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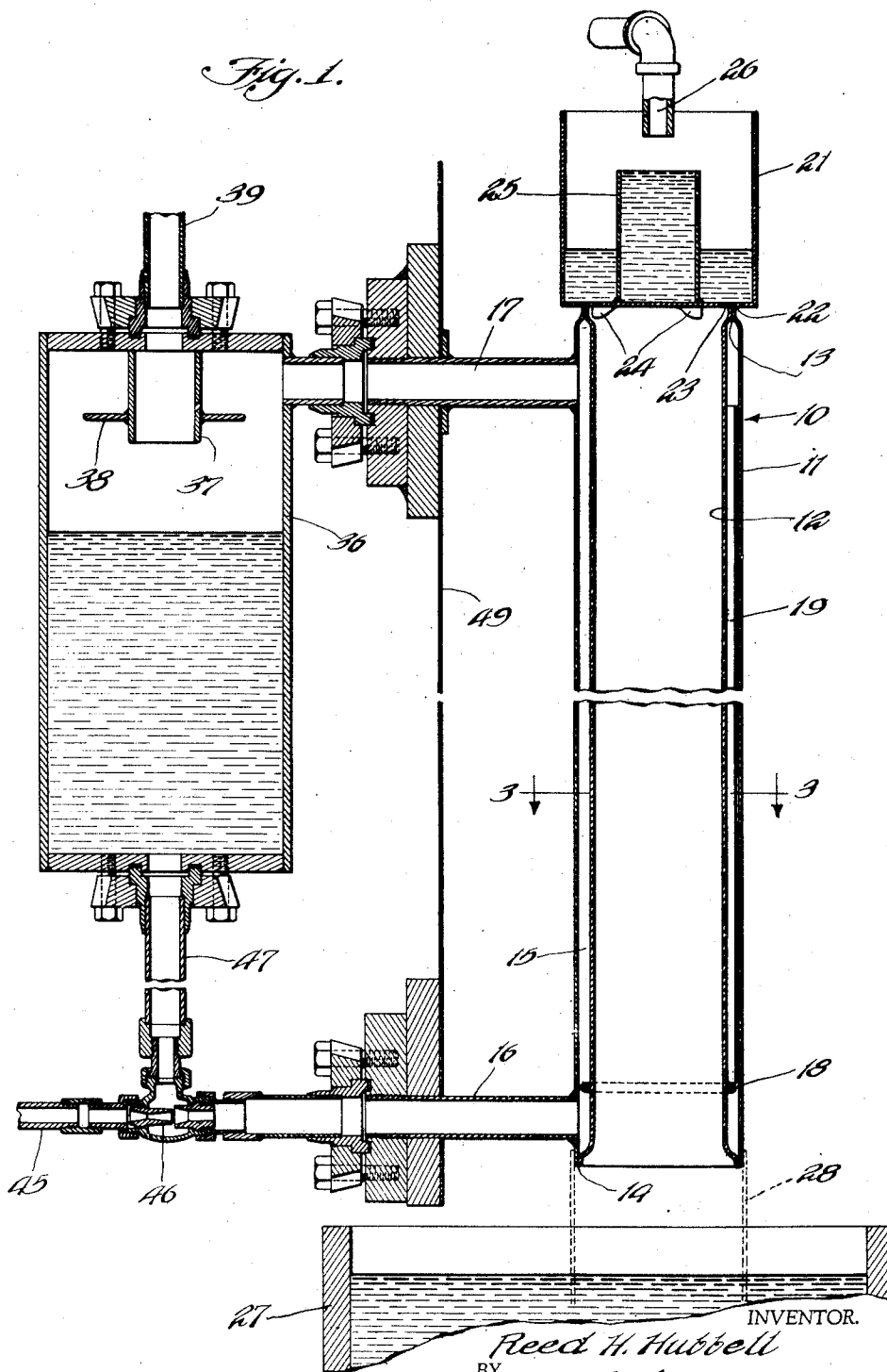
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2,301,546

LIQUID REFRIGERATOR

Filed Aug. 3, 1940

3 Sheets-Sheet 1



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Fig. 2.

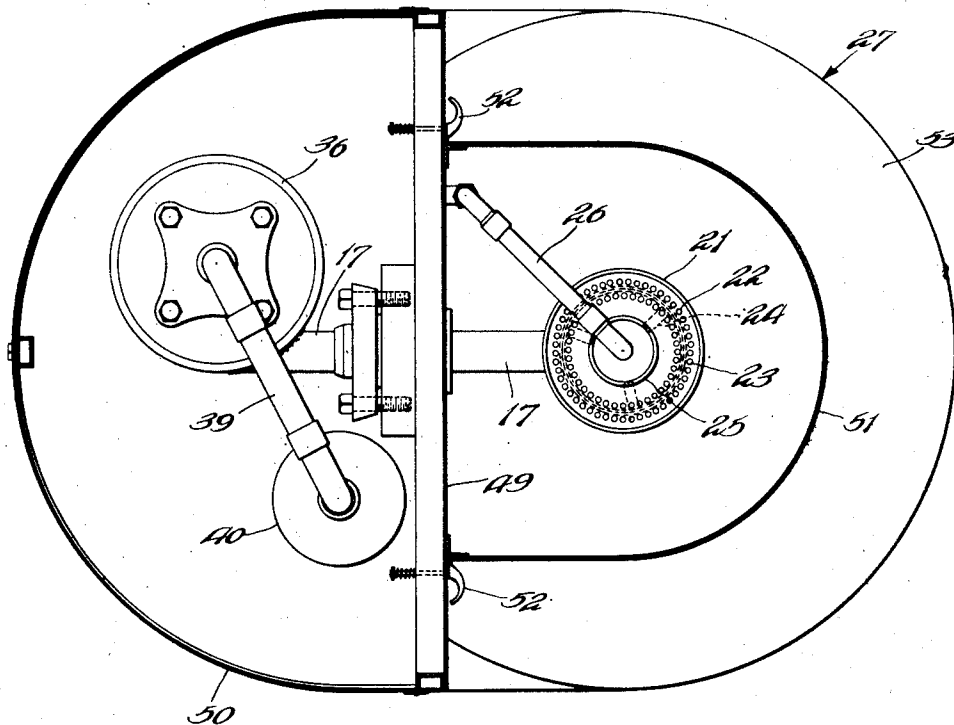
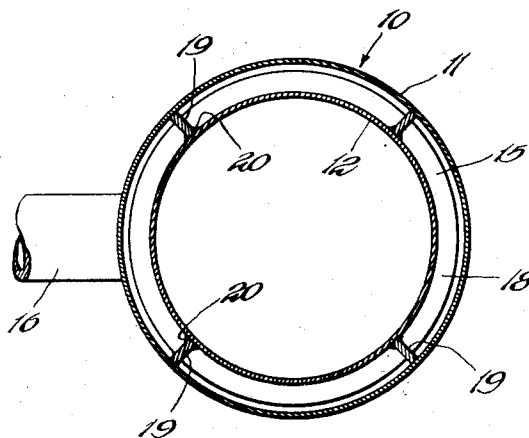


Fig. 3.



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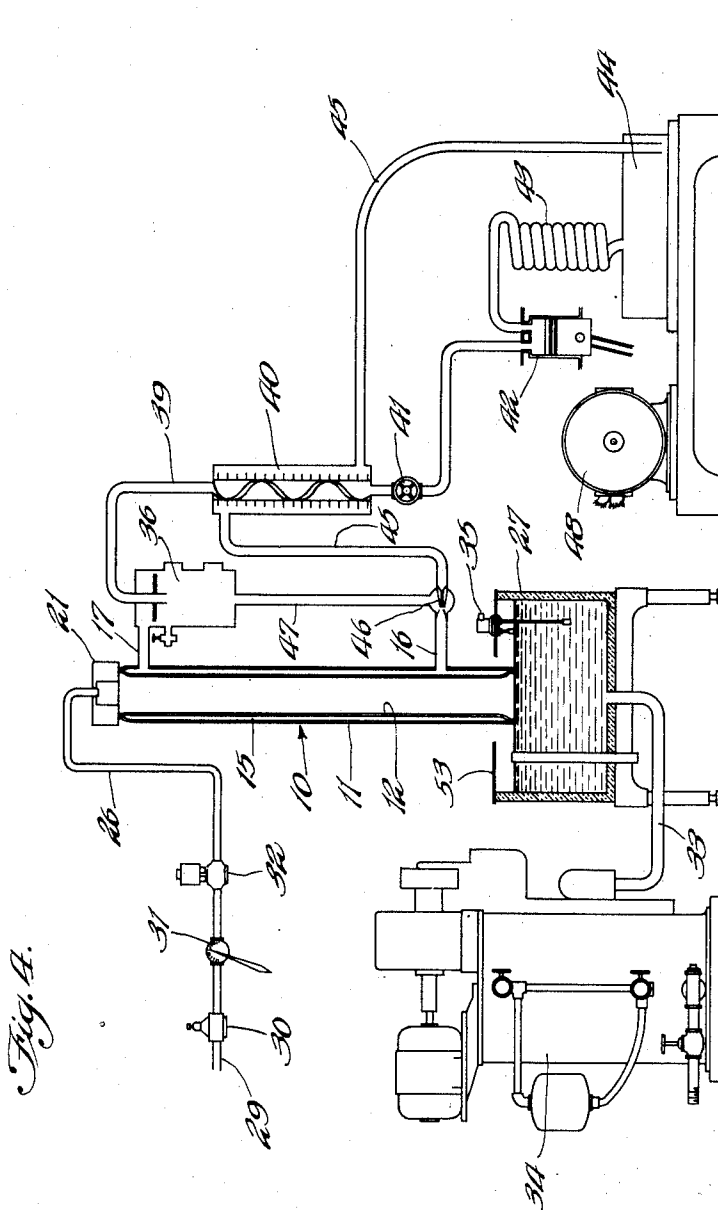
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LIQUID REFRIGERATOR

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3 Sheets-Sheet 3



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LIQUID REFRIGERATOR

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Application August 3, 1940, Serial No. 350,774

12 Claims. (Cl. 62-141)

My invention relates to liquid refrigerators, and more especially to liquid refrigerators of the type where the liquid to be cooled runs over the surface of a hollow (double-walled) evaporator of a refrigerating system.

My liquid refrigerator is disclosed herein as applied specifically to cooling the water for a carbonator, but I contemplate that it may cool water for other purposes and that it may cool other liquids than water, such as for example milk.

Among the objects of my invention are the following: A refrigerator which has a large cooling capacity in proportion to the area of the surface over which the water runs; uniformity of heat absorption over the surface; a large cooling capacity in proportion to floor area occupied and without such height as to interfere with the installation of a unit in which the refrigerator is incorporated, beneath ordinary ceiling height; ease of cleaning; and general simplicity and economy.

Further objects, features and advantages of my invention are set forth in the following description of specific embodiments thereof and illustrated in the accompanying drawings, wherein:

Fig. 1 is a vertical section of a device embodying my invention;

Fig. 2 is a top plan view of the device showing certain associated structure in section;

Fig. 3 is a plan section taken on the line 3-3 of Fig. 1; and

Fig. 4 is a diagram of the refrigerator and its refrigerating system and a carbonator feeding therefrom.

Referring to Fig. 1, my liquid cooling evaporator 10 is in the form of a double-walled tubular shell. It consists of an outer tube 11 and an inner tube 12. At its upper end, the outer tube 11 is swaged or spun inwardly and, at its upper end, the inner tube 12 is swaged or spun outwardly. The ends of the two tubes thus have mating cylindrical surfaces at their upper ends which are in surface contact and are welded together in fluid-tight connection at 13. The double thickness upper end of the evaporator 11 is centered halfway between the bodies of the tubes 11 and 12, giving, in radial section, a symmetrical form.

The inner and outer tubes are joined together at their bottom ends at 14 in a similar manner, except that for manufacturing economy all of the swaging or spinning is done on the inner tube 12. The refrigerant, which may be Freon, is fed into the annular hollow space 15 between the tubes 11 and 12 adjacent their bottoms by an inlet pipe 16 welded to the outer tube, and is led from the hollow space 15 of the evaporator by

an outlet pipe 17 welded to the outer tube near its upper end.

If the annular refrigerant space 15 were entirely open and unobstructed, there would be a tendency for the refrigerant forced in through the inlet pipe 16 to follow the shortest path to the outlet pipe 17, leaving relatively stagnant regions. To avoid this, I annularly restrict the bottom of the space 15, just above the inlet pipe 16, by a ring 18. This may be a rod formed into an annulus, the rod being of a diameter considerably less than the spacing of the outer and inner tubes 11 and 12. The constriction afforded by the rod 18 causes the pressure therebelow to be enough greater than the pressure thereabove to insure a fairly uniform distribution of the up-flow of refrigerant past the rod 18 at all arcuate regions.

Uniform distribution of the flow of refrigerant through the space 15 is further implemented by a set of arcuately spaced partitioning strips 19 disposed between the inner and outer tubes. These can be arranged as parallel spirals if it is desired to retard the vertical speed of flow of the refrigerant through the space 15. In the form illustrated, because I prefer not to retard the flow, the strips 19 are arranged vertically. They may be welded, as at 20, to the exterior of the inner tube 12 before the inner tube is inserted into the outer tube and welded thereto. The fact that the lower end of the outer tube 11 is not swaged or spun inwardly permits the inner tube 11, with the strips 19 welded or brazed thereto, to be inserted through the lower end of the outer tube 11. Thus, the top and bottom swaging of the tubes may be done before they are assembled.

The partitioning strips 19 extend from the ring 18 to the height of the underside of the outlet pipe 17.

A feed trough 21 sets on the upper end of the evaporator 10. The feed trough 21 is in the form of a cup having outer and inner concentric circular rows of holes 22 and 23 in its bottom. The circle of holes 23 are arranged on such a diameter that they come just inwardly of the top edge of the evaporator while the outer holes 22 come just outwardly thereof. The cup may be centered by positioning ears 24 depending from the bottom of the cup and fitting against the inner margin of the top of the evaporator.

A tubular feed well 25 rises centrally from the bottom of the feed trough. Water to be cooled drops from a centrally positioned feed pipe 26 into the well 25, and overflows the well into the annular trough which surrounds the well. In this

way the splashing of water passing down from the feed pipe 26 is not transmitted to the water level in the annular trough. The water passes out from the bottom of the trough through the holes 22 and 23. That passing through the holes 23 passes down the inside surface of the inner tube 12. That passing through the holes 22 passes down over the outer surface of the outer tube 11. The swaging or spinning of the inner and outer tubes adjacent their upper margins forms rounded shoulders immediately beneath the respective rows of holes 23 and 22, so that the water passing through the holes cannot fall clear of the surfaces of the tubes. These rounded shoulders also tend somewhat to equalize—annularly—the flow of water over the tubes.

The evaporator 10 may conveniently be from five to ten inches in diameter and some five feet high. The water flowing down over the surfaces of the evaporator clings to the metal walls as a film, rather than falling free thereof, despite the speed which the water achieves by the time it reaches the bottom of the evaporator. When the water passes off the bottom of the evaporator, it falls into an insulated receiver 27. Splashing of the water dropping from the bottom of the evaporator may be eliminated by an extension tube 28 in the form of a split cylinder removably surrounding the bottom of the evaporator and extending down substantially to the bottom of the receiver 27. The water will then follow the surfaces of the extension tube.

Referring now to the rather diagrammatic circuit of Fig. 4, the water supply pipe 29 leads through a pressure regulator 30, to assure a constant pressure for the water passing through the adjustable feed valve 31. Thence through a solenoid cutoff valve 32, the water continues to the feed pipe 26. From the receiver 27, water is removed from time to time and taken in through a pipe 33 to a carbonator 34 through an electrical circuit, not shown but well known. A liquid contact switch 35 controls the opening and closing of the solenoid valve 32. When the liquid level reaches the upper contact of the switch 35, the feed valve 32 is closed; when it drops down below the lower electrode, the feed valve 32 is opened. Thus, an adequate supply of cold water is maintained at the receiver 27 to meet the intermittent requirements of the carbonator 34, but the water cooler operates intermittently. The vertical space between the upper and lower contacts of the switch 35 represents a large enough volume of water so that the intermittent operation of the cooler will not involve frequent operations of the cooler for short periods.

Still referring to Fig. 4, I shall now describe the refrigerant cycle. The outlet or suction pipe 17 for the evaporator 10 leads tangentially (see Fig. 2) into a drum-shaped accumulator 36. This gives the returns a swirling motion to aid, by centrifugal force, the separation of the refrigerant gas from the still liquid refrigerant. The refrigerant gas is sucked out of the accumulator 36 through a depending tubular exhaust port 37 (Fig. 1), the baffling out of the liquid being improved by an annular horizontal flange 38 near the bottom of the tubular port.

From the exhaust port 37, the gas passes through a suction line 39, which in turn goes through a heat interchanger 40, and through a back pressure regulator 41 to the suction side of a compressor 42. From the pressure side of the compressor, the refrigerant goes through a condenser 43 to a liquid refrigerant receiver 44.

From the receiver 44, the liquid refrigerant passes through a pressure line 45, the heat interchanger 40, and through an injector nozzle 46 into the inlet pipe 16.

A down pipe 47 also leads to the inlet pipe 16 by way of the injector nozzle 46. By means of the injector nozzle, liquid refrigerant left in the accumulator 36 is caused—despite its low pressure—to recirculate through the evaporator. In fact, I prefer that by and large the greater portion of gas returned through the outlet pipe 17 be still in liquid form and recirculated without going back through the compressor. In this way, the space 15 in the evaporator is more nearly completely filled by liquid refrigerant which offers much greater heat absorption than refrigerant gas. Thereby the capacity of the evaporator is kept much higher in proportion to its surface over which the water travels.

The circuit of the motor 48 may be in parallel with the circuit of the solenoid water feed valve 32 so that, when the water in the receiver reaches its upper lever, and the solenoid circuit is broken to allow the feed valve to close, the circuit of the motor 48 is also closed. And, conversely, when the liquid in the receiver reaches its lower level and the circuit of the solenoid valve is closed to open the valve, the motor circuit is closed to operate the compressor.

As shown in Figs. 1 and 2, the evaporator is partitioned from the accumulator 36 by a vertical wall 49, through which the inlet and outlet pipes 16 and 17 pass. A semicircular removably mounted rear shell 50 may enclose the back side of the wall 49, the accumulator 36, heat interchanger 40, and incidental fittings. The evaporator and feed trough may be enclosed by a front semi-cylindrical shell 51 detachably mounted to the front side of the wall by clamps 52. At its bottom, the front shell 51 may carry, or rest upon, a horizontal apron 53 which covers the top of the receiver 27. This aids sanitation by keeping dust and dirt out of the water being cooled. When the shell and apron are removed for cleaning the trough, evaporator and receiver, the wall 49 forms a readily clean partition which keeps any dirt from the more difficultly cleaned parts on the back side of the wall getting on to the evaporator or into the receiver.

The inner and outer tubes 11 and 12 of my evaporator may be made of stainless steel, but in the interest of greater conductivity, I prefer to make them from copper tubes with their exposed surfaces chromium plated to prevent corrosion but dull finished to facilitate heat transfer. The exposed surfaces of the evaporator present a minimum of hard-to-clean pockets, ridges or the like, such as are often encountered in corrugated coolers. The interior of the evaporator, being of a few inches in diameter, is large enough to permit its being cleaned, although a hot liquid wash will ordinarily suffice without the use of a brush. The feed trough 21 merely rests upon the upper edge of the evaporator but is unattached to the evaporator or to the feed pipe 26 so that the trough 21 may readily be taken out for easy cleaning. Because the refrigerant is fed into the bottom and travels upwardly, it is coldest near the bottom where the water, which becomes colder as it passes downwardly, encounters the coldest refrigerant at the end of its travel. This makes possible the maximum reduction of the water temperature in proportion to the temperature of the refrigerant as it is fed into the evaporator.

If the tubes 11 and 12 of my evaporator were annularly corrugated, they would tend to throw off the fast moving water, especially toward the lower end of the evaporator when the water is moving fastest, so that the water would fall clear of the evaporator surfaces instead of clinging to them. Also, the use of corrugated surfaces would, when the water is passing over the under-cut faces of the corrugations, be under less pressure of contact with the surface of the evaporator and the evaporator would not absorb so much heat from the water during those phases. By providing my evaporator with smooth cylindrical vertical surfaces, I preserve a uniform pressure of contact of the water with the surfaces throughout the length of the evaporator. This pressure of contact, it will be understood, comes from the attraction of the water to the surfaces causing the down traveling water to film thereupon. Because of the skin friction of the water, there is a continual eddying of the water providing a circulation as between the outer and inner layers of the water film, and this further accelerates the absorption of heat by the evaporator of all of the water passing over it.

Because of the advisability of keeping the height of the evaporator within limits in the order of five feet so that the cooler unit can be installed beneath any ordinary sealing height, and also to avoid the difficulty of holding a thick water film on the surface of the evaporator when it has gained too much speed, I prefer, in enlarging the capacity of my cooler, not to do so by making it longer but rather by making it of greater diameter to provide more surface. When the capacity required would involve an excessive diameter, a battery of evaporators may be employed, arranged side-by-side, in one cooler unit with the refrigerant inlet and outlet pipes and the water feed pipe appropriately manifolded. It will be seen that my evaporator is peculiarly susceptible of such battery installation in a single unit.

The water, constantly gaining speed from gravity, although held back somewhat by the attraction of the metal surface of the evaporator and skin friction therewith, will be moving very much faster toward the bottom of the evaporator than toward the top. Consequently, the thickness of the water film on the evaporator surfaces will be considerably thicker at the top than at the bottom. It is desirable to have the water film thinner as it approaches the bottom of the evaporator, partly to offset the increased speed with the attendant lessened time interval of contact of the water film with each vertical inch of surface and partly to increase the final transfer of heat. The thinner the film, the more effective is the absorption of heat from all of the water in the film because there is not so much water in outer layers insulated by the inner layer of water in the film.

The elimination of a header on the top of the evaporator eliminates the problem of carrying the water around the header before it is fed on to the heat transfer surfaces of the evaporator. This and the water feed trough combine to produce a high degree of uniform distribution of the water upon the cooling surfaces. The distribution is also rather evenly balanced as between the inner surface and the outer surface of the annular evaporator throughout wide variations of water feed.

The heat transfer capacity of an evaporator

increases as the "refrigerant weight-velocity" increases. By this I mean that heat transfer is increased with an increase in the weight of the refrigerant passing over the heat transfer surface and the velocity with which it travels over the surface. One of the virtues of my liquid cooling evaporator is that it achieves a high degree of refrigerant weight-velocity. The refrigerant passage through the evaporator is a straight streamlined passage free from those turns and pockets which are apt to foster oil pockets, gas pockets, retarding eddies, stagnant regions, and general sluggishness in the refrigerant flow. Throughout substantially all of the height of the refrigerant passage through the evaporator, the walls are equally spaced and the cross-sectional area of the annular space is constant at all heights. This preserves a uniformity of the high velocity with little pressure drop. The cross-sectional annular area of the passage is small enough, in relation to refrigerant fed, to induce a high velocity.

The high velocity fosters greater heat absorption because it brings the liquid refrigerant into more of a scouring contact with the transfer wall. The high velocity also carries off accumulating gas bubbles from evaporation more rapidly so that a higher percentage of the refrigerant may remain in liquid form, a liquid in contact with the transfer surface absorbing heat very much more rapidly than gas in contact with it.

The elimination of a float valve with its flow-retarding effect and the use of the surge drum or accumulator permits a high percentage of the refrigerant removed from the evaporator to be removed in the form of a liquid and recirculated along with liquid coming from the condenser. This permits the refrigerant in the evaporator to be maintained much more "solidly" as liquid.

When I mention the advantages of the inner and outer tubes of my evaporator being cylindrical and uncorrugated, I am referring to the absence of horizontal corrugations. The cylindrical tubes might be concentrically ovalized, although that would be more expensive to manufacture; and they might be similarly fluted or corrugated vertically to increase the surface without increasing the heights, although I prefer, rather than incurring that expense, to increase the diameter of the evaporator or to use a battery of evaporators.

My evaporator is very easy to clean, has a high capacity in proportion to its size, and its cross-sectional area is very small and compactly arranged so that in designing the other parts of the cooling unit in which the evaporator will be incorporated, the evaporator itself becomes a very minor factor in the floor space which the evaporator must occupy and therefore, in general, a liquid refrigerating unit employing my evaporator may be designed more compactly and occupy less floor space.

Having thus described my invention, what I claim is:

1. A liquid cooler comprising concentrically and vertically disposed inner and outer metal tubes having straight vertical walls and sealed together at top and bottom to form a headerless evaporator with an annular refrigerant space between the tubes substantially co-extensively with the tubes, means for feeding liquefied vaporizing refrigerant into the bottom of the refrigerant space and for exhausting refrigerant from the top, means at the top of the tubes for feeding

a liquid to be cooled on to the outer surface of the outer tube and inner surface of the inner tube to run downwardly under gravity as a film over the surfaces, and means within the refrigerant space for substantially uniformly distributing the upflowing refrigerant through such space.

2. A liquid cooler comprising concentrically and vertically disposed inner and outer metal tubes having straight vertical walls and sealed together at top and bottom to form a headerless evaporator with a refrigerant space between the tubes substantially co-extensively with the tubes, means for feeding liquefied vaporizing refrigerant into the bottom of the refrigerant space and for exhausting refrigerant from the top, means at the top of the tubes for feeding a liquid to be cooled on to the outer surface of the outer tube and the inner surface of the inner tube to run downwardly under gravity as a film over the surfaces, the upper margin of the outer tube being annularly ensmallled and the upper margin of the inner tube being annularly enlarged to bring the tubes into sealing contact at the upper end, and partitions fixed upon the inner tube to lie within the refrigerant space between the tubes, the lower margin of the inner tube being annularly enlarged beyond the circumscribing diameter of the partitions into sealing contact with the outer tube.

3. A liquid cooler comprising concentrically and vertically disposed inner and outer metal tubes having straight vertical walls and sealed together at top and bottom to form a headerless evaporator with a refrigerant passage between the tubes substantially co-extensively with the tubes, means for feeding liquefied vaporizing refrigerant into the bottom of the passage and for exhausting refrigerant from the top, means at the top of the tubes for feeding a liquid to be cooled on to the outer surface of the outer tube and the inner surface of the inner tube to run downwardly under gravity as a film over the surfaces, and arcuately and parallelly spaced strips extending upwardly through the passage to partition the passage into parallel subpassages, for the purpose described.

4. A liquid cooler comprising concentrically and vertically disposed inner and outer metal tubes having straight vertical walls and sealed together at top and bottom to form a headerless evaporator with a refrigerant passage between the tubes substantially co-extensively with the tubes, means for feeding liquefied vaporizing refrigerant into the bottom of the passage and for exhausting refrigerant from the top, means at the top of the tubes for feeding a liquid to be cooled on to the outer surface of the outer tube and the inner surface of the inner tube to run downwardly under gravity as a film over the surfaces, arcuately and parallelly spaced strips extending upwardly through the passage to partition it into subpassages, and a ring interposed between the tubes above the refrigerant feeding means but below the strips, for the purpose described.

5. A liquid cooler comprising concentrically and vertically disposed inner and outer metal tubes having straight vertical walls and sealed together at top and bottom to form a headerless evaporator with an annular refrigerant space between the tubes substantially co-extensively with the tubes, means for feeding liquefied vaporizing refrigerant into the bottom of the refrigerant space and for exhausting refrigerant from the

top, means at the top of the tubes for feeding a liquid to be cooled on to the outer surface of the outer tube and the inner surface of the inner tube to run downwardly under gravity as a film over the surfaces, a receiver located beneath the evaporator, and an extension sleeve substantially aligned annularly with the evaporator and extending downwardly from the lower end thereof into the receiver to receive and guide the films of water when they leave the surfaces of the evaporator.

6. A liquid cooler comprising concentrically and vertically disposed inner and outer metal tubes having straight vertical walls and sealed together at top and bottom to form a headerless evaporator with a refrigerant space between the tubes substantially co-extensively with the tubes, means for feeding liquefied vaporizing refrigerant into the bottom of the refrigerant space and for exhausting refrigerant from the top, and means at the top of the tubes for feeding a liquid to be cooled on to the outer surface of the outer tube and the inner surface of the inner tube to run downwardly under gravity as a film over the surfaces, said refrigerant feeding and exhausting means including an accumulator placed within the height of the evaporator for receiving and separating refrigerant liquid and gas from the upper end of the evaporator and also including a passage for recirculating the liquid refrigerant from the accumulator into the bottom of the evaporator.

7. A liquid cooler comprising, in combination, a headerless cooling device including inner and outer vertically extending and substantially co-extensive tubular metal wall members sealed together at the top and bottom of the device and spaced apart throughout their major extent to define a vertical passage for a heat abstracting medium, means for introducing a heat abstracting medium into the bottom portion of the vertical passage and for exhausting said medium from the top portion of the passage, means at the top of the cooling device for feeding a liquid to be cooled as substantially completely covering downwardly flowing films on to those respective surfaces of said wall members which are exterior to said passage, and means constructed and arranged within said passage for uniformly distributing the heat abstracting medium for upward flow therein to sweep the passage surfaces of the wall members.

8. A liquid cooler according to claim 7, wherein the distributing means comprises structure effective adjacent to the medium introducing means at the bottom portion of the passage to restrict and uniformly distribute the heat abstracting medium for upward flow.

9. A liquid cooler according to claim 7, wherein the distributing means comprises structure effective to equalize upward flow of the heat abstracting medium from the medium introducing means throughout the passage, and also structure which divides the passage into separated vertical subpassages for preventing deflection of the upflowing medium from the distributed condition before the medium has risen high enough in the passage to be exhausted.

10. A liquid cooler as set forth in claim 7, in which the distributing means is carried by one of said tubular wall members, and the members are constructed and arranged to be assembled by a relative longitudinal assembly movement.

11. A liquid cooler comprising, in combination, a device for cooling liquid by external contact

with the liquid flowing vertically as a film there-
over and including a pair of vertical metal tubes
of substantially different diameters and arranged
one substantially co-extensive within the other to
provide a flow passage therebetween for heat ab- 5
stracting medium, and means on one of said tubes
constructed and arranged to distribute the heat
abstracting medium in uniform flow through said
passage, said tubes having opposite end portions
joined together in abutment and sealed, with the 10
end portion of the tube carrying said distributing
means deformed to accommodate the distributing
means and the remaining tube having its com-
plementary end straight so as to receive the tube
carrying the distributing means with a relative 15
longitudinal movement in the assembly of the
tubes, said deformed end abutting said straight
end and being sealed thereto.

12. In combination, in a liquid cooler, substan-
tially co-extensive upright heat transfer walls
spaced apart throughout their major areas to de-
fine a vertical flow passage of substantial height
and of a cross-section narrow in one horizontal
direction but of substantially greater extent in
the transverse horizontal direction, the interior
of said passage being arranged for vertical flow
of heat abstracting medium from the bottom to-
ward the top thereof, means for feeding the liquid
to be cooled in downward flowing films substan-
tially covering the respective surfaces of said
walls exterior to said passage, and means con-
structed and arranged to substantially uniformly
distribute the heat abstracting medium for up-
ward flow within the passage.

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