June 25, 1935. C. FIELD 2,005,734

HEAT EXCHANGE APPARATUS

Filed Aug. 14, 1931 7 Sheets-Sheet 1

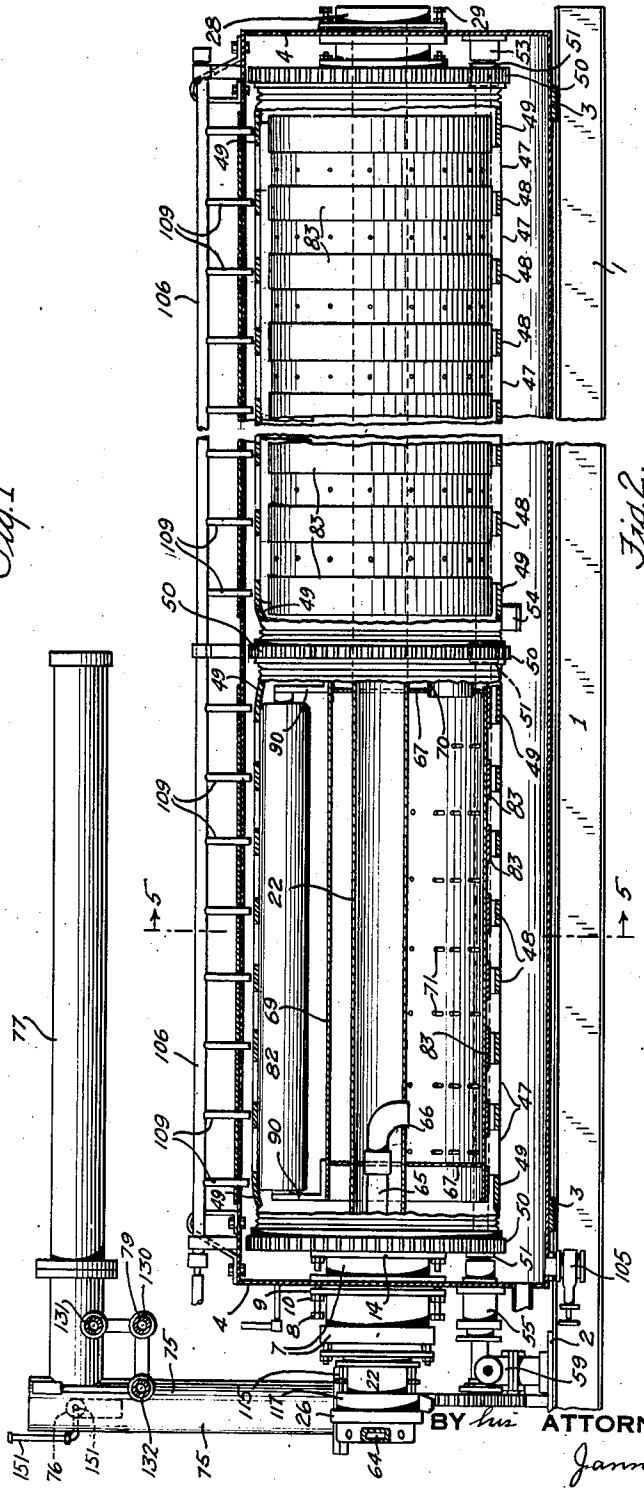


Fig. 1

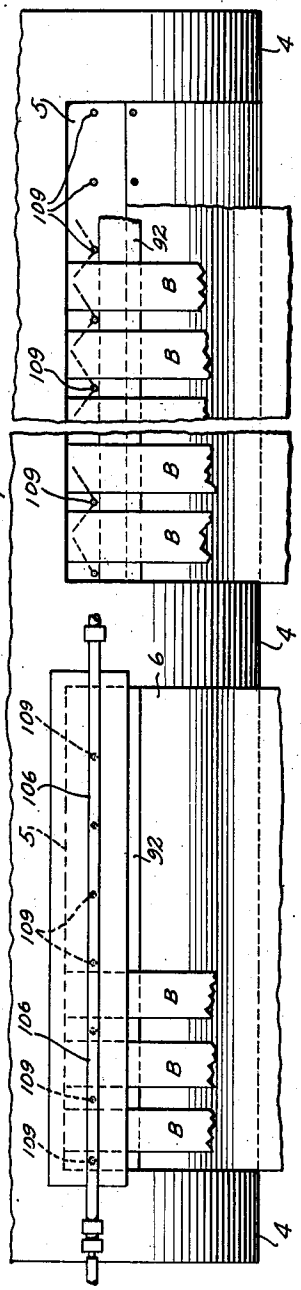


Fig. 2.

INVENTOR
CROSBY FIELD

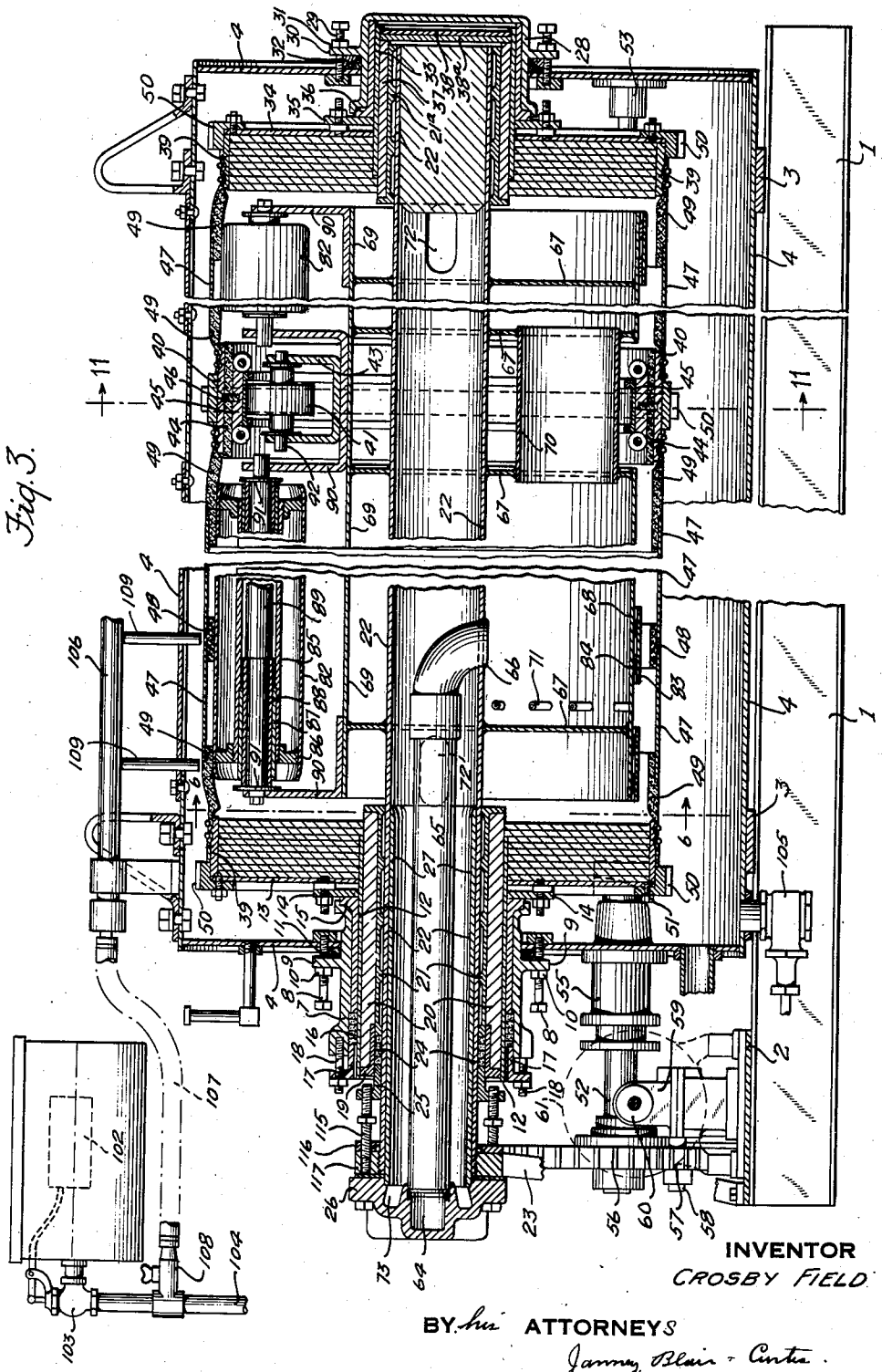
BY his ATTORNEYS
Janney, Blair & Curtis

June 25, 1935. C. FIELD 2,005,734

HEAT EXCHANGE APPARATUS

Filed Aug. 14, 1931 7 Sheets-Sheet 2

Fig. 3.



INVENTOR
CROSBY FIELD

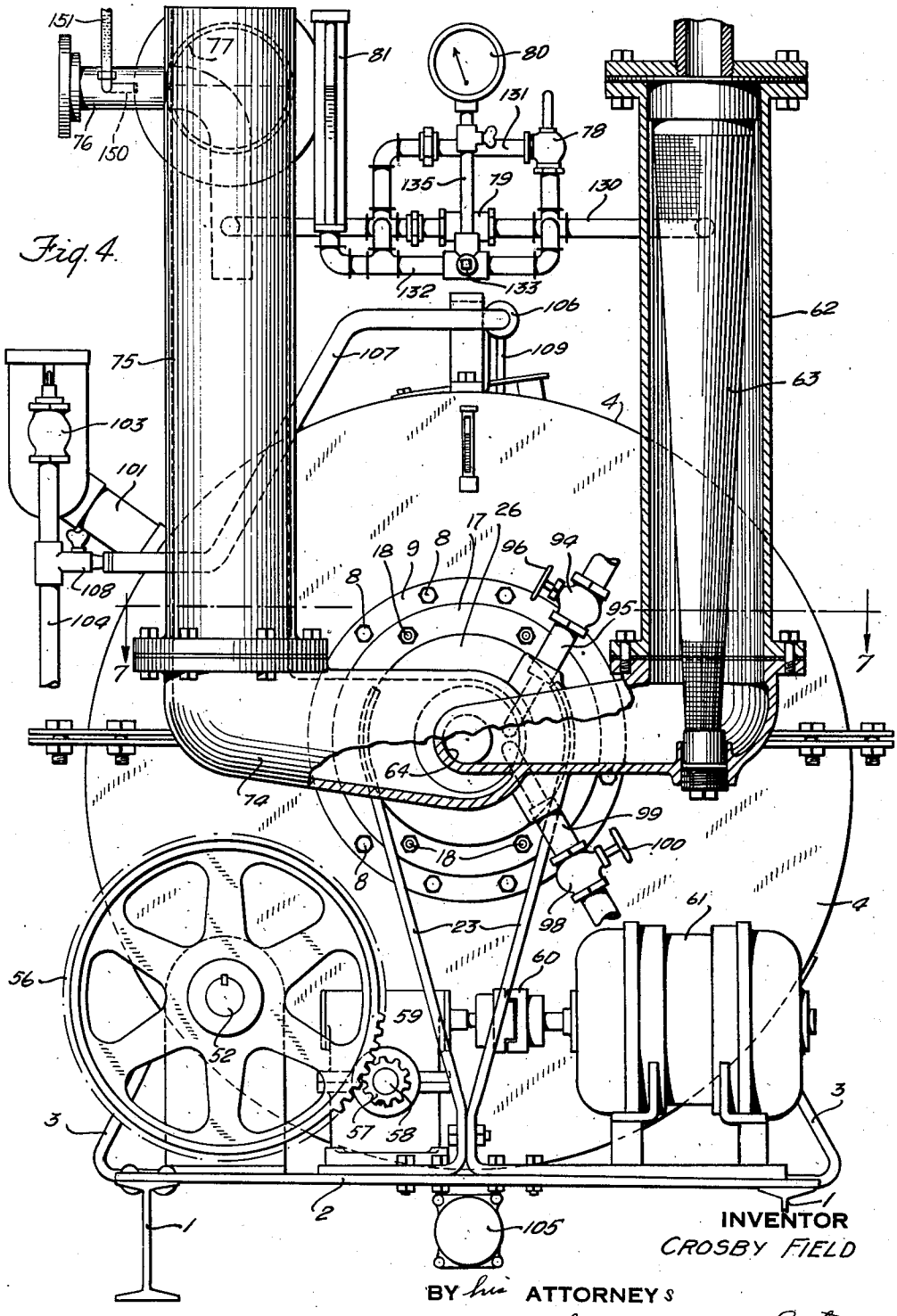
BY his ATTORNEYS
Janney, Blair & Curtis.

June 25, 1935. C. FIELD 2,005,734

HEAT EXCHANGE APPARATUS

Filed Aug. 14, 1931 7 Sheets-Sheet 3

Fig. 4.



INVENTOR
CROSBY FIELD

BY Lee ATTORNEYS
Janney, Blair & Curtis.

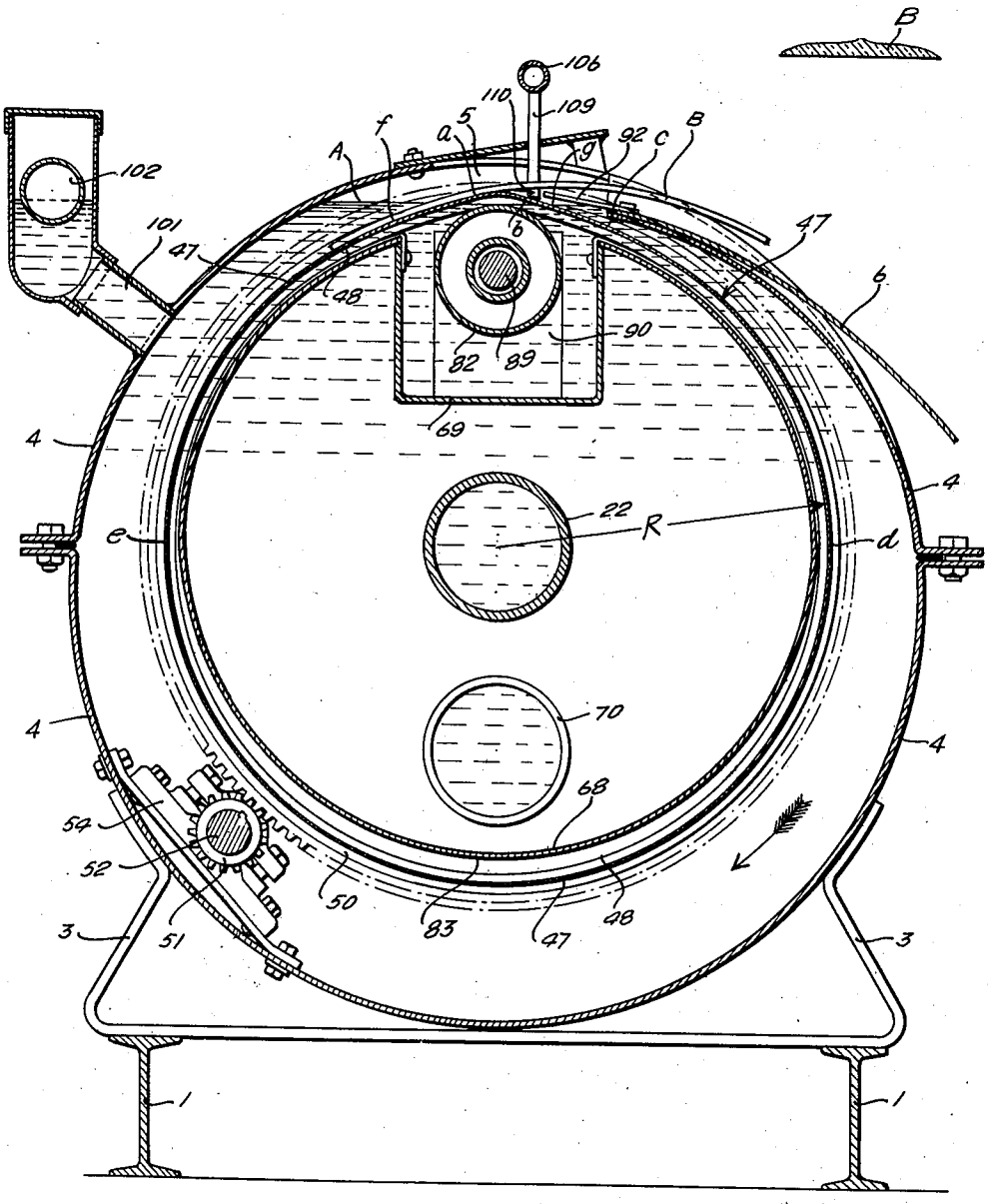
June 25, 1935. C. FIELD 2,005,734

HEAT EXCHANGE APPARATUS

Filed Aug. 14, 1931 7 Sheets-Sheet 4

Fig. 5.

Fig. 14



INVENTOR
CROSBY FIELD

BY his ATTORNEYS
Janney, Blair & Curtis.

June 25, 1935. C. FIELD 2,005,734

HEAT EXCHANGE APPARATUS

Filed Aug. 14, 1931 7 Sheets-Sheet 5

Fig. 6.

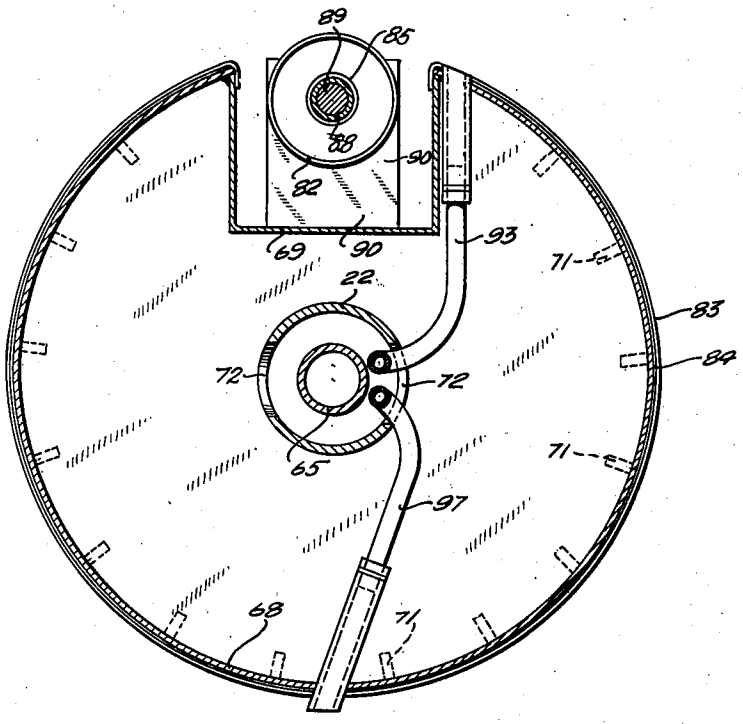
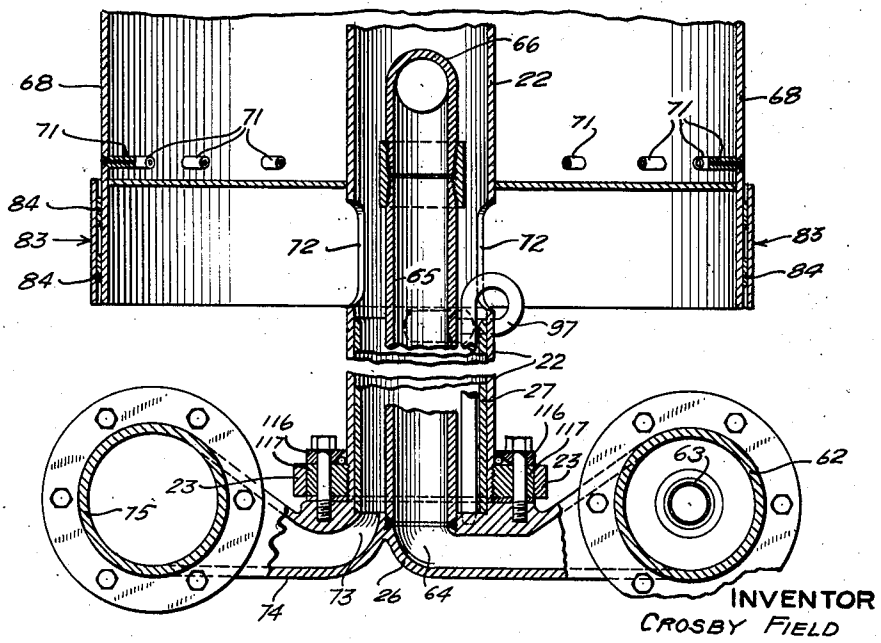


Fig. 7.



INVENTOR
CROSBY FIELD

BY Lee ATTORNEYS
Janney, Blair & Curtis.

June 25, 1935. C. FIELD 2,005,734

HEAT EXCHANGE APPARATUS

Filed Aug. 14, 1931 7 Sheets-Sheet 6

Fig. 8

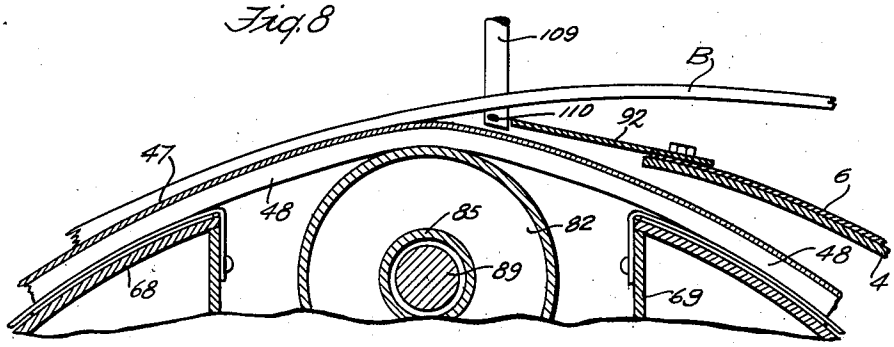


Fig. 9.

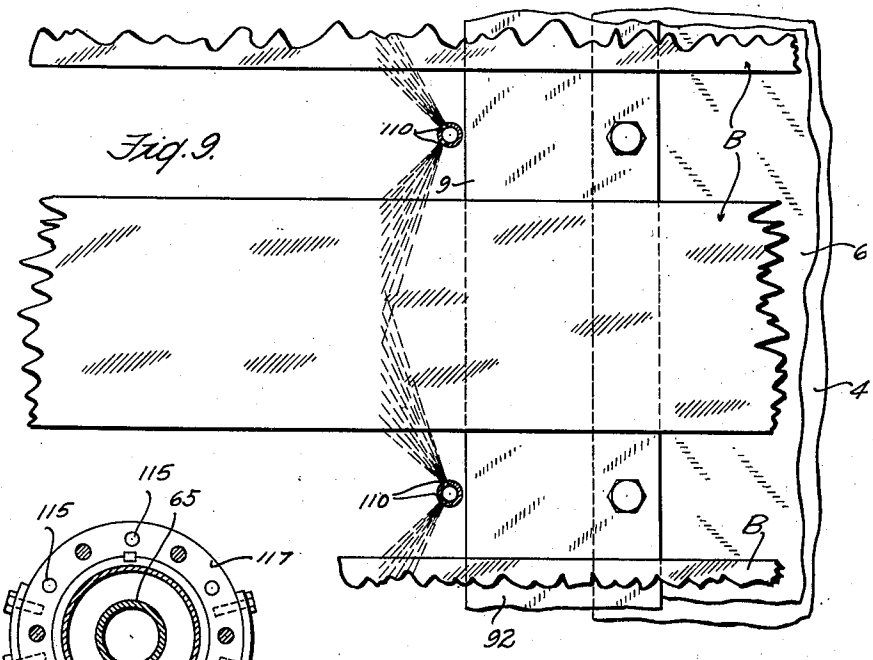
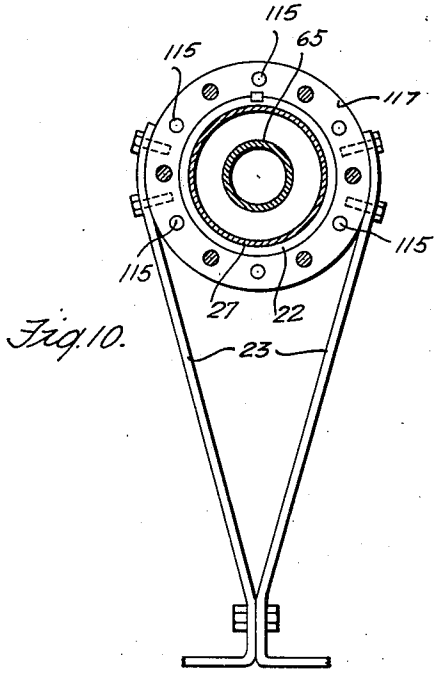


Fig. 10.



INVENTOR
CROSBY FIELD

BY his ATTORNEYS
Janney, Blair & Curtis

June 25, 1935. C. FIELD 2,005,734

HEAT EXCHANGE APPARATUS

Filed Aug. 14, 1931 7 Sheets-Sheet 7

Fig. 11.

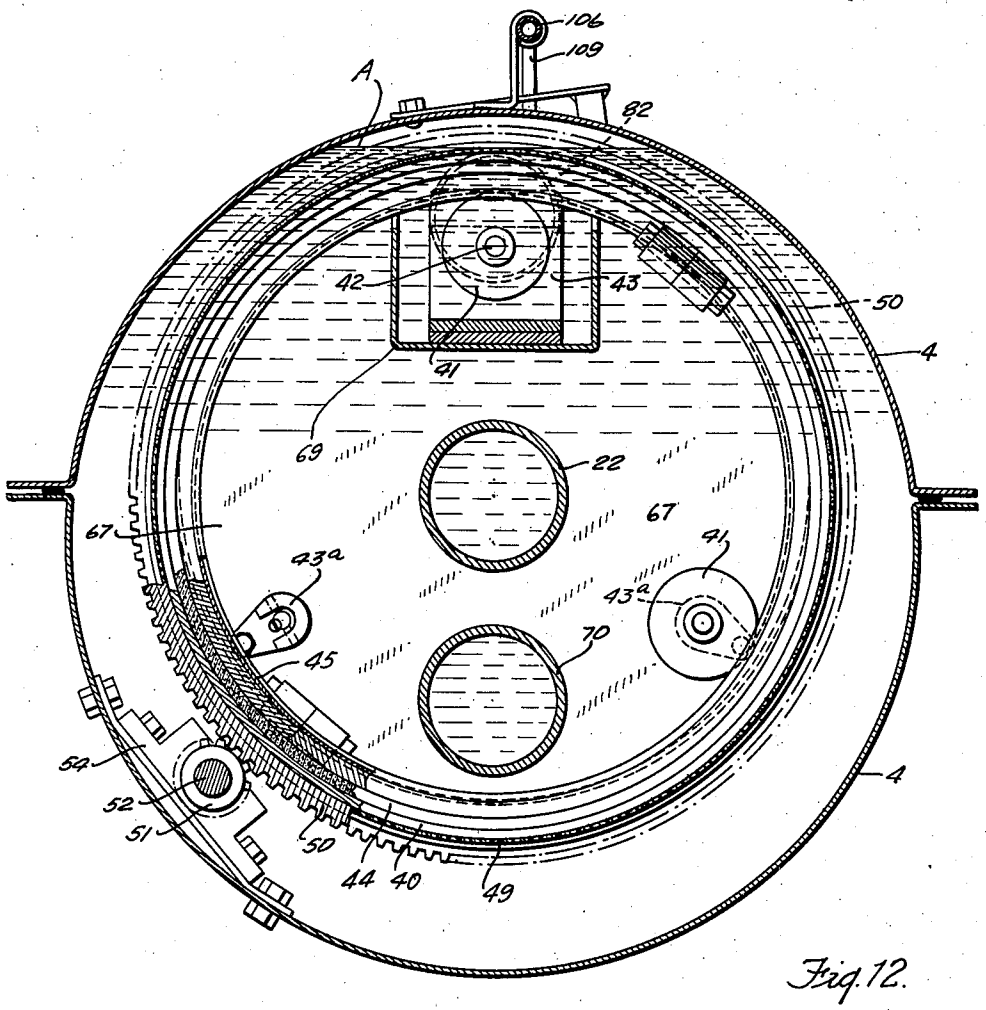


Fig. 12.

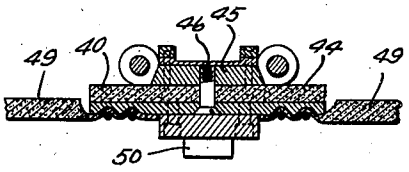
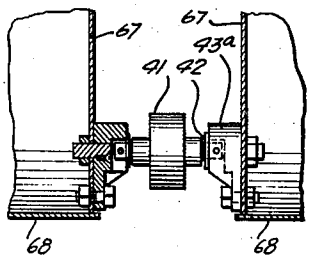


Fig. 13.



INVENTOR
CROSBY FIELD

BY ATTORNEYS
Janney, Blair & Curtis

Patented June 25, 1935 2,005,734

UNITED STATES PATENT OFFICE

2,005,734

HEAT EXCHANGE APPARATUS

Crosby Field, Brooklyn, N. Y., assignor to Flakice Corporation, Wilmington, Del., a corporation of Delaware

Application August 14, 1931, Serial No. 557,108

37 Claims. (Cl. 62—106)

This invention relates to heat exchange apparatus of the type in which a coating of brittle material is formed upon and subsequently removed from a deformable member through which the exchange of heat occurs for causing the brittle material to form thereon. In its present employment the invention relates more particularly to ice making apparatus wherein the ice is formed upon a thin flexible sheet, such as a cylinder, which is subsequently flexed to cause peeling of the ice therefrom. It is an object of the present invention to provide improved apparatus of this type which will be more particularly suitable for exacting commercial operating requirements.

The nature and further objects of the invention will be apparent to those skilled in the art from the following description and accompanying drawings of one illustrative embodiment of the invention.

In the drawings:

Figure 1 is a side elevation partly in section of an assembled machine embodying the invention.

Fig. 2 is a partial plan view of the top of the assembly and showing the manner in which the strips of ice are peeled from the freezing cylinder.

Fig. 3 is an enlarged longitudinal central vertical section of the water tank and freezing cylinder.

Fig. 4 is an enlarged end elevation seen from the left in Fig. 1.

Fig. 5 is an enlarged transverse vertical section taken on the line 5—5 of Fig. 1.

Fig. 6 is a transverse vertical section taken on the line 6—6 of Fig. 3; certain parts being omitted for clearness of illustration.

Fig. 7 is a horizontal section taken on the line 7—7 of Fig. 4.

Fig. 8 is an enlarged vertical section of the top of the water tank and freezing cylinder showing the manner of spraying and peeling a strip of ice.

Fig. 9 is a top plan view of the same.

Fig. 10 is an enlarged partial end view seen from the left in Fig. 1 and showing the torque arms for preventing rotation of the central shaft.

Fig. 11 is a transverse vertical section taken on the line 11—11 of Fig. 3; certain parts being omitted for clearness of illustration.

Fig. 12 is an enlarged sectional view of a portion of the central cylinder ring and showing the attachment of the cylinder thereto.

Fig. 13 is an enlarged detail of one of the rollers for the center ring and its mounting.

Fig. 14 is a cross-section of one form of ice strip which may be produced on the machine.

The present apparatus in general comprises a thin flexible cylinder journaled for rotation within a vessel containing water maintained at a level slightly below the top of the cylinder. Brine or another suitable refrigerating medium is circulated through a drum located within the cylinder, and is forced from the drum in submerged jets against the inner surface of the cylinder, causing ice to form very rapidly upon that part of the outer surface of the cylinder which is submerged in the water.

The thin wall of the cylinder which extends above the water level is deflected by suitable mechanism to alter the normal radius of curvature of the cylinder at that point, and thereby cause the ice which is formed thereon during rotation of the cylinder in the water to peel from the cylinder above the water level in long sheets or ribbons which break off and pass down a chute into a suitable receptacle or storage bin. Substantially the normal curvature of the cylinder beneath the water level is maintained so that ice may form thereon without cracking during rotation of the cylinder.

The peeling of the ice above the water level permits the production of a drier and colder ice in long sheets or ribbons which may be passed directly from the cylinder to storage bins, thus avoiding the necessity of recovering the ice from the water in the vessel and accelerating and reducing the cost of production.

The drum for circulating the brine substantially fills the interior of the cylinder and acts as a guide therefor. Such an arrangement simplifies the construction of the machine and reduces its cost of production and maintenance.

Foundation and tank

At the bottom of Fig. 4 are shown foundation beams 1, 1 connected by a foundation plate 2, which beams and plate support the entire machine. Secured to the foundation beams 1, 1 are suitably formed brackets 3 to support a cylindrical tank 4 which is adapted to receive and hold the water, and in which the freezing cylinder rotates. Tank 4 is formed in two sections, as shown, to facilitate the installation and removal of the freezing cylinder and associated mechanism. As shown in Fig. 5, the upper section of the tank 4 is provided at the top and intermediate its ends with longitudinal openings 5 to permit the peeled ice to pass out of the tank onto a chute 6 supported by the tank 4 and leading to a storage bin (not shown).

Freezing cylinder assembly

Referring to the left hand side of Fig. 3, the front end wall of the tank 4 is provided with a central opening to receive a bored hub 7 which is secured to the end wall of the tank by bolts 8 which pass through a flange 9 of hub 7 and are locked thereto by nuts 10. Interposed between the tank end wall and the flange 9 is a gasket 11 which may be in the form of rubber tubing to prevent leakage of water from the tank.

Hub 7 forms a surrounding bearing for a hollow stub shaft 12 welded at its inner end to a disc-shaped head 13 which closes one end of and rotatably supports the freezing cylinder hereinafter described. Endwise adjustment of head 13 and hub bearing 7 is effected by thrust plate 14 carried on head 13 by suitable studs, nuts and spacing collars. The plate 14 bears against a babbitt 15 interposed between the bearing 7 and the shaft 12. Leakage between the shaft 12 and its bearing is prevented by packing 16 placed in an annular recess in the bearing hub and held by a pack gland 17 adjustably secured to the hub 7 by studs 18.

Shaft 12 is secured to a packing sleeve 19. Interposed between shaft 12 and sleeve 19 is a bushing 20, preferably of impregnated wood to provide a heat insulated bearing surface. The interior surface of bushing 20 rides upon a journal 21, which is fitted closely and secured to a hollow shaft 22 extending centrally and longitudinally of the machine through the tank 4 and freezing cylinder. The hollow shaft 22 is fixed against rotation by torque arms 23 (see Fig. 4) bolted to a flange on the shaft and to the foundation plate 2. The shaft 22 serves as a circulating medium for the brine as hereinafter described.

Leakage between bushing 20 and journal 21 is prevented by packing 24 interposed between sleeve 19 and shaft 22 and held by a pack gland 25 adjustably secured by right and left hand screws 115 to clamp ring 116 bolted to a flange 117 on shaft 22.

Bolted to flange 117 of shaft 22 is an end casting 26 provided with ports for the ingress and egress of the brine. Secured to the inner surface of the shaft 22 and extending beneath the bearings heretofore described is a sleeve of insulating material 27 to protect the bearings against the action of the brine in the shaft 22.

Turning now to the right hand side of Fig. 3, the back end wall of the tank 4 is also provided with a central opening to receive a bored hub bearing 28 secured to the end wall of the tank by bolts 29 which pass through a flange 30 of hub 28 and are locked thereto by nuts 31. Interposed between the tank end wall and the flange 30 is a gasket 32 which may be in the form of rubber tubing to prevent leakage. Hub bearing 28 is closed exteriorly of the tank, as shown.

Hub 28 forms a surrounding bearing for a hollow stub shaft 33 welded at its inner end to a disc-shaped head 34 which closes that end of the freezing cylinder. Endwise adjustment of head 34 and hub bearing 28 is effected by a thrust plate 35 carried on the head 34 by suitable studs, nuts and spacing collars. The plate 35 bears against a babbitt 36 interposed between the bearing 28 and the shaft 33.

Shaft 33 rotates on a journal 21*a* secured to the shaft 22. Interposed between the shaft 33 and the journal 21*a* is a bushing 37 preferably of impregnated wood which rotates with the shaft 33 and the journal 21*a*. Welded or otherwise tightly fastened to the end of the shaft 33 is an end plate 38 to prevent leakage of the brine into the water tank. Inside the plate 38 is secured a heat insulating disc 38*a*.

Cylinder construction

As shown in Figs. 1 and 3, the illustrative cylinder is made in two sections which are secured to and supported by end rings 39 and a center ring 40. End rings 39 are welded respectively to heads 13 and 34 to rotate therewith, and center ring 40 rotates on rollers 41, of which there are three, spaced equal distances apart about the interior periphery of the ring 40. Top roller 41 rotates on a shaft 42 supported by a bracket 43 supported by a wall of the interior guide drum hereinafter described. The other rollers 41 each rotate on a shaft 42 supported by castings 43*a* secured to center plates 67, which are in turn supported by shaft 22. The inner surface of ring 40 is insulated with a rubber strip 44, and bearing against the strip 44 is a track 45 to ride on the rollers 41, the track 45 and strip 44 being secured to the ring 40 by screws 46.

Each section of the cylinder is preferably made up of a plurality of very thin edge-to-edge arranged sheets 47 of metal having great flexibility and strength which are secured together by interior circumferential strips 48 of fabric reenforced rubber and longitudinal lock seams and a strip of rubber. The outer ends of the cylinder thus formed are provided with other fabric reenforced rubber aprons 49, which are secured to the end and center rings respectively by wire strands wound over the thin ends of the aprons 49 to bind them into circumferential grooves formed in the end and center rings.

The strips 48 and the end aprons 49 are of substantial thickness for the dual purpose of providing heat insulation to prevent formation of the ice beneath the edges of the metal sheets which would tend to separate the metal from the rubber and of providing tracks for the cylinder guiding and deflecting means presently to be described. For a more detailed description of the freezing cylinder, reference is made to applicant's copending application, filed August 14, 1931, Serial No. 557,107 directed particularly to the freezing cylinder and its manufacture.

Cylinder driving mechanism

Referring to Figs. 1 and 3, each end ring 39 and center ring 40 carries a gear 50 secured thereto by studs, nuts or screws. Gears 50 are rotated by pinions 51 (see Fig. 5) carried by a jack shaft 52 which extends within and lengthwise the tank 4 and is journaled on the back end of the machine in bearing 53 (see Fig. 1), centrally of the machine in bearing 54, and at the front end of the machine in jack shaft box and gland 55, said bearing members being secured to the walls of the tank 4, as shown.

Referring to the left hand side of Fig. 3, the end of shaft 52 which extends out of the tank 4 carries a gear 56, which meshes with a pinion 57 carried on a shaft 58 of a reduction gear 59 which is connected by a flexible coupling 60 (see Fig. 4) to a motor 61. The reduction gear and the motor are suitably supported on the foundation plate 2.

The parts thus far described are sufficient for the observation that if the water level in the tank is maintained at the line A in Fig. 5 ice will be formed from the water contacting with the outer surface of the cylinder below the line A if a cold producing medium such as brine is circulated

through the interior of the cylinder. And further, that since the cylinder is capable of rotation upon its own axis, the brine may be projected to all points along its interior surface by fixed nozzles, if desired. The mechanism for circulating the brine through the cylinder will now be described.

Brine circulating system

Referring to Fig. 4, cold brine under pump pressure enters the machine through a pipe **62** provided with a strainer **63**, then through a port **64** in casting **26** (see Fig. 3), into pipe **65** which extends into hollow shaft **22**, and passes through an opening **66** formed in the side of shaft **22**. The brine passes out of the open end of pipe **65** into a hollow drum located within the freezing cylinder. The drum is formed in two sections, one on either side of the center ring **40**. Each section of the drum consists of end walls **67** (see Fig. 3), a peripheral wall **68** (see Fig. 5), and a U-shaped wall **69** for a purpose hereinafter described. The end walls **67** which close the ends of the sections of the drum are welded or otherwise securely fastened to central shaft **22** so as to rigidly fix the drum against rotation. The two sections of the drum are connected by a pipe **70** located near the bottom of the drum to permit the brine to flow from one section of the drum into the other, thus providing in effect a single drum.

Referring to Figs. 6 and 7, the peripheral wall **68** of the drum is provided with a plurality of openings, each provided with a nozzle **71** through which the brine in the drum is projected at high velocity against the inner surface of the metal sheets **47** of the cylinder. In the illustrative machine (see Fig. 1) the nozzles **71** for each metal sheet **47** of the cylinder are located in line with the center line of the sheet and equi-distant from the edges of adjacent rubber strips **48**. Such an arrangement of the nozzles produces a strip of ice having the cross-sectional formation shown in Fig. 14, i. e., having an upper surface which is raised at the center and tapers downwardly toward each side of the strip. The nozzles **71** may be so located as to cause the formation of strips having other cross-sectional formations or having a uniform thickness throughout. The cross-sectional form of strip shown in Fig. 14 has advantages in handling and storing the ice for some purposes because the varying thickness and irregular contour of a strip has a tendency to prevent two strips from adhering to each other. The nozzles **71** preferably extend inwardly some little distance from the wall of the drum, and the nozzle inlet is preferably located at the innermost end of the nozzle to permit any small amount of solid matter in the brine to settle without obstructing the inlet to the nozzles. During the operation of the machine the drum is kept filled with cold brine which is constantly projected against the inner surface of the freezing cylinder through the nozzles **71**. The brine which is sprayed into the cylinder flows to either end thereof and passes into hollow shaft **22** through openings **72**. The brine entering shaft **22** through openings **72** passes out of the shaft through a port **73** in casting **26**, thence through the exit end **74** of casting 26 (see Fig. 4) and into a return pipe **75**, from which it is drawn through an outlet turn tube **76** welded into the side of pipe **75**. From turn tube **76** the brine flows through suitable piping (not shown) to a brine cooling apparatus (not shown). Return pipe **75** is open at the top so that the pressure against the cylinder due to the hydrostatic head of the brine may be controlled. Entering turn tube **76** is a Pitot tube **150** provided with a glass indicator **151**. The lower end of Pitot tube **150** faces the outflowing brine and causes the indicator **151** to indicate the volume of brine passing out of the turn tube **76**. Pitot tube also functions to prevent the brine from syphoning out of the machine when shut down, by admitting air into turn tube **76** and breaking the syphon.

Provision is made to care for the increase or decrease in the volume of the brine due to variations in the temperature of the brine. As shown at the top of Fig. 1, a brine storage tank **77** is connected to the brine return pipe **75** above the lower end of turn tube **76**. Tank **77** preferably takes the form of a long horizontal pipe and may be supported by brackets (not shown) from the ceiling of the room or building. Tank **77** functions as a storage space for an excess amount of brine. The arrangement is such that under normal conditions the brine will half fill the tank **77**. Should the temperature of the brine be lowered, causing a reduction in the volume of the brine in circulation, a portion of the brine in the storage tank will be drawn into circulation and the level of the brine in the tank will be lowered. Should the temperature of the brine be increased, causing an increase in its volume, the excess volume will find room in tank **77**. The proportions are such that a considerable variation in the volume of the brine may take place without unduly raising or lowering the level of the brine in the storage tank **77**.

Referring to Fig. 4, safety valve connections are interposed between the inlet brine pipe **62** and the outlet brine pipe **75** to care for any excess brine pressure which might be developed. As there shown, pipe **62** is connected to pipe **75** by a pipe **130** having by-pass pipes **131** and **132** connected thereto. Pipe **130** is provided with a check valve **79** and pipe **132** is provided with a three-way cock **133** normally turned to prevent passage of brine from inlet pipe **62** to outlet pipe **75**. Pipe **131** carries a safety valve **78** adapted to open under excess pressure and permit the brine to flow from the inlet pipe **62** directly into the outlet pipe **75** through pipe **131**.

Check valve **79** is adapted to interrupt any back syphoning of the brine through inlet pipe **62** by admitting air into pipes **130** and **62** when the level of the brine in outlet pipe **75** falls below the open end of pipe **130**.

For observing the brine pressure a gauge **80** is provided which is connected to pipe **132** by a pipe **135**.

A sight glass **81** may also be provided for observing the level of the brine in tank **77**.

Mechanism for guiding and deflecting the freezing cylinder to form ice thereon and peel it therefrom

It is clear from the foregoing description that the cylinder rotates past jets of cold brine issuing from the nozzles **71**, which causes a continuous layer of ice to form on the metal sheets of the cylinder as they move through the water in the tank **4**. This ice formation clings to the cylinder with great tenacity so long as the cylinder retains its normal shape, but is readily removed if the cylinder is deflected sufficiently from its normal shape. Because the ice will peel from the cylinder at any point where the cylinder is sufficiently deflected and because it is desirable to

peel the ice only at the top of the cylinder where it projects above the water level in the tank, provision is made to maintain substantially the normal shape of the cylinder at points below the water level where the ice is forming thereon, and to deflect that portion of the cylinder which extends above the water level to cause peeling of the ice at that point only. The deflecting mechanism is also designed to remain in constant deflecting position at the top of the cylinder, so that as the cylinder rotates a substantially continuous peeling of ice from the cylinder will occur at that point and the ice will be peeled off in long strips or ribbons and pass onto the chute **6** for delivery to a storage bin. The cylinder guiding and deflecting mechanism in its illustrated embodiment will now be described.

As shown in Fig. 5, the cross-sectional form of the cylinder is controlled by the peripheral wall **68** of the drum and by a deflecting roller **82**. The exterior of wall **68** of the drum is provided with a plurality of strips **83** of Monel metal or other resistant material of sufficient width to permit the rubber strips or tracks **48** of the cylinder to bear thereagainst. Interposed between the strips **83** and the wall **68** is a resilient packing **84** or other suitable means for adjusting the contour of the strips **83**. The rubber strips **48** of the cylinder contact with and slide upon the strips **83** of the drum except at and adjacent to the bottom of the drum, at which point a slight space intervenes between the strips **83** on the drum and the strips **48** on the cylinder, thus permitting a free flow of the brine longitudinally of the cylinder at its bottom. Thus it will be seen that the drum by its contact with the cylinder maintains substantially the normal curvature of the cylinder below the water level while the ice is being formed thereon. Such an arrangement insures the production of ice which is free of cross-cracking.

As shown in Fig. 5, deflecting roller **82** is located in the space formed by the U-shaped wall **69** of the drum. Roller **82** is located a sufficient distance above the axis of rotation of the cylinder to raise and deform the cylinder at this point, i. e., above the water level A. As shown in Fig. 3, roller **82** is supported upon a spider pipe **85** by means of spacers **86** secured thereto by set screws. Spider pipe **85** rotates on bushings **87** interposed between the pipe **85** and a sleeve **88** carried by a roller shaft **89**. The sleeves **88** at either end of the shaft provide anti-friction bearings for the bushings **87**. The shaft **89** is held in brackets **90** secured to U-shaped wall **69** of the drum. End play of shaft **89** is cared for by plate washers **91**. A roller **82** mounted as described is provided for each section of the drum.

As best shown in Fig. 5, the drum **68** and the deflecting roller **82** cause the freezing cylinder to take a general shape as follows: section *a* to *b* assumes the curvature of the deflecting roller **82**; section *b* to *c* assumes almost a straight tangent to the point of tangency *c* with the cylinder; section *c* to *d* assumes the curvature of the drum; section *d* to *e* assumes an elliptical shape depending upon the relative pressure and weight of the brine and fluid within the cylinder and the water between the cylinder and the tank; section *e* to *f* assumes the curvature of the drum similar to the curvature of section *c* to *d*; and section *f* to *a* assumes the curved tangent similar to section *b* to *c*. As a result of this configuration of the cylinder, when it is rotated in the direction indicated by the arrow in Fig. 5 and with the water maintained at level A, the water in the cylinder begins to freeze at the point marked *g*. The ice remains, however, quite flexible, because of its extreme thinness from points *g* to *d*, and continues to build up and thicken until it assumes a rigid shape having a definite curvature of the radius "R" shown in Fig. 5. Due to the curvatures of the section *a* to *b*, the ice peels off between the points *a* and *b* in long strips which pass onto a plate **92** secured to the tank **4** and thence onto the chute **6**, down which they slide into a storage bin. The peeled strips are caused to break off at intervals when the end of a strip comes in contact with the chute **6**.

Air vent and brine drainage for the cylinder

Mechanism is provided to permit the escape of air from the freezing cylinder when the brine is initially run into the machine preparatory to starting it, and when it is desired to drain the cylinder of brine after a run. A drain for the brine is also provided. Such mechanisms are best shown in Figs. 4, 6 and 7.

Referring to Fig. 6, an air vent tube **93** is provided having an opening near the upper inner surface of the cylinder. Tube **93** passes into hollow shaft **22** through one of the openings **72**, thence through the shaft **22** to the front end of the machine where the tube **93** (see Fig. 4) is connected to a valve **94** by a nipple **95**. Valve **94** may be opened or closed by a hand wheel **96**.

A brine drainage tube **97** is provided having an opening near the lower inner surface of the cylinder. Tube **97** passes into hollow shaft **22** through one of the openings **72**, thence through the shaft **22** to the front end of the machine where tube **97** (see Fig. 4) is connected to a valve **98** by a nipple **99**. Valve **98** may be opened or closed by hand wheel **100**.

In normal operation of the machine valves **94** and **98** are both closed. To drain the brine from the cylinder both valves are opened. If there is no brine in the drum when the machine is started, air vent valve **94** is opened until the normal amount of brine has entered the drum, then valve **94** is closed.

Water regulation

Since the level of the water in the tank **4** is to be maintained below the top of the freezing cylinder and since the body of water in the tank is constantly being used up in the formation of ice which is removed, it is necessary to replenish the water supply and it is desirable that the additional water be added gradually and constantly so that the water level in the tank may remain substantially the same at all times.

As shown particularly in Figs. 4 and 5, water is supplied at one side of the tank by an inlet pipe **101** controlled by a float **102** and a control valve **103**, a well being provided for the float if desired to protect it. Water is fed from a source of supply to the inlet pipe **101** through a pipe **104**.

At another point near the top of the tank an over-flow pipe (not shown) may be located to insure the maintenance of the water level below the top of the freezing cylinder. At the bottom of the tank a drain cock **105** is provided to remove all the water from the tank when desired.

Water spray for peeled ice

As shown in Fig. 5, the strip of ice B peels from the freezing cylinder above the water level A. The under surface of the ice so peeled and which has been in contact with the freezing cylinder is colder than the upper surface of the ice which has been in contact with the water in the tank. Thus

the temperature of the under surface of the peeled ice is considerably below 32° F., while that of the upper surface is only slightly below the freezing point. As heretofore pointed out, ice thus peeled in the air is drier and colder than ice which has been peeled in the water and warmed by the water to a temperature slightly below freezing, and such dry cold ice has many advantages for some purposes. However, for other purposes a wet and less cold ice is desirable. Provision is therefore made to spray the under side of the peeled ice with water as it is peeled from the freezing cylinder to produce, when desired, the same character of ice as would be produced by peeling the ice while submerged in the water of the tank.

Referring to Fig. 4, a pipe **106** extends lengthwise the tank **4** directly above the point where the ice is peeled from the freezing cylinder. Water is supplied to pipe **106** from source supply pipe **104** through a connecting pipe **107**. The flow of water through the pipe **107** is controlled by a valve **108**. Extending downwardly from the pipe **106** and between each sheet of peeled ice is a spray pipe **109** provided with orifices **110** (see Fig. 8) formed and directed to spray water upwardly against the under side of the peeled ice, as clearly shown in Fig. 9. A portion of the water sprayed on the under side of the ice freezes thereon and adds to the thickness of the ice. Thus it will be seen that when valve **108** is opened the water will flow from source supply pipe **104** through pipe **107** into pipe **106**, and down through spray pipes **109** and out through orifices **110** against the under side of the peeled ice. When a dry cold ice is desired, valve **108** is closed. When a wet warmer ice is desired valve **108** is left open during the operation of the machine.

It should be noted at this point that while provision is made for producing either dry or wet ice, both forms of ice are peeled from the cylinder above the level of the water in the tank and pass directly from the cylinder onto a chute which delivers the ice to a suitable receptacle or storage bin; also that the thickness of the peeled ice may be controlled by the speed of rotation of the cylinder or by the coldness of the brine or by the pressure of the brine.

For clarifying the ice which is frozen on the cylinder the water in the tank **4** may be agitated while freezing by compressed air introduced into the water through nozzles (not shown) located in the tank at a series of spaced points about the cylinder. The nozzles are preferably located adjacent the surface of the cylinder to reduce the amount of compressed air required.

The operation of the machine will be apparent from the foregoing description without further amplification. The machine in operation will make ice much more rapidly and efficiently than is possible with the usual types of ice making machines. Either dry or wet ice may be produced in long strips or ribbons which are delivered directly from the cylinder to a suitable receptacle or storage bin. The ice produced may be of uniform thickness or of variable thicknesses as desired, and free from cross-cracking. It has been found that strips of ice thus formed break up into pieces which have a greater tendency toward uniformity of size and shape than pieces of ice formed by the breaking up of wider strips or sheets; and for this reason the strips of ice as described have been found to produce a product of greater commercial value.

While one specific embodiment of the invention has been described with particularity it is to be understood that the invention is not meant to be limited thereby, but may have numerous other embodiments within the scope of the appended claims.

I claim:

1. Apparatus of the character described comprising in combination, a rotatable flexible freezing cylinder, a drum within the cylinder fixed against rotation and having contact with portions of the inner surface of the cylinder to maintain substantially the normal curvature of the cylinder at said points, means to apply a refrigerating medium to the inner surface of the cylinder to freeze a liquid applied to its outer surface, means to apply a liquid to the outer surface of the cylinder at points where its normal curvature is substantially maintained, and means to deflect the cylinder at another point to cause the frozen liquid to peel therefrom at said latter point.

2. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having contact with portions of the inner surface of the cylinder to maintain substantially the normal curvature of the cylinder at said points, means to apply a refrigerating medium to the inner surface of the cylinder to freeze a liquid applied to its outer surface, means to apply a liquid to the outer surface of the cylinder at points where its normal curvature is substantially maintained, and means to deflect the cylinder at another point to cause the frozen liquid to peel therefrom at said latter point.

3. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, a drum within the cylinder fixed against rotation and having a plurality of raised tracks on its outer surface to contact with portions of the inner surface of the cylinder and maintain substantially the normal curvature of the cylinder at and adjacent contact points, means to apply a refrigerating medium to the inner surface of the cylinder to freeze a liquid applied to its outer surface, means to apply a liquid to the outer surface of the cylinder at points where its normal curvature is substantially maintained, and means to deflect the cylinder at another point to cause the frozen liquid to peel therefrom at said latter point.

4. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having a plurality of metal tracks on its outer surface to contact with portions of the inner surface of the cylinder and maintain substantially the normal curvature of the cylinder at and adjacent contact points, means to apply a refrigerating medium to the inner surface of the cylinder to freeze a liquid applied to its outer surface, means to apply a liquid to the outer surface of the cylinder at points where its normal curvature is substantially maintained, and means to deflect the cylinder at another point to cause the frozen liquid to peel therefrom at said latter point.

5. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having a plurality of metal tracks having a resilient backing to contact with portions of the inner surface of the cylinder and maintain substantial-

ly the normal curvature of the cylinder at said points of contact, means to apply a refrigerating medium to the inner surface of the cylinder to freeze a liquid applied to its outer surface, means to apply a liquid to the outer surface of the cylinder at points where its normal curvature is substantially maintained, and means to deflect the cylinder at another point to cause the frozen liquid to peel therefrom at said latter point.

6. Apparatus of the character described comprising, in combination, a flexible freezing cylinder having interior circumferential tracks, a drum within the cylinder fixed against rotation and having a plurality of raised tracks on its outer surface to contact with portions of the tracks of the cylinder and maintain substantially the normal curvature of the cylinder at said points of contact, means to apply a refrigerating medium to the inner surface of the cylinder to freeze a liquid applied to its outer surface, means to apply a liquid to the outer surface of the cylinder at points where its normal curvature is substantially maintained, and means to deflect the cylinder at another point to cause the frozen liquid to peel therefrom at said latter point.

7. Apparatus of the character described comprising, in combination, a flexible freezing cylinder having interior circumferential rubber tracks, a drum within the cylinder fixed against rotation and having contact with portions of said tracks to maintain substantially the normal curvature of the cylinder at said points of contact, means to apply a refrigerating medium to the inner surface of the cylinder to freeze a liquid applied to its outer surface, means to apply a liquid to the outer surface of the cylinder at points where its normal curvature is substantially maintained, and means to deflect the cylinder at another point to cause the frozen liquid to peel therefrom at said latter point.

8. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having contact with portions of the inner surface of the cylinder to guide the rotation thereof, said drum being adapted to receive a refrigerating medium and apply it in jets to the inner surface of the cylinder, means to apply a liquid to the outer surface of the cylinder, and means to deflect the cylinder to peel the frozen liquid therefrom.

9. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having contact with portions of the inner surface of the cylinder to guide the rotation thereof, said drum being adapted to receive a refrigerating medium and apply it in jets to the inner surface of the cylinder, means to apply a liquid to the outer surface of the cylinder, and a deflecting roller to deflect the cylinder to cause the frozen liquid to peel therefrom.

10. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having contact with portions of the inner surface of the cylinder to guide the rotation thereof, said drum being adapted to receive a refrigerating medium and apply it in jets to the inner surface of the cylinder, means to apply a liquid to the outer surface of the cylinder, and a deflecting roller in fixed relation to the drum to deflect the cylinder and cause the frozen liquid to peel therefrom.

11. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having contact with portions of the inner surface of the cylinder to guide its rotation, the drum being adapted to receive a refrigerating medium and having nozzles to apply the refrigerating medium to the inner surface of the cylinder, means to apply a liquid to the outer surface of the cylinder, and means to deflect the cylinder to cause the frozen liquid to peel therefrom.

12. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, a drum within the cylinder having contacts with portions of the inner surface of the cylinder to maintain substantially the normal curvature of the cylinder at contact points, means to deflect the cylinder at another point, and means to cause relative movement between the cylinder and the drum.

13. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, a drum within the cylinder having contact with portions of the inner surface of the cylinder to maintain substantially the normal curvature of the drum at contact points, means in fixed relation to the drum to deflect the cylinder at another point, and means to cause relative movement between the cylinder and said deflecting means.

14. Apparatus of the character described comprising, in combination a flexible freezing cylinder, a drum within the cylinder having contact with portions of the inner surface of the cylinder to maintain substantially the normal curvature of the drum at contact points, means in fixed relation to the drum to deflect the cylinder at another point, and means to cause relative movement between the cylinder on the one hand and the drum and deflecting means on the other hand.

15. Apparatus of the character described comprising, in combination, a tank for the liquid to be frozen, a flexible freezing cylinder partially submerged in the liquid in the tank, a drum within the cylinder fixed against rotation and having contact with portions of the inner surface of the cylinder to maintain substantially the normal curvature of the cylinder below the level of the liquid in the tank, means to apply a refrigerating medium to the inner surface of the cylinder, and means to deflect the cylinder above the level of the liquid in the tank.

16. Apparatus of the character described comprising, in combination, a tank for the liquid to be frozen, a flexible freezing cylinder partially submerged in the liquid in the tank, a drum within the cylinder fixed against rotation and having contact with the inner surface of the cylinder to maintain substantially the normal curvature of the cylinder below the level of the liquid in the tank, means to apply a refrigerating medium to the inner surface of the cylinder, and cylinder deflecting means to cause the frozen liquid to peel from the cylinder above the level of the liquid in the tank.

17. Apparatus of the character described comprising, in combination, a tank for the liquid to be frozen, a flexible freezing cylinder partially submerged in the liquid in the tank, a drum within the cylinder fixed against rotation and having points of contact with the inner surface of the cylinder to maintain substantially the normal curvature of the cylinder below the level of the liquid in the tank, means to apply a re-

frigerating medium to the inner surface of the cylinder, and cylinder deflecting means constructed and arranged to cause the frozen liquid to peel in strips from the cylinder above the liquid level in the tank.

18. Apparatus of the character described comprising, in combination, a tank for the liquid to be frozen, a flexible freezing cylinder partially submerged in the liquid in the tank, means to rotate the cylinder, a drum within the cylinder fixed against rotation and having points of contact with the inner surface of the cylinder to guide it in its rotation, and means constantly deflecting the cylinder above the level of the liquid in the tank to cause the frozen liquid to peel from the cylinder above the level of the liquid in the tank.

19. Apparatus of the character described comprising, in combination, a flexible freezing cylinder, means within said cylinder for resiliently supporting and shaping said cylinder over a considerable portion of the circumference thereof, and means for deflecting said circumference at a point not supported or guided by said supporting and guiding means.

20. Apparatus of the character described comprising, in combination, an endless flexible freezing surface, means within said endless flexible freezing surface for resiliently supporting and shaping it extending substantially across the freezing surface and contacting it over a considerable portion of the periphery thereof, and means located above and centered with respect to said support for deflecting said periphery at a point not supported or guided by said supporting and guiding means.

21. In apparatus of the character described, the combination of an endless deformable freezing surface, means to supply a fluid to be frozen to one surface thereof and means to remove heat from predetermined spaced peripheral areas of said freezing surface to cause the fluid freezing on the said surface to have an undulating cross section, and means to deflect said freezing surface to remove the frozen fluid therefrom.

22. In apparatus of the character described, the combination of an endless deformable freezing surface, means to supply a liquid to be frozen to one surface thereof, means to remove heat from predetermined spaced peripheral areas of said freezing surface to cause the liquid to freeze on said surface in spaced strips, and means to deflect the freezing surface to remove the strips therefrom.

23. In apparatus of the character described, the combination of an endless deformable freezing surface, means to supply a liquid to be frozen to one surface thereof, means to remove heat from predetermined spaced peripheral areas of said freezing surface to cause the liquid to freeze on said surface in spaced strips, and means to deflect the freezing surface to remove continuously the frozen liquid therefrom in continuous strips.

24. A method of freezing liquids which consists in supplying a freezable liquid to an endless flexible deformable freezing surface, applying a refrigerating medium to predetermined spaced peripheral areas of said freezing surface to remove heat from such spaced areas to cause said freezable liquid to freeze on said spaced areas, and deflecting said freezing surface to remove the frozen liquid therefrom.

25. A method of freezing liquids which consists in supplying a freezable liquid to an endless flexible deformable freezing surface, applying high velocity brine jets to predetermined spaced peripheral areas of said freezing surface to remove heat from such spaced areas to cause said freezable liquid to freeze on said spaced areas, and deflecting said freezing surface to remove the strips of frozen liquid therefrom.

26. Apparatus of the character described, comprising, in combination, a flexible freezing cylinder, a drum within the cylinder forming a way for guiding said cylinder, said drum having jets formed therein for projecting a refrigerating medium against the inner wall of the cylinder, means to apply liquid to the outer surface of the cylinder, and means to cause relative movement between the cylinder and the drum.

27. Apparatus of the character described comprising, in combination, an endless flexible freezing belt, means for causing said belt to travel about a predetermined path, means for applying a liquid to be frozen to the outer surface of said freezing belt, a stationary way located within the bounds of said belt for guiding it over a portion of its path, and said way having jets associated therewith for projecting a refrigerating medium against the surface of said belt.

28. In apparatus of the character described, in combination, an endless flexible belt, means for closing the ends of said belt for forming a closed cylinder, means for applying a liquid to be frozen to the outer surface of the belt, means for filling the interior thereof with a refrigerating medium, and means including a series of nozzles for projecting high velocity submerged jets of the refrigerating medium against the inner surface of the belt at spaced points, arranged along spaced peripheral lines around the belt, and means to cause relative movement between the belt and the jets.

29. Apparatus of the character described, comprising, in combination, a tank for holding a liquid to be frozen, an endless flexible freezing surface, the ends of said freezing surface being closed to form a closed cylinder but having free radial movement, and said freezing surface being over fifty but less than one hundred per cent immersed in a liquid in said tank; means within said endless flexible freezing surface for supporting and shaping it over that portion of the periphery thereof immersed in said liquid, and means for deflecting a portion of the periphery above the liquid whereby liquid congealed on said endless flexible freezing surface is peeled therefrom above the liquid level.

30. Apparatus of the character described, comprising, in combination, a tank for containing liquid to be frozen, an endless flexible freezing surface at least ninety but less than one hundred per cent immersed in said liquid, means for causing said endless flexible freezing surface to travel about a closed path, the curve of that portion of said path below said liquid level being such that the liquid congealed on said freezing surface remains affixed thereto, and the curve of that portion of said path above said liquid being such that the congealed liquid peels from said freezing surface.

31. Apparatus of the character described comprising, in combination, a tank for containing liquid to be frozen, an endless flexible freezing surface more than fifty but less than one hundred per cent immersed in said liquid, means for causing said endless flexible freezing surface to travel about a horizontal axis; guide means for maintaining a substantially uniform curvature of that portion of the flexible freezing surface im-

mersed in the liquid, and guide means for changing the curvature of the endless flexible freezing surface above the liquid to cause liquid congealed thereon to peel therefrom.

32. In apparatus of the class described, in combination, an endless flexible freezing surface, means for causing said endless flexible freezing surface to travel about a closed path, means for maintaining a substantially uniform curvature over a first portion of said path, and a second curvature over a second portion of said path, means for supplying water to be frozen to that portion of said freezing surface passing over the said first portion of the path and said surface being supplied with water only while passing over said first portion, and means for sub-cooling the ice frozen on said freezing surface as it passes from the first to the second path.

33. The process of forming ice comprising the steps of passing an endless flexible freezing surface into a bath of the liquid to be frozen to cause the liquid to congeal thereon in sheet formation, of passing said freezing surface and the congealed liquid from said bath and protecting the congealed liquid thus removed from flow of heat thereto, whereby the temperature thereof is further lowered by said freezing surface, of deflecting said freezing surface to cause the liquid congealed thereon to be continuously peeled therefrom in sheet formation, and of removing the peeled sub-cooled frozen liquid from the vicinity of the surface without contact with the bath of the liquid.

34. Process for forming ice consisting in the steps of passing a freezing surface into a bath of liquid to be frozen, refrigerating spaced areas of said surface to cause the liquid to congeal on said spaced areas, of removing said freezing surface and congealed liquid from said bath to lower the temperature of the congealed liquid, and then of removing the congealed liquid from the freezing surface without raising the temperature of said congealed liquid to its melting point.

35. A method of freezing liquids which consists in applying a freezable liquid to an endless flexible freezing surface, applying a refrigerating medium to predetermined spaced peripheral areas of said freezing surface at predetermined radial positions to remove heat from around the periphery of said spaced areas at a predetermined rate, and deflecting said freezing surface to remove the frozen liquid therefrom.

36. Apparatus of the character described, comprising, in combination, a flexible rotatable freezing cylinder, the inner surface of which is provided with spaced rubber tracks extending around the periphery thereof, a stationary drum within the cylinder having resiliently mounted Monel metal ways for providing non-frictional guides for said rubber tracks, said cylinder being filled with a refrigerant such as brine which acts as a lubricant for the rubber tracks as they slip over the Monel metal ways as the cylinder rotates with respect to the drum.

37. Apparatus of the character described comprising in combination a flexible rotatable freezing cylinder, spaced rubber tracks extending around the periphery of the inner walls of the cylinder, spaced stationary ways within the cylinder having a non-corrodible polished surface for providing non-frictional guides for said rubber tracks, said cylinder being filled with a refrigerant which acts as a lubricant between the rubber and the non-corrodible surfaces of said ways as the cylinder rotates with respect to the ways.

CROSBY FIELD.