March 21, 1961 E. H. OLSON 2,975,610

CONTROL APPARATUS

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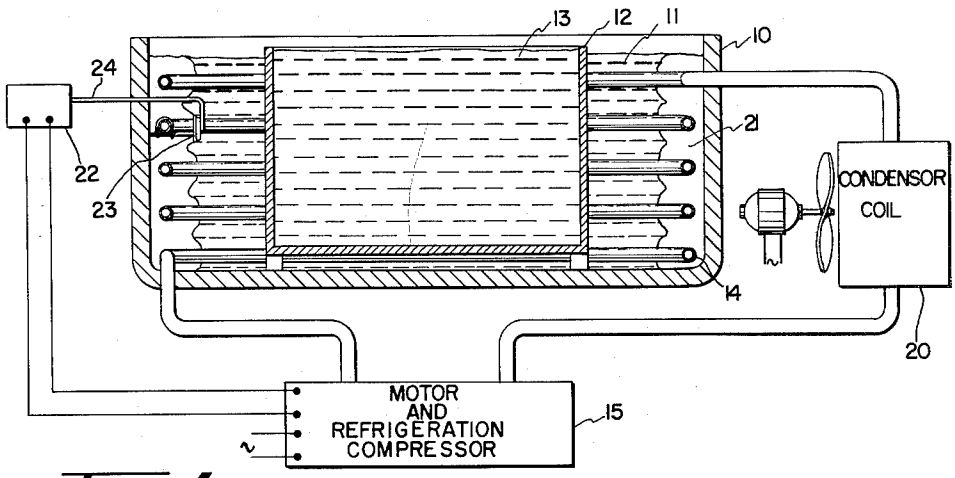

Fig. 1

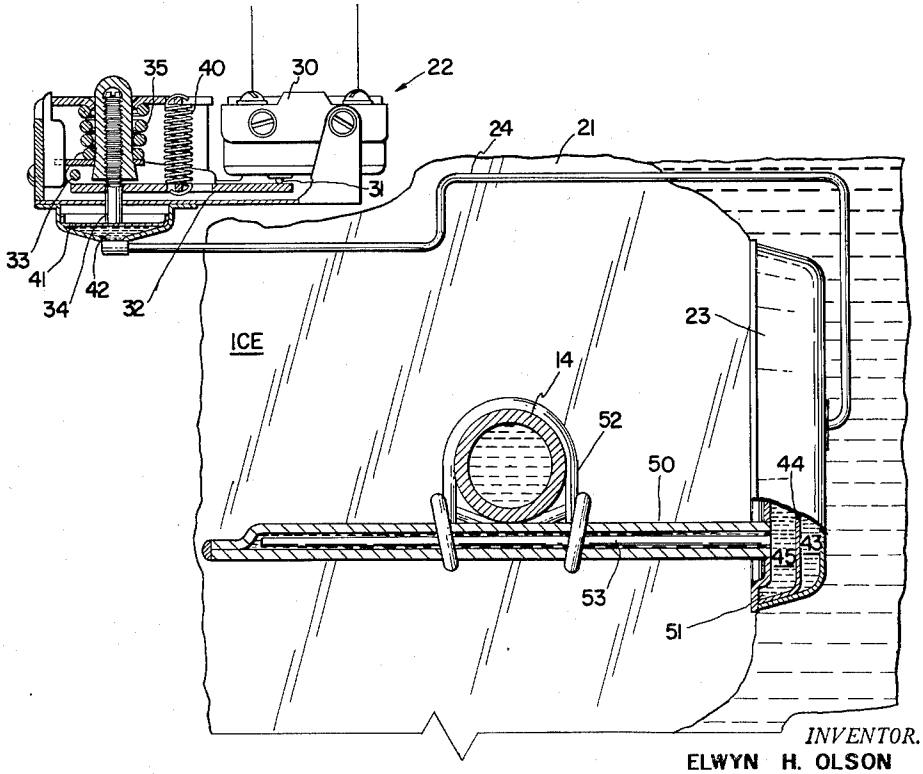

Fig. 2

INVENTOR.
ELWYN H. OLSON
BY Robert S. Craig
ATTORNEY

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CONTROL APPARATUS

Elwyn H. Olson, St. Paul, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

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The present invention is concerned with an improved ice bank control; in particular, a control in which the sensing element has a portion thermally associated with the cooling unit. The portion contains a material for promoting the crystal formation as the liquid therein freezes.

When storage of cooling capacity is desired, the use of an ice bank is quite common. Such a system is generally used where the loads are intermittent; so that, during a period of no load the cooling apparatus can operate to build up the ice bank. By means of this thermal storage capacity, the capacity of the cooling equipment required is greatly reduced. One particular application of this type of thermal storage is in a bulk milk tank. A milk tank is placed in a tank containing water. An ice bank is formed in the water tank; so that, when the milk tank is filled with a supply of warm milk, a reserve cooling capacity is available by melting the ice bank.

Heretofore, the control of the ice bank has been accomplished by a number of ways. One particular method of control is the use of a liquid filled sensor positioned in the area of the cooling coil; so that, as the ice bank forms around the cooling coil to surround the sensing element, the liquid in the sensing element freezes. A pressure responsive device in the sensing element responds to the expansion of the freezing liquid, and by means of appropriate control apparatus, the cooling equipment is de-energized.

Wherever a quantity of water or liquid is changed to a solid state by a change in temperature, the particular temperature at which this change is made often varies as a result of a phenomenon commonly known as supercooling. In a sensing unit of the type described, the temperature is lowered quite gradually as the ice bank forms. This gradual change in the temperature of the liquid fill frequently results in supercooling of the liquid before a change to a solid state takes place. Since the temperature at which the liquid is supercooled varies from operation to operation, obviously, the control point of the apparatus changes. As a result, the formation of the ice bank varies in depth; such that, under certain conditions, the ice bank may only build up to the sensing unit. While under other conditions, the ice bank may build up to a sufficient size to cover or go beyond the sensing element.

Since the size of the ice bank is quite critical, there have been a number of methods of preventing this supercooling. The present invention extends a small section of the sensing unit in close contact with the cooling coil. Contained in this small section is a silver wire coated with silver iodide. Since the temperature of this small section would drop quite rapidly when the cooling apparatus is energized, the growth of ice crystals is started to prevent the supercooling.

It is therefore an object of the present invention to provide an improved ice bank control.

Another object of the present invention is to provide

an improved ice bank control wherein the liquid filled sensing element has a portion which contains silver iodide extended in close proximity to the cooling unit.

And still another object of the present invention is to provide in an improved ice bank control a water filled sensing element having a thin tube portion containing water and a silver wire coated with silver iodide.

These and other objects of the invention will become apparent upon the study of the following specification and drawings of which:

Figure 1 is a schematic representation of one particular environment of the present invention; and

Figure 2 is an enlarged view showing the sensing element with the extended portion containing the wire coated with silver iodide.

Referring to Figure 1, a bulk milk tank cooling installation is shown. An outer tank **10** contains water **11**. A second tank **12** placed inside the tank **10** is surrounded by the water. The milk contained in tank **12** is cooled as heat is transferred or conducted through the walls of tank **12** to the water **11**. While the particular showing has tank **12** partly submerged in water, many bulk cooling installations only spray the water along the outer surface of tank **12**; however, the type of installation has nothing to do with the present invention.

Cooling coils **14** mounted around the periphery of tank **10** are connected to a conventional refrigeration compressor **15**. Connected as a part of this refrigeration apparatus is a condenser coil **20** having a fan for removing the heat from the coil. As the compressor is energized, heat is removed from coil **14**; so that, the water surrounding the coil freezes to form an ice bank **21**. The ice bank starts building up from the coils to extend in all directions.

The refrigeration compressor is controlled by a controller or switch unit **22** which has a sensing element **23** connected thereto by a capillary tube **24**. The sensing element is held in a position with respect to the cooling coil depending upon the size of the ice bank desired. As the refrigeration compressor operates and the ice bank builds up, sensing unit **23** is contacted by the ice to reduce its temperature and to render the refrigeration compressor inoperative through controller **22**.

Referring to Figure 2, controller **22** has a switch **30**. Switch **30** has an operating button **31** which operates the switch to an open position when the button is pushed upward by lever **32**. The lever is pivoted about a shaft **33**; so that, when pin **34** is moved upward against the force of spring **35**, lever **32**, is pulled upward in a counterclockwise direction about pivot **33** by spring **40**. Pin **34** is connected to a diaphragm **41** which forms one side of a chamber containing a liquid fill **42**.

Sensing unit **23** contains a first chamber **43** bounded one one side by a diaphragm **44**. Chamber **43** is connected by capillary tube **24** to the chamber of controller **22**; so that any movement of diaphragm **44** is reflected to diaphragm **41** through the liquid fill common to the two mentioned chambers and the capillary tube. A second chamber **45** of sensor **23** also has diaphragm **44** as one side. Connected to the sensing unit to enlarge a volume of chamber **45** is a long thin tube **50** which is sealed at its remote end. The tube as well as the second mentioned chamber **45** is filled with a liquid or water **51** which changes state from liquid to solid at a predetermined temperature. By means of a spring clip **52**, the tube **50** of the sensing element is held against the cooling coil **14**. The clip not only fixes the position of the sensing element with respect to the cooling coil to select the size of the ice bank which is formed, but tube **50** is held against the cooling coil to obtain a maximum thermal conductivity for heat transfer between the tube and the coil.

Contained in tube 50 is a filament or wire 53. This filament is small enough to allow sufficient room for water 51 to fill the space between the filament and the inner walls of tube 50. Filament 53 has a surface of silver iodide and might be a silver wire which was exposed to fumes of iodine for a sufficient period to develop a coating of silver iodide thereon.

Operation

Let us assume, for the purposes of explanation, that the refrigeration compressor of Figure 1 is in operation, and the ice bank 21 is slowly building up around coil 14. Since the temperature of coil 14 is quite low, the liquid fill 51 of tube 50, referring to Figure 2, is quite cold with respect to the temperature of the main portion of sensor 23. Since the silver iodide crystals are similar in structure to the ice crystals, the formation of ice crystals in tube 50 is quite likely to take place.

With tube 50 extended to thermally contact the cooling coil 14, the phenomena of supercooling in the tube is not entirely eliminated, but a more uniform operation takes place. The cooling coil is much colder and the growth of ice crystals in tube 50 begins shortly after the refrigeration compressor begins operation. Once the ice forms in tube 50, there would be no supercooling in chamber 45 and its temperature will be affected by the temperature of the water surrounding element 23 rather than the temperature of coil 14.

By the early formation of ice crystals in tube 50 the growth of ice crystals or the formation in ice chamber 45 takes place immediately upon the temperature of fill 51 reaching the freezing temperature there being no supercooling in chamber 45. As the fill in chamber 45 freezes, diaphragm 44 is moved to the right to displace the fluid in chamber 43. This causes the upward movement of diaphragm 41 in controller 22 to operate switch 30 to de-energize refrigeration compressor 15.

Upon the demand for cooling by the addition of warm milk to tank 12, the ice bank is melted. The ice in chamber 45 melts to decrease the pressure in chamber 43; so that the switch 30 is again closed initiating operation of refrigeration compressor 15. Since supercooling is lessened by the addition of the silver iodide filament to the leg 50, the control point of controller 22 is quite stable. By the stable control point, the size of the ice bank is uniform each time it is built up.

While other means obviously may be used to distribute the silver iodide in the part of the element engaging the cooling coil, the disclosed structure using a silver wire coated with silver iodide at present appears to be the simplest way to attain the desired result.

I claim:

1. An ice bank control for controlling the quantity of ice which forms on a cooling coil of a refrigeration apparatus comprising, switch means adapted to control the energization of the refrigeration apparatus, sensing means responsive to the quantity of ice on the cooling coil, and means connecting said sensing means to said switch means so that the refrigeration apparatus is operated to maintain a selected quantity of ice on the cooling coil, said sensing means comprising a water filled chamber bounded on one side by a flexible diaphragm, a tube sealed at one end and connected at the other end to said chamber to form a part thereof, said tube being supported in thermal contact with the cooling coil and providing a support for said sensing unit whereby the relative location of said sensing element and the coil can be adjusted to select the size of the ice bank desired, and a thin silver wire contained in said tube to be in contact with the water in said tube, said wire having been exposed to iodine fumes so that it has a coating of silver iodide on its outer surface to provide an even distribution of silver iodide in said tube.

2. An ice bank control for maintaining a selected quantity of ice on a cooling unit of a cooling apparatus comprising, switch means adapted to control the cooling apparatus to cause the formation of ice on the cooling unit, sensing means associated with the cooling unit for sensing a predetermined quantity of ice formation on the unit, and means connecting said sensing unit to said switch means, said sensing unit comprising a chamber filled with liquid which changes to a solid upon freezing, said chamber including a long thin section extending from the main portion of the chamber, said thin section being an integral part of said chamber and being filled with said liquid, supporting means including said thin section for holding said sensing means a predetermined distance from said cooling unit as determined by the thickness of the ice desired to be maintained on the cooling unit, and a wire coated with material contained in said thin section and in contact with said liquid for encouraging the freezing of said liquid in said thin section when the temperature of the cooling unit reaches a predetermined value whereby the initial freezing of said liquid is not begun in said chamber of the sensing unit.

3. In an ice bank control for controlling the size of an ice bank formed on a heat exchanger upon the operation of cooling apparatus, switch means adapted to control the cooling apparatus, water filled responsive means responsive to a predetermined size of an ice bank by the freezing of the water in said responsive means, means connecting said responsive means to said switch means, means mechanically supporting said responsive means on the heat exchanger having a thin section containing water in which ice first forms, said water of said responsive means and said thin section being in contact, and a filament of silver iodide contained in said thin section for aiding the growth of ice crystals when the temperature of the heat exchanger reaches a predetermined value, said filament maintaining an even distribution of silver iodide in said thin section whereby ice crystals are readily grown wherever a sufficient quantity of heat is removed from said water in the thin section, said water in said responsive means freezing without super cooling when ice contacts said responsive means a predetermined amount since ice in said thin section is in contact with said water in said responsive means.

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