

Dec. 15, 1936.

E. A. HUMBLE

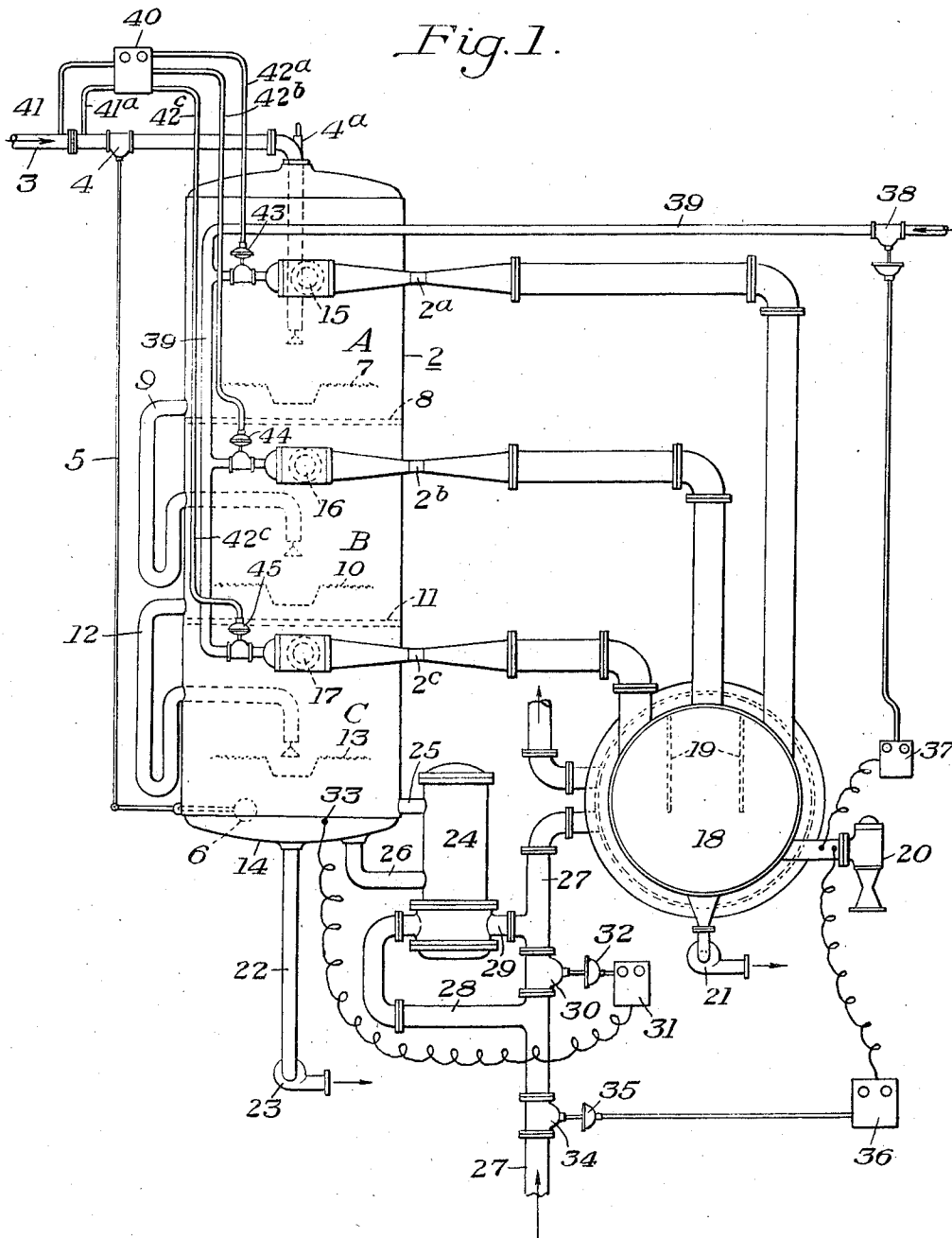
2,064,609

METHOD AND APPARATUS FOR COOLING LIQUIDS

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5 Sheets-Sheet 1

Fig. 1.



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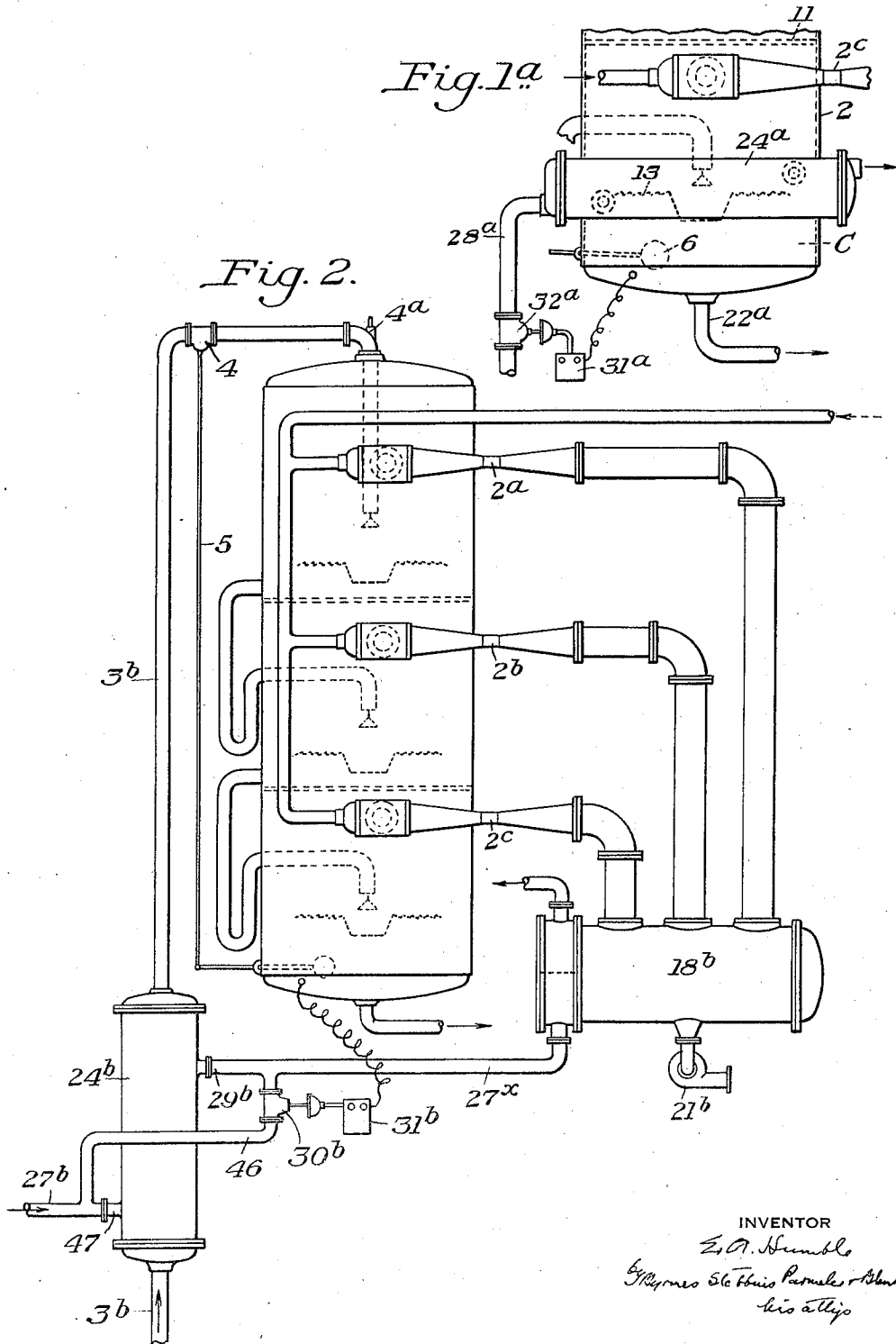
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METHOD AND APPARATUS FOR COOLING LIQUIDS

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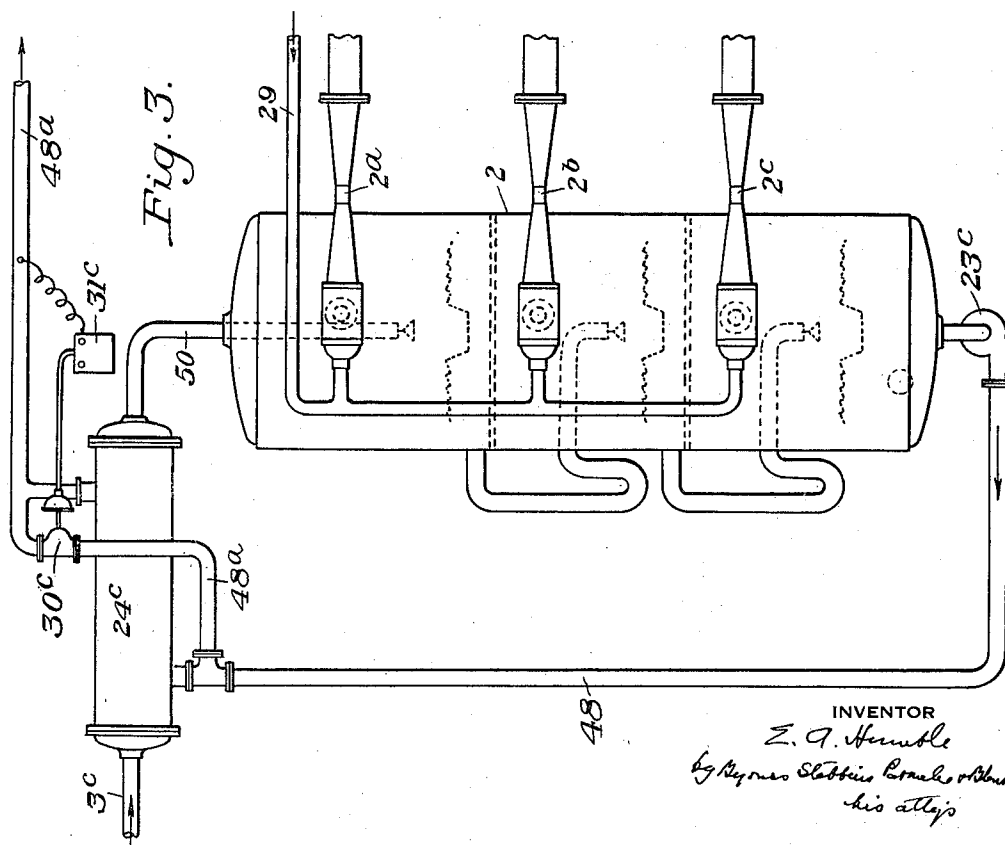
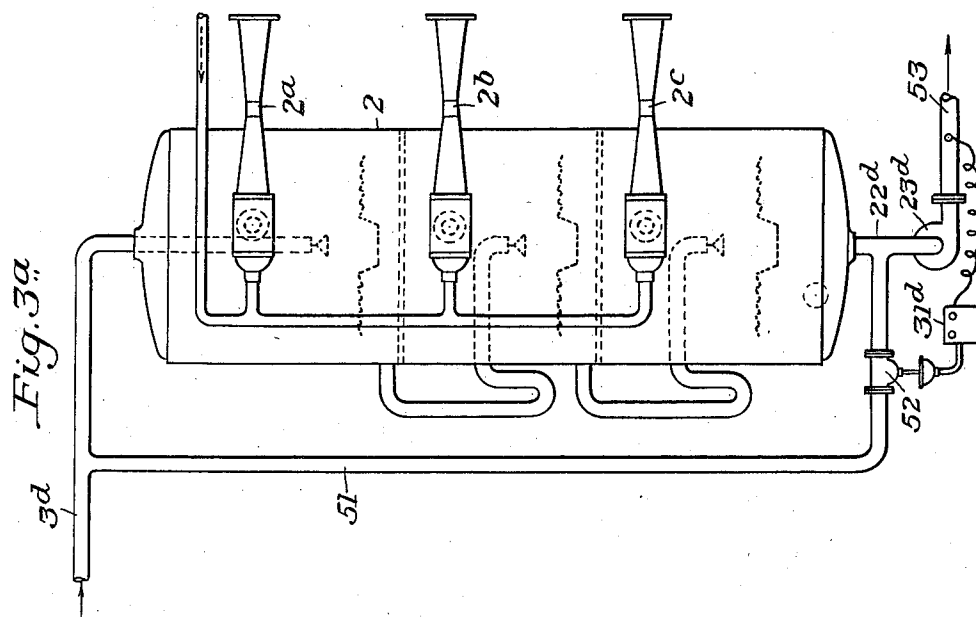
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METHOD AND APPARATUS FOR COOLING LIQUIDS

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5 Sheets-Sheet 3



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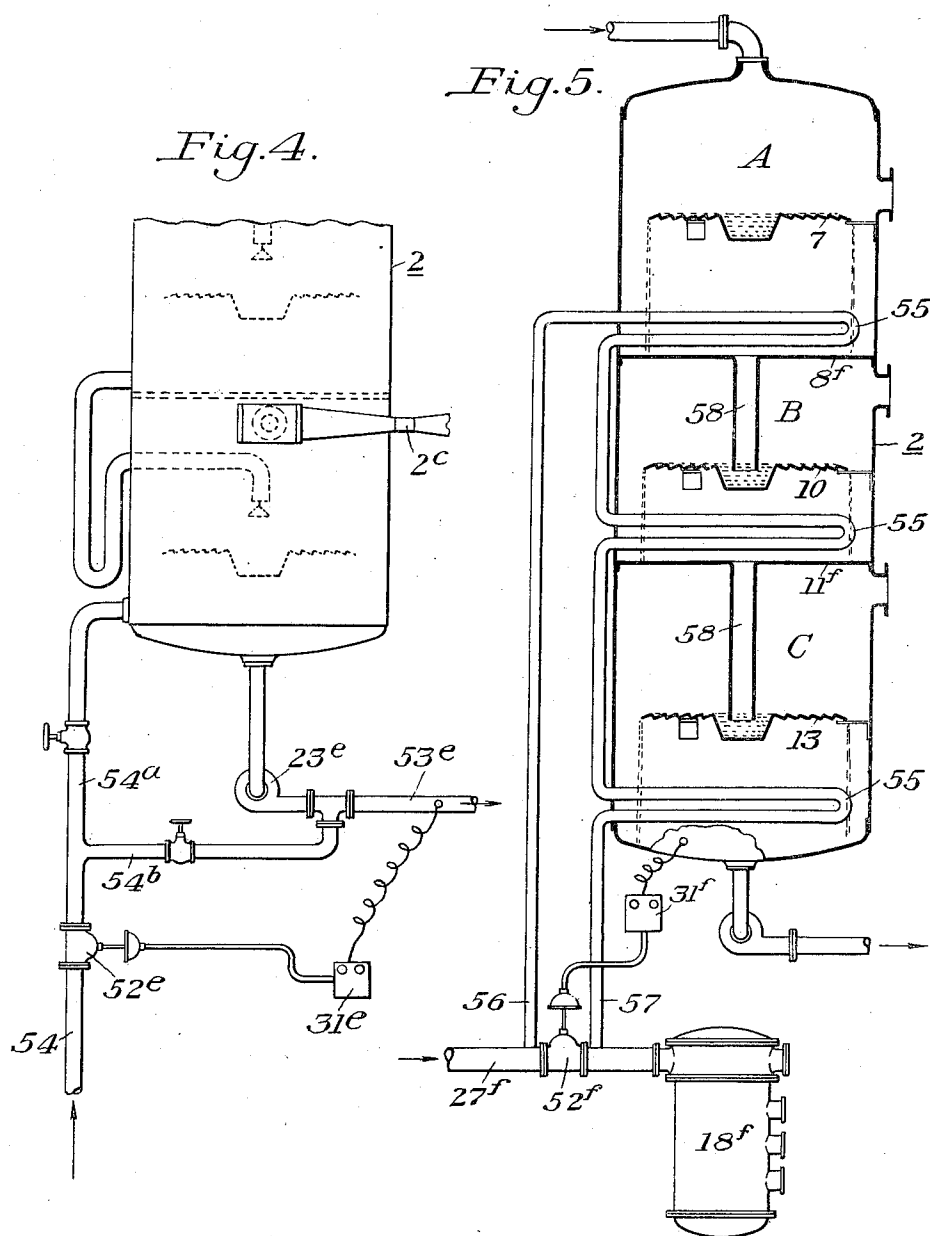
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METHOD AND APPARATUS FOR COOLING LIQUIDS

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METHOD AND APPARATUS FOR COOLING LIQUIDS

Filed June 14, 1933

5 Sheets-Sheet 5

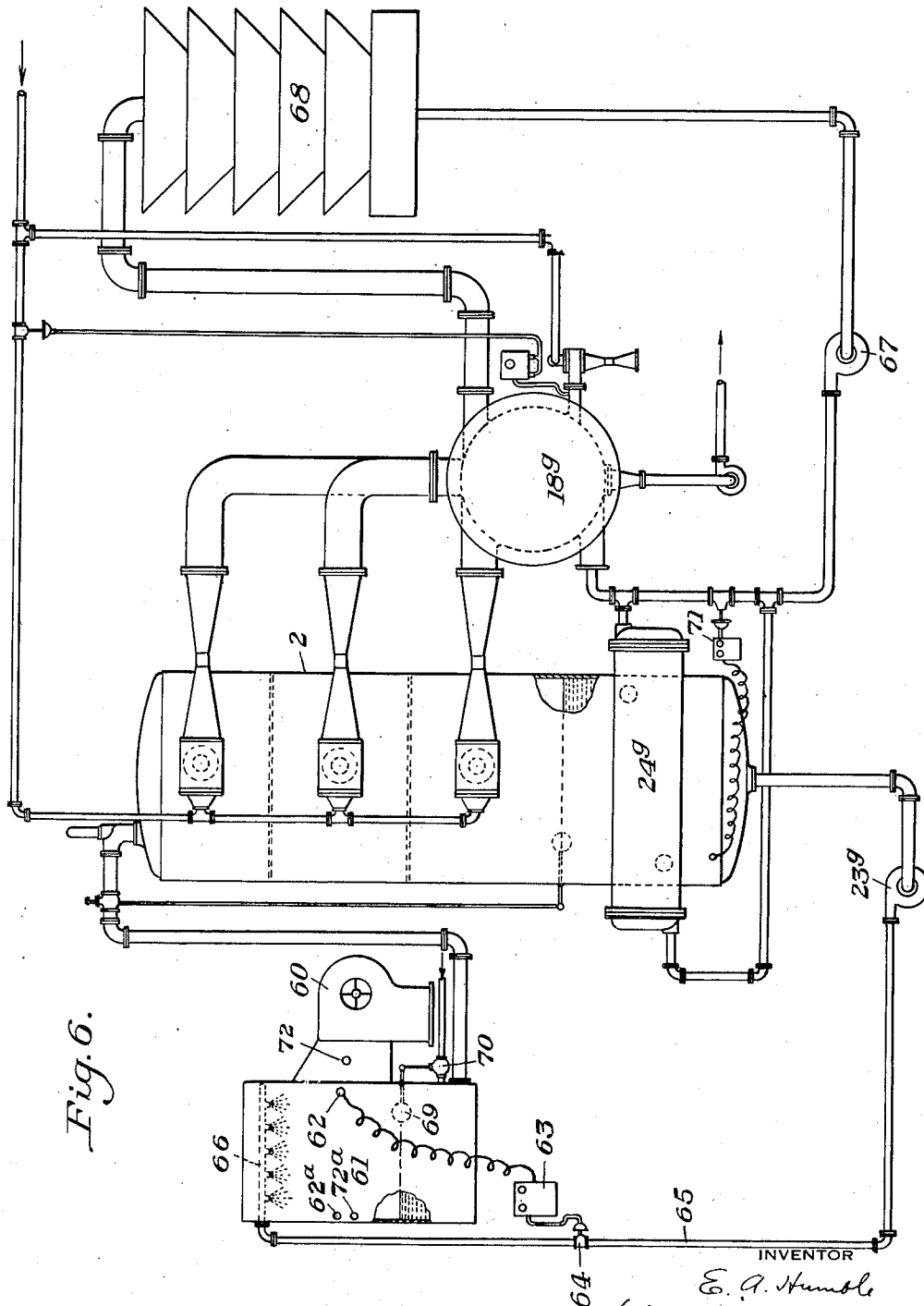


Fig. 6.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR COOLING LIQUIDS

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Application June 14, 1933, Serial No. 675,724

16 Claims. (Cl. 62—152)

This is a new and useful improvement in method and apparatus for cooling liquids, of which the following is a full, clear and exact description, reference being had to the accompanying drawings in which:

Figure 1 is a diagrammatic side elevation showing a preferred form of apparatus for carrying out my invention;

Figure 1^a is a similar view showing a modification of the form of Figure 1;

Figure 2 is a diagrammatic view similar to Figure 1 showing another form of apparatus for carrying out my invention;

Figures 3, 3^a, 4, and 5 show other modified constructions for carrying out my invention; and

Figure 6 is a diagrammatic side elevation showing the application of one form of my system to an air-conditioning system.

My invention relates to the treating and cooling of water by subjecting it to reduced pressure, and is designed to improve the controlling and economy of such types of apparatus by automatic control.

My system will be illustrated in connection with plural stage withdrawal of air and vapor from water at successively higher vacuums, although it will be understood that it may be applied to single stage treatment of water.

In the drawings, Figure 1 illustrates diagrammatically a preferred form of apparatus for carrying out my invention, 2 being a flash chamber containing three separate and individual flash compartments A, B and C. While the use of three such chambers is shown, one chamber or any desirable number of chambers may be used. The water to be treated enters through an inlet pipe 3 having a valve 4 with a suitable connection 5 to a float 6, resting on the body of water in the lowest compartment C. This pipe 3 also has a flash valve 4^a at the entrance to the flash chamber. The entering water is sprayed upon a pan 7 of the filming type having a circumferentially grooved outer portion and a depressed central portion and supported in any suitable manner above the bottom 8 of this compartment. From the bottom of this compartment, the water is led through pipe 9 having a water sealing U leg to another spray nozzle which sprays the water upon a second filming pan 10, from which the water drops upon the bottom 11 of this compartment and is taken out through pipe 12 having a water leg similar to 9 and leading to another spray nozzle which sprays water upon a third filming pan 13 from which it drops upon the bottom 14 of the

lower compartment and rests as a body of chilled water.

Each compartment has side outlets 15, 16 and 17 connected to booster ejectors 2^a, 2^b and 2^c, which create successively higher vacuums in the three successive chambers. All three of these booster ejectors, which may be thermo compressors of any desired type, discharge into common condenser 18, which may be of the surface, jet or barometric type and is preferably provided with baffles indicated at 19. In case the refrigerating load on the system is decreased to such an extent that the automatic device 40 cuts off the propelling steam supply to the booster for the first compartment, the propelling steam supply to the boosters for the second and third compartments might return from the condenser in a reverse direction through the booster for the first compartment. These baffles prevent this and insure the condensation of the propelling steam entering the condenser from the second and third compartments. An ejector 20 is connected to condenser 18, which ejector may be of the single or multi-stage type or may be of the mechanical motor or turbine-driven vacuum pump type. A condensate pump 21 is connected to the bottom of this condenser. A pipe 22 leads from the bottom of the lower chamber compartment C of the flash chamber to a refrigerating water removal pump 23.

Adjacent the lower compartment is a small control condenser or cooler 24 having a separate shell connected to the lower compartment C of the flash chamber by pipes 25 and 26. A pipe 27 supplies cooling water to the main condenser 18 and also to the control condenser through branch inlet pipe 28 and return connection 29 to pipe 27. Between the branches 28 and 29, the pipe 27 is provided with a valve 30 actuated by temperature controller 31 through the diaphragm device 32, the temperature controller having a connection to a thermostat 33, lying in the body of water in the lower compartment C of flash chamber 2. Below the branch 28 the pipe 27 is also provided with a control valve 34, connected through the usual diaphragm device 35 to a pressure controller 36.

The numeral 37 designates another pressure controller whose control connection, like that of pressure control 36, leads into the connection to ejector 20 of the main condenser. Pressure control 37 has the usual actuating connection with valve 38 in the steam line 39 leading to the ejectors 2^a, 2^b and 2^c. The numeral 40 designates a special differential pressure control de-

vice having connections 41 and 41^a leading to pipe 3 on either side of an orifice therein. From this controller, connections 42^a, 42^b and 42^c lead to diaphragm devices 43, 44 and 45, respectively, which control valves for the several main ejectors 2^a, 2^b and 2^c. This differential controller may or may not be used, but is specially desirable where there are wide variations in the duty or load imposed on the system. If, for example, the quantity of water supplied to the flash chamber is decreased 40%, this differential controller will act to close the valve 43 in the steam supply line to booster 2^a, shutting off the steam supply to this booster. If the load is then reduced an additional 40%, for example, this differential controller acts to shut off the steam supply to booster 2^b. When one or more steam supplies to the boosters are shut off, the duty on the booster condenser will be reduced and the pressure in the vapor space of this condenser will decrease. The pressure controller 37 will then act through valve 38 to throttle the steam pressure, and consequently, the quantity of steam supplied to the booster or boosters then remaining in service in proportion to the permissible reduction in steam consumption made possible by the decreased absolute pressure in the main booster condenser.

As an example of operation, assume a unit designed to cool one hundred gallons of water per minute from an initial temperature of 60° F. to a final temperature of 40° F. Under full load conditions of operation, one hundred gallons of water per minute will be admitted to the float control valve 4 and flash valve 4^a to upper compartment A of chamber 2. The pressure in this compartment will be maintained by booster ejector 2^a at a value which will cause some evaporation of the water entering this chamber at 60° F. The absolute pressure in chamber A may be predetermined at some figure which will economically distribute the cooling between the three compartments A, B and C. Assuming that the pressure in compartment A is maintained at .4 inch of mercury absolute, the one hundred gallons of water per minute would be cooled in compartment A to a temperature of approximately 52.6° F. by reason of the evaporation and consequent removal of heat occurring in tending to a condition of equilibrium in this compartment. The vapors so flashed off will be compressed by booster ejector 2^a and discharged into condenser 18. Slightly less than one hundred gallons of water per minute will then pass down into compartment B, in which an assumed pressure of .3 inch of mercury absolute is being maintained by booster 2^b. In this compartment, the liquid would be reduced to a temperature of approximately 45° F. by flash evaporation, and the vapors would be compressed by booster 2^b and discharged into the condenser 18.

A further slight reduction in the one hundred gallons per minute of water originally admitted occurs in compartment B, and the remainder passes down into compartment C in which an assumed absolute pressure of .25 inch of mercury is maintained by booster 2^c. In this compartment, the final flash would take place, cooling the water to 40° F. The cooled liquid at a temperature of 40° F. is removed from compartment C by pump 23 and is delivered to the point of use.

In condenser 18, common to ejectors 2^a, 2^b, and 2^c, the steam is condensed and the non-condensable gases removed from this condenser, to-

gether with any water vapor with which they may be saturated, by ejector 20. These gases may be discharged to the atmosphere or may be recovered, if desired, by suitable apparatus, not shown. The condensed steam is removed from the condenser 18 by condensate pump 21.

The characteristic performance of ejectors, such as shown at 2^a, 2^b and 2^c, is such that if a less load is imposed upon them than that assumed, they automatically produce a lower absolute pressure than that assumed. If the demand for refrigerated water is less than full load requirements, there is a tendency for the water being delivered by pump 23 to be reduced below 40° F. in the example given; and a continued reduction of load might result in freezing of the liquid in chamber 2.

As a further safeguard—not required, but often desirable—against freezing or excessive lowering of temperature, especially in a single flash system, I provide a control system which constitutes one of the main features of my invention. This system comprises the temperature control device 31 and the pressure control devices 36 and/or 37, together with the control cooler 24. This control cooler may be simply a tube bundle installed in the bottom part of flash chamber 2. It also may be eliminated, as will be described later.

If the cooled water delivered by pump 23 is reduced to 50% of normal capacity or to about fifty gallons per minute, the float 6 will act to throttle valve 4 a corresponding amount, and only fifty gallons per minute of water will be admitted through flash valve 4^a into compartment A. Hence, the load on the booster ejectors will be reduced 50% and they will automatically produce lower absolute pressures in chambers A, B and C than those previously assumed, and the temperature of the water leaving each of the compartments A, B and C will be correspondingly reduced. When, however, the temperature of the liquid in the bottom of compartment C starts to fall below 40° F. in the assumed example, the temperature controller 31 will act to partially close the valve 30, thus permitting some of the water passing through the main line 27 to be bypassed through branch 28 and through control cooler 24. The water thus passing through control cooler 24 will be cooled and, in turn, will impart heat to the liquid lying in the bottom portion of chamber C to maintain it at about 40° F. The cooled water leaving the control cooler 24 will mix with the balance of the water passing through main line 27, and thus reduce the temperature of the condensing liquid entering condenser 18. If the temperature of the condensing liquid entering condenser 18 is reduced, this condenser will automatically produce a higher vacuum or lower absolute pressure. As the absolute pressure in condenser 18 is reduced, pressure controller 37 will act to throttle valve 38 to reduce the steam pressure, and consequently, the steam quantity supplied to the boosters 2^a, 2^b and 2^c, thus proportioning the steam flow or steam consumption of these boosters in correlation with the quantity of water admitted through valve 4 to the flash chamber 2 and also correlating to the seasonal temperature of water in line 27. Thus, through the temperature control device and the pressure control device, automatic regulation is effected.

In Figure 1^a, I show a form similar to that of Figure 1, except that the water supply pipe 28^a leading to the control cooler 24^a is independent

of the water supply to the main condenser. The action in this case is the same as that in Figure 1, except that the fluid passing through the tubes of control cooler 24^a is taken from a source separate and independent of the water supply to the main condenser 18. For example, warm water from any desirable source may be used, and conceivably steam might be admitted to the control cooler in such amounts as required to maintain the refrigerated liquid leaving the flash chamber at a constant predetermined value, this being determined by the temperature controller 31^a corresponding to 31 in Figure 1, but actuating a supply valve 32^a leading from the independent source to the control cooler.

In Figure 2, I show another form of the invention which differs from the previous forms in that the control cooler 24^b is interposed in the water line 3^b for the water passing to the flash chamber. The cooling fluid for the control cooler 24^b enters through pipe 27^b having a bypass 46 around the control cooler to the supply pipe 27^x to the booster condenser. The fluid entering pipe 27^b passes through branch 47 into the shell of the control cooler and thence through exit pipe 29^b where it joins the water through 46 and passes on through line 27^x to the booster condenser 18^b for the ejectors 2^a, 2^b and 2^c. The pipe 46 has a valve 30^b, controlled by the temperature control device 31^b having a temperature connection into the lower part of the flash chamber. The fluid passing through the shell of the control cooler may in this case be either a portion of the condensing water supplied to the booster condenser 18^b or may be taken from an independent source and discharged independently; but in most cases, the temperature of the water supplied to the booster condenser will be at a substantially higher temperature than the temperature of the liquid entering the flash chamber. In this form, the water supplied to the flash chamber after passing through the control cooler enters through the continuation 3^b of the water supply pipe and through the flash valve at the top of the upper compartment of the flash chamber. Other parts may be similar to those shown in Figure 1. In this case, I utilize the fact that a refrigerating apparatus of this type will accomplish certain duty or a certain number of tons of refrigeration. For example, if an apparatus is designed to cool a given quantity of water from a temperature of 60° F. to a final temperature of 40° F., it will cool a lesser quantity of water over a greater range of temperature. Hence, if the quantity of water supplied to the flash chamber is reduced by 25% and the cooling range is increased 25% by reason of increasing the temperature of the water admitted to the flash chamber from 60° up to 65°, as in the example, the temperature of the liquid leaving the flash chamber will still be 40°. In this case, by changing the temperature of the water entering the flash chamber in accordance with the demands, I attain the desired result of keeping the temperature of the refrigerated liquid leaving the flash chamber substantially constant.

In Figure 3, the shell of control cooler 24^c is connected to the outlet of the pump 23^c which withdraws the chilled water from the flash chamber. The pipe 48 from the discharge pump 23^c leads into the shell of the control cooler and has a bypass 48^a around the control cooler. In bypass line 48^a is located a control valve 30^c controlled by temperature controller 31^c connected into the pipe line 48^a which leads away the re-

frigerated liquid. In this case, the water to be refrigerated enters the tubes of the control cooler at 3^c and leaves it at 50, whence it passes into the upper compartment of the flash chamber. In this case, the refrigerated liquid leaving the lower compartment of the flash chamber will absorb as much heat from the liquid admitted to the flash chamber as is required to maintain the refrigerated liquid at a constant predetermined value. This is a simple form and provides for bypassing through the control cooler that percentage of the refrigerated liquid leaving the flash chamber which will absorb sufficient heat from the liquid admitted to the flash chamber to bring the mixture to the desired constant value. The flash chamber and its compartments, connections and booster condenser are similar to those of Figure 1.

Figure 3^a shows a view similar to Figure 3, except that the water entering through pipe 3^d is divided. Part of this water may pass down through pipe 51 to join the pipe 22^d which leads refrigerated water to the pump 23^d. The pipe 51 has a valve 52, controlled by temperature controller 31^d whose thermocouple is in the line 53 leading from the pump 23^d for refrigerated liquid. In this form, the control cooler is entirely eliminated.

In Figure 4, I again show a form generally like Figure 1, where the control cooler is entirely eliminated for the sake of simplicity and cheapness. In this case, instead of mixing the refrigerated water with the entering water to be flashed, I take the tempering water from an independent source.

In this case, pipe 54 leads from a source of relatively warm fluid and has branches 54^a and 54^b, each with hand control valves, so that the warm fluid may be admitted either at the suction side or the discharge side of the pump 23^e. In this case, the temperature controller 31^e having its temperature connection into the pipe 53^e from the refrigerated liquid pump is arranged to actuate a valve 52^e in the supply pipe 54.

In this case, the warm fluid will be supplied to the refrigerated water in such quantities as may be required to maintain the temperature of the mixture at the constant predetermined value.

In Figure 5, I show a form somewhat similar to Figure 3, but in which the control cooler is dispensed with and in its place, I show a series of continuous pipe coolers 55 lying in the three compartments of the flash chamber and connected to inlet pipe 56, leading from the supply pipe 27^f which supplies water to the booster condenser 18^f for the three boosters. From these coils, the water re-enters line 27^f through pipe 57 and in pipe 27^f between the pipes 56 and 57 is the valve 52^f, which is controlled by temperature controller 31^f having its control connection leading to a thermocouple device in the bottom of the lower compartment. In this case, the control valve 52^f is in the bypass between the inlet and outlet of the coils 55 in the compartments of the flash chamber. In this case also, I have shown the bottoms 8^f and 11^f of the upper compartments as provided with central discharge tubes 58, leading down into the sealing depressed central portions of the next lower pans, instead of using the external U-tubes of Figure 1. These discharge tubes 58 lead the water from one of the compartments down into the filming pan of the next compartment.

In all forms, it will be noted that the temperature of the refrigerated liquid is maintained at a substantially constant value irrespective of vari-

ations in the duty or load imposed upon the system.

Also in each case the control devices are actuated by pressure within the vapor space of the booster condenser to control and actuate valves arranged to restrict either the steam consumption of the booster ejectors or the water supplied to said booster condenser, or both, in a certain relation to the load or duty imposed upon the refrigerating apparatus. In addition thereto, I may use a differential pressure controller to supplement the control devices actuated by the pressure within the vapor space of the booster condenser wherever wide variations in the duty imposed upon the refrigerating apparatus would occur, in order to carry out my principle of conservation of fluids in relation to varying duty imposed on the system. This has been described above in connection with the said differential pressure controller shown in Figure 1.

The inherent characteristics of the booster ejector are such that for satisfactory operation, it must be supplied with a given quantity of steam for certain definite load or duty imposed; when it is operating against the discharge pressure for which it is designed. If the absolute pressure at the discharge is reduced below the value for which it is designed, less steam will be required to satisfactorily operate the booster, and therefore, under such condition, the steam supply to it may be throttled.

I have explained above how pressure controller (Fig. 1) actuating the steam supply valve conserves steam consumption to the boosters. Instead of this or in addition to it, the pressure controller 36 may be employed to actuate the valve 34 in the line supplying water to the booster condenser, thus economizing in the water supply to said condenser in accordance with the load or duty thereof. A given condenser will produce a given absolute pressure when supplied with a certain quantity of water and when condensing a given quantity of steam. The absolute pressure may be maintained constant in this condenser if and when it is condensing a lesser quantity of steam, by supplying thereto a lesser quantity of water. If, therefore, the steam load on the booster condenser is reduced, the pressure controller 36 (Figure 1) will react to throttle the water supplied to the condenser through valve 34 and thus conserve water. Hence, pressure controllers 36 and 37 may either or both be employed to effect saving in either or both steam and water consumption.

In the preferred forms, it will be noted that a decrease in the temperature of the refrigerated water from the flash chamber acts to decrease the absolute pressure in the booster condenser. This in turn, acts to decrease the steam consumption or the water consumption or both.

The temperature and the pressure conditions in the vapor space of the booster condenser will always vary in direct relation to each other. Hence, the controllers connected into the vapor space of the booster condenser may be actuated either by the pressure or the temperature existing within the vapor space of the booster condenser. Moreover, if the supply of only one fluid—either steam or water—is to be varied, only one such controller need be used, this acting upon either the steam supply or the water supply thereto. Thus, by means of one or more temperature or pressure controllers actuated by conditions within the booster condenser, I am able to obtain the de-

sired control while conserving a supply of a fluid or of both fluids thereto.

I consider myself the first to employ a controller actuated by the temperature or pressure in the booster condenser which acts to conserve the consumption of fluids in the system, that is, either the steam or the condensing water employed, or both. While previous systems have proposed different means for maintaining or attempting to maintain substantially constant conditions in the flash chamber or otherwise, they have been wasteful of the operating fluid or fluids employed as compared with my system. The controller or controllers by which the conservation of steam consumption or condensing water economy is accomplished are preferably employed in connection with the controlling means illustrated for regulating the temperature of the refrigerated liquid; but either system may be used independently of the other. In many of my forms for controlling the temperature of the refrigerated water, economy is effected in correlation with varying refrigerating duties placed upon the system. This I also consider to be new. In some of my forms, as the temperature tends to lower in the flash chamber, the pressure in the booster condenser is lowered, as for example, by supplying colder water to it as the temperature starts to decrease in the flash chamber.

In Figure 6, I show one of my systems applied to an air-conditioning system. In this form, is a fan for circulating air through air-washing chamber 61. This chamber has a thermostat 62, connected to a temperature controller 63, actuating a control valve 64 in the pipe 65 leading from the pump 23^a which receives the cooled water from the flash chamber. Thermostat 62 may be located as shown in Figure 6 or plugged into socket 62^a located in air outlet duct of the spray chamber. Hence, the supply of water to the spray chamber of the air-conditioning apparatus is controlled by the temperature of the air leaving the fan of the spray chamber. 66 is the spray system in the air-conditioning chamber to which the cooled water is led from the pump. The numeral 67 designates a pump leading from the bottom of a cooling tower conventionally shown at 68, this pump discharging into the booster condenser 18^a having a branch which, in the form shown, extends through the tubes of the control cooler. 69 is a float control in the air washer which actuates valve 70 in the line supplying make-up water to the flash chamber. Otherwise this system is generally similar to that shown in Figure 1, having the temperature controller for the water entering the control condenser, and the pressure controller actuated by the main condenser and controlling the steam valve to the booster ejectors.

The temperature controllers, pressure controllers and other devices or appliances indicated in the drawings are well known pieces of apparatus which may be obtained in the open market.

In the form shown, when applied to air conditioning, regulating of the air temperature is achieved through regulation of the quantity of refrigerated water admitted to the spray chamber. An alternate system may be employed, wherein the air temperature may be used to regulate the refrigerated water temperature. In the form of Figure 6, this may be easily accomplished by plugging the wire connection of controller 71 into the socket 72 or 72^a in the air duct from the fan discharge, or from the spray chamber, respectively. In this case variation in the

temperature of the air will correspondingly vary the amount of water passing through the control cooler, thus regulating the refrigerated water temperature in accordance with the temperature of the air supplied to or leaving the air-conditioning chamber.

I claim:

1. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, condensing at least a portion of the withdrawn vaporous fluid, and varying the quantity of propelling fluid supplied to the thermo compressors in accordance with the quantity of liquid to be cooled.

2. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, delivering at least a portion of the withdrawn vaporous fluid to a condenser, and varying the quantity of condensing fluid supplied to the condenser in accordance with the quantity of fluid to be cooled.

3. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, delivering at least a portion of the withdrawn vaporous fluid to a condenser, and varying the quantity of propelling fluid supplied to the thermo compressors and the quantity of condensing fluid supplied to the condenser in accordance with the quantity of liquid to be cooled.

4. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, and condensing at least a portion of the withdrawn vaporous fluid, and maintaining the temperature of the refrigerated liquid at a substantially constant value by exchanging heat between the refrigerated liquid and at least a portion of the condensing fluid supplied to the condenser.

5. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, and condensing at least a portion of the withdrawn vaporous fluid, and maintaining the temperature of the refrigerated liquid at a substantially constant value by interchanging heat between the refrigerated liquid and an independent source of fluid.

6. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, and condensing at least a portion of the withdrawn vaporous fluid, and maintaining the temperature of the refrigerated liquid at a substantially constant value by interchanging heat between the liquid to be cooled and at least a portion of the condensing fluid supplied to the condenser.

7. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, and condensing at least a portion of the withdrawn vaporous fluid, and maintaining the temperature of the refrigerated liquid at a substantially constant value by interchanging heat between a portion of fluid from an independent source and the liquid to be cooled.

8. In a refrigerating system of the vacuum flash type, a multiple compartment closed vessel, means for introducing liquid progressively into each compartment, means for withdrawing vapor fluid from each compartment in order to maintain a different degree of vacuum in each compartment, means for preventing the equalization of pressures between adjacent compartments, means for condensing at least a portion of the vaporous fluid withdrawn from each compartment in a common condenser, and baffling means in the common condenser for preventing a back flow of vapor from the common condenser to one or more flash compartments not in normal use.

9. In a refrigerating system of the vacuum flash type, a multiple compartment closed vessel, means for introducing liquid progressively into each compartment, means for withdrawing vapor fluid from each compartment in order to maintain a different degree of vacuum in each compartment, means for preventing the equalization of pressure between adjacent compartments, means for condensing at least a portion of the vaporous fluid withdrawn from each compartment in a common condenser, and heat interchange means for controlling the temperature of the refrigerated liquid.

10. In a refrigerating system of the vacuum flash type, the steps comprising introducing liquid into a closed vessel, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, condensing at least a portion of the withdrawn vaporous fluid, regulating the quantity of the refrigerated liquid delivered, in accordance with the temperature of air being cooled by the refrigerated liquid, and supplying heat to the refrigerated liquid when below a predetermined temperature to compensate overcooling thereof.

11. A method of refrigerating including the steps of introducing liquid into a closed chamber, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, condensing at least a portion of the withdrawn vaporous fluid, withdrawing uncondensed vapor from the region where the withdrawn vaporous fluid is partly condensed, and controlling the supply of propelling fluid for the thermo compressors in accordance with the pressure of said withdrawn uncondensed vapor.

12. A method of refrigerating including the steps of introducing liquid into a closed chamber, withdrawing vaporous fluid therefrom by means of thermo compressors to maintain a vacuum therein, condensing at least a portion of the withdrawn vaporous fluid, withdrawing uncondensed vapor from the region where the withdrawn vaporous fluid is partly condensed, and controlling the degree of condensation of said withdrawn vaporous fluid in accordance with the pressure of said withdrawn uncondensed vapor.

13. In a method of refrigerating, the steps including introducing liquid into a closed chamber, withdrawing vaporous fluid therefrom to maintain a vacuum therein and cool the liquid, condensing at least a portion of the withdrawn vaporous fluid, delivering the cooled liquid to a point of use, and causing an interchange of heat between the liquid being introduced to the chamber and the cooled liquid delivered thereby while preventing direct contact thereof, when the temperature of the air will correspondingly vary the amount of water passing through the control cooler, thus regulating the refrigerated water temperature in accordance with the temperature of the air supplied to or leaving the air-conditioning chamber.

I claim:

perature of the latter is below a predetermined value.

14. The method of cooling liquids which includes the steps of introducing a liquid to be cooled into a closed vessel, withdrawing vaporous fluid from the liquid in the vessel by means of thermo compressors to maintain a vacuum therein and to cool the liquid, condensing at least a portion of the vaporous fluid within a vessel by supplying liquid to the vessel, taking off the cooled liquid from the first vessel, and controlling the temperature of the liquid introduced into the first vessel by heat transfer between liquid supplied to the second vessel and the liquid being introduced into the first vessel.

15. The method of cooling liquids which includes the steps of introducing a liquid to be cooled into a series of closed vessels, withdrawing vaporous fluid from each of the closed vessels, condensing at least a portion of the vaporous

fluid withdrawn from each of the closed vessels, and automatically varying the withdrawal of vaporous fluid from each of the closed vessels in accordance with the quantity of liquid introduced into the series of closed vessels.

16. The method of cooling liquids which includes the steps of introducing a liquid to be cooled into a closed vessel, withdrawing vaporous fluid from the closed vessel, condensing at least a portion of the vaporous fluid withdrawn in a second closed vessel by means of a condensing fluid supplied to the second vessel, and automatically increasing and decreasing the withdrawal of vaporous fluid from the first closed vessel and the quantity of condensing fluids supplied to the second vessel in direct accordance with an increase and decrease of pressure within the second vessel.

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