Jan. 15, 1957 A. W. ECKSTROM 2,777,514

METHOD AND APPARATUS FOR CONCENTRATING LIQUIDS

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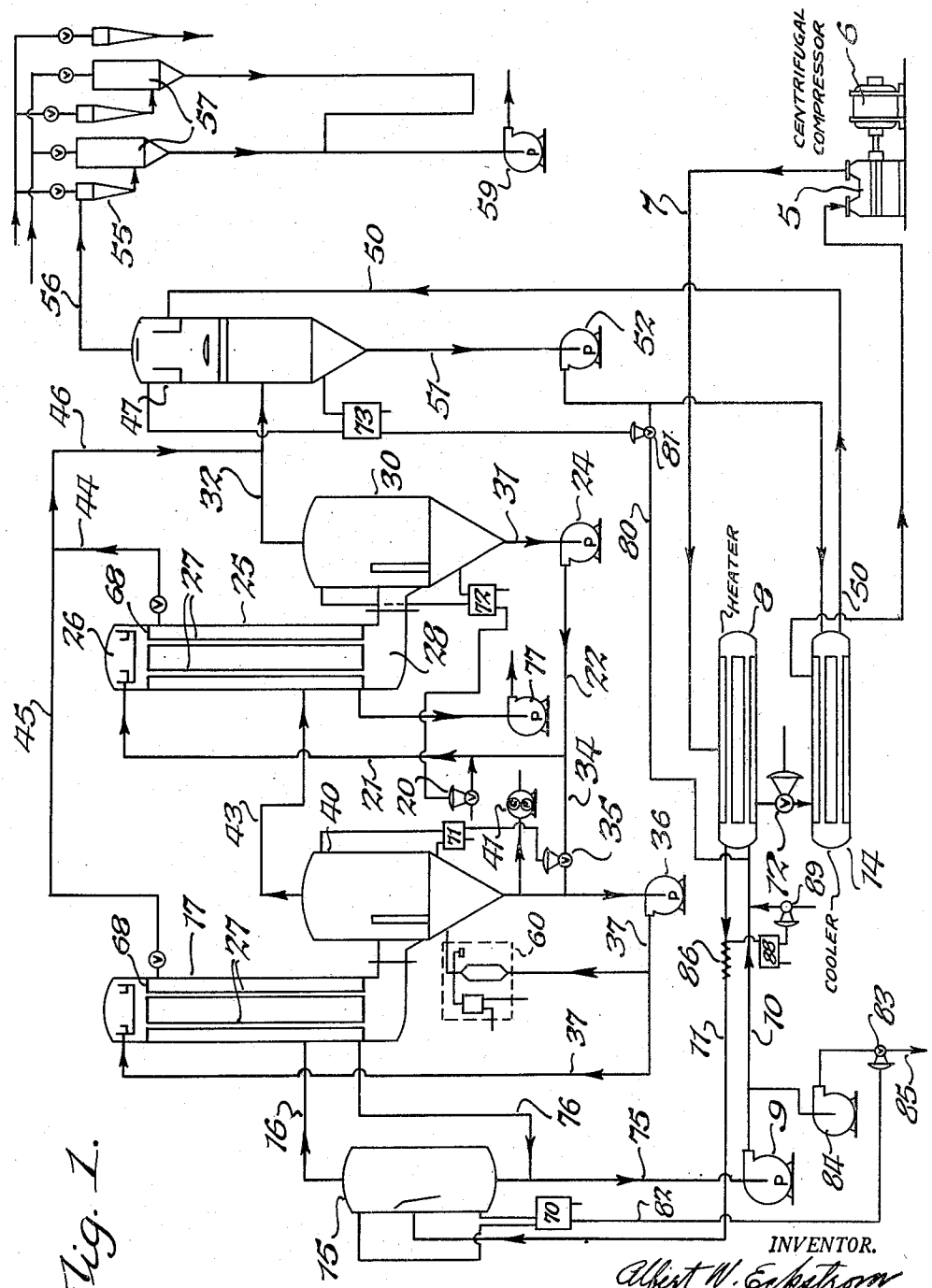


Fig. 1.

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Fig. 3.

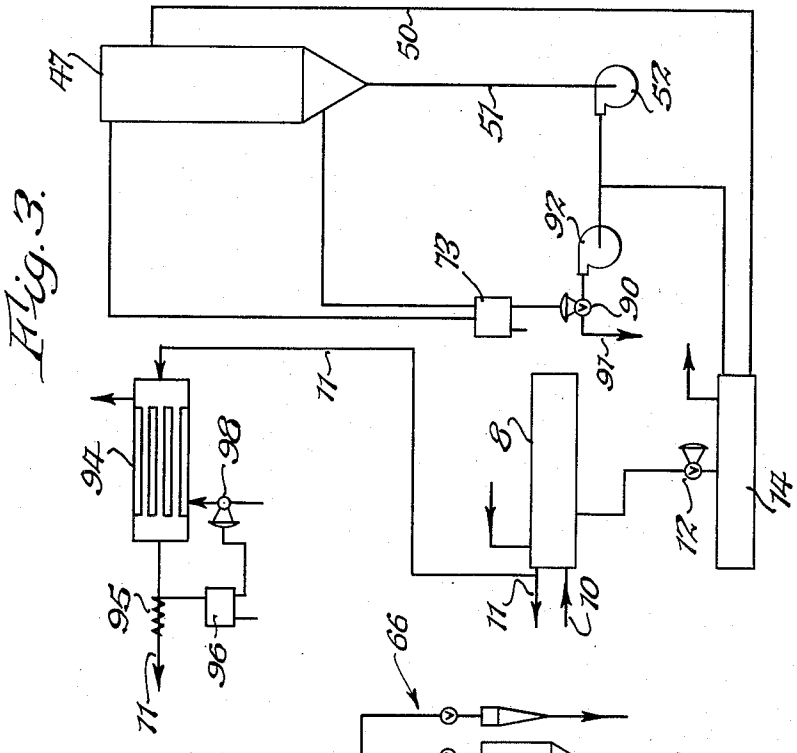
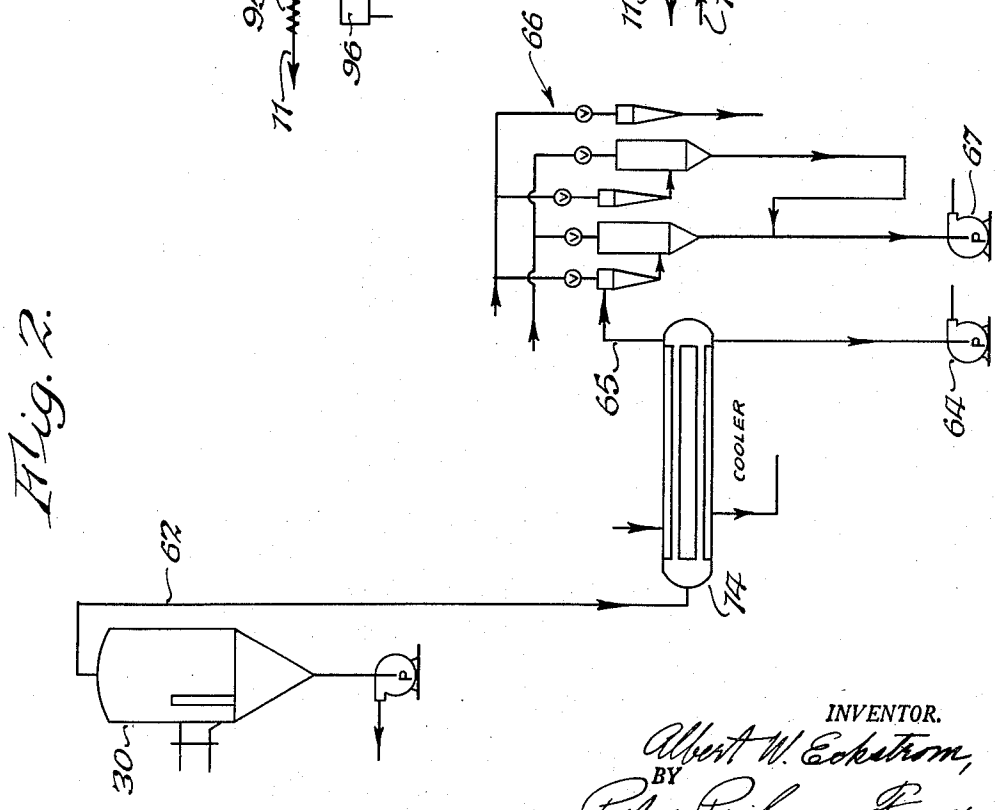


Fig. 2.



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METHOD AND APPARATUS FOR CONCENTRATING LIQUIDS

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Application March 11, 1949, Serial No. 80,813

7 Claims. (Cl. 159—17)

This invention relates to concentration by low temperature evaporation of liquid food products and pharmaceuticals to concentrate the same while preserving the vitamins and flavors or other active principles thereof.

In the ordinary type of single and multiple effect vacuum evaporator, operating temperatures are largely determined by the temperature of the cooling water available for condensation of the vapors leaving the evaporator. A considerable difference in temperature between cooling water and vapors must be maintained to limit the quantity of cooling water required for condensation to a reasonable quantity. In accordance with any seasonal variation in cooling water temperature, either the operating temperature must be allowed to fluctuate or the quantity of cooling water must be varied to maintain a uniform operating temperature throughout the year.

To operate an evaporator at a higher vacuum than can be obtained by direct condensation of the vapors by the available cooling water, it is possible to compress the vapors by means of high pressure steam in a thermo-compressor to a pressure at which they can be condensed in the usual manner. Such a thermo-compressor requires a large amount of steam at high pressure and additional cooling water since this high pressure steam also must be condensed.

In the concentration of liquid food products and many pharmaceuticals, it is necessary to operate the evaporator at temperatures below 80 degrees F., which temperatures cannot be maintained throughout the year except with an ample supply of cooling water of very low temperature. In order to operate such an evaporator successfully, it also is necessary to heat the evaporator with steam at sub-atmospheric pressure, at which the temperature is sufficiently low to prevent injury to the quality of the product being concentrated. Within these limits, the economic benefits of multiple evaporation may be obtained if a sufficient difference between steam and water temperature is available.

One of the objects of this invention is to provide an improved method and apparatus of this type which will operate at lower temperatures than can be obtained with the available water supply, which will be economical in the use of steam and water, and which will operate uniformly regardless of variations in atmospheric temperatures and in temperatures of the available water supply. Another object is to provide a method and apparatus of this type in which the heat developed in the compressor and condenser of a refrigerating unit or machine is employed to heat an intermediate liquid which in turn supplies heat for evaporation of the liquid which is being concentrated. A further object is to control the operation of the apparatus by regulating the temperature of the intermediate liquid and disposing of excess heat developed by the compressor. A further object is to provide a method and apparatus including a refrigeration cycle for condensing the vapors of the liquid which is being concentrated at low temperature and for producing low temperature water vapor to supply heat to the liquid, so that

injury to the liquid is prevented. Another object is to provide an improved method and apparatus of this type in which the overheating of the liquid being concentrated is avoided. A further object is to provide apparatus of this type in which contamination of the liquid which is being treated is avoided. Other objects and advantages will be apparent from the following description of the embodiments of the invention shown in the drawings, and the novel features will be particularly pointed out in the appended claims.

According to this invention a refrigeration system is employed, in which the evaporator of the refrigerant is used for condensing the vapors from the product evaporator directly or for cooling the water used for condensing these vapors, and in which the compressed refrigerant vapors are condensed by a coolant or intermediate liquid which then is allowed to flash and thereby furnish vapors which are used to furnish the necessary heat to condense the liquid which is being treated.

In the accompanying drawings, which illustrate by way of example, some embodiments of this invention:

Fig. 1 is a diagrammatic view or flow diagram of a double effect back flow apparatus embodying this invention.

Fig. 2 is a partial diagrammatic view showing a modification of a portion of the apparatus shown in Fig. 1.

Fig. 3 is a fragmentary diagrammatic view showing a modified arrangement for regulating the temperature of the intermediate liquid supplied to the flash chamber.

In accordance with this invention, the heat produced in compressing and condensing a refrigerant is used to heat water or other intermediate liquid, a part of which is then flashed into vapor, which vapor, through the medium of heat exchangers or steam chests, raises the temperature of the liquid to be concentrated at low temperatures and high partial vacuum. For this purpose, in the construction shown in the drawings by way of example, **5** represents a compressor for the refrigerant which may be a centrifugal compressor driven by means of a motor **6**. Hot compressed refrigerant passes through a conduit **7** to a heater or heat exchanger **8** through which water or other intermediate liquid is circulated by means of a pump **9** and conduits **10** and **11**. The condensed refrigerant vapors then pass through an expansion valve **12** to reduce the pressure of the same. The liquid refrigerant then passes to another heat exchanger **14** in which it is evaporated and in which water or other intermediate liquid is cooled or water vapor condensed, as will be hereinafter more fully described. The intermediate liquid may, for example, be a solvent other than water, particularly if operating temperatures below the freezing temperatures of water are desired or a solvent other than water is to be evaporated from the liquid under treatment.

The heated water or intermediate liquid from the conduit **11** passes into a flash chamber **15** in which it is partly vaporized. The vapor then passes through conduit **16** to a heat exchanger or steam chest **17** in which heat of the vapor from the flash chamber **15** is transferred to the liquid to be concentrated.

Referring now to the liquid to be concentrated which may, for example, be citrus fruit juices, pharmaceuticals or other liquids which cannot be heated to high temperatures without loss of vitamins, flavors or the like, this liquid is introduced into the system through a suitable control valve **20** into a conduit **21** which connects with a conduit **22** connected with the discharge of a pump **24**. The liquid passes through the pipe **21** into the upper end of a heat exchanger or steam chest **25** which may be similar in construction to the steam chest **17**. The steam chest **25** may, for example, have an upper compartment **26** into which the liquid to be treated enters, and a plu-

rality of tubes 27 through which the liquid flows to a lower compartment 28 of the steam chest and in which it is partly concentrated. The space surrounding the tubes 27 is filled with vapor for supplying heat to the liquid to be treated. From the lower end of the steam chest, this liquid enters a separator 30, in the lower portion of which the liquid collects and passes to the pump 24 through a pipe or conduit 31. Vapor is withdrawn from the upper portion of the separator 30 through a conduit 32. By means of this construction, a continuous down flow of the liquid to be concentrated results. This down flow type of evaporator is desirable, since it offers the least amount of thermal resistance by eliminating any increase in the boiling point of a liquid, such as occurs in a partially filled evaporator tube of the upflow type through hydrostatic head exerted by the column of liquid on the liquid at the bottom of the tube. For this purpose, a down-flow evaporator, in which the liquid flows downwardly on the inside of a bundle of vertical tubes, is most suitable. This type of evaporator also can be cleaned readily and kept in sanitary condition. If the liquid under treatment contains air or other gas, it may be desirable to admit this liquid from the valve 20 into the lower compartment 28 of the steam chest for immediate passage to the separator 30 in which such air or gas will be withdrawn. This liquid is then passed by the pump 24 to the pipe 21.

Some of the liquid being concentrated which has passed through the steam chest 25 and separator 30 is discharged by means of the pump 24 into the pipe 21 and returned to the steam chest 25, while another part of the liquid flows through a pipe 34 controlled by a valve 35 to a pump 36 by means of which it is pumped through pipes or conduits 37 to the upper end of the steam chest 17 to pass through the tubes 27 thereof. The exterior surfaces of these tubes are subjected to vapor from the flash chamber 15. The liquid from the lower end of the steam chest passes into a separator 40 from which at least a portion of the treated liquid is withdrawn from the system, for example, by means of a gear pump 41. Another portion of this liquid may pass to the pump 36 for recirculation through the steam chest 17.

Heat for effecting evaporation of the liquid under treatment may be supplied to the steam chest 25, as in the construction shown, in which the vapor from the separator 40 is passed by means of a conduit 43 to the steam chest 25 and serves to heat the liquid passing through the tubes 27 of this steam chest. If desired, vapor from the flash chamber 15 may be supplied to the steam chest 25.

Non-condensible gases are withdrawn from the steam chest 25 through a conduit or air vent 44. The conduit or air vent 44 connects with another conduit 45, which withdraws air or other non-condensible gases from the steam chest 17, the two conduits connecting with a common pipe 46 which joins with the pipe 32 connecting the separator 30 with a barometric condenser 47 or other apparatus for condensing these vapors. In the condenser 47, the vapors are condensed by cold water or other fluid received from the cooler 14 through the pipe 50. This fluid from the condenser together with condensate is withdrawn through conduit 51 and pump 52 and again passed through the cooler 14. When an intermediate liquid other than water is used, or vapors other than water vapors are to be condensed, a surface condenser (not shown) may be employed.

A vacuum is maintained in the system and non-condensible gases are removed in any suitable manner, for example, with a three-stage series of steam air ejectors 55 of any suitable and well known construction with barometric intercondensers 57, to which gases from the barometric condenser are conducted through pipe 56. The cooling water for the intercondensers may be withdrawn by a pump 59.

In the operation of my improved process, various steps of the process may be carried out at different temperatures, depending upon the nature of the liquids under treatment. For example, when the method and apparatus is used in connection with the concentration of citrus fruit juice, the method may be operated as follows:

Raw juice which may have a gravity of about 11 degrees Brix (of approximately 11% solids), enters the tube 21 through valve 20 and is circulated through the steam chest 25 and separator 30 from which the vapor produced in the steam chest is separated from the liquid and withdrawn to the barometric condenser 47 while the juice at approximately 18.6 Brix passes to the circulating pump 24, a part of the juice being recirculated and the balance passing through a regulating valve 35 to the suction side of the circulating pump 36 by means of which it is passed to the steam chest 17, and then to the separator 40 from which the vapor produced by the heating of the juice passes to the steam chest 25 through conduit 43, where it supplies heat to the relatively cool juice circulated through this steam chest.

A part of the liquid under treatment passes to the circulating pump 36 for recirculation through the steam chest 17 and the balance is discharged at approximately 58 Brix as finished product by the pump 41.

In the use of the method in connection with citrus fruit juices, the vapor entering the steam chest 17 from the flash chamber 15 may be at about 103 degrees F. and the vapor passing from the separator 40 to the steam chest 25 may be approximately 60 degrees F. and vapors will leave the separator 30 at a temperature of about 45 degrees F., the relations between these temperatures being determined by the heat transfer rates in the two effects and the temperature of the vapor in the flash chamber and of the cooling water.

These vapors are condensed in the barometric condenser 47 upon contact with chilled water from the cooler 14. The water which may be at about 40 degrees F. is removed from the bottom of the barometric condenser and recirculated through the cooler, in which heat from the water is absorbed by the refrigerant which boils around the tubes in the cooler 14. The refrigerant vapor is withdrawn from the cooler 14 by the compressor 5 and the heated vapor discharged from the compressor is conducted to the heater 8 for heating the water or intermediate liquid to a temperature which may be about 110 degrees F. for discharge to the flash chamber 15, where it is flashed to produce water vapors at about 103 degrees F. These temperatures may be regulated by regulating the compression ratio of the compressor 5 and the quantity of fluids circulated. Level control devices 70, 71, 72 and 73 of any usual or suitable construction are preferably employed to operate valves 83, 35, 20 and 81 respectively, to control the liquid levels in the flash chamber 15, the separators 40 and 31 and the barometric condenser 47 respectively.

Each of these level control devices as shown has four external connections, the upper two connections being a liquid inlet pipe and a pressure equalizing pipe which serve the purpose of registering the differential pressure established by the level of the liquid in the separator, condenser or flash chamber. One of the lower connections of the instrument is connected to a supply of compressed air and the other to the diaphragm-operated valve. Each instrument registers the differential pressure and controls the pressure applied to the valve diaphragm, thereby opening and closing the valve as may be required. These control instruments are not herein shown in detail, since they are of the conventional, pneumatic type well known in the art of process control.

Intermediate liquid not vaporized in the flash chamber 15 and condensate in the steam chest 17 may be withdrawn through pipes 75 and 76 respectively leading to the inlet to pump 9 to be again circulated through the heater 8. The condensate from the lower portion of the

steam chest 25 may be withdrawn and discharged from the apparatus by means of a pump 77.

Various control means may, of course, be used to render the operation of the method and apparatus substantially automatic. Excess heat generated in the refrigeration compressor can be removed by bleeding of hot water at 103 degrees and adding water at 40 degrees to replace the same, since cold condensate is available in excess from the barometric condenser. Cool water or intermediate liquid can, of course, be introduced by other means if desired. The process described may be materially modified as to the temperatures in various parts of the apparatus, which may be regulated as required in accordance with the nature of the liquid which is being concentrated. 60 represents in general density control apparatus which may be employed in any usual or suitable manner for controlling the rate of discharge by the pump 41, and which may be constructed as shown in my pending application for Patent No. 604,464, filed July 11, 1945, and now abandoned. The valves 20 and 35, which vary the flow of liquid to be concentrated into the steam chests 17 and 25 are regulated to maintain a uniform level in the separators 40 and 30.

Since the refrigeration requirements of the system determine the size of the compressor, the cooler and the heater, the heater, which must dissipate all the heat pumped from the compressor plus the energy required to effect such compression delivers more heat than is required in the liquid passing to the flash chamber 15. This extra heat must, consequently, be dissipated. For this purpose, control of the temperature of the liquid supplied to the flash chamber 15 to prevent overheating of the same due to excess heat available in the compressed refrigerant supplied to the heater 8 may be effected as illustrated in Fig. 1, in which some of the cold water or other intermediate liquid leaving the barometric condenser 47 is discharged by the pump 52 into a branch pipe 80 controlled by a valve 81 actuated by the level control device 73 is conducted to the pipe 10 leading to the heater 8. If excess liquid is supplied to the flash chamber 15, such excess liquid is discharged by the action of the level control device 70 through conduit 82 and valve 83, which controls the discharge of liquid by a pump 84 through a discharge conduit 85. A thermostatic device 86 is responsive to the temperature of the liquid in conduit 11 and serves through the usual control device 88 and valve 89 to introduce outside cold water to conduit 10 when the temperature of the liquid in conduit rises above that desired. If the temperature of the liquid falls below that desired, the supply of outside water is shut off by closing valve 89.

In Fig. 2, I have shown a modification of a part of the apparatus illustrated in Fig. 1, in which the barometric condenser may be omitted. In this figure, the separator 30 is connected with a tube 62 which conducts vapor from this separator directly to the cooler 14 in which liquid refrigerant is boiled about the tubes thereof through which the vapor passes. Condensate may be removed from the cooler by means of a pump 64 and a high partial vacuum is maintained in the cooler through a pipe 65 connecting with suitable apparatus for maintaining a vacuum in the system, such for example as a series of air injectors with barometric intercondensers represented generally by the reference character 66. Cooling water from the intercondensers is withdrawn by means of a pump 67.

In Fig. 3 is shown an arrangement for the removal of surplus heat of compression by means of an auxiliary cooler. Parts in Fig. 3 which are also present in the construction shown in Fig. 1 are referred to by the same reference numerals used in Fig. 1. It may not be desirable to use the liquid from the barometric condenser as described in connection with Fig. 1, in the event that the condensate in condenser 47 becomes contaminated with material entrained from the liquid under treatment, and in that event, excess liquid from the barometric condenser resulting from the condensing of vapors therein may be discharged by means of the liquid level control device 73 by opening a valve 90 in a conduit 91 leading from the discharge of a pump 92, so that excess liquid may be discharged from the system through the pipe 91.

In the event that the cold water from the barometric condenser is not used for moderating the temperature of liquid discharged to the flash chamber or in case it is undesirable to allow outside cold water to enter line 11, surplus heat of the compressed refrigerant, not required in the flash chamber 15, may be disposed of in an auxiliary cooler 94 which receives intermediate liquid discharged from the heater 8 and cools the same in the usual manner by means of outside water before the intermediate liquid is discharged to the flash chamber 15. By the use of this auxiliary cooler 94, together with suitable regulating means, such for example as a thermostatic device 95, control valve 96 and valve 98, the temperature of the liquid discharged from the heater 8 to the conduit 11 leading to the flash chamber may be controlled.

The apparatus described has the advantage that no high pressure refrigerant vapors surround the tubes in the steam chest 17 and there is no danger of such vapors becoming mixed with the liquid under treatment due to leakage, so that no damage to this liquid will result. The apparatus described is very efficient and effective in the concentrating of liquid which cannot tolerate high temperatures without loss of vitamins, flavors, or other properties.

In arranging a multiple effect evaporator for the concentration of liquids at low temperature any one of the well-known arrangements may be followed. In case the liquid to be concentrated does not change greatly in viscosity and boiling point as concentration proceeds forward flow may be practiced in which the liquid enters the first effect and flows through the following effects, leaving the last effect when the desired concentration is accomplished and in which each effect except the first is heated by vapors from the next preceding effect.

If viscosity does materially increase with concentration of the liquid, it is preferable to have the liquid enter the last effect, as illustrated in Fig. 1, move it progressively through the preceding effects and discharge it from the first effect heating each effect except the first by vapor from the next preceding effect. In the event the liquid cannot be heated to the temperatures prevailing in the various effects of a multiple effect evaporator, except the last effect, minimum heating surface can be obtained by parallel steam flow which may be combined with forward flow of the liquid, heating all of the effects with vapor from the flash chamber and condensing the vapor from all effects in the condenser, obtaining maximum possible heat transfer rates compatible with the concentration of the liquid in each effect.

This system provides an economic method for the concentration of liquid products at low temperature without the use of steam from an outside source for heating the evaporator, without any demand for cooling water other than to remove the surplus heat from the compressed refrigerant vapors and operate the vacuum system and with maintenance of uniform operating conditions throughout the year.

It will be understood that various changes in the details, materials, and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention, as expressed in the appended claims.

I claim as my invention:

1. Apparatus for concentrating liquids by low temperature evaporation under partial vacuum, including a compressor for a refrigerant, a heater for an intermediate liquid, means connecting said compressor and said heater for conducting hot refrigerant gases from the compressor to said heater, said heater having a passage in which said

hot refrigerant gases flow in heat exchange relation with said intermediate liquid, a flash chamber, means connecting said heater and flash chamber for conducting heated liquid from said heater to said flash chamber for vaporizing the same, means for conducting vapor from said flash chamber to a steam chest in which the liquid under treatment to be concentrated flows in heat exchange relation to said vapor, means for providing a partial vacuum in said steam chest and flash chamber and on the liquid under treatment, an expansion valve connected with said heater for liquefied refrigerant discharged therefrom, a cooler into which liquefied refrigerant is discharged from said expansion valve, means including said cooler for condensing vapors formed in said apparatus, and a pump for withdrawing treated liquid from said apparatus.

2. Apparatus according to claim 1, in which two steam chests are provided and in which said liquid under treatment is passed successively from the first steam chest to the second steam chest and in which the vapors of the liquid treated in said second steam chest are conducted to the first chest into heat exchange relation to the liquid under treatment in the first chest.

3. Apparatus for concentrating liquids by low temperature evaporation under partial vacuum, including a compressor for a refrigerant, a heater for an intermediate liquid, means connecting said compressor and said heater for conducting hot refrigerant gases from the compressor to said heater, said heater having a passage in which said hot refrigerant gases flow in heat exchange relation with said intermediate liquid, a flash chamber, means connecting said heater and flash chamber for conducting heated liquid from said heater to said flash chamber for vaporizing the same, means for conducting vapor from said flash chamber to a steam chest in which the liquid under treatment to be concentrated flows in heat exchange relation to said vapor, a condenser to which vapors from said liquid under treatment are conducted, means for producing a partial vacuum in said condenser, said steam chest and said flash chamber, an expansion valve connected with said heater for liquefied refrigerant discharged from said heater, a cooler into which refrigerant liquefied in said heater is discharged, means including said cooler for condensing vapors formed in said apparatus, means for discharging condensate from said condenser into liquid passing to said flash chamber to reduce the temperature of said liquid passing to said flash chamber, and means for withdrawing treated liquid from said apparatus.

4. Apparatus for concentrating liquids by low temperature evaporation under partial vacuum, including a compressor for a refrigerant, a water heater, means connecting said compressor and said heater for conducting hot refrigerant gases from the compressor to said heater, said heater having a passage in which said hot refrigerant gases flow in heat exchange relation with water, a flash chamber, means connecting said heater and flash chamber for conducting heated liquid from said heater to said flash chamber for vaporizing same, means for conducting vapor from said flash chamber to a steam chest in which the liquid under treatment to be concentrated flows in heat exchange relation to said water vapor, a barometric condenser to which vapors from said liquid under treatment are conducted, means for providing a partial vacuum in said condenser, said steam chest and flash chamber and on the liquid under treatment, an expansion valve connected with said heater for liquefied refrigerant discharged therefrom, a cooler into which liquefied refrigerant is discharged in heat exchange relation to cooling water used in said condensate, means for circulating cooling water in a circuit including said condenser and said cooler, thermostatically controlled means responsive to the temperature of the water passing from said heater to said flash chamber for admitting cooling water to the water passing to said flash chamber, means for withdrawing treated liquid from said apparatus, and means for withdrawing surplus water from said heater.

5. Apparatus for concentrating liquids by low temperature evaporation under partical vacuum, including a compressor for a refrigerant, a water heater, means connecting said compressor and said heater for conducting hot refrigerant gases from the compressor to said heater, said heater having a passage in which said hot refrigerant gases flow in heat exchange relation with said water, a flash chamber, means connecting said heater and flash chamber for conducting heated liquid from said heater to said flash chamber for vaporizing the same, means for conducting vapor from said flash chamber to a steam chest in which the liquid under treatment to be concentrated flows in heat exchange relation to said water vapor, a barometric condenser, means for conducting vapors from said liquid under treatment to said condenser, means for providing a partial vacuum in said condenser, a steam chest and flash chamber and on the liquid under treatment, an expansion valve connected with said heater for liquefied refrigerant discharged therefrom, a cooler into which liquefied refrigreant is discharged in heat exchange relation to cooling water used in said condenser, means for circulating cooling water in a circuit including said condenser and said cooler, a conduit for conducting cold water from said condenser to said heater to remove surplus heat from the refrigerant therein, thermostatic means subjected to the temperature of water passing from said heater to said flash chamber, an inlet valve controlled by said thermostatic means for admitting outside cold water to the water circulated in a circuit including said heater and said flash chamber when said thermostatic means are subjected to temperatures in excess of those desired, means for withdrawing treated liquid from said apparatus, and means for discharging excess water from said circuit.

6. Apparatus for concentrating liquids by low temperature evaporation under partial vacuum, including a compressor for a refrigerant, a heater for an intermediate liquid, means connecting said compressor and said heater for conducting hot refrigerant gases from the compressor to said heater, said heater having a passage in which said hot refrigerant gases flow in heat exchange relation with said intermediate liquid, a flash chamber, means connecting said heater and flash chamber for conducting heated liquid from said heater to said flash chamber for vaporizing the same, means for conducting vapor from said flash chamber to a steam chest in which the liquid under treatment to be concentrated flows in heat exchange relation to said vapor, a condenser, means for conducting vapors from said liquid under treatment to said condenser, means for producing a partial vacuum in said condenser, said steam chest and said flash chamber, an auxiliary cooler to which said intermediate liquid passes from said heater, said auxiliary cooler removing from said intermediate liquid heat in excess of that required for heating the liquid under treatment, a main cooler, an expansion valve connecting said heater with said main cooler to discharge to said main cooler refrigerant liquefied in said heater, means including said cooler for condensing vapors formed in said apparatus, means for discharging from the apparatus condensate from said condenser, and means for withdrawing treated liquid from said apparatus.

7. A method of concentrating liquids by low temperature evaporation under partial vacuum, which comprises the steps of compressing a refrigerant gas, transferring heat produced by compressing the refrigerant gas, to water by condensing said gas, vaporizing a portion of said heated water under partial vacuum, transferring heat from the resulting water vapor to the liquid to be concentrated while the same is under partial vacuum, cooling another body of water by means of liquefied refrigerant, condensing vapors of the liquid to be concentrated by transfer of heat from said vapors to said cooled water, reducing the temperature of said heated water by adding thereto a part of said cooled water after the same has

been warmed by vapors of said liquid to be concentrated, and removing excess heated water from the system.

References Cited in the file of this patent

UNITED STATES PATENTS

1,119,011	Grosvenor	Dec. 1, 1914
1,216,187	Trump	Feb. 13, 1917
1,465,020	Monti	Aug. 14, 1923
1,605,375	Reid	Nov. 2, 1926
2,193,483	Hinckley	Mar. 12, 1940
2,342,419	Martin	Feb. 22, 1944
2,343,085	Savell	Feb. 29, 1944
2,477,959	Brown	Aug. 2, 1949
2,535,777	Bickley	Dec. 26, 1950
2,570,212	Cross	Oct. 9, 1951
2,704,120	Peterson	Mar. 15, 1955

FOREIGN PATENTS

163,549	Great Britain	May 26, 1921