

March 9, 1926.

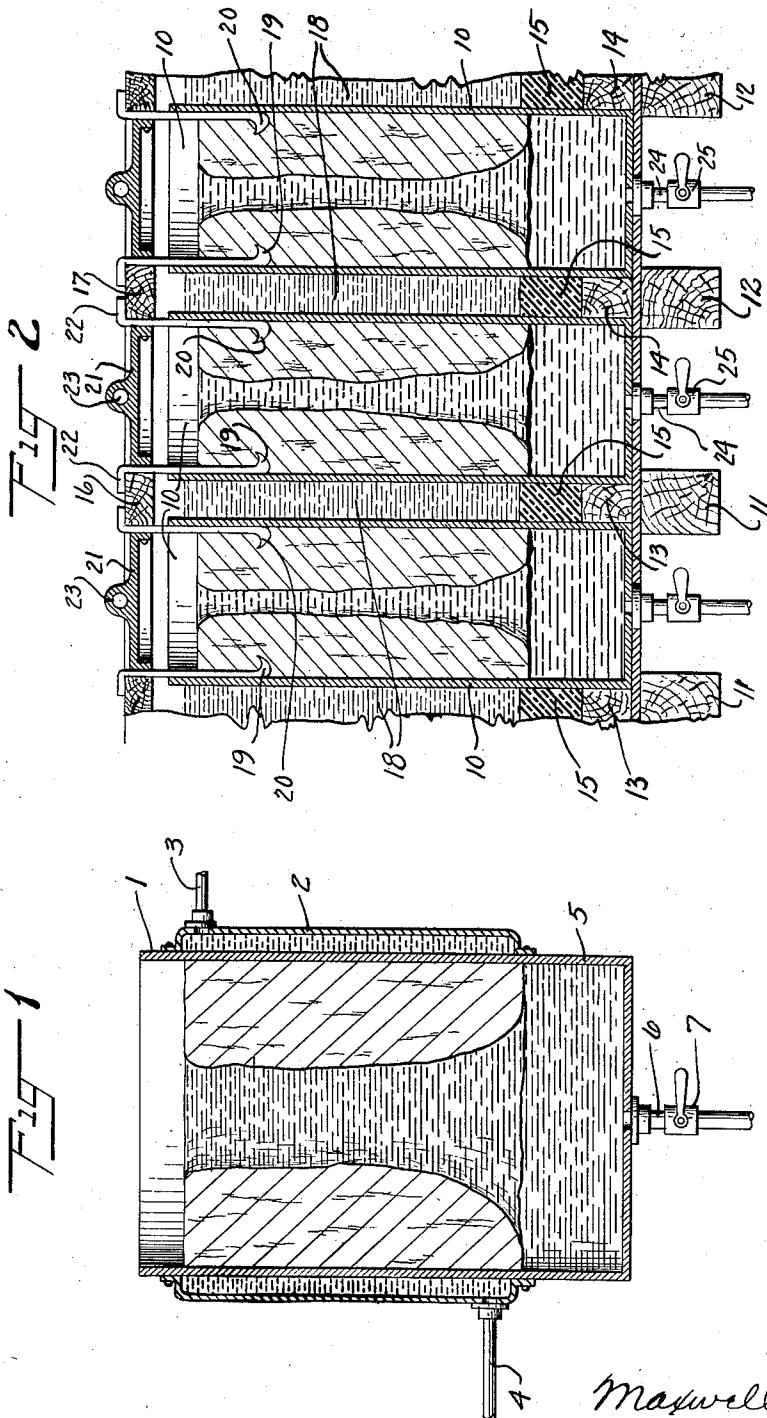
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M. O. JOHNSON

APPARATUS FOR CONCENTRATING SOLUTIONS

Filed Sept. 19, 1921

3 Sheets-Sheet 1



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Fig 3

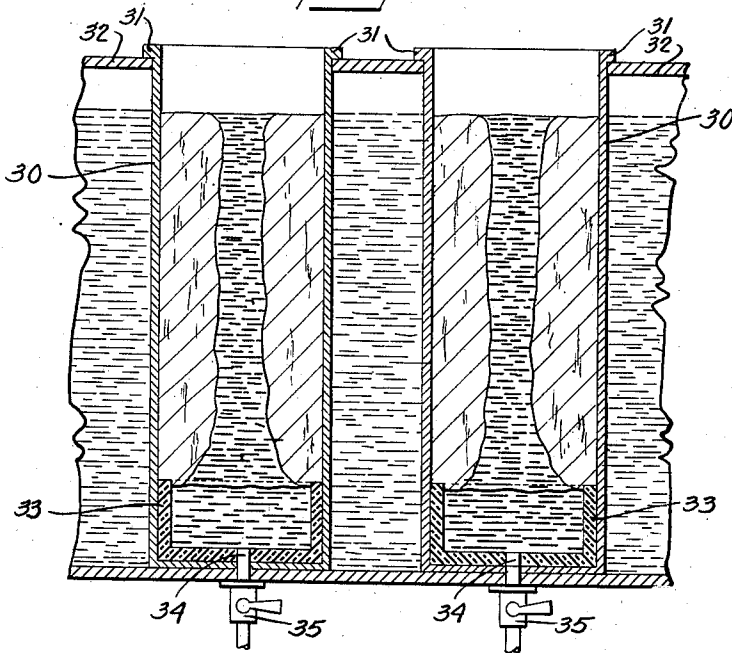
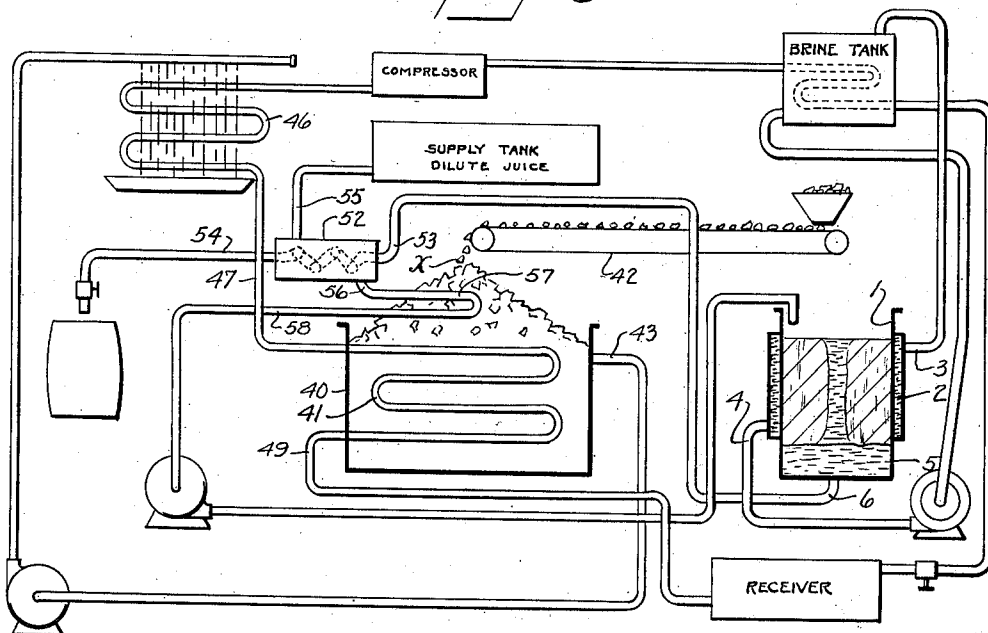


Fig 5



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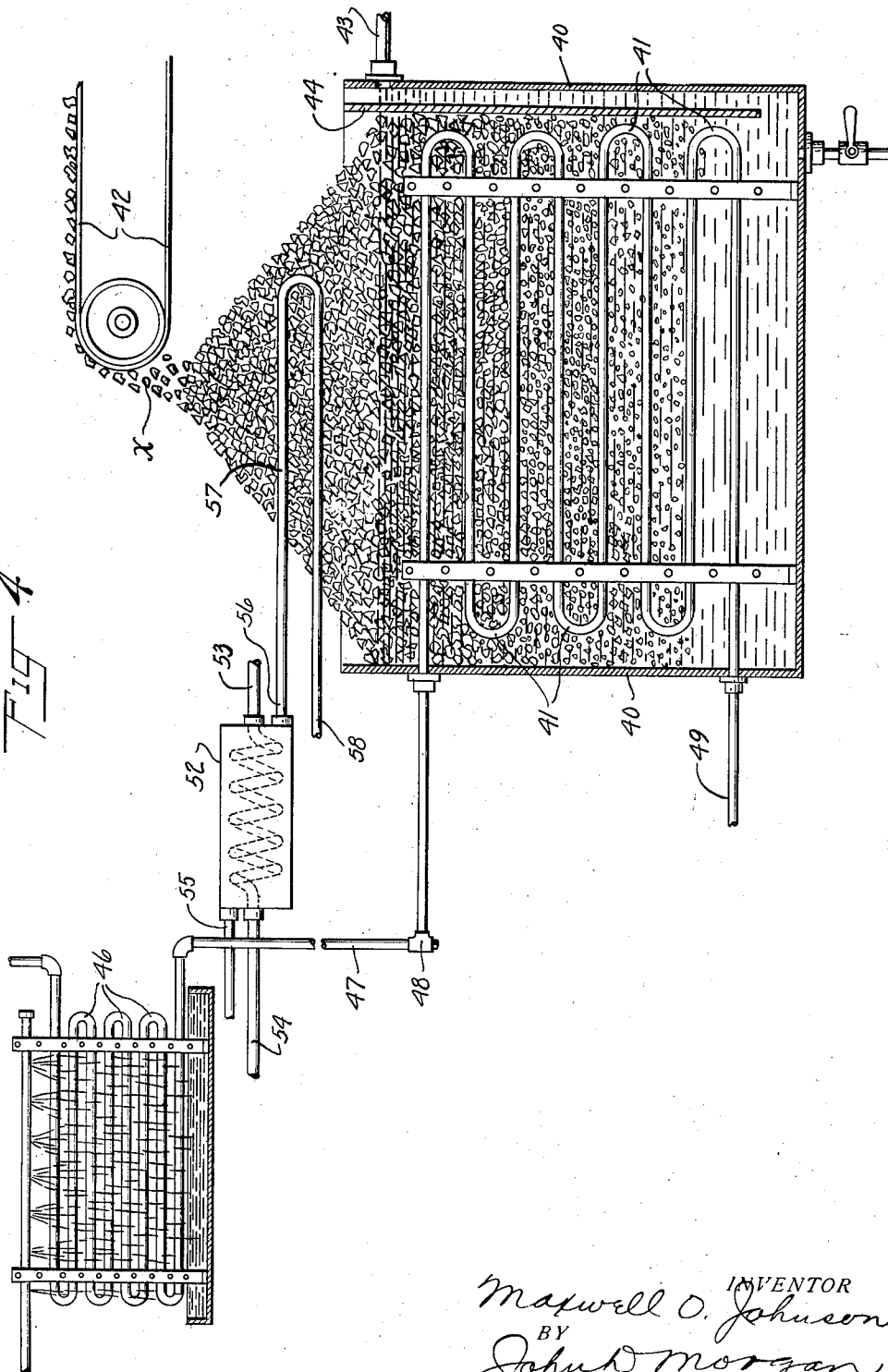
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE.

MAXWELL O. JOHNSON, OF WAIPIO, TERRITORY OF HAWAII.

APPARATUS FOR CONCENTRATING SOLUTIONS.

Application filed September 19, 1921. Serial No. 501,855.

To all whom it may concern:

Be it known that I, MAXWELL O. JOHNSON, a citizen of the United States, residing at Waipio, in the county of Honolulu, Territory of Hawaii, have invented certain new and useful Improvements in Apparatus for Concentrating Solutions, of which the following is a specification.

The invention relates to a novel means for concentrating solutions, and more particularly to such a means wherein the concentration is effected by freezing, and regenerative features, or steps and means are employed.

Objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious herefrom, or may be learned by practice with the invention, the same being realized and attained by means of the instrumentalities and combinations pointed out in the appended claims.

The invention consists in the novel means, parts, constructions, arrangements, steps, improvements herein shown and described.

The accompanying drawings, referred to herein and constituting a part hereof, illustrate exemplarily the present preferred form of means or apparatus employed in carrying out the invention, and illustrate certain steps in the method or process; the drawings being more or less diagrammatic in character.

Of the drawings:—

Fig. 1 is a transverse vertical section of one form of freezing and concentrating apparatus included in the invention;

Fig. 2 is a like vertical section of a somewhat different form of such apparatus;

Fig. 3 is a similar view showing a yet different form of such apparatus;

Fig. 4 is a diagrammatic elevation showing the regenerative steps in the process and the apparatus preferably employed in connection therewith; and

Fig. 5 is a diagrammatic elevation, on a smaller scale, of the same steps and apparatus, but showing certain parts in addition to those shown in Fig. 4.

The concentration of solutions of many various kinds and constituents are widely and generally effected by evaporation, and usually involve the application of relatively high temperatures. This type of process is objectionable in case of very many solutions and for a number of reasons. This application of heat, especially at high tem-

peratures, and for relatively long periods, is very injurious to many solutions, and particularly to organic solutions such as fruit juices, milk, dye-wood extracts, and many others. In the case of many such solutions the employment of relatively high temperatures effects decomposition or dissociation of some of the highly organized compounds essential to or characteristic of the solutions. It will be understood that the term "solution" herein is used generally to designate any relatively dilute liquid to be concentrated, and the term "solvent" to indicate the diluent, that is the part thereof which is separated out by the freezing action in order to concentrate the liquid.

These evils and disadvantages are obviated in concentrating by freezing, and this process usually improves or maintains the quality of the original solution in the concentrate, as it avoids the breaking down of the highly organized compounds characteristic of the solutions, and avoids foaming and other evils.

In connection with the freezing process also, certain features of easy and rapid separation of the concentrated fluid are realized, together with capacity for maintaining a continuous process, and also for employing regenerative steps or means which render the process easy, rapid and economical.

Referring now in detail to the present preferred manner of carrying out the process and the present preferred form of apparatus, and referring first to the direct step of freezing to concentrate the solution and to effect separation of the frozen solvent and of the remaining concentrated liquid, the process is primarily described as applied to aqueous solutions, such a fruit juices, although it will be understood that in its main features the invention is applicable to the concentration of other kinds of solutions.

By my invention, an apparatus is provided for freezing a solution in a can, tank or other suitable container of heat-conducting material, one level or portion of the container being subjected to freezing temperature, and another level or portion being maintained above the freezing temperature, the aqueous or other more dilute part of the solution being frozen within the container, and the condensed residue of the solution collecting in that part of the container which is maintained above freezing temperature. As embodied, a refrigerating

medium is applied to the exterior of a part of the can or compartment, and preferably to the upper part thereof, and the lower part of the can or container is maintained above the freezing temperature. The aqueous or other thin part of the solution in such a can or container under these conditions, will freeze out in an almost pure condition as ice on the sides or walls of the container, while the greater part of the concentrated solution, which is of greater specific gravity than the dilute solution, will settle into the bottom or non-freezing portion or part of the container.

When the desired or required degree of concentration is reached, the concentrated fluid or solution may be drawn off without disturbing the ice or frozen part of the original dilute solution.

This will remove the greater part of the concentrated solution, but by allowing the portion of the can or compartment which was subject to freezing to rise in temperature above the freezing point, the ice in the can will gradually thaw or melt, and the remainder of the concentrated part of the solution (which is of intermediate concentration between the very dilute and highly concentrated parts) will come off in the first draining, as it forms a softer or "mushier" ice or like solid. Practically all of this string concentrated solution may be drained off before the pure or harder ice begins to melt and at this time almost pure ice is left in the can or container, and the concentrated juice is practically entirely drained off, thus effecting an easy, rapid, economical and complete separation of the two.

If desired, the blocks of ice formed in the can may be thawed loose, lifted out, broken up and centrifuged to recover the relatively small residue of concentrated juice. This, however, is usually unnecessary where the draining, thawing and again draining process as just described is employed. The pure ice secured may be broken up and used in the regenerative process hereinafter described.

Referring now in detail to Fig. 1 of the drawings, a can 1 of sheet metal or other highly heat conductive material is employed as a container for the solution to be concentrated. I have found that the most efficient form of can is one which is relatively deep vertically and of comparatively small horizontal cross-section. This permits a better and more efficient heat interchange with the circulating refrigerating medium.

The can may be of any suitable or desired form, but is preferably relatively narrow and deep, and rectangular, oblong or cylindrical in horizontal cross-section. Means are provided for applying a refrigerating medium, and preferably a circulating refrigerating medium, to a portion of the ex-

terior wall of the can. As shown in Fig. 1, the can 1 is surrounded by a hollow jacket 2, from a point near the top of the can well down the sides thereof toward the bottom, while the bottom portion of the can is outside of the jacket 2. Inlets and outlets 3 and 4 are provided for the circulating refrigerating means.

The portion of the can 1 within the jacket 2 may be conveniently termed the freezing portion, and the portion 5 thereof external to and below the jacket 2 may be termed the non-freezing portion of the can.

The relative size of these portions will depend partly on the degree of concentration desired. Usually about one-half to two-thirds of the water in a solution is as much as it is convenient to remove in one operation. A ratio of about four or five to one between the freezing and non-freezing portions of the can or container is approximately correct and efficient for this amount of concentration. This also allows or causes a core of concentrated solution to extend through the center of the can, as shown in Fig. 1, and shortens the time of freezing, since the ice need not be frozen solid through the diameter of the can 1 to effect the desired concentration.

Means are provided for draining off the concentrated solution, and as embodied a pipe 6 communicates with the bottom of the can 1, and is provided with a valve 7. Any suitable supply may be provided for the dilute solution, and the process may be practically continuous. It will be understood that the ice must be periodically removed, which can be accomplished by slightly thawing and then lifting out the ice block, and this may be done either with or without the step of thawing to recover the remainder of the concentrate as already described.

In Fig. 2 a vertical section is shown through a somewhat different form of can or tank. In this form, the can or tank 10 is one of a series, and rests on supports 11 and 12. Between this can 10 and the adjoining cans are spacing blocks 13 and 14, resting upon the blocks or supports 11 and 12. Over these blocks and around the can 10 there is poured or placed a waterproof, heat insulating compound or material 15, such as pitch, or any other suitable material. This is filled in to such a depth as will give the desired proportion between the freezing and non-freezing portions of the can or tank 10, as already explained in connection with Fig. 1.

The cans or tanks 10 are separated at or near their top by means of bars 16 and 17. Through the spaces 18 between the cans or tanks, the refrigerating medium, such as cold brine, is circulated in the same manner as within the jacket 2 of the can or tank

of Fig. 1. Suitable inlets and outlets (not shown) will be provided.

In this figure, hooks 19 and 20 are shown which are connected by a cross yoke 21 and are suspended from the top edges of the can by their hook ends 22, and become imbedded in the ice during the freezing operation. An eye 23 is formed in the cross bar 21, to which a hook or other device may be attached to lift out the cake of ice after it has been sufficiently thawed. The pipe 24 communicating with the bottom of can 10 serves for the drawing off of the concentrated liquid in the bottom of the can, and is provided with a valve 25.

With the construction of the can or tank just described, the difference in level and relative position of the freezing and non-freezing parts of the can or tank are dependent on the difference in specific gravity of the dilute solution and the concentrated solution, the latter being the heavier. If in any case the concentrated liquid should be lighter, the parts of the can would be reversed. The cans or tanks may be provided with suitable closures, not shown.

In Fig. 3 a form of tank or can 30 is shown, adapted to be suspended in a brine tank which may be of the usual form. The tank 30 is suspended by a ring 31 around the top edge thereof, resting upon a plate or supports 32 supported on the tank structure.

The non-freezing part of the can or tank 30 is provided in this case by a layer or layers 33 of heat-insulating material, such as sheet cork or other suitable material.

A pipe 34, provided with a cock 35, serves to drain the concentrated solution from the can. If desired the can may be lifted from the brine tank and the concentrated solution may be poured out through the top of the can. This form of can, while adapted for use with a common or standard type of brine tank, is usually not as efficient as the two forms previously described, as some heat may be transmitted through the insulation 33 and as a consequence some mushy ice may be formed in the concentrated solution, thereby rendering the separation more difficult.

With certain kinds of solutions the separation is more effectively accomplished by agitation, and this may be effected by any known or other suitable means, such as a stream of air, a circulating pump, a rotating screw, or other suitable means. With certain solutions, such as fruit juices for example, agitation may cause foaming and be objectionable on this account.

Referring now more particularly to the regenerative or energy conserving features of the invention, it may be stated generally that the ice formed during the concentrating process is employed or consumed in cooling

the ammonia, or other refrigerating medium, to effect or assist in effecting the required reduction in temperature, and it is also preferably employed to pre-cool the dilute solution, that is to cool it preparatory to concentration. As one feature of the regenerative or energy-saving process, the cold concentrated solution is also preferably employed to pre-cool the dilute solution.

In the preferred embodied form thereof, it is shown applied to a refrigerating system of the ammonia compression type, as this is the type in most common use, but it will operate equally well with other types of refrigerating systems and other refrigerating media besides ammonia; or will operate with the ammonia absorption type or system, as the condenser or expansion coils which are utilized in connection with the present invention, are similar or sufficiently similar in all these types.

By using the centrifuged or otherwise separated ice or equivalent frozen component of the solution for cooling the condenser of the refrigerating system, a very material saving may be effected in the amount of energy required to maintain the system in operation. The frozen solvent may be conveniently referred to as ice, since aqueous solutions are most commonly employed in concentration processes.

The refrigerating capacity required to lower a solution to its freezing point is small compared to the capacity required to freeze out the solvent. If the ice be utilized in cooling the condenser of the refrigerating apparatus, the refrigerating work or energy expended in freezing the ice is returned to the system. Thus aside from radiation and mechanical losses, the only capacity required of the refrigerating apparatus is the small amount necessary to lower the temperature of the dilute solution to the freezing point.

The cooling of the condenser by the ice will lower the condensing pressure in the refrigerating apparatus very materially. The efficiency of a refrigerating apparatus is proportionately greater the less the difference between the condenser pressure and the low or expansion pressure. By melting the ice which was formed in the concentration process in the operation of cooling the condenser, a great saving is secured or effected in the amount of energy required to operate the refrigerating apparatus; or the same refrigerating apparatus may be made to furnish increased capacity or product with the same energy consumption. By utilizing the outgoing cold concentrated solution and also the ice to cool the incoming dilute solution an additional saving is effected.

The matters of theory just stated are true and applicable to the best of my present knowledge and experience, but it will be un-

derstood that the invention is not affected should any errors or discrepancies be later found therein.

Referring now in particular to Figs. 4 and 5, which illustrate in an exemplary manner the present preferred manner of carrying out this feature of the invention, and also show the preferred form of the apparatus employed in so doing, a cooling tank 40 is provided for the condensing coil 41 of the refrigerating apparatus. This tank is preferably full of water to cover the coils, and the ice x from the concentrating process is supplied to the condensing coils in a suitable manner.

As shown in Fig. 4, a conveyor 42 (which is supplied from a centrifugal, or ice-breaker, operating in conjunction with the concentrating apparatus) dumps or pours the broken ice over the coils 41 of the condenser. The ice is rapidly melted by contact with the coils 41, and the water is drawn off through an overflow pipe 43. A baffle plate 44 may be employed to keep the outlet clear.

Usually the hot ammonia gas from the compressor passes into the fore-cooling coils 46, which coils are cooled by water running thereover, and if desired, this may be the water from the melted ice in the tank 40. Thus a considerable portion of the heat of compression is removed from the gas by this apparatus. The supply of water to the coil 46 is regulated so as to give a low condensing pressure, but not so much so as to cool the compressed gas so that it cannot melt all the ice around the submerged condensing coils 41. The gas at this desired temperature passes from the cooling coils 46 by pipe 47 through check valve 48 into the condensing coil 41. The liquid ammonia passes through the pipe 49 to the receiver.

Referring now to the pre-cooling of the dilute solution, in accordance with certain features of the invention, this is effected both by the action of the cold condensed liquid and also by the action of the ice or frozen solid. As embodied, the cold concentrated liquid enters the counter-current apparatus 52 through a pipe 53, and passes out therefrom through a pipe 54. The dilute solution to be cooled enters the counter-current apparatus 52 through a pipe 55, and passes out therefrom through a pipe 56. Thus some portion of the heat is abstracted from the warm dilute solution by the cold concentrated solution in the counter-current apparatus.

In the embodied manner of utilizing the ice or frozen solid to cool the dilute solution, pipe 56 communicates with a pipe or pipe coils 57, over which the ice x from the conveyor 42 passes to the condenser coils 41. The coils 57 are above the surface of the liquid in tank 40, and are spaced relatively farther apart than are the condensing coils 41.

There is thus no tendency for the ice to block or hang on the coil 57, since it is being melted below by the coils 41. The cool dilute solution passes from coils 57 through a pipe 58 to the cans or tanks, previously described, for the freezing concentration process.

The concentrated solution and the melted ice or solvent, that is, the water from the tank 40, leave the system but little below ordinary temperature, and thus their low temperatures, imparted during the concentration process, have been transferred very largely to the refrigerating means and to the dilute solution, and but very little additional refrigerating capacity or energy need be added or supplied to the system or cycle to keep it in operation.

The invention in its broader aspects is not limited to the precise form of apparatus shown and described, but changes may be made therein without departing from the principles of the invention and without sacrificing its chief advantages.

What I claim is:—

1. An apparatus for concentrating solutions by freezing, comprising in combination a freezing tank, a compressor, a fore-cooler, means for further cooling the compressed refrigerant with ice from the freezing tank, means for expanding the refrigerant, means for extracting heat from the freezing tank through the medium of the expanded refrigerant, means for drawing off the cold unfrozen concentrated solution from the freezing tank, means for conducting dilute solution to the freezing tank, and a heat exchange device in which the incoming dilute solution is pre-cooled by means of the outgoing cold concentrated solution.

2. An apparatus for concentrating solutions by freezing comprising in combination a freezing tank, a compressor, a fore-cooler, means for further cooling the compressed refrigerant with ice from the freezing tank, a brine tank, means for expanding the refrigerant and cooling the brine and applying the cooled brine to the freezing tank, means for drawing off the cold unfrozen solution from the freezing tank, means for leading the dilute solution to the freezing tank, and a heat exchange device for cooling the incoming dilute solution by bringing it into heat interchanging relationship with the outgoing cold unfrozen concentrated solution.

3. An apparatus for concentrating solutions by freezing comprising in combination a freezing tank, a compressor, a fore-cooler, means for further cooling the compressed refrigerant with ice from the freezing tank, a brine tank, means for expanding the refrigerant and cooling the brine and applying the cooled brine to the freezing tank, means for drawing off the cold un-

frozen solution from the freezing tank, means for leading the dilute solution to the freezing tank, a heat exchange device for cooling the incoming dilute solution by bringing it into heat interchanging relationship with the outgoing cold unfrozen concentrated solution, and means for additionally cooling the incoming dilute solution with ice from the freezing tank.

4. An apparatus for concentrating solutions by freezing comprising in combination, a freezing tank, a compressor, a cooling tank containing ice from the freezing tank, for cooling the compressed refrigerant from the compressor, means for cooling the compressed refrigerant before it enters said cooling tank, with water obtained from the melting of the ice in the cooling tank, means for drawing off the cold unfrozen solution, means for supplying dilute solution to the freezing tank, a heat exchange device through which the cold unfrozen solution and the incoming dilute solution are passed, for pre-cooling the incoming dilute solution, a brine tank, means for expanding the re-

frigerant and cooling the brine and applying the cooled brine to the freezing tank for freezing the contents thereof, and means for additionally cooling the incoming dilute solution with ice from the freezing tank.

5. An apparatus for concentrating solutions by freezing, comprising in combination a freezing tank, a brine tank, means for subjecting the upper part only of the freezing tank to the cooling action of the brine, a compressor, a forecooler, a cooling tank for the compressed refrigerant, containing ice from the freezing tank for further cooling the compressed refrigerant, means for expanding the cooled refrigerant and cooling the brine therewith, means at the lower part of the freezing tank for conducting away the cold unfrozen solution, means for delivering dilute solution to the freezing tank, and a heat exchange device through which the dilute and concentrated solutions are passed, for pre-cooling the dilute solution.

In testimony whereof, I have signed my name to this specification.

MAXWELL O. JOHNSON.