Feb. 28, 1950 W. L. EDEL 2,498,945

GENERATOR AND HEAT EXCHANGER IN AN ABSORPTION REFRIGERATOR

Filed March 29, 1946 2 Sheets-Sheet 1

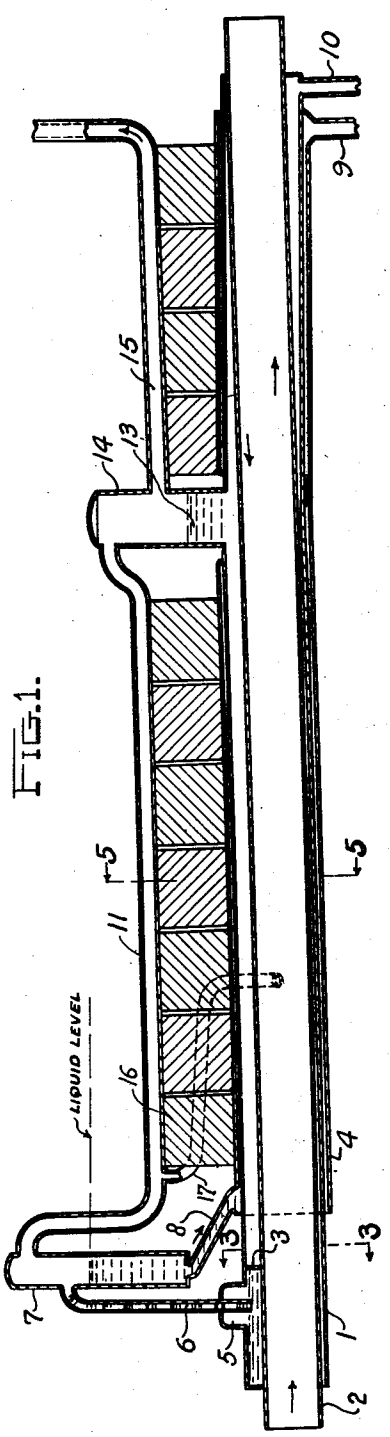


FIG. 1.

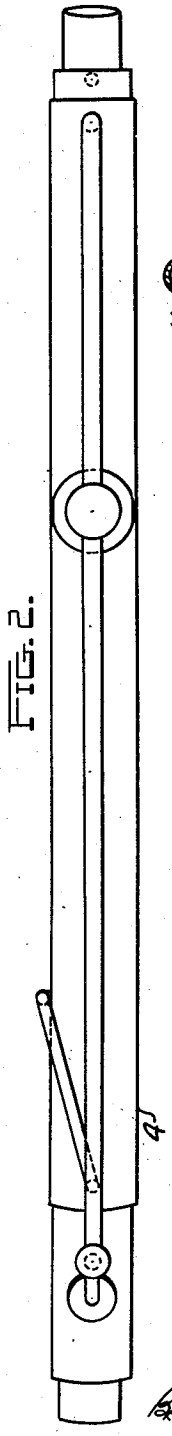


FIG. 2.

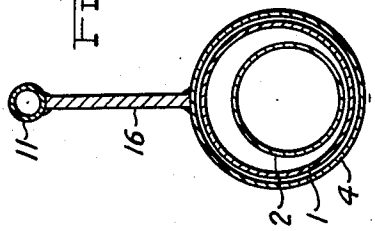


FIG. 5.

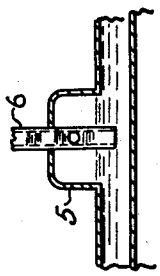


FIG. 4.

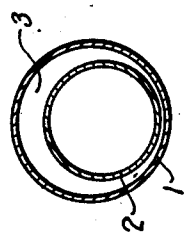


FIG. 3.

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GENERATOR AND HEAT EXCHANGER IN AN ABSORPTION REFRIGERATOR

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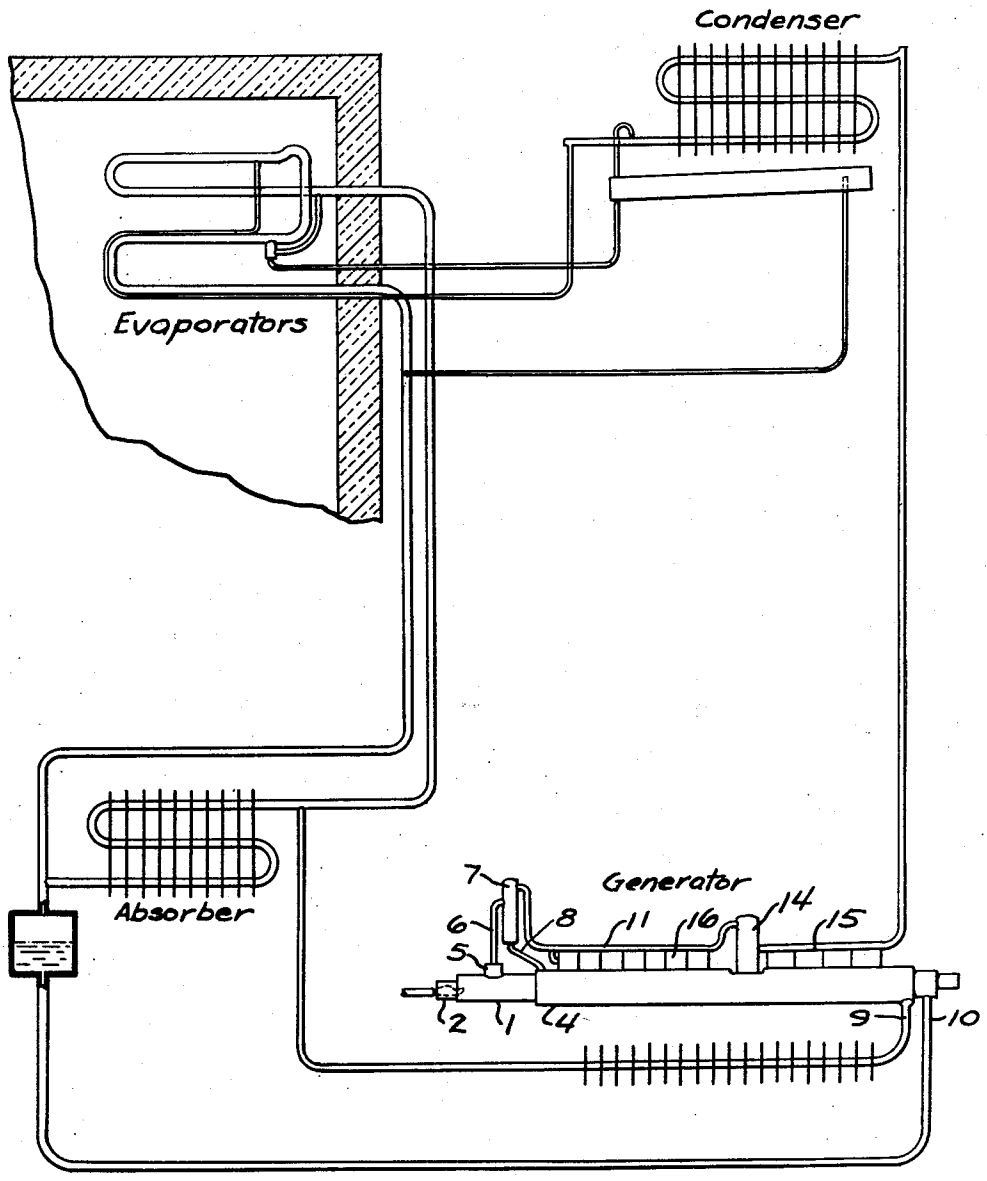


FIG. 6.

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GENERATOR AND HEAT EXCHANGER IN AN ABSORPTION REFRIGERATOR

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15 Claims. (Cl. 62—119.5)

1

This invention relates to absorption refrigeration.

The object of the invention is to combine in a single integral device the functions of boiler, analyzer, and heat interchanger (and "rectification") in a manner that leads to the most efficient separation of substantially pure ammonia and weak liquor of a quality required for specified refrigeration needs. The heat transfer takes place most efficiently, thermodynamically considered, because of the low temperature differences.

It is old to provide triple heat exchangers, that is, heat exchange between the vapor passing from the generator and the weak liquor and the strong liquor, the three fluids all being arranged in juxtaposition for simultaneous and mutual heat exchange. The purpose served by cooling the vapor through heat interchange with the incoming countercurrent cool rich liquor from the absorber is to condense out of the vapor a considerable fraction of the water progressively by a process of fractional condensation. By this means the water constituent accompanying the vapor evolved at a higher temperature is condensed accompanied by an amount of ammonia determined by the vapor liquid equilibrium conditions which are a function of temperature. The result is a cooler ammonia vapor of enhanced purity which passes to the condenser where it is reduced to the liquid phase for delivery to the evaporator. Arrangements for heat exchange and partial water vapor condensation have been proposed in systems having a vapor lift pump to cause the liquid circulation. In order to bring about such heat exchange it is necessary to bring the vapor conveying tube from the point of connection near the higher of the liquid levels of the absorber-boiler to the lower level of the system. In order to obtain partial condensation, with attendant enrichment of the ammonia vapor, by heat interchanges between the vapor and the rich liquid, it has hitherto been proposed to keep the two fluids out of physical contact but in heat exchange relation in a heat exchange device, or it has been proposed to pass the vapor through a cascade or bubble-cap type analyzer. It has also been proposed to force the vapor along the surface or through a body of the rich liquor or through a countercurrent of the rich liquor with the vapor in actual physical contact or bubbling through the liquor. But so far as I am aware, this has always been accomplished by means of a separate analyzer, rectifier (partial condensation) or heat exchanger external to but

2

associated with the boiler, or indeed, entirely independent and separated from the boiler.

It is the object of the present invention to provide a heat exchanger and analyzer which, in contradistinction with prior apparatus, is built into the generator itself so that one unit performs not only the expulsion of the gas from the liquid but also accomplishes heat exchange, analyzation and rectification. This unit takes heat out of the vapors generated in the separator and returns it to the rich liquor in the boiler, and condenses out the water vapor and recovers the heat liberated by such condensation and returns the condensate and the heat liberated by condensation to the generator. This is all accomplished in the boiler itself. Furthermore, the heat exchange takes place under optimum conditions, thermodynamically considered, because at all points along the boiler and the heat exchanger there is a minimum temperature differential between the outflowing vapor and the inflowing weak liquor and the countercurrent of rich liquor coming from the absorber.

When the rich liquor from the absorber or a heat exchanger reaches the end of the boiler remote from the burner the rich liquors are cool, as compared to their temperature at the hot end of the boiler, and the outgoing vapors are in their coolest condition. As the rich liquor passes through the horizontal boiler from the cooler end into the hotter end it becomes progressively hotter due to three factors: (1) the heat obtained from the products of combustion, (2) heat obtained from the hot weak liquid passing along the boiler in heat exchange relation with the rich liquors and (3) the heat obtained from the hot vapors drawn off the separator and also the hot vapors flowing through the rich solution. At all points along this heat exchanger there is a temperature disparity between the fluids but the differential is small at all points along the boiler and heat exchanger. The heat exchange in the improved apparatus is four-fold or quadruple, namely, between the hot combustion gases and the rich liquor flowing in countercurrent to one another and the hot vapor driven off the separator and the generator and the hot weak liquor returning to the absorber in countercurrent to the flow of the rich liquor from the absorber. In this arrangement and mode of operation the heat exchange is therefore most efficient.

Referring to the drawings:

Fig. 1 is a longitudinal section of the generator and heat exchanger.

Fig. 2 is a plan view of the same.

Fig. 3 is a section on the line 3—3 of Fig. 1.

Fig. 4 is an enlarged fragmentary section of the vapor lift or percolator.

Fig. 5 is a section on the line 5—5 of Fig. 1.

Fig. 6 is an all-over view of the system showing the generator in relation to the condenser, evaporator, and absorber.

1 is a cylindrical boiler or still shell relatively long and having a relatively small diameter. Passing through this shell is a flue 2 for the products of combustion. Contradistinguished from the usual practice, this flue is not in concentric relation with the boiler shell but is set eccentrically thereto and obliquely thereto when viewed in a vertical longitudinal section. This provides a downward slope from the cooler end of the boiler to the hotter end and, consequently, the vapors being driven along the horizontal boiler have their travel facilitated and are not liable to be pocketed or trapped. The baffle plate or partition 3 may be placed between the upper portion of the flue and the boiler, as shown particularly in Fig. 1, leaving the small space below the flue and the boiler open. This baffle plate is just to the right of the vapor lift or percolator. This partition divides the boiler into a weak liquor section and a strong liquor section, but I have found in actual practice that this partition plate is unnecessary and that the boiler and heat exchanger will operate satisfactorily and efficiently without the partition. Slightly to the right of this partition or toward the cooler end of the boiler is an annulus or cylindrical jacket 4 which is of only slightly greater diameter than the boiler shell so there is only a small space between the boiler shell and the jacket. This jacket is for the reception of the hot weak liquor on its way back to the absorber.

A vapor lift is provided from the weak liquor end of the boiler and comprises a steam dome 5 in which is located the small tube 6 which has one or more orifices in the tube to admit gas so that combined gas and liquid are lifted through the tube in a well understood way. These vapor lifts or percolators are old in absorption systems for raising the liquid to a separator 7 which provides a liquid level high enough to cause the liquid to flow into the top of the absorber by gravity due to this elevated head. This is an old system known to the expired patented art. The elevated liquid or the hot weak liquor collects in the bottom of the separator, then passes through the downgoing tube 8 to the hot end of the weak liquor jacket 4. The hot liquor spreads out in a thin annulus or almost a film around the outside of the boiler and then flows to the cooler end of the boiler where it passes out through tube 9 that connects with the absorber.

The cool rich liquor comes from the bottom of the absorber and it may or may not pass through a common type of liquid heat exchanger before it arrives at the cooler end of the boiler. The pipe 10 discharges into the cooler end of the boiler and the rich liquor flows toward the hot end of the boiler in countercurrent to the weak liquor on the outside but out of physical contact therewith. It will be apparent that the cool rich liquor is being simultaneously heated both on the inside and the outside, in the one case by the products of combustion and in the other case by the hotter weak liquor returning to the absorber. It is also receiving a considerable heat from the vapors in the vapor pipe 11 leading from the top of the separator. This vapor pipe passes from

the top of the separator directly downward and then in substantially parallel relation above the boiler shell, but sufficiently spaced therefrom to be at all times above the lower liquid level in the system, which is the level 13 in the stand pipe 14. Pipe 11 connects the vapor space of the separator with the vapor space of the stand pipe. Vapor pipe 15 connects the vapor space of the stand pipe with the condenser. This vapor pipe 15 extends along the boiler in parallel relation therewith and slightly inclined upwardly. The boiler and jacket are slightly inclined downwardly from the stand pipe to the cooler end of the boiler. Heat exchange plates 16 are silver soldered or welded to the vapor tubes 11 and 15 and the outer jacket 4 of the boiler. I prefer to use a plurality of plates as it is easier to solder or weld them in place. These plates serve to transmit the heat of the vapors passing through the vapor pipes to the boiler, and particularly the outer jacket of the boiler. This serves to extract heat in the vapor line and return this to the generator so as to save it. It also serves to lower the temperature of the contents of the vapor line sufficiently to condense water vapor but not the ammonia or refrigerant vapor. This condensation liberates more heat which is also dissipated by the heat transmitting plates and brought back to the boiler to do useful work in vaporizing more ammonia.

The condensate in the vapor tube 11 runs back through drain tube 17 into the inner boiler annulus. This drain pipe discharges into the interior of the boiler at a point where the ammonia concentrate is substantially in equilibrium with the condensate. The condensate in the vapor tube 15 is largely water and this drains back into the stand pipe 14. This stand pipe 14 is located at the highest point along the long still at which the heat exchange and the products of combustion first heat the countercurrent of rich vapors sufficiently to liberate ammonia vapor. There is no ammonia vapor in the boiler or practically none on the side of the stand pipe remote from the burner. The hot end of the boiler slopes slightly upwardly to the stand pipe and the cool end slightly downwardly from the stand pipe. Consequently, none of the ammonia vapor is trapped in the boiler. That portion of the boiler on the side of the stand pipe remote from the burner is really not a generator but a pre-heater of the rich liquor coming in from the absorber by both heat exchange and the products of combustion. It also aids in rectification of the vapor in the vapor line by means of the heat exchange between the boiler and the outgoing vapor tube 15.

The concentration of ammonia in the strong liquor passing to the left in the boiler is progressively decreasing and its temperature rising, and the vapor passing countercurrent to the right is at each point in approximate equilibrium with the liquid. This means that the vapor mixture of ammonia and water coming from the left is not only at a higher temperature but its ammonia concentration must be less than the cooler liquid with which it comes in contact. In coming to temperature equilibrium and also concentration equilibrium it is not the ammonia constituent but the water constituent which will be largely deposited, that is, water vapor in large measure with some accompanying ammonia will condense out but no ammonia can be absorbed because the strong solution is at a temperature

and concentration too high to do any further absorbing.

As the condensed water solution flows to the left in the vapor tube 11 it becomes increasingly hotter, thereby giving up more and more ammonia vapor. This action is essentially that of partial condensation of vapors rich in water. Likewise the ammonia vapors in tube 15 leaving the stand pipe for the condenser pass through colder and colder zones. Water vapor condensed out runs along the bottom of the tube to the left through hotter and hotter zones, causing absorbed ammonia vapor to evaporate off. This is rectification action.

I claim:

1. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation for separation of the vapors and to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and a conduit for conducting and rectifying the vapors separated from the liquid at said elevation longitudinally of the boiler in countercurrent but heat exchange relation with the rich liquors in the boiler flowing from the cooler to the hotter end.

2. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and a lift and separator for lifting liquid from the hot end of said boiler to an elevation and for separation of vapor and weak liquor to flow the liquor by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and conduits for separately conducting both the vapors from the top of the separator and the said hot elevated and weak liquid out of contact with but in countercurrent heat exchange relation to the rich liquors flowing from the cooler end of the boiler to the hotter end.

3. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means for conducting the vapors separated from the liquid at said elevation longitudinally of the boiler in countercurrent but heat exchange relation with the rich liquors in the boiler flowing from the cooler to the hotter end, said conducting means comprising a vapor tube substantially paralleling the boiler and having a heat conduction connection therewith comprising metal heat conducting members.

4. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having a generally horizontal elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means at all times above the liquid level in the generator for conducting the vapors separated from the liquid at said elevation longitudinally of the boiler in countercurrent but heat exchange relation with the rich liquors in the boiler flowing from the cooler to the hotter end, said means comprising a vapor tube leading from the space above said elevated liquid and substantially paralleling the boiler and a plurality of heat conduction plates united to the vapor tube and the boiler.

5. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means for conducting both the vapors from the top of the elevated liquid and the said hot elevated and weak liquid in countercurrent heat exchange relation to the rich liquors flowing from the cooler end of the boiler to the hotter end, the said means comprising a jacket about the boiler shell with a tube connection near the hot end of the boiler with the elevated liquid for conveying the hot weak liquor along the outside of the boiler from near the hot end of the boiler to the cooler end and a vapor tube from the space above the elevated liquid substantially paralleling the boiler but in heat conduction relation with the said jacket around the boiler.

6. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means for conducting the vapors separated from the liquid at said elevation longitudinally of the boiler in countercurrent but heat exchange relation with the rich liquors in the boiler flowing from the cooler to the hotter end, the said boiler being substantially horizontal and the said conducting means comprising a vapor tube having a slight inclination upwardly from the hot end of the boiler and a drainage tube for draining the condensate in said tube

therefrom and delivering the same to the boiler at a point where the concentration of the liquid in the solution in the boiler is substantially the same as the concentration in the condensate.

7. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means for conducting the vapors separated from the liquid at said elevation longitudinally of the boiler in countercurrent but heat exchange relation with the rich liquors in the boiler flowing from the cooler to the hotter end, the said boiler being substantially horizontal and sloping slightly upward from the hot end to a point spaced from the cooler end and from this point slightly downward and a stand pipe located at this point for the escape of vapors from the boiler, the said means conveying the hot vapors from the elevated vapor space and leading into the vapor space of said stand pipe and a second vapor tube leading from the vapor space of said stand pipe and substantially paralleling the cooler end of the boiler and having a heat conduction relation with the boiler and arranged to drain any condensate back into the boiler.

8. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means for conducting the vapors separated from the liquid at said elevation longitudinally of the boiler in countercurrent but heat exchange relation with the rich liquors in the boiler flowing from the cooler to the hotter end, the said boiler being substantially horizontal and having at the midpoint a stand pipe and the said conducting means for the vapor comprising the vapor tube leaving the vapor space above the elevated liquid and substantially paralleling the boiler but in heat conduction relation with the boiler and leading into a vapor space in the stand pipe and a second vapor tube leading to the condenser and connecting with the vapor space of the stand pipe and in heat conduction relation with the cooler end of the boiler, both of said vapor tubes arranged to drain the condensate back to the boiler, the boiler shell sloping slightly upwardly from the hot end to the stand pipe and slightly downwardly from the stand pipe to the cooler end.

9. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means for conducting both the vapors from the top of the elevated liquid and the said hot elevated and weak liquid in countercurrent heat exchange relation to the rich liquors flowing from the cooler end of the boiler to the hotter end, the said boiler being near horizontal and at its midportion provided with a stand pipe and having a jacket around the boiler for connection with the elevated liquid to convey the hot weak liquor therefrom in heat exchange relation with the boiler along the exterior thereof to the cooler end of the boiler and a vapor tube leaving the vapor space above the elevated liquid and entering the vapor space of said stand pipe and in heat conduction relation with the outer jacket of the boiler and a second vapor tube leaving the vapor space of the stand pipe and for connection with the condenser and in heat conduction relation with the outer jacket at the cooler end of the boiler.

10. In absorption refrigeration having liquid circulation from the absorber to the generator and generator to absorber by the aid of a lift and gravity, the combination of a generator having an elongated boiler or still with a flue extending therethrough for products of combustion and means for lifting liquid from the hot end of said boiler to an elevation to flow the liquid by gravity to the upper part of the absorber, means for delivering the cool rich liquor from the absorber to the cooler end of the boiler to flow through the boiler and around the combustion flue to the hot end of the boiler and means for conducting both the vapors from the top of the elevated liquid and the said hot elevated and weak liquid in countercurrent heat exchange relation to the rich liquors flowing from the cooler end of the boiler to the hotter end, the said boiler being near horizontal and at its midportion provided with a stand pipe and having a jacket around the boiler for connection with the elevated liquid to convey the hot weak liquor therefrom in heat exchange relation with the boiler along the exterior thereof to the cooler end of the boiler and a vapor tube leaving the vapor space above the elevated liquid and entering the vapor space of said stand pipe and in heat conduction relation with the outer jacket of the boiler and a second vapor tube leaving the vapor space of the stand pipe and for connection with the condenser and in heat conduction relation with the outer jacket at the cooler end of the boiler, the said heat conduction relation between the two tubes and the jacket of the boiler being provided by metal conduction plates united to the tubes and to the said jacket.

11. In fluid separation, the method of conserving heat energy and rectifying the vapors expelled from the liquid solution in the generator which comprises passing the separated vapors out of contact with but in heat exchange relation and in a countercurrent to the rich liquor current in the boiler.

12. In fluid separation, the method of conserving heat energy and rectifying the vapors expelled from the liquid solution in the generator which comprises passing the separated vapors out of contact with but in heat exchange relation and in a countercurrent to the rich liquor current in the boiler and also conducting the hot weak liquor from the hot end of the generator in a counter-

current out of contact with but in heat exchange relation with the rich liquor current entering the boiler at the cool end.

13. In fluid separation, the method of conserving heat energy and rectifying the vapors expelled from the liquid solution in the generator which comprises passing the separated vapors out of contact with and in heat exchange relation and in a countercurrent to the rich liquor current in the boiler and draining condensate from the vapor back into the boiler at a point in the rich liquor current where the concentration of the rich liquor is substantially that of the condensate.

14. In an absorption refrigeration system having two liquid levels and liquid circulation from the absorber to the generator and generator to absorber by aid of a lift and by gravity, the combination of an absorber, a generator, an elevated separator, weak and strong liquor conduits circulating liquor from the generator to the absorber through the separator and from the absorber to the generator, a lift in the said liquor line for lifting liquor from the low liquid level to the elevated separator, a vapor tube leading from the separator, the vapor tube lying above the low liquid level in the system and acting as a rectifying tube and draining the condensate back to the low liquid level, the said weak liquor flowing to and the rich liquor coming from the absorber being in heat exchange relation around and in the generator below the low liquid level and also and at the same location being in heat exchange relation with the vapor tube or rectifier which is located above the low liquid level.

15. In an absorption refrigeration system having two liquid levels and liquid circulation from the absorber to the generator and generator to absorber by aid of a lift and by gravity, the combination of an absorber, a generator, an elevated separator, weak and strong liquor conduits circulating liquor from the generator to the absorber through the separator and from the absorber to the generator, a lift in the said liquor line for lifting liquor from the low liquid level to the elevated separator, a vapor tube leading from the separator, the vapor tube lying above the low liquid level in the system and acting as a rectifying tube and draining the condensate back to the low liquid level, the said weak liquor flowing to and the rich liquor coming from the absorber being in heat exchange relation below the low liquid level and also in heat exchange relation with the vapor tube or rectifier which is located above the low liquid level, heat conducting plates connecting the vapor tube with the weak liquor conduit to establish said heat exchange relation and allow the vapor tube to be somewhat above and removed from the weak liquor and the rich liquor heat exchanger.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,960,809	Dahlgren	May 29, 1934
2,203,074	Anderson, Jr.	June 4, 1940