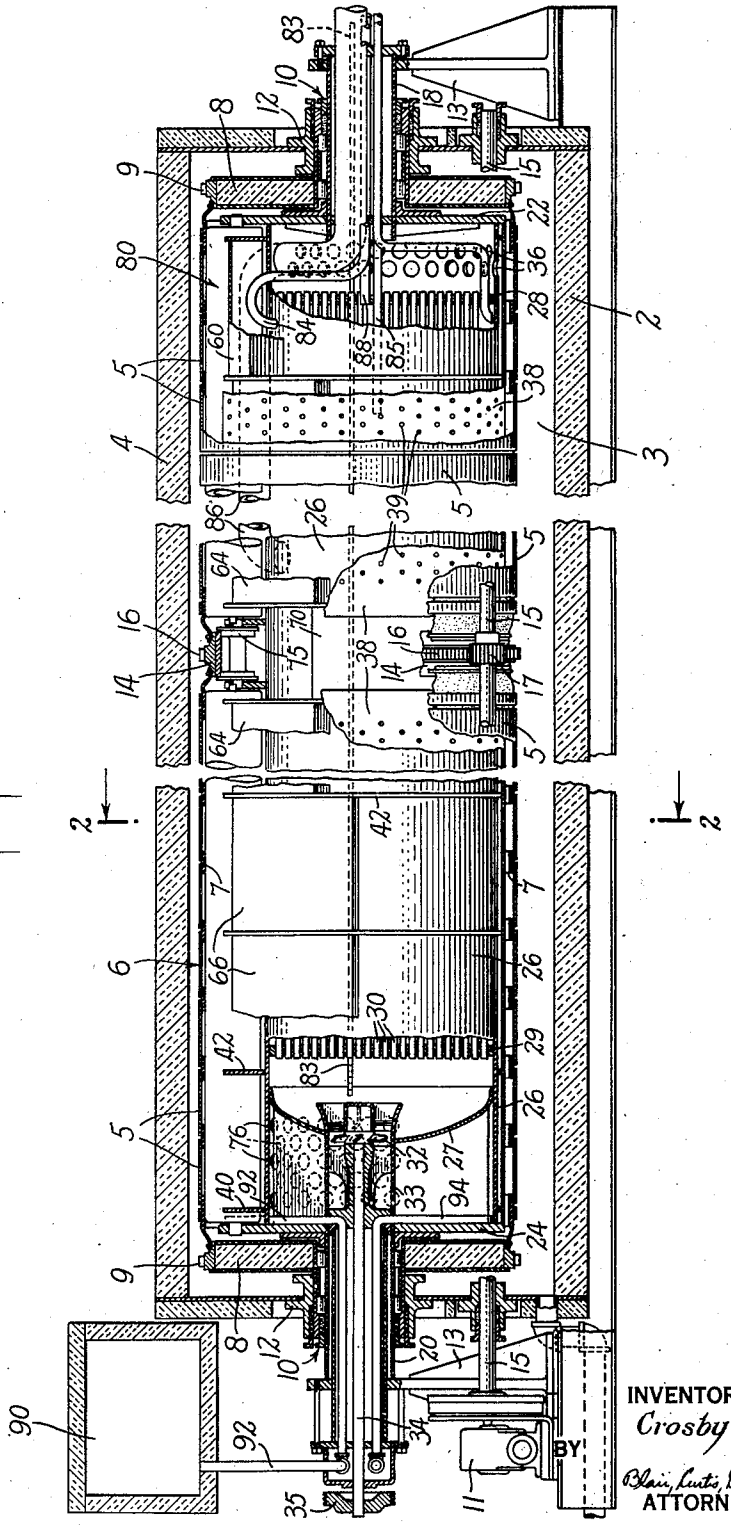
Oct. 7, 1941. C. FIELD 2,257,904

HEAT EXCHANGE APPARATUS

Filed Jan. 20, 1939 3 Sheets-Sheet 1

Fig. 1.

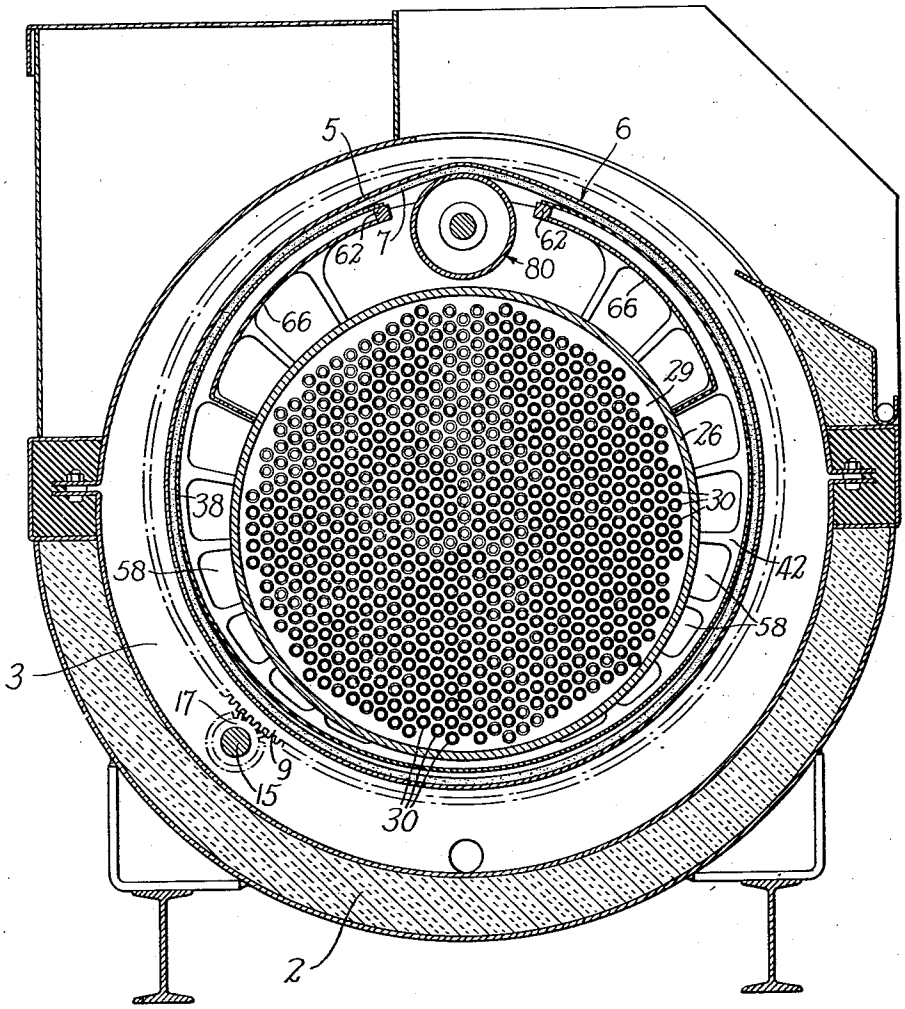


Oct. 7, 1941. C. FIELD 2,257,904

HEAT EXCHANGE APPARATUS

Filed Jan. 20, 1939 3 Sheets-Sheet 2

Fig. 2.



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HEAT EXCHANGE APPARATUS

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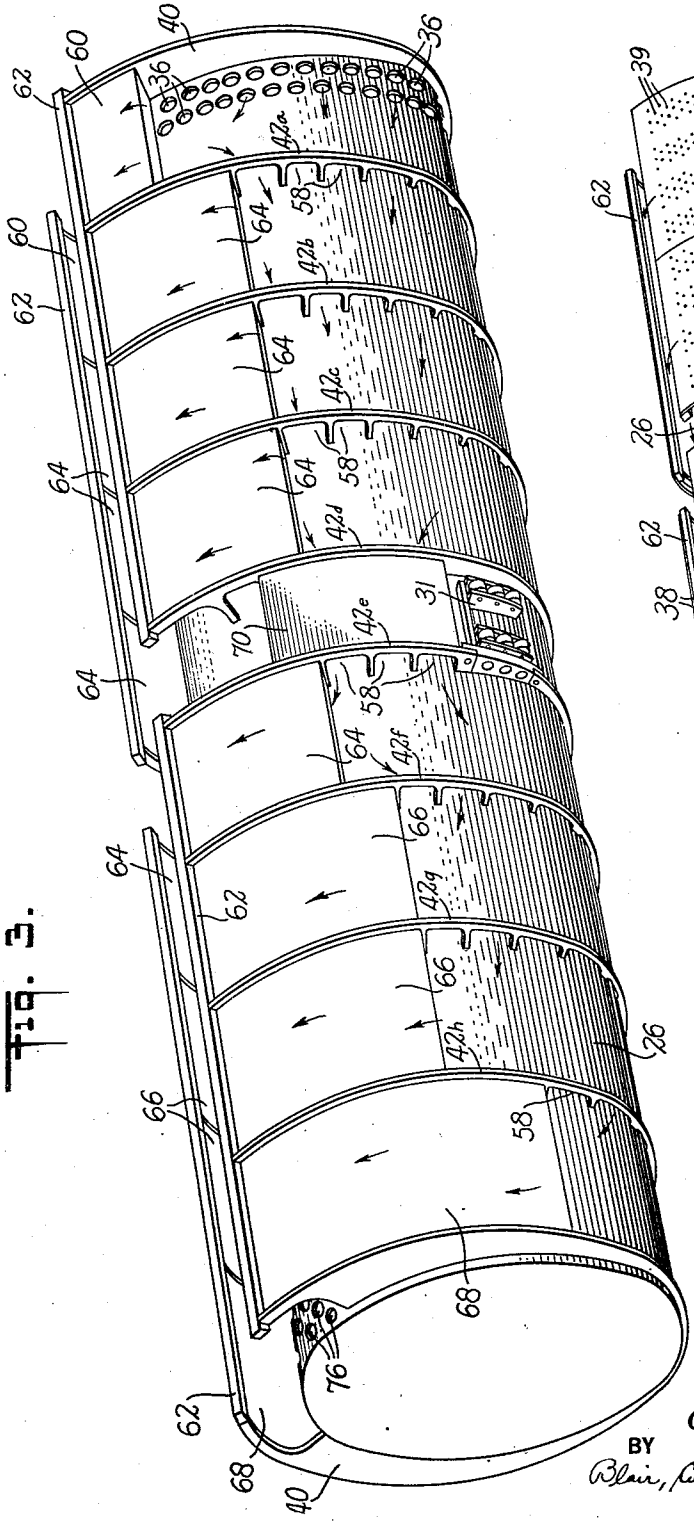


Fig. 3.

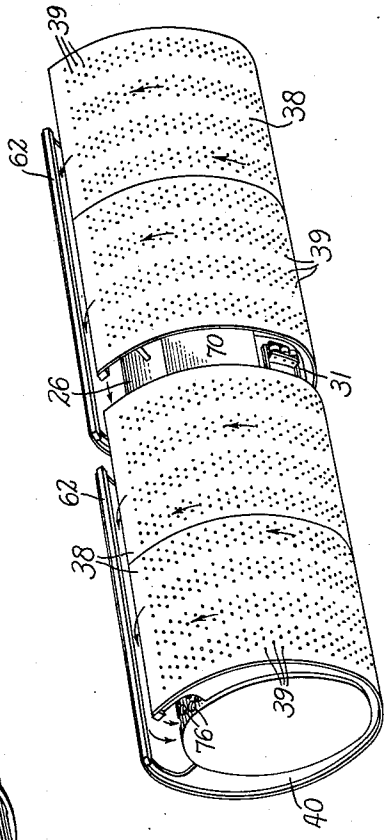


Fig. 4.

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UNITED STATES PATENT OFFICE

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HEAT EXCHANGE APPARATUS

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Application January 20, 1939, Serial No. 251,910

17 Claims. (Cl. 62—106)

This invention relates to heat exchange apparatus and more particularly to apparatus for solidifying materials such as water.

An object of this invention is to provide apparatus which may be operated continuously to congeal materials and more particularly to produce ice. A further object is to provide apparatus of the above character which is sturdy and compact in construction, dependable and efficient in its operation, and which is economical to build and to operate. These and other objects will be in part obvious and in part pointed out below.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts as will be exemplified in the stucture to be hereinafter described and the scope of the application of which will be indicated in the following claims.

In the drawings, wherein like reference characters refer to corresponding parts throughout the several views.

Figure 1 is a vertical section showing parts of certain of the elements in elevation;

Figure 2 is a vertical section on the line 2—2 of Figure 1;

Figure 3 is a perspective view of the stationary drum and web construction showing the path of circulation of the cooling brine; and

Figure 4 is a view similar to Figure 3 but with the drum sheet structure in position.

In some respects the present embodiment of my invention may be considered an improvement upon that shown in my prior Patent No. 2,078,938, issued May 4, 1937, entitled "Heat exchange apparatus." The present apparatus will be discussed as used for making ice in the form of thin ribbons which are peeled from a flexible metal cylinder formed of a plurality of flexible metal bands. The cylinder is mounted with its axis in a horizontal position and is partially immersed in water with only its upper side extending above the water.

A cold liquid such as brine is circulated within the cylinder thereby causing ice to form on the outer surface of the cylinder, and the cylinder is rotated; during rotation, the cylinder is flexed along the upper side where it extends from the water. Thus, as the cylinder rotates, ice is formed upon the portion of the drum immersed in the water, and by the time the ice reaches a certain predetermined thickness, it is moved out of the water and is peeled from the cylinder.

The brine within the cylinder is maintained at a low temperature by means of a refrigeration system having an evaporator within the cylinder. Accordingly, ammonia is supplied to the evaporator in the liquid form and is withdrawn after evaporation in the gaseous form; a brine agitator moves the brine through and around the evaporator and into contact with the inner surface of the cylinder in a manner more fully pointed out below.

Referring particularly to Figure 1 of the drawings, the insulated outer casing 2 forms a water tank 3 with a cover 4. A flexible metal cylinder construction formed of a plurality of individual freezing bands or panels 5, and generally indicated at 6, is supported at each end by an end bell 8 having a hub assembly generally indicated at 10; each hub assembly 10 extends through a water tight bearing 12.

In this embodiment, the flexible metal cylinder 6 is divided at the center to form in effect two separate cylinders; the adjacent ends of these two separate cylinders are attached to a center ring 14 by rubber flanges. Center ring 14 assists in supporting the flexible cylinder and is in turn supported by three internal roller units; one roller unit 75 is positioned at the top, and (see Figure 3) a roller unit 31 is positioned on each side near the bottom. Each unit 31 comprises six roller bearings rotatably mounted in a suitable frame construction which is welded in place upon the adjacent wall of the evaporator.

Surrounding center ring 14 and attached thereto is a center gear 16 and at each end upon the end bell 8 is a similar gear 9. Positioned near the bottom of each of gears 16 and 9 and engaging therewith is a pinion 17; pinions 17 are rigidly mounted upon a stud shaft 15 which is supported at the ends of the casing and extends to the left where it is driven by a motor 11. Thus, during operation the flexible cylinder construction is rotated by motor 11 through stud shaft 15, pinions 17, and gears 9 and 16.

Additional support is provided for the flexible cylinder 6 at the top by the flexing roller construction generally indicated at 80 (see also Figure 2) and the flexible cylinder is thus in a sense partially suspended but is held definitely in position by the stationary structure. This stationary structure, including the evaporator and the brine circulating mechanism, is supported at the right end by a stationary hollow shaft 18 and at the left end by a similar hollow shaft 20. Each of the hollow shafts extends through the center of the hub assembly 10 to the exterior of casing 2 where it is supported by a stationary bracket 13. Shafts 18 and 20 carry circular end plates

22 and 24 respectively which are within the flexible cylinder 6. Supported by and extending between these end plates, with its axis below the center of the end plates, is a drum 26. Mounted within drum 26 and near its respective ends are two header plates 28 and 29 which seal the central portion of drum 26 to form a cylindrical evaporator. Extending the length of the evaporator through the two header plates are tubes 30 which are open at their ends. The brine being circulated as mentioned above passes through these tubes and is cooled.

As indicated above, cylinder 6 is filled with cold brine, and this brine completely surrounds drum 26 and also fills tubes 30 and the spaces within the drum between the header plates 28 and 29 and the end plates 22 and 24 respectively. Near the left end of drum 26 is mounted a dished head 27 which carries a fluted funnel 33 and a brine agitator 32; brine agitator 32 is rotated by means of a shaft extending to the left through hollow shaft 20 and carrying a pulley 35. When brine agitator 32 is rotated, it takes brine in through openings in the fluted funnel 33 and forces the brine to the right through tubes 30 and out the right end of the tubes past header plate 28 and then out radially through a plurality of openings 36. The brine thus refrigerated by its passage through tubes 30 is moved into contact with the flexible cylinder and is returned to the agitator in a manner more fully pointed out below.

As shown best in Figure 4, drum 26 is surrounded by two sections of drum sheets 38; the drum sheets are formed of sheet metal and are provided with a large number of small openings or jets 39. The two sections of drum sheets 38 are spaced apart at the center and are supported on drum 26 by a web structure, shown best in Figures 2 and 3. The drum sheets not only provide the nozzles or jets to direct the refrigerated brine against the interior surfaces of the flexible freezing panels, but also provide part of the support for the flexible cylinder. As shown in Figure 2, the flexible cylinder has a plurality of circumferential rubber bands 7 fastened between the panels comprising the cylinder. These bands serve to carry the flexible cylinder over the drum sheets and also to space the flexible panels from the drum sheets so that the spent brine after flowing against the flexible panels can flow between the flexible panels and the drum sheets to the top of the flexible cylinder.

The web structure supporting the drum sheets comprises ten webs equally spaced along the drum, as shown in Figure 3. The tops of the web structures are welded to four longitudinally extending frame members 62. The end webs 40 are solid and thus form the end walls of a passageway which extends from openings 36 to the left between drum 26 and drum sheets 38. The webs 42 spaced between the end webs 40 are designated by the sub-letters *a*, *b*, *c*, *d*, *e*, *f*, *g* and *h*, all of which are cut away on each side to provide openings 58 so that the brine may pass from the openings 36 to the left along the drum. Drum sheets 38 are welded to the webs 40 and 42 and to the frame members 62.

During movement of the brine to the left within the drum sheets 38 from one section to another, sufficient head is maintained to cause some of the brine to move outwardly through the jets 39 in the drum sheet of each section; jets 39 are grouped as shown in Figure 4 to impinge the brine upon the inner surface of each of the freezing panels 5 of cylinder 6 (see also Figures 1 and 2). Freezing panels 5 are thus maintained at a low temperature, and water within tank 3 freezes upon the outer surface of the panels.

Under some conditions of operation, difficulty may be encountered if all of the freezing panels 5 are not cooled at a uniform rate throughout. In the present embodiment, this result is obtained by maintaining a uniform pressure head upon all of the jets 39 with the result that there is a uniform flow of brine through the jets and against the freezing panels 5. This uniform pressure head is maintained by making the passageway which extends from the openings 36 to the left between drum 26 and drum sheets 38 progressively decrease in cross-sectional area. This decrease in cross-sectional area is made by using a plurality of baffles, shown best in Figure 3, and indicated by the numerals 60, 64, 66 and 68. These baffles extend varying distances downwardly from the top of the drum sheets 38, and they are spaced sufficiently from the drum sheets to permit the brine to move upwardly to the jets 39 opposite the baffles. At the top each baffle is welded to its frame member 62, and at the bottom it extends inwardly as shown in Figure 2 and is welded to drum 26; along the sides, each baffle is welded to the adjacent web structures. The various webs 42 are cut away to provide openings 58 only where brine is to pass; thus, the cold brine is directed to the left along the drum 26 and the baffles.

At the extreme right of Figure 3, the brine moves outwardly through openings 36 to the chamber between webs 40 and 42*a*; it is here confined at the top by baffle 60 and as it moves to the left through openings 58, it enters the chamber between web 42*a* and 42*b* which is smaller than the space between web 40 and 42*a* as baffle 64 is longer than baffle 60. At the left end of the drum, baffles 66 and 68 are progressively longer thereby to restrict further the brine passageway.

No freezing occurs at the center of the drum between the drum sheets 38, as the center supporting ring 14 (Figure 1) and support units 31 (Figure 3) are provided at this point. The cold brine is conducted past this center section of the cylinder through a tunnel-like baffle 70 which extends between webs 42*d* and 42*e* and is arcuate similar to baffles 60, 64, 66 and 68. The upper and lower edges of baffle 70 extend inwardly to drum 26; all of the edges of the baffle are welded to the adjacent portions of webs 42*d* and 42*e* and drum 26.

Referring particularly to Figures 4 and 2, after the brine is impinged through jets 39 against the freezing panels 5, it moves upwardly between the freezing panels 5 and the drum sheets 38 beyond the edge of the drum sheets, and then (see Figure 3) it moves to the left through a passageway which is provided between drum 26 and the inner side of baffles 60, 64 and 66; this passageway is progressively increased in cross-section from right to left as the passageway for the cold brine is decreased. At the left-hand end of the cylinder beneath baffles 68, the brine moves into drum 26 through a plurality of openings 76. The flow of brine as traced above is shown by arrows in the various figures.

During operation, ice forms upon the freezing panels 5, and, as shown best in Figure 2, the flexing roller 80 causes an abrupt change in the

curvature of the freezing panels as they rotate and pass over the flexing roller. The ice moves to the right from casing 2 where it is conveyed to a suitable storage chamber. An automatic water supply control is provided to maintain a constant water level within tank 3; this water is supplied through three pipes (not shown) one of which directs a stream of water against each of end gears 9 and center gear 14. In this manner, the formation of ice upon the gears is effectively prevented, and at the same time the supply water is pre-cooled.

Referring to the right of Figure 1, liquid ammonia is supplied to the evaporator through a pipe 85, and the gaseous ammonia is withdrawn through a pipe 86; a liquid pressure equalizing pipe 88 and a gas equalizing pipe 84 extend from the end of the evaporator to the ammonia supply. At the right of agitator 32 is positioned the end of a brine sample tube 83 which extends to the right through shaft 18 by means of which the brine agitator pressure may be tested and the brine may be tested. During operation, the flexible cylinder is entirely filled with brine, and when the temperature of the brine changes, expansion and contraction occur; accordingly, at the left end of casing 2, a surge tank 90 is provided. Surge tank 90 is connected to drum 26 by a surge pipe 92 which extends to the right through the hollow shaft construction 20 to the interior of drum 26 and then upwardly to the top of the drum. A drain pipe 94 extends inwardly through the hollow shaft construction 20 and downwardly to the bottom of drum 26.

I claim:

1. In congealing apparatus of the type wherein the material to be congealed is supplied to the outer surface of a flexible cylinder and the inner surface of the flexible cylinder is cooled by a heat exchange fluid, fluid cooling and circulating means to deliver cold heat exchange fluid to the inner surface of the flexible cylinder comprising, a cylindrical evaporator positioned longitudinally of the flexible cylinder, a drum sheet surrounding said cylindrical evaporator and having a plurality of jets evenly spaced to impinge the heat exchange fluid against the inner surface of the flexible cylinder, and a fluid pump and baffle construction to move the fluid through said jets and in heat exchange relationship with said evaporator.

2. In congealing apparatus of the type wherein the material to be congealed is supplied to the outer surface of a flexible cylinder and the inner surface of the flexible cylinder is cooled by a heat exchange fluid, fluid cooling and circulating means to deliver cold heat exchange fluid to the inner surface of the flexible cylinder comprising, a cylindrical evaporator positioned longitudinally of the flexible cylinder, a drum sheet surrounding said cylindrical evaporator and having a plurality of jets evenly spaced to impinge the heat exchange fluid against the inner surface of the flexible cylinder, a rotating agitator positioned to direct the heat exchange fluid into one end of said evaporator, and baffle means to direct the fluid from the other end of the evaporator along the exterior of the evaporator and through said jets.

3. In heat exchange apparatus, the combination of: a heat exchange drum adapted to be filled with a heat exchange fluid; and liquid cooling and circulating means within said drum comprising, a cylinder having a pair of headers one of which is positioned at each of its ends, a plurality of tubes extending between said headers, means to circulate the heat exchange fluid, and means to direct the heat exchange fluid in its movement from one end of said cylinder through said tubes and out the other end of said cylinder into contact with the inner surface of said heat exchange drum.

4. In heat exchange apparatus, the combination of: a heat exchange drum adapted to be filled with a heat exchange fluid; and liquid cooling and circulating means within said drum comprising, a cylinder having a pair of headers one of which is positioned at each of its ends, a plurality of tubes extending between said headers, means to circulate the heat exchange fluid, and means to direct the heat exchange fluid in its movement from one end of said cylinder through said tubes and out the other end of said cylinder into contact with the inner surface of said heat exchange drum, said last-named means including means to direct the fluid back along the outside of the cylinder and impinge it in a controlled manner upon the inner surface of the drum.

5. In heat exchange apparatus, the combination of: a heat exchange drum adapted to be filled with a heat exchange fluid; and liquid cooling and circulating means within said drum comprising, a cylinder having a pair of headers one of which is positioned at each of its ends, a plurality of tubes extending between said headers, means to circulate the heat exchange fluid, means to direct the heat exchange fluid in its movement from one end of said cylinder through said tubes and out the other end of said cylinder into contact with the inner surface of said heat exchange drum, said last-named means including means to direct the fluid back along the outside of the cylinder and impinge it upon the inner surface of the drum, means to supply a congealable liquid to the outer surface of the drum, and means to deflect the drum to remove the congealed material.

6. In congealing apparatus, the combination of: a flexible drum, means to supply a congealable material to the exterior of said drum, and means to extract heat from the liquid through a heat exchange fluid within said drum; said last-named means comprising an evaporator adapted to receive liquid refrigerant and permit the refrigerant to evaporate and be withdrawn in gaseous form, jet means arranged to discharge against the under surface of the drum, and a liquid agitator to move heat exchange liquid into heat exchange relationship with respect to said evaporator and then through said jet means to cause the heat exchange liquid to impinge against the inner surface of said drum.

7. In congealing apparatus, the combination of, a flexible drum, means to supply a congealable material to the exterior of said drum, and means to extract heat from the liquid through a heat exchange fluid within said drum; said last-named means comprising an evaporator adapted to receive liquid refrigerant and permit the refrigerant to evaporate and be withdrawn in gaseous form, said evaporator comprising a cylinder with headers therein and a plurality of tubes extending between said headers, jet means arranged to discharge against the under surface of the drum, and a liquid agitator to move heat exchange liquid into heat exchange relationship with respect to said evaporator and then through said jet means to cause the heat exchange liquid to impinge against the inner surface of said drum.

8. In congealing apparatus of the type wherein

a material to be congealed is supplied to the outer surface of a flexible cylinder and the flexible cylinder is flexed to free the congealed material, a flexible cylinder containing a heat exchange liquid the volume of which changes when there are changes in temperature, an evaporator positioned within said cylinder and immersed in the heat exchange liquid, and a surge tank in communication with said flexible cylinder to deliver heat exchange liquid to the flexible cylinder when the volume of the liquid within the cylinder decreases and to receive liquid therefrom when the volume of the liquid in the cylinder increases, whereby the volume of the liquid within the cylinder is maintained substantially constant.

9. In congealing apparatus of the type wherein a material to be congealed is supplied to the outer surface of a flexible cylinder and the flexible cylinder is flexed to free the congealed material, a flexible cylinder containing a heat exchange liquid the volume of which changes when there are changes in temperature, an evaporator positioned within said cylinder and immersed in the heat exchange liquid, and liquid level control means to compensate for changes in temperature and thereby maintain a substantially constant liquid level and pressure head upon the heat exchange liquid.

10. In congealing apparatus of the type wherein a material to be congealed is supplied to the outer surface of a flexible panel and some heat is withdrawn from the inner surface of the flexible panel by a heat exchange liquid, means to support the flexible panel and withdraw heat from the material being congealed through the wall structure of the flexible panel comprising, a central supporting member, and a web structure and baffle means mounted upon said central supporting member and engaging the flexible panel and controlling the curvature thereof, said web structure and baffle means being so constructed as to distribute the heat exchange liquid along the flexible panel.

11. In congealing apparatus of the type wherein a material to be congealed is supplied to the outer surface of a flexible panel and some heat is withdrawn from the inner surface of the flexible panel by a heat exchange liquid, means to support the flexible panel and withdraw heat from the material being congealed through the wall structure of the flexible panel comprising, a central supporting evaporator member which is adapted to receive refrigerant to be evaporated, and a web structure and baffle means mounted upon said evaporator member and engaging the flexible panel and controlling the curvature thereof, said web structure and baffle means being so constructed as to distribute the heat exchange liquid along the flexible panel.

12. In congealing apparatus of the type wherein a liquid to be congealed is supplied to a flexible panel which is cooled to form ice thereon and wherein the flexible panel is cooled by means of a heat exchange fluid upon the side of said panel opposite the congealable liquid, means to extract heat from the heat exchange fluid comprising, a refrigerator evaporator immersed within the heat exchange fluid and operatively connected with a refrigerating system to supply liquid refrigerant thereto and withdraw gaseous refrigerant therefrom, said evaporator comprising a cylindrical member with end headers and heat exchange tubes extending between the headers to permit the heat exchange fluid to flow therethrough.

13. In congealing apparatus of the type wherein the material to be congealed is supplied to the outer surface of a cylinder and heat is extracted from the material through the wall structure of said cylinder, means to cool a heat exchange fluid within the cylinder comprising, a stationary cylinder construction having two header plates one of which is mounted adjacent each end of said stationary cylinder to form two end compartments and a center compartment, a plurality of heat exchange tubes extending through said center compartment and said header plates and open at their ends to said end compartments, said stationary cylinder having openings in its outer wall to permit heat exchange fluid to flow into one of said end compartments through said heat exchange tubes and into the other of said end compartments and then radially therefrom.

14. In congealing apparatus of the type wherein a metal cylinder is positioned in a tank containing material to be congealed and during operation the congealed material is deposited upon the outer surface of the freezing cylinder, the combination of: a freezing cylinder; a stationary cylindrical construction positioned within the freezing cylinder and extending longitudinally thereof comprising, a pair of end plates positioned coaxially with respect to the freezing cylinder with one plate at each end of the freezing cylinder, a hub means rigid with and extending outwardly from each of said end plates, an evaporator cylinder rigidly mounted between said end plates, a pair of header plates mounted within said evaporator cylinder with one spaced from each of said end plates to divide said evaporator cylinder into two end compartments and a center compartment, a plurality of heat exchange tubes extending through said center compartment and said header plates and open at their ends to said end compartment; means to supply a heat exchange fluid through one of said hub means to the adjacent one of said end compartments; and means to supply a liquid refrigerant to, and withdraw gaseous refrigerant from, said center compartment through the other of said hub means.

15. In congealing apparatus of the type wherein the material to be congealed is supplied to the outer surface of a flexible cylinder and heat is withdrawn from the inner surface of the said flexible cylinder by a heat exchange fluid, the combination of: a flexible cylinder; a baffle construction; a stationary cylindrical jet construction carried by said baffle construction and supporting said cylinder for movement thereover, said jet construction comprising a plurality of jets evenly spaced and arranged to impinge the heat exchange fluid against the inner surface of said flexible cylinder; and an agitator positioned axially of said cylinder and cooperating with said baffle structure to deliver fluid evenly to said jets; the apparatus being so arranged that fluid moves axially from one end of the said flexible cylinder to the other end and then moves longitudinally along said baffle construction and the fluid is delivered to said jets under a uniform head.

16. In congealing apparatus of the type wherein a liquid to be congealed is supplied to a flexible panel which is cooled to congeal such liquid and wherein the flexible panel is cooled by means of a heat exchange fluid supplied to the side of said panel opposite the side to which the congealable liquid is supplied, means to extract heat from the heat exchange fluid com-

prising, a refrigerator evaporator immersed in the heat exchange fluid and operatively connected with a refrigerating system which supplies liquid refrigerant thereto and withdraws gaseous refrigerant therefrom, said evaporator comprising a shell construction having two end headers and heat exchange elongated members between the headers to permit thorough heat exchange relationship between the refrigerant in said evaporator and the heat exchange fluid, said apparatus including means to cause the heat exchange fluid to flow into heat exchange relationship with said evaporator and then into heat exchange relationship with said panel.

17. In congealing apparatus of the type wherein a liquid to be congealed is supplied to a flexible panel which is cooled to congeal thereon liquid supplied thereto and wherein the flexible panel is cooled by means of a heat exchange fluid supplied to the side of said panel opposite the side to which congealed fluid is supplied, means to extract heat from the heat exchange fluid comprising, a refrigerator evaporator and fluid-circulating construction immersed in the heat exchange fluid with the evaporator portion operatively connected with a refrigerating system to supply liquid refrigerant thereto and withdraw gaseous refrigerant therefrom, said evaporator and fluid-circulating construction comprising a member with end-headers and heat exchange tubes extending between the headers to permit the heat exchange fluid to flow therethrough and agitating means to impart movement to the heat exchange fluid to cause the heat exchange fluid to flow through said tubes so that cooled refrigerant is delivered to said panel.

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