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METHOD AND APPARATUS FOR DEHYDRATION

Original Filed Jan. 18, 1950 2 Sheets-Sheet 1

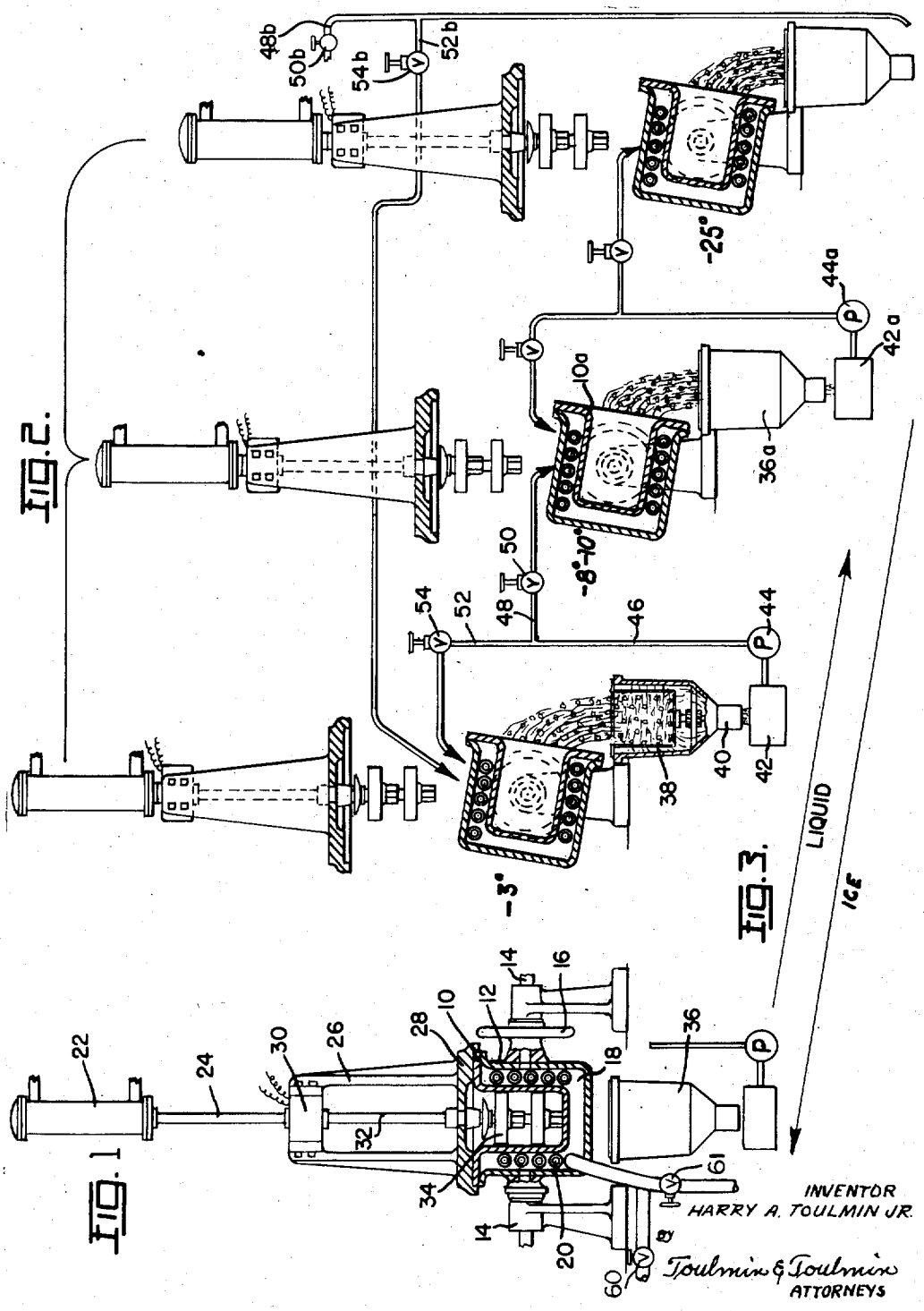


FIG. 2.

FIG. 3.

FIG. 1

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Fig. 4

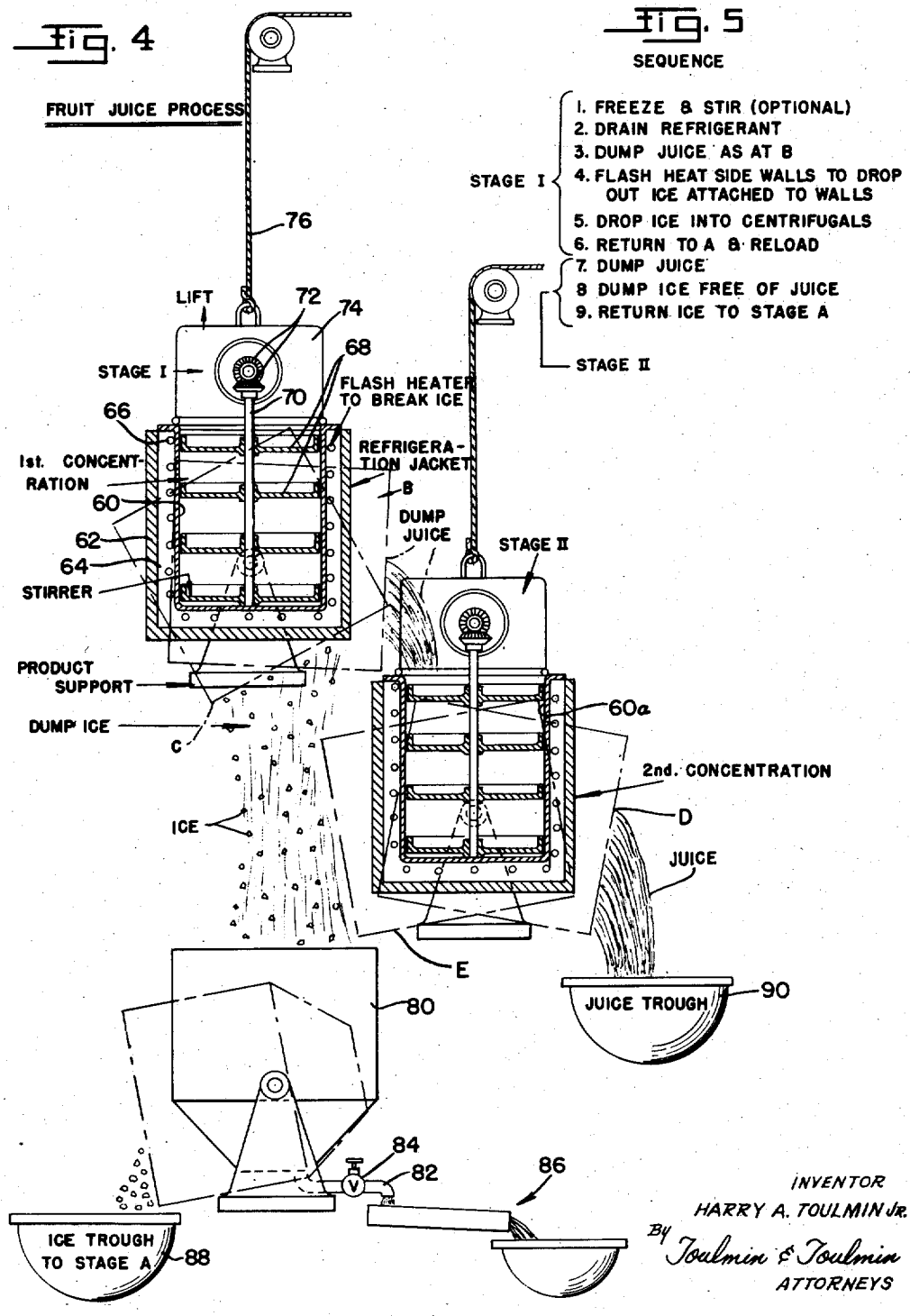


Fig. 5

SEQUENCE

STAGE I
1. FREEZE & STIR (OPTIONAL)
2. DRAIN REFRIGERANT
3. DUMP JUICE AS AT B
4. FLASH HEAT SIDE WALLS TO DROP OUT ICE ATTACHED TO WALLS
5. DROP ICE INTO CENTRIFUGALS
6. RETURN TO A & RELOAD

STAGE II
7. DUMP JUICE
8. DUMP ICE FREE OF JUICE
9. RETURN ICE TO STAGE A

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METHOD AND APPARATUS FOR DEHYDRATION

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13 Claims. (Cl. 99—205)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates to a method and apparatus for concentrating aqueous substances by the dehydration thereof through a freezing process.

The concentration of fruit and vegetable juices has heretofore generally been accomplished by the application of heat or vaccum or both, in order to bring about evaporation of the water to concentrate the substance to the desired degree. This has the disadvantage of being rather time consuming and, in addition, causes a substantial change in the flavor of the substance, so that when it is reconstituted by the addition of the same amount of water that was removed therefrom, it is much less palatable, and, accordingly, has not met with wide public approval.

The concentration of juices as set forth above is also accompanied by a considerable loss of the vitamin content of the juice, so that it usually has considerably less food value when reconstituted than it had before.

Certain other substances which it may be desired to concentrate contain ingredients which may be injured by the application of heat, either as to actual chemical and physical structure, or as to color or other qualities, and, accordingly, substances of this nature have not heretofore successfully been concentrated by dehydration.

The principal object of the present invention is to provide a method and apparatus for concentrating aqueous substances by dehydration through a freezing process whereby the disadvantages referred to above in connection with prior art processes are substantially completely eliminated.

Another object of this invention is to provide an arrangement whereby very viscous substances can be successfully treated in order to remove the water therefrom.

A still further object is the provision of a method and apparatus for dehydrating substances by freezing, wherein the substance being treated is passed through a plurality of stages so that the number of stages can be increased or decreased to obtain the desired degree of concentration.

These and other objects and advantages will become more apparent upon reference to the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a sectional view through one form which an apparatus according to my invention may take;

Figure 2 is a view showing the apparatus of this invention arranged for concentrating substances according to a three-stage process;

Figure 3 is a flow chart showing the movement through the process of the substance being concentrated and the ice removed therefrom;

Figure 4 is a diagrammatic view of another form which the apparatus according to my invention may take; and

Figure 5 is a chart outlining the sequence of operations in connection with the apparatus in Figure 4.

Referring to the drawings, in particular to Figure 1, the arrangement shown therein comprises a tank or container **10** supported in a tiltable carrier **12** mounted on trunnions **14**, adapted for being tilted by hand wheel **16**. A space **18** is provided between container **10** and supporting means **12**, and within this space are coils **20** which are operable for chilling container **10** when receiving a refrigerating medium as controlled by the valve **60**.

Vertically disposed over the axis of container **10** is a hydraulic motor **22**, including reciprocal ram **24**, connected to a yoke **26**, which terminates at its lower end in a part **28**, adapted for engaging and closing the upper end of container **10**. Mounted on yoke **26** is a motor **30** having a shaft **32** extending through part **28**, and having thereon an agitator **34** adapted for being positioned within container **10** in order to agitate the contents thereof.

When supporting means **12** is tilted by hand wheel **16**, contents of container **10** are delivered to a centrifuge **36** which has a perforated basket **38** therein, which, when rotated at high speed, throws the liquid therefrom while retaining ice therein. The liquid thrown outward from basket **38** passes downwardly through discharge basket **40** into a tank or sump **42** to which is connected a pump **44**.

In Figure 2 it will be seen that a three-stage process is set up, and that each of the stages comprises mechanisms substantially identical with that just described in connection with Figure 1.

In Figure 2 the various elements of the apparatus in stage 1 are identified by the same reference numerals as employed in Figure 1, while in stage 2 the same numerals are employed with the addition of a subscript "a," and in stage 3 the same numerals are employed with the addition of a subscript "b."

Pump **44** which draws liquid from stage 1 delivers through a pipe **46** which has one branch pipe **48** leading through valve **50** so as to deliver liquid to container **10a**, and another branch pipe **52** leading through valve **54**, so that a certain portion of the liquid which pump **44** draws from sump **42** can be refluxed back through stage 1.

Sump **42a** associated with stage 2 is similarly connected through its pump **44a** so that a portion of the liquid extracted in centrifuge **38a** can be refluxed through stage 2 and a portion thereof delivered to stage 3.

The sump of stage **3**, not shown, is also connected so that a portion or all thereof can be delivered through pipe **48b** and valve **50b** to product stage, while another portion can be delivered through pipes **52b** and valve **54b** back to stage 1.

In operation, the containers **10**, **10a**, and **10b** are adapted for being flash heated by passing a heating medium such as steam through the coil **20**, as controlled by the valve **61**, or about the outside of the containers, so that after an ice film has formed inside the said containers it can be flashed loose therefrom, and then, when the containers are tilted to the discharge position, all of the ice and liquid therein will be delivered to the associated centrifuge.

In most instances, I have found that it is satisfactory to operate stage 1 at about minus 3 degrees centigrade, stage 2 from about minus 8 to minus 15 degrees centigrade, and stage 3 at about minus 25 degrees centigrade.

It will be understood that the particular temperatures employed will vary with the juices being concentrated and with the number of stages through which it is desired to carry it, and with the ultimate degree of concentration desired, and that the temperatures referred to above are merely examples of one operative process which has been carried out.

It has been mentioned before that the process of this invention is adapted for treating highly viscous substances,

and for this purpose the agitator **34** is employed. By utilizing the agitator **34**, the substance in the container **10** is kept in motion, and all parts of it are brought into contact with the periphery of the said container so that a freezing action can take place. This materially speeds up the process and insures a high efficiency of ice removal.

It is preferable, in carrying out the process, to convey the ice from each centrifuge to the refrigerated container of the preceding stage. In this manner ice crystals formed in one stage are supplied to the preceding stage and act as nuclei about which larger ice crystals can grow in the substance in the container. This not only further increases the efficiency of the process, but also, by causing the ice to pass through the process in counterflow relation to the flow of the liquid, the ice is always removed from the liquid at the point of least concentration, while the liquid is removed from the process at its point of greatest concentration.

Figure 4 shows a somewhat different arrangement, which operates, however, on substantially the same principles as that described in connection with Figures 1 and 2.

In Figure 4 the first stage of the process is carried out within a tiltable container comprising the inner container **60** and the outer container **62** between which there is a space **64** for supplying refrigerant to chill the inner container.

The flash heater **66** surrounds the inner container and is employed for breaking the ice off the container. Agitator means represented by multiple blades **68** on shaft **70** driven through gear **72** from a power means **74** provide agitating means for keeping the liquid stirred up within the inner container. A lift cable **76** is provided for elevating the agitating means upwardly out of the inner container so that it can be tilted to the position shown in dot-dash lines at "B," where the liquid in the inner container will pour into inner container **60**a of the second stage.

According to this process, the container then is tilted to the position indicated by the letter "C," and any remaining liquid therein will flow into the centrifuge **80**. At the same time, the ice is loosened within the container by the flash heater and is also discharged into the said centrifuge.

The centrifuge is operative to extract the liquid from the ice and to discharge it into pipe **82** and valve **84** into a collecting means, indicated at **86**. The centrifuge is also tiltable so the ice can be discharged into an ice trough **88**, when a certain portion is refluxed back through the process.

In stage 2 the same apparatus is employed as is employed in stage 1, except that when it is desired to empty the container in stage 2, it is first tilted rightwardly to the position indicated by the dot-dash lines at "D," so the juice will run therefrom to a juice trough **90**. Thereafter, the container of stage 2 is tilted leftwardly to the position indicated by the dot-dash lines at "E," and the ice discharged therefrom after it has been broken up by the action of the flash heater.

The parts of the apparatus employed in stage 2 which correspond to those employed in stage 1 are identified by the same reference numerals with the addition of a subscript "A."

It has been found in practice that the first concentration can advantageously be carried out at from 3 to 10 degrees below zero centigrade, while the second stage can be carried out at from 15 to 25 degrees below zero centigrade, but it will be understood that these temperatures are merely exemplary, and that other temperatures could be employed where the nature of the substance being processed indicated.

Also, while I have shown a two-stage process in Figure 4, it will be understood that as many stages as necessary to effect the desired degree of concentration could be employed under the same principles of operation, and the same advantages would obtain.

By practicing my invention and apparatus of the type illustrated, it is found that juices such as fruit and vegetable juices can be concentrated very rapidly, thereby avoiding deleterious exposure to the atmosphere, the resulting concentrate can be reconstituted to its original dilution by the addition of pure water and have substantially the same flavor of fresh juice, and the value of the reconstituted juice as a food is not impaired because it has substantially the same vitamin content as before it was processed.

It will be understood that I do not wish to be limited to the exact proportions, ratios, and other factors specifically set forth in the foregoing description and the accompanying drawings, but desire to comprehend such changes thereof as may be further desirable to adapt my invention to different conditions and usages.

I claim:

1. In an apparatus for freeze-dehydrating aqueous substances; a tiltably supported container, means for chilling the container to cause ice to form on the walls thereof when the substance to be dehydrated is in the container, a centrifuge positioned to receive at least a portion of the contents of the container, means for tilting said container, and means for flash heating the container to loosen the ice on the walls thereof.

2. In an apparatus for freeze-dehydrating aqueous substances; a tiltably supported container, means for chilling the container to cause ice to form on the walls thereof when the substance to be dehydrated is in the container, a centrifuge positioned to receive at least a portion of the contents of the container, means for tilting said container, means for flash heating the container to loosen the ice on the walls thereof so tilting of the container will discharge its entire contents to the centrifuge, and a movably mounted agitator positioned over the container so as to be movable therein when the container is upright.

3. In an apparatus for freeze-dehydrating aqueous substances; a plurality of tiltably supported containers, a centrifuge for each container positioned to receive the contents therefrom when the respective container is tilted on its support, means for chilling said containers to cause ice to form on the walls thereof when the substance to be treated is in the containers, means for flash heating the containers to release the ice therefrom for discharge to the centrifuges with the liquid in the containers, said centrifuges being operable to separate the ice from the liquid, and a pump for each centrifuge connected to pump the liquid therefrom to another container, whereby the liquid becomes more concentrated by the removal of water therefrom as ice, said containers being chilled to progressively lower temperatures in the direction of movement of the substance therethrough.

4. In an apparatus for freeze-dehydrating; a tiltable container, means for refrigerating the container, a second container positioned beneath and to one side of said tiltable container so as to receive liquids therefrom and including means for tilting said container, a centrifuge positioned beneath the tiltable container, and a flash heater for said tiltable container whereby the said tiltable container can be inverted and the flash heater energized to release ice from the walls of the container to the centrifuge.

5. In an apparatus for freeze-dehydrating; a tiltable container, means for refrigerating the container, an agitator movable into the container from above for agitating substances in the container and retractable to permit tilting of the container, a second container positioned beneath and to one side of said tiltable container so as to receive liquids therefrom and including a centrifuge positioned beneath the tiltable container, and a flash heater for said tiltable container whereby the said tiltable container can be inverted and the flash heater energized to release ice from the walls of the container to the centrifuge.

6. In an apparatus for freeze-dehydrating; a pair of tiltable refrigerated containers for the material being dehydrated, an ice receiver, and a liquid receiver; said containers and receivers being so arranged that tilting of one of the containers will position it to discharge to the other container, and inverting of the one container will position it to discharge to the ice receiver, and tilting of the other container in respective opposite directions will position it to discharge to said liquid receiver and ice receiver, respectively, and means for flash heating the containers to release ice from the walls thereof when positioned to discharge to said ice receiver.

7. In an apparatus for freeze-dehydrating; a pair of tiltable refrigerated containers for the material being dehydrated, an ice receiver, and a liquid receiver; said containers and receivers being so arranged that tilting of one of the containers will position it to discharge to the other container, and inverting of the one container will position it to discharge to the ice receiver, and tilting of the other container in respective opposite directions will position it to discharge to said liquid receiver and ice receiver, respectively, and means for flash heating the containers to release ice from the walls thereof when positioned to discharge to said ice receiver, each of said containers having a retractible agitator suspended from thereover.

8. In an apparatus for freeze-dehydrating; a pair of tiltable refrigerated containers for the material being dehydrated, an ice receiver, and a liquid receiver; said containers and receivers being so arranged that tilting of one of the containers will position it to discharge to the other container, and inverting of the one container will position it to discharge to the ice receiver, and tilting of the other container in respective opposite directions will position it to discharge to said liquid receiver and ice receiver, respectively, and means for flash heating the containers to release ice from the walls thereof when positioned to discharge to said ice receiver, said other container being refrigerated to a lower temperature than said one container.

9. In an apparatus for freeze-dehydrating; a pair of tiltable refrigerated containers for the material being dehydrated, an ice receiver, and a liquid receiver; said containers and receivers being so arranged that tilting of one of the containers will position it to discharge to the other container, and inverting of the one container will position it to discharge to the ice receiver, and tilting of the other container in respective opposite directions will position it to discharge to said liquid receiver and ice receiver, respectively, and means for flash heating the containers to release ice from the walls thereof when positioned to discharge to said ice receiver, said ice receiver comprising means to centrifuge the liquid from the ice received therein.

10. In an apparatus for freeze dehydrating aqueous substances, a container for receiving an aqueous substance for freeze dehydration, refrigeration and heating means operatively connected to said container for respectively refrigerating and heating said chamber, an agitator within said chamber, means connected with said agitator for lifting the same out of said container, means tiltably supporting said container, and a receptacle at one side of said container to receive substances therefrom upon tilting of the container relative to said receptacle, said receptacle being adapted for separating liquids and solids delivered thereto.

11. In an apparatus for freeze dehydrating aqueous substances, a container for receiving an aqueous substance for freeze dehydration, refrigeration and heating means engaging said container for respectively refrigerating and heating said chamber, an agitator within said chamber, means connected with said agitator for lifting the same out of said container, means tiltably supporting said container, and a receptacle at one side of said container to receive substances therefrom upon tilting of the container relative to said receptacle, said receptacle comprising a centrifuge.

12. In an apparatus for freeze dehydrating aqueous substances, a container for receiving an aqueous substance for freeze dehydration, refrigeration and heating means engaging said container for respectively refrigerating and heating said chamber, an agitator within said chamber, means connected with said agitator for lifting the same out of said container, means tiltably supporting said container, a receptacle at one side of said container to receive substances therefrom upon tilting of the container relative to said receptacle, said receptacle comprising a centrifuge, and a circulatory system connected between the centrifuge and said container through which at least a part of the fluid discharged from the centrifuge is returned to said container.

13. A process for concentrating fruit juice to a predetermined concentration which comprises subjecting said juice to a series of successive coordinated freezing stages and wherein the freezing stages are carried out in freezing containers at progressively lower temperature, whereby water in the juice is frozen out as fine ice crystals which are formed during each freezing stage, flash heating the container after each freezing stage to flash loose ice formed on the inner walls of the container, thereafter delivering all of the ice and liquid to a centrifuge whereby the ice is separated from the liquid, and refluxing a portion of the recovered liquid along with ice seeding crystals to the preceding stage, and recovering a final juice concentrate containing refluxed juice portions.

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