

Oct. 13, 1931.

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1,826,791

LIQUID COOLING APPARATUS

Filed March 5, 1929.

3 Sheets-Sheet 1

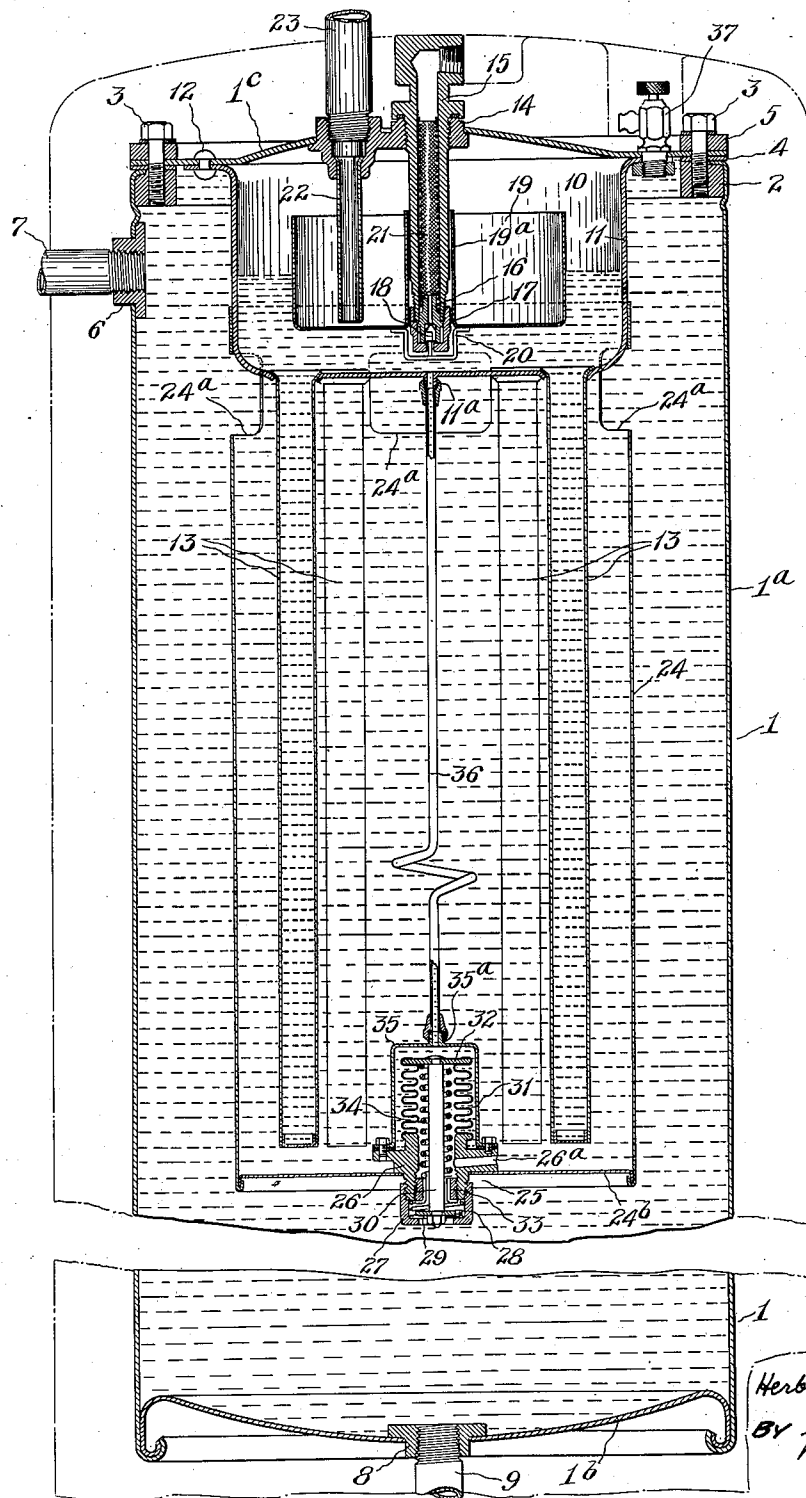


FIG. 1

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3 Sheets-Sheet 2

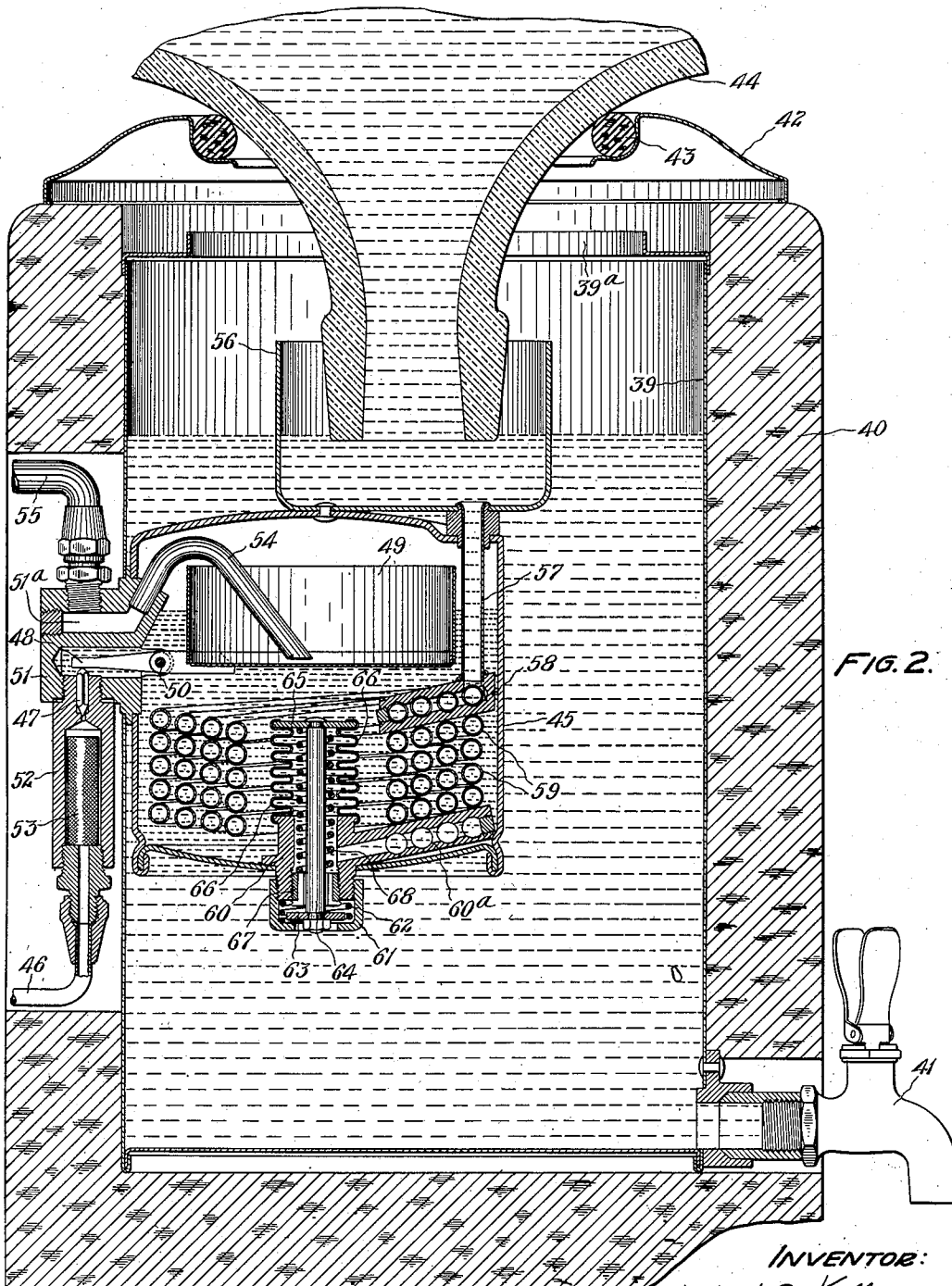


FIG. 2.

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3 Sheets-Sheet 3

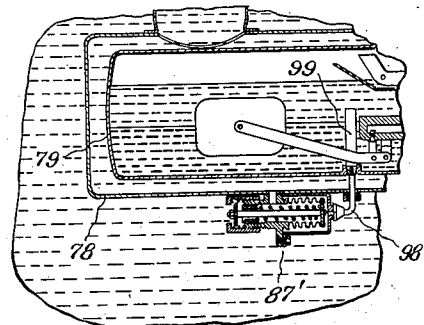
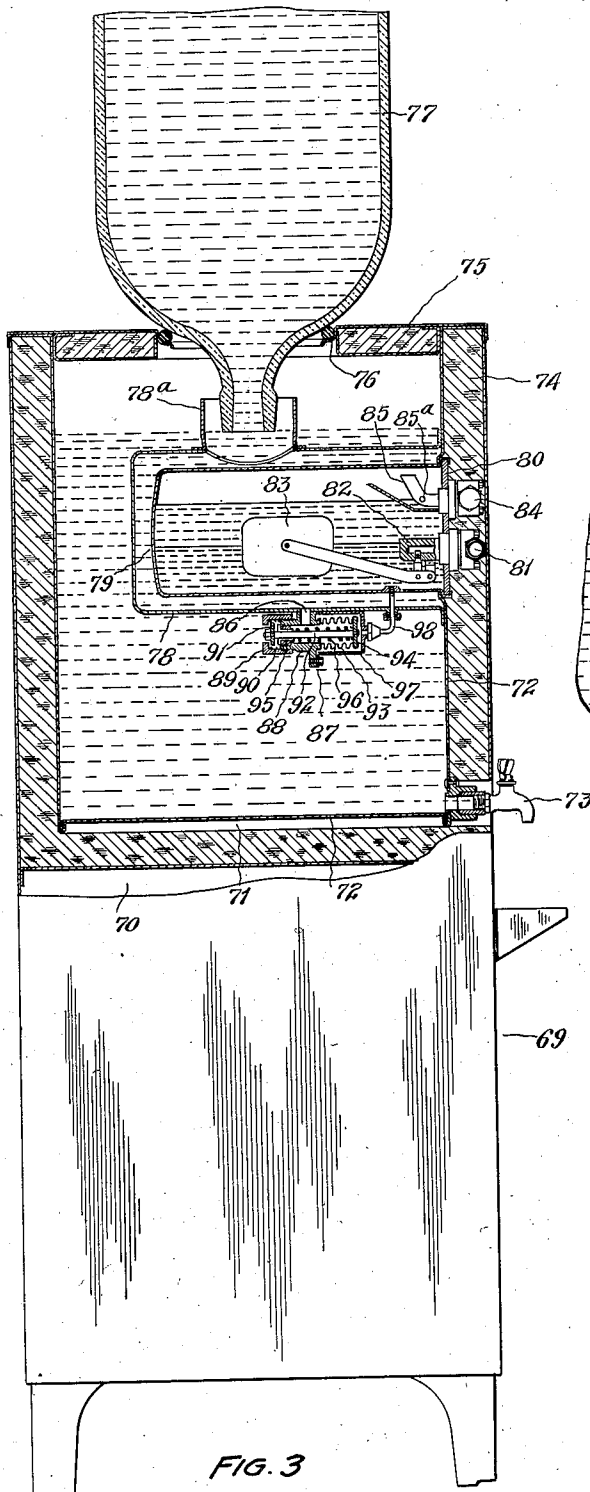


FIG. 4

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LIQUID COOLING APPARATUS

Application filed March 5, 1929. Serial No. 344,497.

This invention relates to liquid cooling apparatus such, for example, as is suitable for cooling drinking water.

The general object of the invention is to insure the close regulation of the temperature of the cooled liquid. More specifically, a further object of the invention is the provision of liquid cooling apparatus in which the cooling is effected by the evaporation of a liquid refrigerant and which has automatic means responsive to the temperature of the refrigerant in the evaporator for controlling the rate of discharge of the liquid to be cooled from the cooling surfaces through which heat is abstracted from the liquid by the refrigerant.

A further object is the provision in a liquid cooler of the type comprising a refrigerant evaporator with surfaces through which heat is abstracted from the liquid to be cooled and a storage chamber in which the cooled liquid is received and held subject to draft, of automatic means for controlling the rate at which the cooled liquid is discharged from the cooling surfaces of the evaporator into the storage chamber, thereby facilitating the close regulation of the temperature of the liquid in the said chamber.

Other objects of the invention will be apparent from the following description in which some of the preferred embodiments of the invention are set forth in connection with the accompanying drawings.

Fig. 1 of the drawings is a vertical axial sectional view, partly broken away, of a water cooler embodying my improvements, the construction being adapted to coolers of large storage capacity and being intended for connection to the mains of a water supply system.

Fig. 2 is a vertical sectional view of the main parts of a water cooler of the inverted bottle type, showing another application of my improvement.

Fig. 3 is a view, partly in vertical section and partly in side elevation, of an inverted bottle type of water cooler of modified construction.

Fig. 4 is a fragmentary vertical sectional

view illustrating a modification of the cooler shown in Fig. 3.

Referring in detail to the constructions illustrated and first to that shown in Fig. 1, 1 designates as an entirety a tank or casing which is designed to serve both as a reservoir for cooled liquid and as an enclosure for the liquid cooling apparatus. For convenience I will refer to the casing as a reservoir. It comprises a cylindrical side wall 1^a of sheet metal, a bottom wall 1^b permanently secured in the side wall and a removable top wall 1^c. The side wall has a heavy metal ring 2 permanently secured in its upper end and this ring serves to receive tap screws 3 which secure the top wall section 1^c. A suitable packing ring 4 is interposed between the side wall and top wall of the reservoir and a stiffening ring 5 is preferably applied to the top wall so that the tightening of the screws 3 will insure a tight joint between the top and side walls. Near the top of the reservoir it has a fitting 6 to receive the end of a pipe section 7 through which water or other liquid to be cooled may be introduced into the reservoir. The bottom wall 1^b of the reservoir is provided with a similar pipe fitting 8 to receive a discharge pipe 9 through which cooled liquid may be drawn from the reservoir. The reservoir may be considerably elongated to give it desired storage capacity, as is indicated in Fig. 1 by the breaking away of a portion of the structure.

The means for cooling the liquid introduced into the reservoir is in the form of an evaporator which is designated in its entirety by the numeral 10. This evaporator comprises a cylindrical cup-shaped casing 11, the upper edge of which is hermetically secured, as by rivets 12 and soldering or brazing, to the under side of the removable wall section 1^c so that the latter forms the top wall of the evaporator chamber. The bottom of the evaporator casing 11 is formed with a circular series of openings in which are hermetically secured the open ends of straight depending tubes 13, the lower ends of which are hermetically closed. The top wall section 1^c of the reservoir is provided with a fitting 14 which has a threaded opening to receive a tu-

bular fitting 15 which serves as an inlet for liquid refrigerant. In the lower end of the fitting 15 is a valve seat member 16 secured in position by a cap 17 which is threaded to the lower end of the fitting 15. 18 is a needle valve which cooperates with a seat on the fitting 16 and is actuated by an open-topped cup-shaped float 19 having a strap 20 on its lower side to engage the stem of the valve 18 and lift the valve against its seat. The float has a central opening formed by a tube 19^a which surrounds and is guided by the fitting 15. 21 is a tubular gauze filter or screen carried by the valve seat member 16.

The fitting 14 has a second opening in which is secured a tube 22 which depends within the cup-shaped float and has its open end near the bottom of the cup. The second opening in the fitting 14 is also threaded to receive a discharge tube 23. The fitting 15 is intended to be connected to the condenser of a refrigerant compressor and the tube 23 may lead to the suction or inlet side of such compressor. To insure a uniform cooling, or close temperature regulation of the cooled liquid, a depending cylindrical casing 24 is secured to the lower part of the casing 11 of the evaporator. The casing 24 is formed at its upper end with a series of openings 24^a through which water or other liquid to be cooled may flow from the space surrounding the casing 24 to the interior thereof. The bottom wall 24^b of the casing 24 has a passage to permit discharge of cooled liquid from the interior of the casing 24 to the space outside of it and automatic means is provided to control the flow of liquid through this latter passage.

The means last referred to is designated as an entirety by the numeral 25 and comprises a tubular casing member 26 which is secured in an opening in the bottom wall 24^b. A valve seat member in the form of an apertured cap 27 is adjustably threaded on the lower end of the casing member 26, the tension of a spring 28 serving to secure the seat member in adjusted position. Between the seat member 27 and the lower end of the casing member 26 is disposed a valve 29 which is carried on the lower end of a stem 30 which in turn is supported by a metallic bellows device 31, the upper end of which is hermetically secured to a disk 32 to which the upper end of the stem 30 is riveted, while the lower end of the bellows member is hermetically secured to the upper part of the valve casing 26. An interiorly slotted sleeve 33 is threaded into the lower end of the casing member 26 and serves as a guide for the lower end of the valve stem 30. It also serves as the lower adjustable abutment of a coil spring 34 which surrounds the valve stem 30 and has the disk 32 as its upper abutment. The main bore of the casing member 26 communicates through a lateral passage

26^a with the space inside the casing 24. The metallic bellows 31 is hermetically enclosed by an inverted cup-shaped casing 35 secured to a flange extension of the casing 26. This casing 35 has a nipple 35^a at its upper end which is connected by a flexible metal tube 36 with the interior of the evaporator. As shown the tube 36 leads upward and connects with a nipple 11^a formed in the bottom wall of the evaporator casing 11, but the tube 36 might instead be connected to the interior of the evaporator through any part of the wall thereof.

The top wall 1^c of the reservoir is fitted with a manual air valve 37 to facilitate the initial filling of the reservoir and the complete emptying or draining thereof. Ordinarily the entire reservoir should be enclosed in a casing of heat-insulating material as indicated by broken lines.

The operation of the device will be readily understood in the light of the above description. For purposes of illustration it may be assumed that the apparatus is to be used for the cooling of drinking water. The pipe 7 will be connected with any suitable source of water supply and the pipe 9 with one or more draught faucets. The evaporator of the apparatus will be connected with any suitable refrigerant compressor and condenser mechanism, the inlet fitting 15 of the evaporator being connected with the discharge of the condenser while the outlet pipe 23 is connected with the inlet or suction passage of the compressor. The compressor will be provided with the usual automatic switch for controlling the operation of the compressor motor. For example, the switch may be actuated by means of the pressure in the low side of the refrigerant system and the switch may be set to close when the pressure rises to a point corresponding to a given temperature of the refrigerant in the evaporator and to open when the pressure falls to a point corresponding to a given lower temperature of the refrigerant in the evaporator, such a form of control apparatus and such operation thereof being well known in the art.

In initially starting the operation of the apparatus, the air valve 37 will be opened when water is admitted to the reservoir 1 through the pipe 7 until the reservoir is filled, thus insuring a complete filling of the reservoir.

The relatively warm water admitted to the reservoir, coming in contact with the walls of the evaporator, gives up its heat to the latter and these walls in turn transmit the heat to the liquid refrigerant in the evaporator with resultant gasification and expansion of the refrigerant. This latter action causes increase of pressure in the evaporator and throughout the low side of the refrigerant system and as soon as the pressure

rises to the predetermined point the compressor is started and its operation reduces the pressure in the evaporator and permits continued evaporation therein and resultant cooling of the water surrounding the evaporator. This continues until the temperature of the water and likewise of the refrigerant in the evaporator is reduced to a point corresponding to the cut-out pressure, whereupon the compressor is stopped. As refrigerant is gasified and withdrawn from the evaporator the liquid level of the refrigerant in the evaporator falls and the resultant lowering of the float 19 permits the valve 18 to open and admit liquid refrigerant from the condenser so that the volume of liquid refrigerant is maintained substantially constant. As in the case of most systems of this character, more or less lubricating oil is dissolved in the refrigerant that enters the evaporator and as the refrigerant is evaporated the oil tends to accumulate in the evaporator. In the construction illustrated this is prevented because when the liquid refrigerant boils its level rises and the gasified refrigerant escaping from the liquid causes a foaming of the oil floating at the top with the result that the foam flows over into the cavity of the float 19 and from there is drawn out through the tube 22 and the pipe 23 by the suction of the compressor, thus being returned to the compressor for lubrication of the latter. I will not here describe the operation of the particular evaporator shown in further detail because the present invention is not limited to the specific form of evaporator shown and for the further reason that the type of evaporator shown forms the subject of my copending application Serial No. 330,838, filed January 7, 1929, in which the operation is set forth in complete detail.

The water within the casing 24 is the first to be cooled as the major part of the cooling surfaces of the evaporator is within said casing, and the water within the casing 24, being cooler than that outside of it, tends to flow out at the bottom of the casing 24 through the control device 25, while warmer water from the space surrounding the casing 24 flows into the latter through the openings 24^a at the top thereof. The rate at which this convection circulation takes place is controlled by the position of the valve 29 of the control device 25, and this in turn is determined by the pressure within the casing 35 to which the bellows 31 is subjected. In turn this pressure is determined by the temperature of the refrigerant in the evaporator.

As has been explained the sleeve 33 can be adjusted to vary the tension of the spring 34 which is opposed to the refrigerant pressure on the outside of the bellows 31 and in this manner the pressure in the evaporator can be made to hold the valve 29 closed as long as the temperature of the refrigerant in the evaporator is above a given value and to permit the valve 29 to be opened more or less by the spring 34 when the temperature of the refrigerant falls below that point. Thus, for example, if the automatic control of the compressor is set to maintain the temperature of the liquid refrigerant within the range of 47 to 53 degrees Fahrenheit for the purpose of providing drinking water of an average temperature of 50°, the tension of the spring 34 of the control device 25 would be set so that the valve 29 would be held shut while the refrigerant pressure was above that corresponding to a temperature of 53°, and would be permitted to start to open when the refrigerant pressure falls below that point. When a substantial body of relatively warm water surrounds the evaporator in contact with the walls thereof, as when the reservoir is first filled or when there has been a very substantial draught of cooled water from the reservoir with resultant admission of a corresponding volume of warm water into the top of the reservoir, the rapid initial evaporation in the evaporator and the resultant increase in pressure therein causes the closing of the water control valve 29 in the manner described. Then when the compressor is started as a result of the increase of pressure in the evaporator, the said pressure is rapidly reduced with the result that the water control valve 29 begins to open and moves to a more or less widely open position such that the rate of transfer of heat from the water around the evaporator to the refrigerant therein corresponds to the maximum capacity of the compressor working within the temperature range for which the motor switch is set; and the said valve remains in this position until the water in the upper part of the reservoir is cooled to such a degree as to reduce the rate of heat transfer, whereupon the operation of the compressor causes a relatively rapid lowering of the pressure in the low side of the system which in turn results in the stopping of the compressor.

The water valve 29 thus serves automatically to effect a balance between the heat transfer from water to refrigerant and the capacity of the compressor of the system so that the rate of heat transfer is not permitted to exceed the capacity of the compressor with the result that the water or other liquid being cooled is always lowered to the desired temperature before it is discharged from contact with the cooling surfaces. In other words, in the construction shown in Fig. 1 it is insured that the cooled water which is discharged from the cooling surfaces past the control valve 29 and permitted to fall by convection circulation into the lower part of the reservoir 1, has first attained a temperature within a predetermined range of, say, six degrees which it is desired to maintain

for the water to be consumed. Since water for consumption is drawn from the bottom of the reservoir 1, only water that has been cooled to the desired temperature will be drawn. With a wall of suitable heat insulating material around the reservoir 1, as indicated by the broken line 1^a, the reservoir, if made of sufficient height, will hold a relatively large volume of cooled water subject to draught. In this connection it will be understood that in case of long intervals during which water is not drawn from the reservoir, any substantial rise of the temperature of the water in the lower part of the reservoir will result in convection circulation of the warmer liquid to the top of the reservoir where it raises the temperature of the evaporation and causes starting and operation of the compressor with resultant circulation of the warm water into the casing 24 where it is again cooled and discharged past the valve 29 in the manner previously described whence it enters within the casing 24 into contact with the evaporator to be reduced in temperature and again discharged from the casing 24 into the lower part of the reservoir. The construction and operation are such that warm water entering the reservoir 1 through the pipe 7 does not mingle with the cooled water in the lower part of the reservoir, and in the manner explained the water in the lower part of the the reservoir is maintained within the desired low temperature range.

In Fig. 2 I have shown my invention applied to a water cooler of the inverted bottle type. In this form of construction there is a metal wall reservoir or container 39 which is enclosed within walls 40 of suitable lagging or heat insulating material. The reservoir 39 is provided at its lower end with an ordinary draught faucet 41. An annular metallic cover 42 rests upon the top of the structure and is provided with the usual rubber sealing ring 43 for an inverted water bottle 44, the upper wall of the reservoir 39 being formed with a large opening 39^a to receive the depending neck of the bottle.

Within the reservoir is disposed water cooling apparatus through which water discharged from the bottle must pass before it is completely delivered into the reservoir chamber. This cooling apparatus comprises an evaporator shell or casing 45 to which liquid refrigerant is supplied through an inlet tube 46 under the control of a needle valve 47 which in turn is actuated by the lever 48 of an open-topped cup-shaped float 49 which is partially immersed in the liquid refrigerant or refrigerant and oil in the casing 45. The float lever is pivoted at 50 on a fitting 51 which is secured in an opening in the side wall of the evaporator casing 45 and also in a similar opening in a side wall of the reservoir 39. The valve 47 is mounted in a casing 52 which also encloses a suitable screen or

filter 53. Gasified refrigerant is discharged from the evaporator through a bent tube 54 which is connected with a passage 51^a in the fitting 51 that in turn communicates with a discharge pipe 55. The inlet end of the tube 54 depends within the float 49 to a point near the bottom thereof. With the refrigerant in the tube 46 connected to a refrigerant condenser and the discharge tube 55 connected to the suction inlet of a compressor which in turn discharges into the said condenser, the float actuated valve 47 serves to maintain liquid refrigerant, or refrigerant and lubricant, at a given level in the evaporator casing 45.

On the top of the evaporator casing 45 is mounted a cup 56 of a size adapted to receive the mouth of the inverted bottle when the bottle is up-ended on the cooler. A tube 57 leads from the bottom of the cup 56 downward through the top wall of the evaporator casing 45 and opens at its lower end into a header 58 to which the upper end of each of a series of concentrically nested coils 59 is connected. The bottom wall of the evaporator casing 45 is formed with an aperture in which is secured a valve fitting 60 having a tubular arm or branch 60^a which serves as a header to which the lower ends of the coils 59 are connected. A valve seat member in the form of an apertured cap 61 is threaded to the lower end of the fitting 60 and is held in adjusted position by the tension of a coil spring 62 interposed between the cap and the fitting. Within the cap 61 is disposed a disk shaped valve 63 which is carried on the lower end of a stem 64. The upper end of the stem 64 carries a circular disk 65 which in turn is hermetically connected to the upper end of the valve fitting 60 by means of a metallic bellows 66. Within the threaded end of the fitting 60 is adjustably mounted a slotted sleeve or thimble 67 which serves to guide the lower end of the valve stem 64 and also serves as an adjustable abutment for the lower end of a coil spring 68 which at its upper end bears against the disk 65. It will thus be seen that the spring 68 tends to lift the valve 63 upward away from its seat formed by the apertured cap 61 while the pressure of the refrigerant in the evaporator acting on the top of the disk 65 tends to press the said valve toward its seat. By adjusting the thimble 67 the tension of the spring 68 can be varied so that the valve will be held to its seat by the pressure of the refrigerant in the evaporator until that pressure falls to a certain value corresponding to a certain temperature of the refrigerant.

Assuming that the refrigerant tubes 46 and 55 are connected with a suitable refrigerant condenser and compressor apparatus and that the operation of the latter is under the control of a suitable thermostatic switch such as that previously described in connection with Fig. 1, and assuming further that

the cooler is being initially placed in operation, when the bottle of water is up-ended on the cooler, water at the outset flows from the bottle into the cup 56, filling the latter up to the mouth of the bottle, and thence flows into the cooling coils 59. It may be assumed for the purpose of illustration that the water in the bottle is approximately at 80° F. and that it is desired to cool it to an approximate temperature of 50° F. To accomplish this the water valve 63 is adjusted to start to open at approximately sixteen pounds pressure in the evaporator and to be in an open position equal or corresponding to the cross-sectional capacity of the cooling tubes at approximately twelve pounds pressure in the evaporator. The water entering the cooling tubes of the evaporator raises the pressure in the latter to the cut-in point of the compressor control switch, say eighteen pounds. As soon as the compressor is started the pressure and temperature in the evaporator are lowered, the pressure below sixteen pounds, which is the point where the water valve starts to open. The water valve now automatically moves to an open position, depending upon the capacity of the compressor, where the amount of heat transferred from the water to the refrigerant balances the compressor capacity. With a compressor of any given capacity and cooling coils of sufficient surface in proportion to this capacity, the water control valve will hold this open position as long as the level of the water in the reservoir 39 is below the level of the water in the cup 56. As soon as the water in the storage reservoir reaches approximately the level of the water in the cup, the flow of water through the cooling tubes is substantially stopped, assuming that water is not at that particular time being drawn from the storage reservoir. This greatly reduces the rate of heat interchange between the water and the refrigerant with resultant lowering of the pressure in the evaporator and the corresponding further opening of the water control valve and in this way the pressure is lowered to the cut-out point of the compressor control switch, which in the case in question would be approximately ten pounds. It will be seen that in this second construction, just as in the first construction, as long as the water is flowing through the cooler the water control valve remains in a certain position corresponding to the refrigerant pressure in the low side of the system and which causes a delivery of water (and heat) corresponding to the capacity of the compressor.

The cooler filled with cooled water will, notwithstanding the insulation permit the water to absorb some heat from the surrounding atmosphere with resultant rise of the pressure in the evaporator. As this pressure rises the water control valve 63 is grad-

ually moved toward its closed position. If the absorption of heat in this manner is sufficient the pressure will finally rise to the point at which the compressor will be started and operated until the temperature of the water in the cooler is lowered to the lower limit of the range within which it is to be maintained.

When water is drawn from the cooler through the faucet 41 the level in the reservoir 39 is lowered outside the cup 56 with the result that more warm water flows into the cooler from the bottle whereupon the operation of the compressor and of the automatic water control valve will follow in accordance with the preceding description, the operation of the compressor and the movement of the control valve varying according to the amount and rate of the draught of water through the faucet 41.

It will be seen that the automatic switch which controls the compressor acts to keep the temperature of the refrigerant in the vaporizer within a predetermined range, which includes the average or approximate temperature to which it is desired to cool the water, and that the automatic water control valve insures that heat shall not be given up from the warm water to the refrigerant at a rate greater than that corresponding to the capacity of the compressor to maintain the said desired temperature range of the refrigerant. In this connection it may be observed that the cooling coils 59 may be designed of such length and capacity that when water is drawn from the faucet at the rate characteristic of average use, the water will be reduced to the desired temperature while it is flowing through the coils 59, and under such conditions the control valve 63 will be constantly open. However, should there be an abnormally large or prolonged draught of water from the reservoir of the cooler, the capacity of the cooling coils may not under such conditions, be sufficient to reduce the temperature of the water to the desired point as rapidly as the water is drawn. With my improved apparatus, when this occurs the temperature of the refrigerant in the evaporator is not maintained at a sufficiently low temperature to effect the desired cooling at the relatively rapid rate and the pressure in the evaporator thereupon rising, closes the valve 63 more or less completely until the discharge of water from the coils 59 is at a sufficiently low rate to permit complete cooling of the water while passing through them. Thus a relatively large reserve of water cooled to a predetermined temperature can be maintained to meet unusually heavy draughts because the automatic means for controlling the discharge from the cooling coils insures that no water above the predetermined range shall be discharged into and mingle with the cooled

water in the reserve so as to modify its temperature.

Referring now to Fig. 3, the water cooler there shown is of the inverted bottle type but the cooling unit differs from that shown in Fig. 2. The apparatus comprises a cabinet designated as an entirety by 69 and having a lower compartment 70 which may be used to house a compressor-condenser unit and, in the upper part of the cabinet a water compartment 71 containing a metal tank 72 provided at its lower front side with the usual draught faucet 73. Suitable insulation 74 is interposed between the tank and the outer wall of the cabinet. The upper end of the water compartment is closed by a cover 75 which is formed of metal and has a core of heat insulating material. The cover 75 is formed with a central aperture which is fitted with the usual rubber ring 76 to provide a seal for the inverted bottle 77. Within the water chamber 71 is a horizontally disposed cylindrical casing 78 which is closed at one end and has its other, open end secured to the front wall of the water tank 72. The upper side of the cylinder 78 is formed with an aperture which is surrounded by an up-standing wall 78^a which has its open upper end arranged and adapted to receive the depending mouth of the bottle 77.

Within the casing 78 and spaced from the walls thereof, as shown, is a cylindrical evaporator which is designated in its entirety by 79. The wall of the evaporator is secured at its front end to the front wall of the water tank and has said front end closed by a plate 80. This plate on its outer side carries a refrigerant inlet fitting 81 which may be connected by a suitable pipe or tube with the condenser of a compressor-condenser unit which is not shown but which, as above noted, may be housed in the lower compartment 70 of the cabinet. The fitting 81 communicates with the passage of a float valve 82 within the evaporator, said valve being operated by a suitable float 83 which is designed to be submerged in refrigerant and oil in the evaporator and by its operation to maintain a body of liquid refrigerant in the evaporator. As shown, the lower part of the float 83 is submerged in the liquid refrigerant, such as sulphur dioxide, while the upper part of the float is submerged in oil which enters the evaporator dissolved in the liquid refrigerant and accumulates in the evaporator. The plate 80 also has a fitting 84 which is adapted to communicate through a tube (not shown) with the inlet or suction port of the compressor. The fitting 84 communicates also with an open-ended outlet tube 85 within the evaporator, the open upper end of the tube being disposed near the top of the evaporator where it is adapted to draw off the gasified refrigerant and permit it to be led back to the compressor. The wall of the tube 85

is provided with a small aperture 85^a through which oil may drain into the return conduit and find its way back to the compressor.

The lower side of the casing 78 is provided with a discharge aperture 86 which communicates with the inlet passage of an automatic thermostatic valve device 87 which is of the same general character as the thermostatic valve 25 in the apparatus shown in Fig. 1. That is to say, it comprises a casing 88 secured to the under side of the casing 78 and having its inlet passage registering with the aperture 86 of the latter casing. A valve seat member 89 is adjustably threaded on one end of the casing 88 and is secured in adjusted position by the tension of the coil spring 90. Between the seat member 89 and the adjacent end of the casing 88 is a valve 91 carried on the end of a stem 92 which in turn is supported by a metallic bellows 93, one end of the bellows being hermetically secured to a disk 94 to which the end of the valve stem is riveted, while the other end of the bellows is hermetically secured to the adjacent part of the valve casing 88. An interiorly slotted sleeve 95 is threaded into the passage of the casing 88 and serves as a guide for the valve stem 92, and also as an adjustable abutment for a coil spring 96 which surrounds the valve stem and has the disk 94 as its other abutment. The metallic bellows 93 is hermetically enclosed by a cup-shape casing 97 which is secured to a flange extension of the casing 88. The interior of the casing 97 is connected by a tube 98 with the interior of the evaporator 79 so that the space in the casing 97 surrounding the bellows 93 is filled with liquid refrigerant subject to the pressure of the refrigerant in the evaporator.

Assuming that the apparatus comprises a motor driven compressor-condenser unit and that the latter is subject to the control of a thermostatic switch of the character previously described in connection with the other forms of the apparatus, the operation of the device is as follows: a bottle of water being up-ended upon the cooler, the water discharged from the bottle flows into the casing 78 and fills the space within said casing surrounding the evaporator 79. The temperature of the entering water being ordinarily above the desired temperature range within which it is desired to cool the water, heat at once begins to flow from the water to the liquid refrigerant in the evaporator with resultant rise of the temperature and pressure therein. This causes the automatic switch to start the compressor which withdraws gasified refrigerant from the evaporator and permits the evaporation of the refrigerant and the cooling of the water to continue. During this time the water valve 91 is closed, the tension of the spring 96 of the water valve being overcome by the pressure of the refrigerant upon the disk 94 of the valve stem. When

the temperature of the liquid refrigerant and of the water within the casing 78 is lowered to a predetermined point, for example the upper limit of the temperature range within which it is desired to cool the water, the pressure of the refrigerant in the evaporator will have correspondingly fallen and this permits the spring 96 to open the water valve 91 and allow water to escape from the casing 78 into the main water tank 72. This in turn will permit more of the warm water to flow from the bottle into the casing 78 and the water control valve 91 will now take a more or less open position such that warm water from the bottle will continue to flow into the casing 78 and into contact with the evaporator 79 at a rate such that the water, before discharge from the casing 78, will attain approximately the temperature of the refrigerant in the evaporator within the predetermined temperature range at which said refrigerant is held by the operation of the compressor. This rate of water flow will depend upon the capacity of the compressor, as will readily be understood from what has been said about the other forms of construction.

The cooler will continue to operate in the manner last described until the level of the water in the reservoir 72 has risen to the level in the cup 78^a. Then the compressor will be stopped with the water control valve 91 in an open position. When, thereafter, the temperature of the water in the cooler rises by absorption of heat from the atmosphere or when draught of water through the faucet causes discharge of more warm water into the cooler from the bottle, the resultant rise of pressure in the evaporator will close the water valve 91 and start the compressor. Then as the operation of the compressor lowers the pressure in the evaporator the valve 91 will move to an open position such as to bring about a balance between the interchange of heat and the capacity of the compressor and the operation of the latter will continue until all of the water in the cooler is at the predetermined temperature desired. Since the water in the tank surrounding the casing 78 is in heat interchange relation through the wall of said tank with the water within the tank 78 which latter water is in heat interchange relation with the evaporator, the latter will serve to maintain the entire mass of water in the tank within the desired temperature range.

Thus it will be seen that the last described apparatus gives the advantage of the previously described forms of construction, namely that a cooling unit of a very moderate size may be employed to maintain a supply of cooled water at a closely regulated temperature and in sufficient quantity to meet the needs of a rather widely varying draught.

In each of the forms of construction which have been described the operation of the

automatic water valve is controlled by the direct pressure of the refrigerant in the evaporator, this pressure corresponding to the temperature of the refrigerant in the evaporator. It is obvious, however, that the water valve may be controlled by a pressure indirectly generated by change of temperature of the refrigerant in the evaporator. For example, I have shown in Fig. 4 a modification of the cooler shown in Fig. 3 in which the automatic water control valve 87' is of the same construction as the corresponding automatic valve 87 in Fig. 3 but the tube 98' instead of leading directly into the interior of the evaporator 79 leads to and communicates with a tube or bulb 99 disposed within the evaporator 79 and immersed in the refrigerant therein. The bulb 99, the tube 98' and the valve casing surrounding the metallic bellows are filled with some suitable liquid having a relatively high thermal coefficient of expansion, such for example as toluene. The expansion of the toluene when the temperature of the refrigerant in the evaporator rises serves by pressure on the valve mechanism to close the water valve and when the temperature of the refrigerant falls the corresponding contraction of the toluene reduces the pressure and permits the spring of the valve mechanism to open the valve.

I have pointed out in connection with each form of construction that the tension of the spring which actuates the automatic water valve may be adjusted and also that the seat of the said valve is adjustable. By means of these adjustments the automatic water valve may be adapted to any one of a wide range of temperatures at which it is desired to maintain the cooled water.

It will be seen that in each of the forms of construction disclosed, there is (a) a refrigerant evaporating chamber, (b) a chamber for liquid to be cooled which holds the said liquid in contact with cooling surfaces, that is to say, surfaces that are in heat interchange relation with the liquid refrigerant, (c) a reservoir into which the cooled liquid is discharged from the second chamber, and (d) means for controlling the discharge of the cooled liquid into the reservoir. In the constructions shown in Figs. 1 and 3 the second chamber, in which the liquid is cooled in the first instance, surrounds the evaporator chamber and surfaces, while in Fig. 2 the coils 59 form the initial cooling chamber which is, therefore, surrounded by the evaporator.

From the foregoing description it will be seen that in each of the various forms of construction the automatic control of the amount or rate of discharge of water from the cooling surfaces of the cooling unit makes it possible to maintain a very close regulation of the temperature of a relatively large body of liquid subject to variable draught. Thus the

apparatus may be provided with a cooling unit of only the moderate capacity requisite to meet the average rate of draught or use of the cooled liquid, and yet the apparatus because of the large reserve of cooled liquid will be adapted to meet peak loads or demands with water or other liquid which is maintained closely within the desired temperature range.

It is to be understood that while certain specific forms of apparatus have been shown and described for purposes of explanation that the embodiment of the invention may take various other forms within the scope of the appended claims.

What I claim is:

1. In apparatus for cooling liquids, the combination of a structure having a chamber in which refrigerant in the liquid state is evaporated and a chamber for liquid to be cooled, the structure comprising a wall between said chambers through which heat is conducted from the liquid to be cooled to the liquid refrigerant, and automatic means responsive to the temperature of the liquid refrigerant for controlling the rate of discharge of the liquid to be cooled from its aforesaid chamber.

2. In apparatus for cooling liquids, the combination of a structure having a chamber in which refrigerant in the liquid state is evaporated and a chamber for liquid to be cooled, the structure comprising a wall between said chambers through which heat is conducted from the liquid to be cooled to the liquid refrigerant, and the chamber for liquid to be cooled having a liquid inlet in the upper part thereof and a liquid outlet in the lower part thereof and being adapted to direct the said liquid over the said wall in its passage from said inlet to said outlet, and automatic means responsive to the temperature of the liquid refrigerant for controlling the rate of discharge of the liquid to be cooled from its aforesaid chamber.

3. In apparatus for cooling liquids, the combination of a structure having a chamber in which refrigerant in the liquid state is evaporated and a chamber for liquid to be cooled, the structure comprising a wall between said chambers through which heat is conducted from the liquid to be cooled to the liquid refrigerant, a storage reservoir adapted to hold cooled liquid in heat interchange relation with the liquid refrigerant, and automatic means responsive to the temperature of the liquid refrigerant for controlling the rate of discharge of the liquid to be cooled from its cooling chamber into the said reservoir.

4. In apparatus for cooling liquids, the combination of a structure having a chamber in which refrigerant in the liquid state is evaporated and a chamber for liquid to be cooled, the structure comprising a wall be-

tween said chambers through which heat is conducted from the liquid to be cooled to the liquid refrigerant, and automatic means actuated by pressure of the refrigerant within its evaporating chamber and responsive to the temperature of said refrigerant for controlling the rate of discharge of the liquid to be cooled from its aforesaid chamber.

5. In apparatus for cooling liquids, the combination of a reservoir having an opening in its upper part for inlet of liquid to be cooled and an outlet in its lower part for cooled liquid; an evaporator for liquid refrigerant disposed in the reservoir so as to be at least partially immersed in liquid in the reservoir; a casing within the reservoir surrounding at least a part of the evaporator and having an opening in its upper part for inlet of liquid from the space outside of the casing to the interior thereof and an outlet in its lower part for discharge of liquid into said space; and automatic means responsive to the temperature of the refrigerant in the evaporator for controlling discharge of liquid from the interior of the said casing into the reservoir space outside of it.

6. In apparatus for cooling liquids, the combination of an elongated upright reservoir having an opening in its upper part for inlet of liquid to be cooled and an outlet in its lower part for cooled liquid; an evaporator for liquid refrigerant disposed in the upper part of the reservoir so as to be at least partially immersed in liquid in the reservoir; a casing within the reservoir surrounding at least a part of the evaporator and having an opening in its upper part for inlet of liquid from the space outside of the casing to the interior thereof and an outlet in the lower part of the casing for discharge of liquid into said space again; and automatic means responsive to the temperature of the refrigerant in the evaporator for controlling discharge of liquid from the interior of the said casing into the reservoir space surrounding it.

7. In apparatus for cooling liquids, the combination of a reservoir having a removable top wall section and having an opening in its upper part for inlet of liquid to be cooled and an outlet in its lower part for cooled liquid; an evaporator for liquid refrigerant depending from the under side of the removable top wall section of the reservoir and having its wall formed in part by the said removable top wall section of the reservoir; a passage through the said removable wall section for admission of liquid refrigerant into the evaporator, and a second passage through the removable wall section for discharge of a gaseous refrigerant.

8. In apparatus for cooling liquids, the combination of an elongated upright cylindrical reservoir having a removable top wall section and having an opening in its upper

part for inlet of liquid to be cooled and an opening in its lower part for discharge of cooled liquid; an evaporator for liquid refrigerant depending from the under side of the said removable top wall section of the reservoir and comprising a cylindrical cup-shaped casing secured at its upper edges to the removable top wall section of the reservoir so that said top wall section forms the top wall of the evaporator chamber, and a series of tubes depending from the bottom of the cup-shaped casing with their upper ends in open communication with the interior of said casing; a passage through the removable top wall section of the reservoir for admission of liquid refrigerant into the evaporator; and a second passage through said removable top wall for discharge of gasified refrigerant from the evaporator.

9. In apparatus for cooling liquids, the combination of an elongated upright cylindrical reservoir having a removable top wall section and having an opening in its upper part for inlet of liquid to be cooled and an opening in its lower part for discharge of cooled liquid; an evaporator for liquid refrigerant depending from the under side of the said removable top wall section of the reservoir and comprising a cylindrical cup-shaped casing secured at its upper edges to the removable top wall section of the reservoir so that said top wall section forms the top wall of the evaporator chamber, and a series of tubes depending from the bottom of the cup-shaped casing with their upper ends in open communication with the interior of said casing; a passage through the removable top wall section of the reservoir for admission of liquid refrigerant into the evaporator; a second passage through said removable top wall for discharge of gasified refrigerant from the evaporator, a cylindrical casing depending from the cup-shaped casing of the evaporator and surrounding the depending tubes thereof, said last named casing having an opening in its upper part to admit liquid from the space outside of it to the space inside of it and an opening in its lower part to discharge liquid from the space inside of it to the space outside of it; and automatic thermostatic means for controlling the last named discharge of liquid.

10. In apparatus for cooling liquids, the combination of an elongated upright cylindrical reservoir having a removable top wall section and having an opening in its upper part for inlet of liquid to be cooled and an opening in its lower part for discharge of cooled liquid; an evaporator for liquid refrigerant depending from the under side of the said removable top wall section of the reservoir and comprising a cylindrical cup-shaped casing secured at its upper edges to the removable top wall section of the reservoir so that said top wall section forms the

top wall of the evaporator chamber, and a series of tubes depending from the bottom of the cup-shaped casing with their upper ends in open communication with the interior of said casing; a passage through the removable top wall section of the reservoir for admission of liquid refrigerant into the evaporator; a second passage through said removable top wall for discharge of gasified refrigerant from the evaporator; a cylindrical casing depending from the cup-shaped casing of the evaporator and surrounding the depending tubes thereof, said last named casing having an opening in its upper part to admit liquid from the space outside of it to the space inside of it and an opening in its lower part to discharge liquid from the space inside of it to the space outside of it; and automatic means responsive to the temperature of the refrigerant in the evaporator for controlling the last named discharge of liquid.

In testimony whereof, I hereunto affix my signature.

HERBERT C. KELLOGG.