This invention relates to the refrigerating of materials, and more particularly to a process and apparatus in which the materials, for instance, foods, ingredients of foods, etc., are refrigerated through the action of heat transfer surfaces contacting therewith.

This invention is an improvement on the apparatus and process disclosed and broadly claimed in my prior Patents 1,810,740 and 1,810,864, dated June 16, 1931, relating to the continuous formation of a wrapper, the continuous filling of the wrapper as formed, the hardening of the material within the wrapper, and the cutting of the wrapper and hardened material into sections. The present invention is also an improvement upon the type of construction shown in said patents in which there is employed a series of movable refrigerant containing receptacles engaging the advancing material being refrigerated and in part defining or controlling the cross-section of the material.

This application is a continuation in part of my prior pending application Serial No. 535,342, filed May 6, 1931, to the extent that it involves a series of rotatable discs refrigerating the material treated. This invention also involves certain improvements in the construction, mounting and operation of the discs, shown in said last mentioned application.

In carrying out the present invention I may employ an arrangement of ducts through which the material is conveyed, and may refrigerate a gas and circulate it through the ducts as disclosed and broadly claimed in said application.

As one important feature of my invention I secure a sliding contact between a wall of the advancing article which preferably comprises the enclosed material undergoing refrigeration and the surface which conducts away the heat.

As a further feature there is progressive sliding contact between the articles and the heat removing surface, whereby the total amount of heat to be removed from the article is removed in relatively small increments by the progressively applied surfaces.

Another feature of the invention is the use of a plurality of sliding contact surfaces of such size and so arranged that a portion of each of said surfaces contacts with the article or a portion of the article to be refrigerated, and then progressively moves out of contact with the article, and is rechilled while the article comes into contact with another and similar surface, whereby I maintain a maximum temperature differential between the heat conducting surfaces and the article to be refrigerated.

As a further important feature I provide a pair of refrigerated surfaces spaced apart to form a channel or trough therebetween to receive the article to be refrigerated, said surfaces being in the form of discs mounted coaxially and rotatable to give the sliding contact.

As a further important feature I provide two series of refrigerated surfaces arranged along opposite sides of the path of movement of the material, the surfaces of the two series being arranged alternately for successive action on the material.

As a further feature I provide a new and improved construction of refrigerant receptacle, whereby the refrigerant action is more effectively applied to the material and the refrigerant is more effectively recirculated.

As a further feature I employ adjustable means for controlling the frictional engagement between the surfaces of the article and the relatively sliding, heat conducting surfaces.

Other important features and objects will be noted hereinafter or will be apparent from a consideration of the following description and the accompanying drawings.

In the accompanying drawings, there are illustrated certain features of an apparatus embodying my invention and adapted for carrying out my improved process.

In these drawings:

Fig. 1 is a side elevation of the apparatus embodying my invention, certain of the parts being shown in vertical section.

Fig. 2 is a top plan view of the receiving portion of the apparatus shown in Fig. 1.

Fig. 3 is a side elevation on a larger scale of one of the discs shown in Fig. 1.

Fig. 4 is a vertical transverse section on the line 4–4 of Fig. 1, but on a larger scale.

Fig. 5 is a section through one of the sealed refrigerant receptacles shown in Figs. 3 and 4, but on a still larger scale.

Fig. 6 is a side elevation, partly in section showing the arrangement for driving the apparatus.

Fig. 7 is a side elevation, partly in section, of a further form of apparatus.

Fig. 8 is a top plan view of a portion of Fig. 7, and

Fig. 9 is a transverse section on the line 9–9 of Fig. 7, but on a larger scale.

In the specific construction illustrated in Figs. 1 to 4 inclusive, I provide a duct 10 through which the refrigerant gas is circulated, and within 110
which are mounted the heat conducting members, and through which duct the material passes. If the material is to be frozen or solidified in packages or bricks of approximately one pint size, 5 which would be approximately one pound in weight if the material were solid and without substantial air content, the dimensions of such package or brick might be approximately 7½ inches x 3 inches x 1¼ inches. The duct may be proportioned to encase the conveying means for handling packages of such dimensions or for handling a brick which might be cut into bricks of such dimensions. The duct is arranged in a substantially horizontal position in a chamber 11.

Means are provided for withdrawing air or other gas from one end of the duct, refrigerating it and returning it to the opposite end. Such means may consist of a pair of branch conduits 12 leading from opposite sides of the duct 10 adjacent the inlet end of the latter and connected to a manifold 13 leading to a refrigerating chamber 14. Within this chamber is mounted any suitable means for lowering the temperature of gas to the desired degree, such means being shown somewhat conventionally as refrigerant coils or grid 15.

The opposite end of the chamber 14 is connected to the intake of a fan or blower 16 which delivers through a manifold 17 to a pair of branch conduits 18 communicating with the opposite sides of the duct 10 at the delivery end of the latter. I have referred only to a single duct 10, but it will be obvious that there may be a plurality of these ducts all receiving the gas from the same chamber 14 and returning it thereto.

While I have shown the conveying apparatus encased in a duct with a positive countercurrent directional flow of the refrigerant and the material, this duct, as illustrated, is not essential to my present invention and may be dispensed with. Particularly as many plants, such as ice cream factories, are at present equipped with so-called hardening rooms, provided with overhead refrigerating coils, and bunkers to effectively cool the air in the hardening room. These present bunkers in many cases may be used without alteration and the conveying and refrigerating apparatus be installed in the space below the coils.

Inasmuch as the heat dissipating surface of the conveying means hereinbefore described and which I have shown in Figs. 1 to 6 inclusive is many times greater than the surface in contact with the encased material to be refrigerated, the natural air circulation of the hardening room may be depended upon for producing the desired refrigeration of the article, without a duct or positive air circulation. The apparatus without the duct may have a somewhat reduced capacity, but the advantages of lower cost and the greater accessibility would tend to overcome this difference in capacity of the apparatus.

For advancing the material or articles I employ a bottom belt 19 and a top belt 20. These are preferably of metal and may be fitted with short prongs in order to positively advance the articles or material while they are being subjected to refrigeration. These belts also aid, when necessary, in holding such packages, articles or material in a predetermined cross-sectional form. The lower belt passes around pulleys 21 and the upper belt passes around pulleys 22. The return run of the lower belt may be supported by idlers 23. The bottom belt may extend beyond the chamber 11 or any extensions thereof, of, in order to receive and/or deliver the material, articles or packages to be refrigerated, or it may be, as shown, entirely within the chamber 11.

The heat conducting and dissipating means employed form the main feature of my present invention and in the form illustrated in Figs. 1 to 6 there are provided a plurality of discs 24 mounted in upper and lower series and in coaxial pairs. The two discs of each pair engage and support the opposite sides of the encased material between the belts 19 and 20, and the pairs of the upper and lower series are arranged alternately so that substantially the entire side areas of the encased material are supported and refrigerated by these discs. Each disc, on the surface away from the material, is provided with a plurality of receptacles 25 which may be cast integral with the disc or which may be affixed thereto by welding, soldering or any other suitable means.

The receptacles 25 are partially filled with a liquid, such as brine, preferably of a strength which will partially congeal at the operating temperature to be maintained within the chamber 11, and are provided with caps 26 which may be of such flexibility that they may be forced or tapped in place to seal the receptacles, or which may be soldered over the open ends of the receptacles 25 after the liquid has been placed therein. The receptacles 25 as shown in Fig. 5 are not completely filled so that space is left for expansion and contraction on freezing and thawing.

The two discs of each pair may be slidably mounted on a shaft 27. The hubs of the discs may be provided with keyways 28 which engage with corresponding feather keys 29 in recesses in the shaft 27 in the usual manner. Each pair of discs 24 may be provided with means for drawing the opposing faces of the discs toward each other. As illustrated in Fig. 4, this may consist of tension springs 30, one end of each spring being secured to a corresponding lug 31 on one of the pairs of discs, and the other end of the spring being being seated in the base of an adjustable wing nut 32. The purpose of these springs is to insure a contact between the inside surfaces of the disc and the outside of the package or article being refrigerated.

Preferably the first pair of discs which engages the material at the receiving end is not provided with these spring tension members, but is mounted in fixed relation to each other in the shaft 27, the reason for this being that it is not the intention to automatically accommodate packages of various thicknesses, but to make the articles conform in thickness, as well as in height, to a predetermined size. This is especially desirable where the article to be refrigerated is sold by volume, such as is usual with ice cream, where it would be obviously a disadvantage for the apparatus to produce irregular or non-uniform packages at any given setting.

I have found in the case of partially frozen ice cream, that after the column has been subjected to the refrigerating action of one pair of discs there is sufficient case hardening of the outside surfaces so as to eliminate any danger of compressing the column by the engagement of the column with the succeeding pair of discs.

It will also be apparent that if all of the discs were spaced exactly the same distance apart on the shaft and mounted in exact alignment, that the flexibility provided by the springs 30 could be dispensed with. However it is also apparent that with this yielding arrangement the assembly and the alignment of the discs need not be so accur
rate because any misalignment will be automatically compensated for.

The discs 24 are provided with annular projections or flanges 33 which on the upper series may serve as supports for the return run of the belt 20 and on the lower series for the forward run of the belt 19. In refrigerating material of barrel form or for long articles spanning across two or three pairs of discs of the same series, the belts 19 and 20 may be eliminated altogether.

The shafts 27 are journaled in suitable brackets or bearings 34 which in turn are mounted on channels or any suitable frame 35. In Fig. 7 I have shown diagrammatically a motor 36 with reduction gearing 37 and suitable chain drive to upper and lower belt driving pulleys 38 and 39 respectively. The discs 24 may be driven by suitable bevel gearing or may be driven as shown through a chain 40 and sprockets 41. A take-up sprocket 42 is shown near the receiving end to compensate for any stretch present in the chain.

The construction above described may be employed for the freezing of material of various forms, but it is preferably either in packaged or encased form. The disc-type packages are employed they may be fed in succession through the end wall of the chamber 11 to the position where they will be engaged by the belts 19 and 20. For purposes of illustration I have shown the apparatus as used for the progressive freezing of a continuous bar or stream of plastic material fed into, through and out of the apparatus. This part of the apparatus is substantially as shown in my prior Patents 1,810,740 and 1,810,864 and includes means for supporting a roll 45 of paper or other analogous flexible or elastic sheet material, and progressively bending it as fed into substantially channel shape so as to cover the lower belt 19 and form continuous side walls engaging the discs 24 and confining the material. These side walls may be slightly higher than the bar of material to be frozen and the upper edges may be folded over and pressed onto the top of the material by the upper belt.

Extending into the channel shaped strip is a receptacle 46 open at the bottom and having a lateral portion, the desired cross-section of the material and facing in the direction of the travel of the operating flights of the belts.

The liquid, semi-liquid or plastic material to be frozen or hardened is delivered through a conduit 47, and variations in the rate of delivery in respect to the rate of advance of the belts may be taken care of by a plunger 48 which may move up and down in an upper extension of the receptacle 46. The material is progressively delivered under pressure and the plunger 48 may be of such weight as to maintain the desired pressure. The material after being hardened is delivered from the chamber 11 and may be received by a conveyor 49 in connection with which may be employed any suitable means for subdividing the bar into segments of the desired shape. I have illustrated such a subdividing mechanism in the prior patents above referred to.

In the use of the apparatus for freezing ice cream, fruit juices or the like, it is preferable that the material delivered through the conduit 47 be previously frozen, but not to such an extent but what it may be caused to readily flow, particularly with the application of enough pressure.

Each of the discs employed has only a portion of its operating surface in heat conducting relation to the material and the major portion exposed to the direct action of the cold air circulated in the duct or in the room or chamber 11. The partially frozen brine or the ice and salt mixture in the tubes 25 does not rise in temperature appreciably by abstracting heat from the material, but is partially melted and absorbs the heat as latent heat. As the successive portions of the disc move away from the material the partially melted brine ceases to absorb heat, but gives up the heat to the cold air, and the brine is refrozen. Thus a substantially uniform temperature is maintained along the length of the passageway and the heat is abstracted in comparative small increments. The discs have a wiping or sliding contact with the encased material and this causes a more effective rate of heat abstraction than does more stationary surface contact.

Each portion of the disc as it comes into contact with the material has a movement substantially transverse to the movement of the material and then moves along with the latter and leaves the surface by again moving transversely. This causes a very slight tendency toward a wear ing or up and down movement of the material by frictional contact of the casing with the discs. This causes or tends to cause breaking of ice forming in the interior of the mass, and facilitates the breaking up or looseness of the casing of frozen material tending to form along the sides of the moving body of material in advance of the final freezing of the innermost portion, and thus the rate of heat transfer is increased. The major portion of each disc while in contact with the casing of the material is moving lengthwise of the apparatus and therefore the discs may serve as the sole means for advancing the material, and the belts 19 and 20 may, in some cases, be discarded.

The discs being mounted alternately along opposite sides of the material, may be so spaced as to substantially cover the entire side surfaces of the casing of the material, but the exposed portions between successive discs are subjected to the direct withdrawal of heat by the air circulated through the duct or from the overhead coils. In some cases guides may be mounted between adjacent discs so as to form substantially continuous side walls for the material, but this is not ordinarily necessary and is not desirable except possibly at the entrance end of the apparatus where the thin side walls may need additional support before the material has begun to harden.

In Figs. 7, 8 and 9 I have illustrated an apparatus similar in many respects to that above described, but the discs are made hollow and brine is circulated through them instead of the plates being thin with separate closed brine receptacles. The discs may be constructed as shown particularly in Fig. 9 and brine may be delivered through one end of the shaft 27a and then deflected by transverse partitions 80 and through ports into the hollow discs 24a. Thus the brine may flow through all of the successive discs mounted upon the same shaft.

Each disc may have its inlet and outlet ports adjacent to each other and separated by a radial transverse partition 51 so that the brine in each disc is caused to flow substantially the entire distance around the shaft, as indicated by the arrows in the disc shown in section in Fig. 7.

Journals 52 for the shafts may be mounted on transversely extending frame members 53 and all of the hollow shafts for the discs may be con-
nected by branch conduits 54 leading at one end

to a brine supply manifold 55. A similar manifold
and branch conduits are employed at the
opposite side of the apparatus for the outflow of
the brine.

The operation of the discs and the other de-
tails illustrated may be substantially the same as
in the embodiment described.

I have not shown any air circulation in this
construction as there is a continuous supply of
brine to and from the apparatus and this may be
replaced by any suitable refrigerating apparatus.

Having thus described my invention, what I
claim as new and desire to secure by Letters
Patent is:

1. A freezing apparatus, including means for
advancing material along a predetermined path,
and a series of separate refrigerant containers
arranged along said path and having heat con-
cducting walls acting in succession on the material
to abstract heat therefrom.

2. A freezing apparatus, including means for
advancing material along a predetermined path,
and a series of refrigerant containers arranged
at spaced points along the path, and each having a
wall of the container in sliding engagement with
the casing of the material.

3. A freezing apparatus, including means for
advancing along a predetermined path the en-
cased material to be frozen, and a series of rotatable
discs along said path and engaging in succes-
sion with the casing of said material.

4. A freezing apparatus, including means for
advancing along a predetermined path the en-
cased material to be frozen, and a series of rotatable
disks along said path and each having an
axially facing end surface, said surfaces engaging
in succession with the casing of the material
during the advance of the latter.

5. A freezing apparatus, including a pair of
coaxial rotatable discs having flat opposed sub-
stantially parallel end surfaces forming a passage
therebetween for the material to be frozen, each
of said discs having a refrigerant containing
chamber.

6. A freezing apparatus, including a pair of
coaxial refrigerated discs spaced apart and in
heat interchanging relationship with opposite
sides of the material to be frozen, means for ad-
vancing the material along a rectilinear path be-
tween said discs, and means for rotating said discs
during the advance of the latter.

7. A freezing apparatus, including a pair of
coaxial discs spaced apart and in heat interchang-
ing relationship with opposite sides of the ma-
terial to be frozen during the advance of the latter
along a rectilinear path, and means for rotating
said discs during the advance of the material,
each of said discs having means for refrigerat-
ing the surface thereof opposite to the material.

8. A freezing apparatus, including a pair of
coaxial discs spaced apart and in heat interchang-
ing relationship with opposite sides of the ma-
terial to be frozen during the advance of the latter
along a rectilinear path, and means for rotating said discs during the advance of the material,
each of said discs having a refrigerant receptacle
on the side thereof opposite to the surface exposed to the material.

9. A freezing apparatus, including a pair of
c coaxial discs spaced apart and in heat interchang-
ing relationship with opposite sides of the ma-
terial to be frozen during the advance of the latter
along a rectilinear path, and means for rotating said discs during the advance of the material,
each of said discs being hollow for the circulation of refrigerant therethrough.

10. A freezing apparatus, including a pair of
coaxial discs spaced apart and in heat interchang-
ing relationship with opposite sides of the ma-
terial to be frozen during the advance of the latter along a rectilinear path, and means for rotating said discs during the advance of the material,
said discs being relatively movable toward and from each other.

11. A freezing apparatus, including a pair of
coaxial discs spaced apart and in heat interchang-
ing relationship with opposite sides of the ma-
terial to be frozen during the advance of the latter along a rectilinear path, means for rotating said discs during the advance of the material,
said discs being relatively movable toward and from each other, and resilient means for pressing them toward the material.

12. A freezing apparatus, including a pair of
coaxial discs spaced apart and in heat interchang-
ing relationship with opposite sides of the ma-
terial to be frozen during the advance of the latter along a rectilinear path, means for ro-
tating said discs during the advance of the material,
and a belt extending between said discs for
supporting and advancing the material along said path.

13. A refrigerating apparatus, including two
series of rotatable refrigerant containing elements
having their axes upon opposite sides of the path of
movement of the encased material to be re-
frigerated, the elements of one series being ar-
ranged alternately with those of the other, and
all of said elements having sliding surface con-
tact with the casing of the material.

14. A refrigerating apparatus, including two
series of rotatable heat conducting elements hav-
ing their axes upon opposite sides of the path of
movement of the encased material to be refrig-
erated, the elements of one series being arranged
alternately with those of the other, and all of said elements having sliding surface contact with the
 casing of the material, means for refrigerating
said discs, and means for advancing the material
into engagement with said elements in succes-
sion.

15. A refrigerating apparatus, including two
series of rotatable heat conducting elements hav-
ing their axes upon opposite sides of the path of
movement of the encased material to be refrig-
erated, the elements of one series being arranged
alternately with those of the other, and all of said elements having sliding surface contact with the
 casing of the material, and means for refrig-
erating the surface of each element opposite to
the surface juxtaposed to the material.

16. A refrigerating element, comprising a ro-
tatable disc having an axially facing surface for
heat abstracting relationship to an advancing
material, and a plurality of refrigerant recepta-
cles carried by said disc upon the opposite surface thereof.

17. A refrigerating element, comprising a ro-
tatable disc having an axially facing surface for
heat abstracting relationship to an advancing
material, a plurality of refrigerant receptacles
carried by said disc upon the opposite surface
thereof, and means for circulating a refrigerant
in contact with said refrigerant receptacles.

18. A refrigerating apparatus, including a duct,
a plurality of rotatable heat conducting elements
arranged within said duct along the length there-
of, means for circulating a refrigerated gas through said duct, and means for advancing the
material through said duct in heat interchanging relationship with said elements in succession.

19. A refrigerating apparatus, including a duct, a plurality of rotatable heat conducting elements arranged within said duct along the length thereof, means for circulating a refrigerated gas through said duct, and means for advancing the material through said duct in heat interchanging relationship with axially facing surfaces of said elements.

20. A refrigerating apparatus, including a duct, a plurality of discs mounted within said duct and spaced apart along the length thereof and adapted to have heat interchanging relationship in succession with material advanced through the duct, a refrigerant receptacle carried by each of said ducts and projecting in an axial direction from the surface of the disc opposite to the material, and means for circulating a refrigerated gas through said duct in contact with said receptacles.

21. A refrigerating apparatus for encased material, including a pair of belt conveyors having spaced parallel runs for engagement with opposite sides of the casing of the material to be refrigerated and for advancing the latter, and a series of rotatable heat conducting elements arranged at spaced points along the path of movement of the material and each having sliding contact with another side of the casing of the material.

22. A refrigerating apparatus for encased material, including a pair of belt conveyors having spaced parallel runs for engagement with opposite sides of the casing of the material to be refrigerated and for advancing the latter, and a series of rotatable heat conducting elements arranged at spaced points along the path of movement of the material and each having axially facing flat surface mounted in heat abstracting relationship to another surface of the casing of the material.

23. An apparatus for chilling a comestible, including means for advancing a tubular casing containing a continuous bar of the comestible, and a pair of coaxial discs having flat end surfaces engaging opposite sides of said casing, adapted for the circulation of refrigerant therethrough, and adapted to be rotated to advance the comestible and casing.

24. An apparatus for refrigerating an encased comestible, including means for advancing a stream of the comestible, two series of refrigerating elements each including a pair of hollow coaxial discs engaging opposite sides of said casing, the discs of one series being arranged above and alternately with those of the other, and means for circulating refrigerant through said discs.

25. The process of refrigerating a material, which includes advancing the latter along a predetermined path, and sliding heat conducting elements transversely of the path of movement in heat abstracting relationship to the material during said movement.

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