

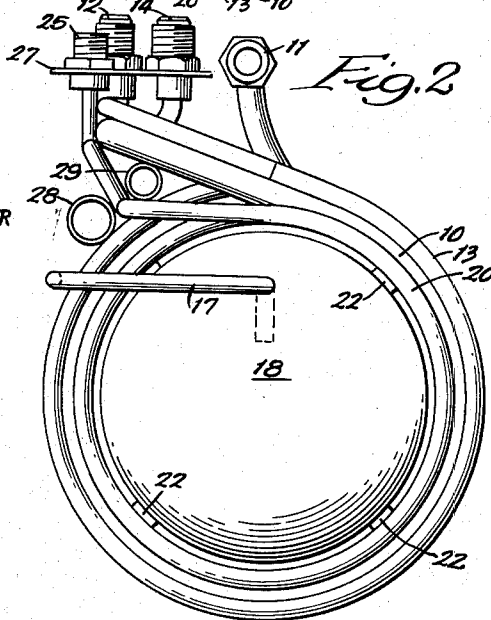
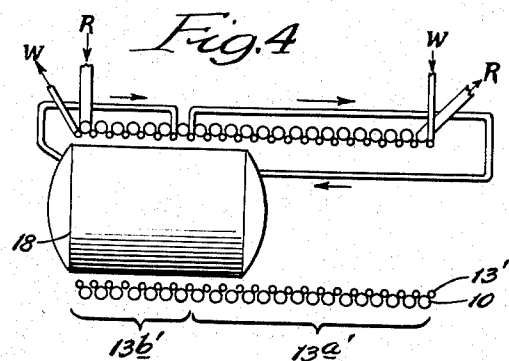
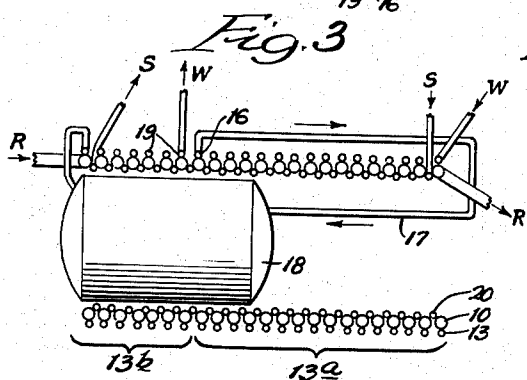
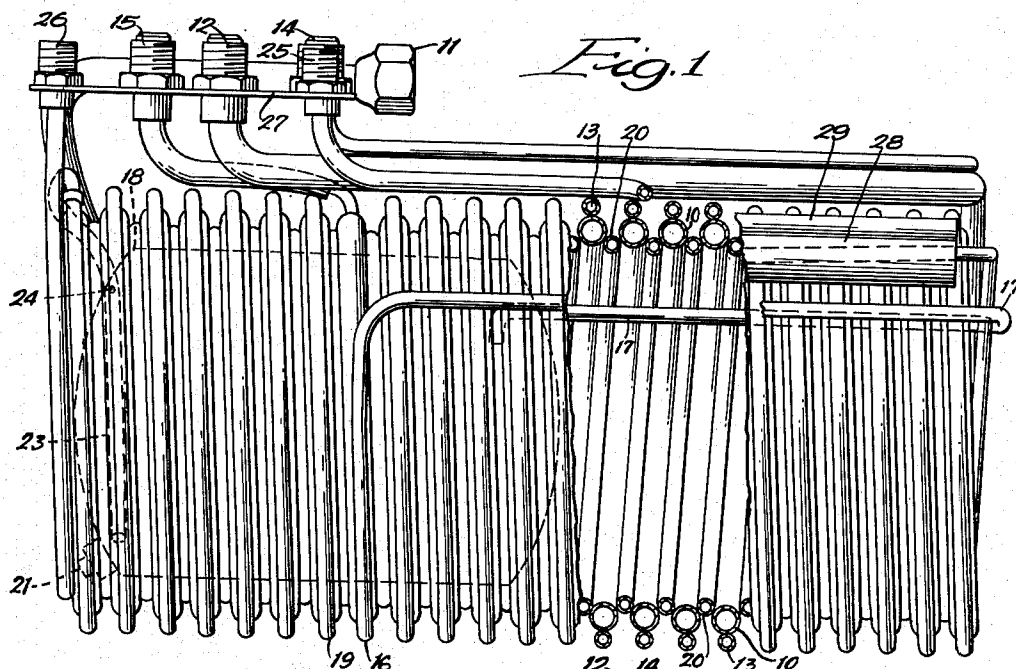
June 22, 1954

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2,681,797

HEAT EXCHANGER FOR COOLING FLUIDS

Filed Feb. 8, 1952



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2,681,797

HEAT EXCHANGER FOR COOLING FLUIDS

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Application February 8, 1952, Serial No. 270,690

17 Claims. (Cl. 257-242)

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This invention relates to a heat exchanger for cooling fluids, and more particularly to a heat exchanger for cooling liquids such as water and other potable liquids for use in drinking fountains, soda bars, etc.

In the design of water and soda or carbonated water cooling equipment for fountain service, space requirements and material costs must both be kept at a minimum. In addition, draws of water, soda, etc. are intermittent and frequently exceed for short intervals the capacity of the cooler and condensing unit serving it. This is especially true on warm days and during certain hours of the day. Under these conditions, it is still necessary to deliver the liquids at or below a predetermined temperature, for example, 40° F. This necessitates a rapidly acting cooling system.

In the past, various types of heat exchangers and cooling systems have been employed, but none of these have proved entirely satisfactory. For many years a water bath with submerged refrigerant, water and soda coils was standard, but such equipment was bulky, unsanitary and costly due to the amount of tubing required. Double and triple tube coolers have been used, but though they operate well at steady flow rates within their rated capacity, they fail on intermittent over-loads, delivering at too high a temperature during such loads. The use of a storage tank after the water cooling coil has proved unsatisfactory since during overload operation, the tank fills with partially cooled water and it must be drawn out completely before water at the desired temperature is again available even though the draw rate following such overload is within the cooler capacity.

It is, therefore, an object of this invention to provide a heat exchanger or cooler that will cool liquids to a desired temperature very rapidly, supplying the liquid at the desired temperature during periods of temporary draw exceeding the capacity of the cooler. Another object of this invention is to provide a heat exchanger for cooling two liquids simultaneously. Still another object is to provide a cooler that will cool two liquids wherein the flow of the liquids is intermittent and the demand for one of the liquids at times exceeds the capacity of the cooler. Still another object is to provide a heat exchanger for cooling a liquid subject to temporary draws exceeding the capacity of the cooler having a pre-cooler, after cooler and storage tank interposed therebetween. Yet another object is to provide a cooler for cooling two

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liquids in which the flow of the liquids through the heat exchanger is in counter-flow relation with the flow of the refrigerant through the unit. A further object is to provide a small, compact, and self-contained, unitary structure having no moving parts in the heat exchanger and which is economical in construction and operation. Additional objects and advantages of this invention will appear as the specification proceeds.

The invention is shown in an illustrated embodiment by the accompanying drawing in which—

Fig. 1 is a side view of a heat exchanger for cooling two liquids in which a portion of the coils is broken away; Fig. 2 is an end view of the exchanger shown in Fig. 1; Fig. 3 is a schematic of the heat exchanger shown in Figs. 1 and 2; Fig. 4 is a schematic of a heat exchanger for cooling one liquid in which the direction of flow of the liquid in the aftercooler has been reversed.

Figs. 1, 2 and 3 illustrate a heat exchanger or cooler for cooling two liquids such as water and a carbonated water or soda useful for fountain service. The unit consists of a tube shaped to form a helically wound coil 10 through which a refrigerant or coolant flows and expands through the heat exchanger. Each turn of the coil 10 is separated from the adjacent turns to form a small spacing therebetween. The coil is provided with an inlet-fitting 11 and an outlet-fitting 12 connecting the coil 10 to an expansion valve, condenser, and remainder of a refrigerating or cooling unit which is not shown. Since refrigerating units are old and well-known in the art, it is not believed that a detailed discussion of such is necessary. The material from which the coil 10 is constructed may be of any metal having a high thermal conductivity such as copper. In the illustration given, the flow of the refrigerant through the coil 10 is from the left to the right.

A helically wound tube forming a water coil 13 is wound parallel to the refrigerant coil 10 along the outer surface thereof and in thermal contact with the surface of the coil 10. The coil 13 is divided into two sections or components, a pre-cooler 13a and aftercooler 13b. The direction of flow of the liquid through the coil 13 is in counterflow relation to the flow of refrigerant through the coil 10, at least in the pre-cooler component of the coil 13.

The water coil 13 is provided with an inlet-fitting 14 and an outlet-fitting 15. Water is introduced through the fitting 14 into the coil 13 at the right end or pre-cooler component 13a, as seen

more clearly in Fig. 3. When a draw is made, the water in the precooler 13a flows through the turns, entering the turn 16 from which it flows through the pipe 17 into a storage tank 18. The water is drawn from the opposite end of the tank 18 and flows in the opposite direction, that is, in the same direction as the refrigerant flow, through the aftercooler component 13b of the coil 13, or from the left to the right in Figs. 1 and 3 and through the turn 19 which is connected to the water out-fitting 15. Any suitable metal having a high thermal conductivity such as copper may be used to form the coil 13.

In fountain service, water is often subject to temporary overdraws exceeding the capacity of the heat exchanger. The tank 18, therefore, provides a reserve of chilled water to maintain delivery of water at the desired temperature during the time interval required to start the refrigerant flowing through the coil 10. Any suitable material may be used to form the tank 18. A plug 21 is provided at the withdrawal end at the bottom of the tank 18 for draining the liquid therefrom during cleaning. The tank 18 is separated from the inner coil 20 by spacers 22. The spacers 22 are provided at approximately 90° intervals about the surface of the tank 18 and extend longitudinally along the tank to maintain it in spaced-apart relation with the inner coil 20. The water out-tube 23 may have an aperture 24 in one wall at a point in the upper portion of the tank to purge air from the system.

The tube forming the helical coil 20 is wound so that each turn is spaced-apart from the adjacent turn by a distance permitting the coil turns to be positioned along the inner side of the refrigerant coil 10 within the spacings provided between each turn of the refrigerant coil. Positioning the carbonated water or soda coil 20 in this manner has been found effective in obtaining the desired cooling since it permits contact with the refrigerant coil 10 along two sides of each turn of the soda coil 20. The coil 20 is preferably made of a non-corrosive material such as stainless steel or monel metal and the thermal conductivity of such metals is relatively low. Thus, permitting each turn of the coil 20 to contact two turns of the refrigerant coil 10 tends to compensate for the lower thermal conductivity of these metals.

The coil 20 is provided with an inlet-fitting 25 and an outlet-fitting 26. Soda is not generally subject to overloads or overdraws as is water, and it is not necessary to provide a storage tank for the storage of soda. It has been found that sufficient cooling is had when the flow of soda through the coil 20 is in counter-flow relation with the flow of refrigerant through the coil 10, that is, from the right to the left of the exchanger shown in Figs. 1 and 3. All of the turns forming the coils 13 and 20 are sweated to the coil 10 to insure a good thermal coupling. The inlet and outlet fittings are securely fastened to a junction plate 27 to assure proper alignment.

The bulbwells 28 and 29 are made of a metal having a high thermal conductivity such as copper and form respectively receptacles for the temperature sensitive portion of the control to start the condensing unit, and for the temperature sensitive portion of the thermal control on the refrigerant suction line controlling the operation of the expansion valve in the feed of refrigerant into the coil 10. The bulbwell 28, receiving the bulb for the control which starts and stops the condensing unit, is positioned in

thermal contact with the first few turns of the precooler coil 13 and also in thermal contact with the input line 30 of the soda coil 20. Either the incoming warm soda or the incoming warm water will then cause the temperature control to start the condensing unit. When liquid is not being drawn from the unit, the chilled water from the tank 18 will cool the bulbwell and thereby render the refrigerant condensing unit inoperative. The bulbwell 29 receives the thermal bulb controlling the thermal expansion valve in the refrigerant feed line, and is positioned in thermal contact with the first few turns of the precooler 13a.

The ratio of turns in the precooler and aftercooler of the water coil 13 should be of such length (or surface) as to reduce the temperature of the incoming water to the desired delivery temperature. It has been found that results are good where the ratio of turns in the precooler to the aftercooler is approximately equal to the product of the inverse ratio of the average temperature difference between the refrigerant and water in the pre to after cooler, times the ratio of the cooling loads in the pre to after cooler.

For example, if the temperature of the incoming water is 80° F. and it is desired to reduce the temperature of the liquid feed to the storage tank 18 to 45° F. through the precooler and to further reduce the temperature of the liquid through the aftercooler to a 40° F. delivery temperature, the ratio of the loads or temperature reductions in the pre and after coolers is 7 to 1. However, if the temperature of the refrigerant flowing through the coil 10 is 34° F., the ratio of the difference between the average temperature of the liquid in the precooler and the refrigerant to the difference between the temperature of the liquid in the aftercooler and the refrigerant is 3 to 1. The ratio of the number of turns in the precooler to the aftercooler is determined as the product of the ratio of the average temperature difference between refrigerant temperature and the temperature of the liquid in the after to precooler (1 to 3), times the ratio of the cooling loads in the pre and after coolers (7 to 1). The product then is $7/3$, or 7 turns in the precooler for every 3 turns in the aftercooler.

It has been found that satisfactory results are obtained in reducing the temperature in accordance with the values above indicated where a refrigerant coil of 23 turns having an inner diameter of approximately 5.4 inches, and a water coil with a like number of turns having 7 turns included in the aftercooler portion are used. Soda is reduced to a corresponding temperature by using a coil having approximately 23 continuous turns.

The above temperature reductions were obtained using the coil dimensions stated where the flow of water was intermittent at a rate of 40 gallons per hour for $7\frac{1}{2}$ seconds, zero flow for $7\frac{1}{2}$ seconds, and then repeated; flow of soda was 15 gallons per hour for $7\frac{1}{2}$ seconds, zero for $7\frac{1}{2}$ seconds, and then repeated; tank capacity was $\frac{1}{2}$ gallon; refrigerant tube size sufficient to give a refrigerant gas outlet velocity at full load of about 2,000 feet per minute; and the condensing unit control set to start the condensing unit before the third six ounce draw. The number of turns in each coil and the direction of flow of the fluids therethrough in accordance with the above specific example can best be seen by reference to Fig. 3.

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Fig. 4 illustrates a modification of the cooler shown in Figs. 1, 2 and 3. In the modified form illustrated, only a single liquid is cooled to the desired temperature. This unit would have particular utility in water cooler drinking fountains. The function of the cooler and construction is generally the same as the heat exchanger discussed above. However, the water coil 13' is placed along the inner surface of the refrigerant coil 10 in a position so that each turn of the coil 13' is in thermal contact with the refrigerant coil along two surfaces. This, of course, facilitates heat exchange.

The direction of flow of the liquid has been changed from that shown in Fig. 3 through the aftercooler section 13b' of the coil 13', and is delivered through the aftercooler in a direction of flow counter to the flow of refrigerant through the coil 10. Changing the direction of flow through the aftercooler is not a necessary modification in the water cooler, and the flow of liquid through the aftercooler may be in the direction of refrigerant flow as shown in Fig. 3. Likewise, the direction of flow through the aftercooler of Fig. 3 could be reversed so that water would be delivered through the aftercooler in a direction opposite or counter to the flow of refrigerant through the coil 10.

The primary purpose of using counter-flow in the precooling and placing the precooling at the exit end of the refrigerant coil is to insure a high superheat in the outgoing expanded refrigerant whose last pass is in heat exchange relation with the warm incoming water. This also places the aftercooler at the inlet end of the refrigerant coil so that in case of heavy overdraw, the aftercooler gets refrigerant first and in sufficient quantity to lower the precooled water stored in the tank to the wanted temperature.

It is to be understood that the ratio of turns in the pre to after cooler, total number of turns of all of the coils, storage tank size, etc. may be varied to correspond with condenser and refrigerant capacity to yield the particular temperature reductions desired. If desired, the whole heat exchanger may be tin-dipped after fabrication to increase the heat exchange capacity of the unit.

During operation at or below the rated capacity of the heat exchanger, the storage tank 18 will be at the temperature of the liquid delivered by the precooling, or in the specific example, 45° F. at full load and down to about 38° F. at low load. When water is drawn, the aftercooler will further cool the water delivered from the tank 18 to 40° F. at full load or to a value below 38° F. at low load. If the following draw is above the capacity of the system, water warmer than 45° will be delivered from the precooling and fill the tank 18. However, the aftercooler will be operating at a much higher mean temperature difference, refrigerant to water temperature, and the water delivered from the aftercooler will further be reduced to a temperature very close to 40° F. Since periods of heavy or full loads are temporary, the tank water is very generally below 40° F.

The positioning of storage tank 18 within refrigerant coils 10 not only makes the water cooling assembly more compact, but also results in a surprising increase in the capacity of the storage tank to prevent wide fluctuations in output water temperature with varying rates of discharge even though the storage tank is of comparatively small

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volume. This is apparently due to the fact that the refrigerant coils maintain the temperature of the air surrounding the storage tank about or slightly above the coolest temperature which the water will reach in the storage tank. Thus, at low rates of flow the storage tank becomes filled with water at a temperature approaching the minimum temperature which can be produced by the refrigerant with the established heat transfer capacity, and in intervening periods of non-use the temperature of the water in the storage tank does not appreciably increase because it is surrounded by the refrigerated air. It is, therefore, unnecessary to insulate the storage tank, which permits the storage tank to be manufactured of relatively thin metal without insulating coverings, etc. A further reduction in cost is achieved by this arrangement in that the storage tank can be of relatively small volume while achieving the desired result of preventing wide fluctuation in output water temperature. In consequence, the storage tank need not even extend for the full length of the refrigerant coils, as indicated in the figures of the drawing. When a tank of shorter length than the refrigerant coils is employed, it is preferred to position it adjacent the upper portion of the refrigerant coils, which in the illustration given is the portion surrounded by the aftercooler 13b.

While in the foregoing specification I have set forth specific structure in considerable detail for the purpose of illustrating an embodiment of the invention, it will be understood that such details may be varied widely by those skilled in the art without departing from the spirit of my invention.

I claim:

1. A heat exchanger for reducing the temperature of a fluid, comprising a tube forming a coil for the flow of a refrigerant therethrough, a second tube forming a coil in heat exchange relation with said refrigerant coil for the flow therethrough of the fluid to be cooled, said second-mentioned coil forming a precooling component adjacent the downstream end of said refrigerant coil and an aftercooler component adjacent the upstream end of said refrigerant coil, and a tank for the storage of precooled fluid interposed between said precooling and said aftercooler for receiving the precooled fluid after the precooling thereof.

2. A heat exchanger for reducing the temperature of a fluid, comprising a tube forming a coil for the flow of a refrigerant therethrough and having an inlet and an outlet, a second tube forming a coil in heat exchange relation with said refrigerant coil for the flow therethrough of the fluid to be cooled, said second-mentioned coil forming a precooling component adjacent the outlet of said refrigerant coil and an aftercooler component adjacent the inlet of said refrigerant coil, and a tank mounted within said coils for the storage of precooled fluid and being interposed between said precooling and said aftercooler for receiving precooled fluid after the precooling thereof.

3. A heat exchanger for reducing the temperature of a fluid, comprising a tube for the flow of a coolant therethrough shaped to form a coil, a second tube for the flow of a fluid therethrough wound in heat exchange relation with said coolant coil and forming a second coil, said second coil forming a precooling component adjacent the downstream end of said coolant coil and an aftercooler component adjacent the upstream end

of said coolant coil, the direction of flow of the fluid through said precooler component being in counter-flow relation to the direction of the coolant flow through said coolant coil, and a tank for the storage of precooled fluid interposed between said precooler and said aftercooler for receiving precooled fluid after the precooling thereof.

4. A heat exchanger for reducing the temperature of a fluid wherein the flow of fluid through said heat exchanger is intermittent, comprising a tube for the flow of a refrigerant therethrough shaped to form a coil and having an inlet end and an outlet end, a second tube for the flow of a fluid therethrough wound in heat exchange relation with said refrigerant coil and forming a second coil, said second coil forming a precooler component at the outlet end of said refrigerant coil and an aftercooler component at the inlet end of said refrigerant coil, and a tank for the storage of pre-cooled fluid interposed between said precooler and said aftercooler mounted within said coils in spaced-apart relation therewith.

5. A heat exchanger for reducing the temperature of a liquid wherein the flow of liquid through said exchanger is intermittent and at times in excess of the heat exchanger capacity for short intervals, comprising a tube for the flow of a refrigerant therethrough shaped to form a substantially helical coil having an inlet section and an outlet section and the turns of which are in spaced-apart relation, a second tube for the flow of a liquid therethrough wound to form a second coil having each turn thereof in thermal contact with two adjacent turns of said refrigerant coil, said second coil forming a precooler component at the outlet section of said refrigerant coil and an aftercooler component at the inlet section of said refrigerant coil, the direction of flow of the liquid through said precooler component being in counter-flow relation to the direction of the refrigerant flow through said refrigerant coil, and a tank concentrically mounted within said coils and spaced-apart therefrom for the storage of precooled liquid, said tank being interposed between said precooler and said aftercooler.

6. A heat exchanger for water coolers and the like wherein the flow of liquid through said exchanger is intermittent and at times exceeding the capacity of said exchanger for short intervals, comprising a helically wound tube forming a coil for the expansion of a refrigerant therein and having an inlet and spaced therefrom an outlet, a second tube wound parallel with said refrigerant tube and in thermal contact therewith and forming a second helical coil for the flow of a liquid therethrough, said second coil forming a precooler component at the outlet of said refrigerant coil and an aftercooler component at the inlet of said refrigerant coil, the direction of flow of the liquid through said precooler component being opposite to the direction of the refrigerant flow through said refrigerant coil, and a tank interposed in the liquid flow path from said precooler to said aftercooler for the storage of precooled liquid, said tank being mounted within said coils at the inlet section of said refrigerant coil.

7. A heat exchanger for reducing the temperature of two fluids comprising a tube for the flow of a refrigerant therethrough shaped to form a coil and providing an inlet section and an outlet section, a second tube for the flow of one of the fluids therethrough wound in heat

exchange relation with said refrigerant coil and forming a second coil, said second coil having a precooler component at the outlet section of said refrigerant coil and an aftercooler component at the inlet section of said refrigerant coil, a third tube wound to form a third coil in heat exchange relation with said refrigerant coil for the flow therethrough of the second fluid, and a tank interposed between said precooler and aftercooler for the storage of precooled fluid therein after the precooling thereof.

8. A heat exchanger for reducing the temperature of two fluids comprising a tube for the flow of a refrigerant therethrough shaped to form a coil and providing an inlet section and outlet section, a second tube for the flow of one of the fluids therethrough wound in heat exchange relation with said refrigerant coil and forming a second coil, said second coil having a precooler component at the outlet section of said refrigerant coil and an aftercooler component at the inlet section of said refrigerant coil, a third tube wound to form a third coil in heat exchange relation with said refrigerant coil for the flow therethrough of the second fluid, and a tank interposed between said precooler and aftercooler for the storage of precooled fluid therein after the precooling thereof and being mounted within said coils.

9. A heat exchanger for reducing the temperature of two fluids, comprising a tube for the flow of a coolant therethrough shaped to form a coil having inlet and outlet sections, a second tube for the flow of one of the fluids therethrough wound in heat exchange relation with said coolant coil and forming a second coil, said second coil having a precooler component at the outlet section of said coolant coil and an aftercooler component at the inlet section of said coolant coil, the direction of flow of the fluid through said precooler component being in counter-flow relation to the direction of the coolant flow through said coolant coil, a third tube wound to form a third coil in heat exchange relation with said coolant coil for the flow of the other fluid therethrough, the direction of flow through said third tube being in a direction opposite to the flow of coolant through said coolant coil, and a tank interposed between said precooler and aftercooler for the storage of precooled fluid therein after the precooling thereof.

10. A heat exchanger for reducing the temperature of two fluids wherein the flow of said fluids through said exchanger is intermittent, comprising a tube for the flow of a refrigerant therethrough shaped to form a substantially helical coil and having inlet and outlet sections, a second tube for the flow of a fluid therethrough wound in heat exchange relation with said refrigerant coil and forming a second coil, said second coil forming a precooler component at the outlet section of said refrigerant coil and an aftercooler component at the inlet section of said refrigerant coil, a third tube helically wound and forming a third coil in heat exchange relation with said refrigerant coil for the flow of the second fluid therethrough, the direction of flow through said third coil being in a direction opposite to the flow of refrigerant through said refrigerant coil, and a tank for the storage of precooled fluid interposed between said precooler and said aftercooler mounted within said coils in spaced-apart relation therewith.

11. A heat exchanger for reducing the temperature of two liquids wherein the flow of liq-

uid through said exchanger is intermittent and the flow of one of said liquids is at times in excess of the heat exchanger capacity for short intervals, comprising a tube for the flow of a refrigerant therethrough shaped to form a substantially helical coil having the turns thereof in spaced-apart relation, a second tube for the flow therethrough of the liquid subject to temporary over-draws wound to form a second coil having each turn thereof in thermal contact with said refrigerant coil, said second coil forming a precooler component at the outlet section of said refrigerant coil and an aftercooler component at the inlet section of said refrigerant coil, the direction of flow of the liquid through said precooler component being in counter-flow relation to the direction of the refrigerant flow through said refrigerant coil, a third tube for the flow of the second liquid therethrough wound to form a helical coil having each turn thereof in thermal contact with two adjacent turns of said refrigerant coil, the direction of flow through said third coil being counter to the flow of refrigerant through said refrigerant coil, and a tank concentrically mounted within said coils in spaced-apart relation for the storage of precooled liquid, said tank being interposed between said precooler and said aftercooler.

12. A heat exchanger for fountain service adapted to cool two liquids wherein the flow of one of the liquids through said exchanger is intermittent and at times exceeding the capacity of said exchanger for short intervals, comprising a helically wound tube forming a coil for the expansion of a refrigerant therein, a second tube wound parallel with said refrigerant tube along the outer surface thereof and in thermal contact therewith forming a second helical coil for the flow therethrough of the liquid subject to temporary overdraws, said second coil forming a precooler component at the outlet section of said refrigerant coil and an aftercooler component at the inlet section of said refrigerant coil, the direction of flow of the liquid through said precooler component being opposite to the direction of the refrigerant flow through said refrigerant coil, a third tube for the flow of the other liquid therethrough wound along the inner surface of said refrigerant coil and forming a third coil in which each turn thereof is in thermal contact with two adjacent turns of said refrigerant coil, the flow of the fluid through said third coil being in a direction opposite to the flow of the refrigerant through said refrigerant coil, and a tank interposed between said precooler and aftercooler components for the storage of the precooled liquid, said tank being concentrically mounted within said coils at the inlet section of said refrigerant coil.

13. The structure of claim 5 in which the ratio of the number of turns in said precooler to the number of turns in said aftercooler is substantially equal to the product of the inverse ratio of the difference between the temperature of the refrigerant and the average temperature of the liquid in said precooler to the difference between the temperature of the refrigerant and the average temperature of the liquid in said aftercooler.

times the ratio of the temperature change of the liquid in said precooler to the temperature change of the liquid in said aftercooler.

14. The structure of claim 9 in which the ratio of the number of turns in said precooler to the number of turns in said aftercooler is substantially equal to the product of the inverse ratio of the difference between the temperature of the refrigerant and the average temperature of the liquid in said precooler to the difference between the temperature of the refrigerant and the average temperature of the liquid in said aftercooler times the ratio of the temperature change of the liquid in said precooler to the temperature change of the liquid in said aftercooler.

15. A heat exchanger for reducing the temperature of a fluid, comprising a tube forming a coil for the flow of refrigerant therethrough, a second tube forming a coil for the flow therethrough of the fluid being cooled and being in heat exchange relation with said refrigerant coil, said second coil forming a precooler component and an aftercooler component, and a tank for the storage of precooled fluid interposed between said precooler and said aftercooler for receiving and storing the precooled fluid after the precooling thereof.

16. A heat exchanger for reducing the temperature of two fluids, comprising a tube providing a conduit for the flow of a refrigerant therethrough and being shaped to form a coil, a second tube providing a conduit for the flow of one of the fluids therethrough and being wound to form a second coil in heat exchange relation with said first-mentioned coil, said second-mentioned coil having a precooler component and an aftercooler component, a third tube forming a third coil and being in heat exchange relation with said first-mentioned coil and providing a conduit for the flow therethrough of the second fluid to be cooled, and a tank interposed between said precooler and said aftercooler and in the fluid flow path therebetween for storing the fluid flowing therein after the precooling thereof.

17. A heat exchanger for reducing the temperature of a liquid, comprising a precooler and an aftercooler each providing a continuous passage for the flow therethrough of the liquid to be cooled, a storage tank interposed in the flow path between said precooler and said aftercooler for receiving and storing liquid therein after the precooling thereof, and a refrigerant expansion coil in heat exchange relation with said precooler and aftercooler whereby the refrigerant expanding through said coil reduces the temperature of the liquid flowing through said precooler and said aftercooler, said refrigerant coil being spaced from said storage tank.

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