the application of a suitable pressure, after a film of appreciable thickness has formed upon the wall, a localized deformation of the flexible wall adjacent to the point of application of such pressure will result and said wall will be separated from the ice film. By moving the wall and the pressure means relative to each other such separation of the wall from the film may be caused to occur progressively, thus permitting the water or other liquid to enter into the space between the wall and film so that the immediate transference of heat by the liquid through said wall takes place and the refrigeration of the liquid is instantly effected. In this manner, by continuously renewed accretions of ice crystals the film is built up upon said wall until it becomes of such thickness that its continuity will no longer be maintained. In other words, the pressure necessary to effect the flexure of the heat transfer wall exceeds the ultimate strength of the ice film and at the point of application of such pressure the film will be fractured and caused to separate from the wall in the form of slabs or cakes of considerable thickness. Unlike prior methods of which the art contains numerous examples, I do not propose to extract heat from the liquid through the ice cake or film which is already formed, but the present method involves the contrary concept of continuously introducing liquid to be refrigerated between the already formed ice film or cake and the surface of the heat transfer wall or element with which the ice film is in contact.

In the accompanying drawing I have illustrated a typical form of apparatus whereby my present method may be successfully practised. Such illustration, however, implies no limitations as it is conceivable that the invention which I shall hereinafter more fully describe and claim might be practised by means of various other forms of apparatus. In this drawing wherein similar reference characters designate corresponding parts throughout the several views:

Figure 1 is a longitudinal sectional view though a refrigerating apparatus operating in accordance with my new method;

Figure 2 is a transverse sectional view showing one means for flexing the wall of the rotating drum;

Figure 3 is a detail sectional perspective view diagrammatically illustrating the manner in which the ice film is formed upon the movable heat transfer wall;

Figure 4 is a detail fragmentary section of the film on an exaggerated scale, and

Figure 5 is a perspective view illustrating the approximate form of the fragments or sections of the fractured ice film.

The form of apparatus shown in the accompanying drawing is to be considered merely as suggestive and while such apparatus well illustrates the fundamental principle of my present invention, the new method of refrigeration could be carried out by means of other apparatus, possibly of simpler construction. As shown, a tank 5 is provided to receive the water or other liquid, the exterior of the tank being covered with a suitable non-heat conducting lagging and said tank having a removable top or cover 6. In suitable standards (not shown) the ends of a fixed shaft 7 extending through the tank are suitably mounted or supported.

Within the tank 5 adjacent to each of its ends a cylinder head 8 is rotatably mounted upon the fixed shaft 7, said heads having suitable bearings in the end walls of the tank which extend exteriorly of the tank walls and to one or both of which suitable operating means may be connected.

A flexible metal cylinder wall 9 is yieldingly connected at its ends to the cylinder heads 8 between the inner and outer annular

glands 10 which are suitably mounted in the inner face of each cylinder head.

As herein disclosed, the fixed shaft 7 is provided with an axially extending passage 11 to which brine or other suitable heat transfer agent is supplied from a convenient source. The inner end of this passage terminates adjacent to one end of the cylinder and the shaft is formed with a radially extending tubular arm 12 constituting a continuation of the passage 11 and through which the refrigerant is discharged into the rotating cylinder. The shaft 7 is further provided with a second axially extending passage 13 and a plurality of openings 14 afford communication between this passage and the interior of the cylinder. Thus the refrigerating agent may find a free outlet through said openings and the passage 13 through which it is returned through a suitable connection to the source of supply.

Within the flexible cylinder wall 9 longitudinally spaced brackets 15 are arranged, said brackets preferably being suitably secured on the shaft 7 and each having oppositely extending radial arms. Rollers 15′ are mounted at their ends in suitable bearings 16 which are longitudinally adjustable upon the arms. By properly adjusting and positioning these rollers they may be caused to exert any desired pressure against the inner face of the cylinder wall 9 at diametrically opposite points. The liquid to be treated is admitted to the tank 5 exteriorly of the cylinder through an opening 17. Preferably, sufficient liquid is supplied to completely cover the rotating cylinder, though this is not essential as the present method can be practised with the cylinder only partly submerged in the liquid. Primarily, my invention is concerned with the manufacture of ice, though certain fluids, gases or liquids may be treated for the recovery therefrom of solid crystals by the transference of heat, and in many cases the crystals may be of greater specific gravity than the fluid, gas or liquid. Therefore, I have shown the tank 5 as provided at the bottom thereof with a conveyor 18 whereby the solid crystals may be drawn off through one end of the tank. In the manufacture of ice, the ice floats to the surface of the liquid and a suitable conveyor may be arranged in the upper portion of the tank to collect and transfer the ice particles from the apparatus to any desired point.

In the practical operation of my improved method, the tank is supplied with water so that the cylinder 9 will be either wholly or partially covered thereby. The brine or other refrigerating agent is supplied to the interior of the cylinder, the glands 10 providing a fluidtight connection between the flexible cylinder wall and the heads 8 so that there can be no escape of the refrigerating agent into the tank 5. The cylinder is then continuously rotated and as the flexible wall passes over the relatively stationary rollers 15′, said wall is flexed and somewhat distorted from its normal conformation so that it assumes the cross-sectional shape approximately corresponding to that illustrated in Figure 2 of the drawings. For a short time after the apparatus is started in operation, the refrigerating agent contacting with the inner wall of the cylinder 9 transfers heat from the liquid in contact with the outer surface of the wall, lowering the temperature of the liquid and congealing the same in the form of ice crystals which adhere closely to the surface of the wall. While this film initially is exceedingly thin, it will freely flex with the wall of the cylinder 9. This metal wall is of such flexibility, that as it approaches each of the pressure rollers 15′ in its rotation, it buckles inwardly to a slight extent as shown more particularly at A in Fig. 3 of the drawing. When the ice film B has acquired an appreciable thickness, it will not follow the cylinder wall as it buckles inwardly adjacent to the pressure roller but will have sufficient rigidity to maintain its unbroken continuity with the portions of the ice film at either side of the pressure roller. It will, therefore, be understood that a limited section of the cylinder wall as it approaches each of the pressure rollers separates from the inner face of the ice film, providing a longitudinally extending space C open at its opposite ends so that the water in the tank 5 may enter between the ice film and the flexible cylinder wall. Thus there is continuous contact of the water directly with the wall of the cylinder and consequently an immediate transfer of heat from the water entering the space C. As the cylinder continues to rotate a part of this water is forced out of the space C while the remainder is converted into ice crystals which are added to the ice film B on its inner face.

Annular insulating members 20 are engaged with the inner surface of the cylinder wall 9 inwardly of the gaskets 10. Thus it is apparent that the ice film B will not extend over the entire surface of the cylinder between the gaskets 10 as the refrigerating agent is not effective to transfer heat through those sections of the cylinder wall engaged by the insulating members 20. Preferably, these members are in the form of inflatable tubes so as to effect complete insulation while at the same time permitting of the flexure of the cylinder wall. It will thus be apparent that as the cylinder wall, upon approaching the pressure rollers, is separated from the inner face of the ice film, a vacuum is formed, drawing the water immediately into the space C at each end of

the ice film between the same and the cylinder gaskets 10.

By effecting a localized separation of the cylinder wall from the surface of the ice film in this manner there occurs a progressive building up, by the process of accretion, of the ice film B as the cylinder rotates. This increase in the film thickness as the cylinder moves over each of the pressure rollers is illustrated on a somewhat exaggerated scale at D in Fig. 4 of the drawing. There is thus attained a more rapid and effective transfer of heat from the liquid than would be the case if it was necessary to effect such transfer through the ice film interposed between the flexible wall and the body of liquid.

After the ice film has been built up in this manner to a thickness of say approximately 1", as the flexible wall with the ice film thereon rides over the pressure rollers, the film will be fractured lengthwise of the cylinder somewhat in the manner shown in Fig. 5 of the drawing and the film will separate from the outer face of the cylinder wall in the form of elongated slabs or sections. The thickness which the film may acquire before such fracture takes place is determined by the degree of pressure which the rollers 15' exert against the flexible wall 9. In other words, as the pressure against the cylinder wall is increased, the greater will be the extent of the inward buckling of said wall at A and the thickness of the ice sections will be less than if the rollers exerted less pressure against the cylinder wall so that its buckling or deformation would be relatively slight. In addition to variations in pressure, the buckling of the cylinder wall and the thickness of the ice sections is also influenced by differences in temperature between the refrigerant and the ice cake and by variations in the velocity of rotation of the cylinder. The buckling of the cylinder wall as shown at A in Figure 2 is considerably exaggerated, such buckling more nearly conforming to the condition illustrated in Figure 3 of the drawings.

The product resulting from the operation of my improved method is in the form of elongated slabs or sections of ice transversely concavo-convex and of substantially uniform thickness. Each of these sections is made up of a multiplicity of laminations or ice films and the product can be aptly referred to as a stratified ice slab. As each stratum or lamination is formed directly on the surface of the heat transfer wall, these laminations will all be of the same temperature and the ice slab or section throughout its structure will, therefore, likewise be of uniform temperature. Accordingly, in the use of such ice slabs they will melt away uniformly. The new product, therefore, lends itself particularly for use in the packing of jackets or containers for ice cream cans. Owing to the concavo-convex form of these slabs they can be very compactly, as well as quickly arranged in the cylindrical jacket of the ice cream freezer.

It is not essential that the product shall be of the exact form shown in the drawings, as it is obvious that by covering the entire inner surface of the cylinder wall with a sheet of rubber or other insulating material provided with openings of different forms and shapes, various ornamental configurations of the ice slabs might be produced. In this manner also, it would be possible to provide monograms of ice for the decoration of confectionery products.

Heretofore in the manufacture of artificial ice, that portion of the ice block next adjacent to the heat transfer wall with which the refrigerating agent is in contact possesses the highest temperature, while the temperature of the ice block at its opposite face is appreciably lower. In other words, assuming that the temperature of the ice on one side which was in contact with the heat transfer wall is 20° F., the temperature of the opposite side face of the ice block will be approximately 25° F. By my improved method, however, each film or stratum of ice crystals successively formed upon the outer face of the flexible heat transfer wall will have identically the same temperature, namely, 20° F. Accordingly, it is evident that the ice slabs or sections so produced will melt away uniformly.

From the foregoing description considered in connection with the accompanying drawing, my improved method of manufacturing ice will be clearly understood. In actual practise it has been found that by reason of the progressive separation of the flexible heat transfer element from the surface of the ice film, refrigeration of the liquid is very materially facilitated so that the rapid and continuous production of ice in large quantities may be realized.

In the drawing I have illustrated the application of pressure to the inner face of the flexible cylinder wall at diametrically opposite points. It is, however, apparent that if desired, but a single one of the pressure rollers need be employed, depending upon the rapidity of rotation of the cylinder and the degree of temperature which is obtained by means of the refrigerating agent. As hereinbefore stated, the method might be carried out with various other forms of apparatus. Thus for instance, while it is most practical and convenient to employ a cylindrical heat transfer wall, a straight or flat flexible wall might be used. A practical form of apparatus having such a flat flexible wall is for instance, shown in my co-pending application Serial No. 469,797, filed May 16,

1921. However, as the concavo-convex form of the ice slabs or sections is an advantageous feature, I prefer to use the cylindrical drum or cylinder.

I have herein disclosed one practical way in which may present improved method might be carried out and have also described the product resulting therefrom. Nevertheless, since it is manifest that the several features of my present invention are susceptible of certain modifications, it is to be understood that I reserve the privilege of resorting to all such legitimate changes as may be fairly embodied within the spirit and scope of the invention as claimed.

I claim:

1. In the method of crystallizing fluids by heat transference, that step which consists in momentarily altering the normal conformation of a heat transfer element upon which a film of crystals is deposited and thereby effecting a separation of said element from said film to permit the fluid to enter between said film and the heat transfer element and directly contact with the latter.

2. The method of crystallizing fluids by heat transference which consists in contacting a heat transfer agent and the fluid to be treated with opposite sides of a flexible heat transfer wall, progressively flexing said wall to separate the same from the film of crystals deposited thereon to permit the fluid to enter between the film and said wall for direct contact with the latter to thereby accelerate the formation of a film of increased thickness by the continuous and substantially uniform accretion of crystals upon the inner face of the film.

3. The method of crystallizing fluids by heat transference which consists in contacting a heat transfer agent and the fluid to be crystallized with opposite sides of a rotating cylinder wall and progressively separating a limited portion of the cylinder wall in its rotation from the inner face of the crystal film deposited thereon to permit direct contact of the fluid with the surface of said wall whereby crystallization of the fluid is effected at the substantially invariable temperature existing at the surface of the cylinder wall whereby a film of the desired thickness and of substantially uniform density is formed.

4. The method of crystallizing fluids by heat transference which consists in contacting a heat transfer agent and the fluid to be treated with the opposite sides of a flexible cylinder wall, rotating said cylinder wall, and producing a localized deformation of the cylinder wall progressively during its rotation to separate said wall from the crystal film deposited thereon and permit direct contact of the fluid being treated with the surface of said wall whereby continuous crystallization of the fluid at a substantially invariable temperature existing at the surface of said wall is obtained to produce, by the process of accretion, a film of a desired thickness having substantially uniform density.

5. The method of manufacturing ice which consists in contacting a heat transfer agent and the liquid to be refrigerated with opposite sides of a flexible cylinder wall, insulating portions of said wall to prevent heat transference therethrough and limiting the area of wall surface upon which the ice film is formed, rotating said cylinder wall, and progressively producing a localized deformation of the cylinder wall in its rotation to separate said wall from the ice film and permit direct contact of the liquid with the surface of said wall, and thereby effect continuous refrigeration at a substantially invariable temperature, the accretion of ice crystals upon the inner surface of the film, whereby an ice film is formed upon the heat transfer wall having substantially uniform density and temperature throughout its area.

In testimony that I claim the foregoing as my invention, and I have signed my name hereunder.

CROSBY FIELD.