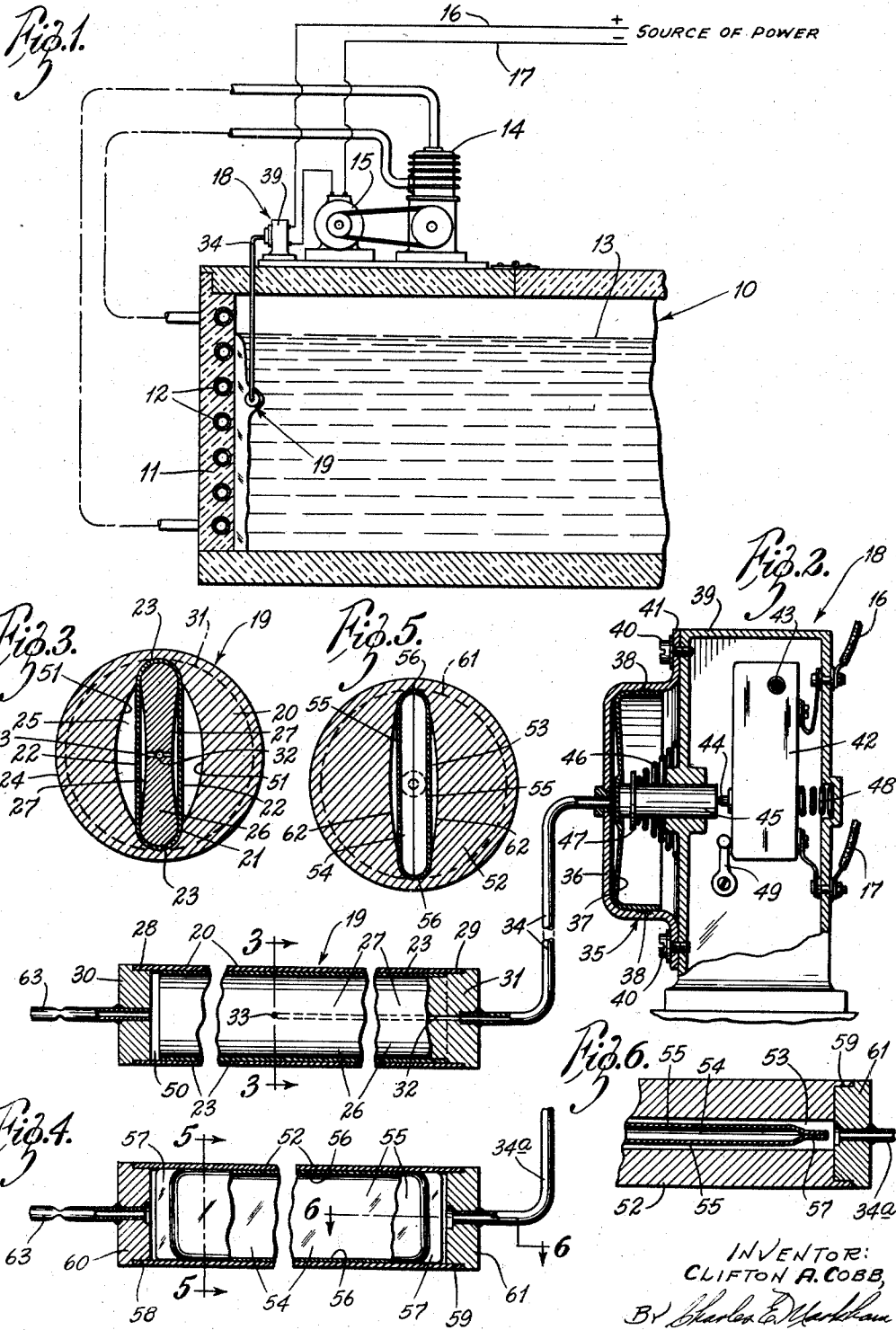


July 24, 1951

C. A. COBB
TEMPERATURE SENSITIVE DEVICE
FOR ICE BANK CONTROLLERS
Filed Nov. 2, 1948

2,561,437



INVENTOR:
CLIFTON A. COBB,
BY Charles E. Markham
HIS AGENT.

UNITED STATES PATENT OFFICE

2,561,437

TEMPERATURE SENSITIVE DEVICE FOR
ICE BANK CONTROLLERSClifton A. Cobb, University City, Mo., assignor to
Missouri Automatic Control Corporation, St.
Louis, Mo., a corporation of Missouri

Application November 2, 1948, Serial No. 57,859

6 Claims. (Cl. 297—3)

1

This invention relates to control devices which are actuated by the change in volume of a liquid as it is frozen or melted. More particularly, it relates to a control device of this character adapted to control the operation of a refrigeration compressor so as to closely control the ice formation or thickness of the ice bank which builds up on or adjacent to the refrigerant coils in a cold water type cooler.

The advantage of employing the considerable volume change of a liquid as it freezes or melts to actuate a refrigeration controller is well known. Also devices have been proposed which employ this principle of operation and which incorporate therewith a non-freezing transmission fluid for transmitting movement of the expansible receptacle or feeler bulb containing the freezing liquid to a remote point, there to cause the expansion of a second expansible element and the actuation of an associated control member.

An object of this invention is to provide a generally new and improved control device of this character which is unusually sensitive and dependable, which is simple and inexpensive to produce, and which will not be damaged by exposure to temperatures considerably below the freezing point of water.

A further object is to provide a control device of this character having an improved all metallic feeler bulb adapted to measure the ice thickness, which comprises a pair of liquid containing chambers separated by a flexible metallic wall wherein many suitable combinations of freezing and non-freezing liquids may be used without danger of absorption by the separating wall or its dissolution, or of dilution of either of the liquids by osmosis.

A further object is the provision of a control device of this character having a feeler bulb comprising a hollow elongated metal outer tube of circular cross section and an inner elongated relatively thin walled metal tube of non-circular cross section, which inner tube contains a non-freezing liquid and has communication with a remote expansible element, and which outer tube contains a volume of pure water surrounding the inner tube.

A further object is the provision of a control device of this character having a feeler bulb comprising a pair of chambers separated by a relatively thin flexible metal wall in which one of the chambers contains pure water and the other contains a non-freezing liquid, the chamber containing the non-freezing liquid being in communication with a remote expansible element, the

2

chamber containing the non-freezing liquid also having a rigid backing wall opposite the flexible separating wall which is shaped to permit uniform deflection of any part of the wall to a point below the elastic limit of the material of which the flexible wall is constructed.

A further object is the provision of a feeler bulb for use in a control device as above comprising an elongated hollow metal outer tube of circular cross section, and an inner elongated and relatively thin metal inner tube of non-circular cross section, which inner tube contains sealed therein a volume of pure water and which outer tube contains a volume of non-freezing liquid surrounding the inner tube and has communication with a remote expansible element.

Other objects and advantages will appear from the following complete description when read in connection with the accompanying drawing.

In the drawing,

Fig. 1 is a schematic view showing a cooler in part together with a motor driven compressor and refrigerant coils and a control device constructed in accordance with the present invention associated therewith so as to control the starting and stopping of the compressor so as to maintain a predetermined thickness of ice formation on the wall of the cooler.

Fig. 2 is an enlarged view of the control device shown in use in Fig. 1 in which parts have been shown in section to more clearly illustrate.

Fig. 3 is an enlarged transverse sectional view taken through the feeler bulb of the control device shown in Fig. 2 and is taken on line 3—3 of Fig. 2.

Fig. 4 illustrates a second form of feeler bulb which may be used in lieu of the one shown in Fig. 3.

Fig. 5 is an enlarged transverse sectional view taken on line 5—5 of the bulb shown in Fig. 4.

Fig. 6 is a part longitudinal section taken on line 6—6 of Fig. 4.

The reference numeral 10 indicates a cooler shown in part having a wall 11 in which are arranged refrigerant evaporator coils 12. The cooler is substantially filled with water as indicated at 13 and the refrigerant coils connect with a compressor indicated at 14 which is driven by an electric motor 15. A circuit for the motor 15 comprising the leads 16 and 17 connected to a source of power is provided and a control device generally indicated at 18 is interposed in the circuit to effect an off and on control of the operation of the compressor. The control 18 includes a feeler bulb generally indicated at 19

3

which is positioned at a predetermined distance from the wall 11 thereby to control the thickness of the ice bank.

The bulb 19 as shown in Figs. 2 and 3 comprises an outer metal tube 20 in which is fitted a relatively thin walled metal tube 21 having flat sides 22 and rounded edges 23. The outer tube 20 in cross section has a circular exterior wall 24 and a passage 25 therethrough which is generally elliptical in cross section and which receives the flattened inner tube 21. The inner metal tube has inserted therein a filler bar 26 having concave surfaces 27 opposite the flat sides 22 of the inner tube. Otherwise the filler 26 nicely fits the interior of tube 21.

At its ends the outer tube 20 is provided with concentric circular counterbores at 28 and 29 to receive the circular end closing plugs 30 and 31. The end closing plug 31 is shown as being an integral part of the filler bar 26. For economical construction the circular plug 31 may be attached to the filler bar 26 by welding or soldering. The end closing plugs 30 and 31 may be rigidly held in place by soldering or welding. The shape of the passage 25 in cross section is such that the rounded edges 23 of the inner tube are contiguous therewith for a full 180° as indicated.

There is a longitudinal passage 32 in the filler bar 26 extending from one end to approximately the center of its length and a transverse passage 33 intersecting the passage 32 providing communication between the passage 32 and the opposite spaces which lie between the concave sides 27 of the filler bar and the flat sides 22 of the inner tube 21. The passage 32 extends through the end closing plug 31 and receives at its outer end a capillary tube 34. The other end of the capillary tube 34 communicates with the interior of an expansible element 35 comprising a rigid outer metal cup member 36 and an inner flexible metal cup member 37. The outer and inner cup members 36 and 37 are attached along their side walls as by continuous welding as indicated at 38. As fluid pressure is applied through the capillary 34 to the space between the bottom walls of the cups, the bottom wall of the inner flexible cup member deflects in a well known manner.

The expansible element 35 is mounted on the side of a casing 39 by attachment screws 40 which pass through a flange 41 on the outer cup member 36. Within the casing 39 there is pivotally mounted a sensitive snap action switching device 42 mounted on a pivot 43, supported by the casing. The switching device 42 is provided with an actuating plunger 44 and the switch mechanism is arranged so as to open upon depression of the actuating plunger 44. Slidably fitted in the wall of the casing is a second actuating plunger 45 which bears at one end on the bottom wall of the inner flexible cup member 37 and at its other end on the switch actuating plunger 44.

A relatively strong diaphragm return spring 46 biased between the front casing wall and a flange 47 on the plunger 45 resists expansion of the element 35. A second relatively strong spring 48 biased between the rear wall of the casing and the switch unit 42 provides for overtravel movement of the expansible element thereby to protect the switch mechanism, and an adjustable stop 49 is provided to adjust the position of the switch 42 with relation to the plunger 45.

The inner thin walled metal tube 21 is sealed

4

at both ends as by soldering or welding and this inner tube, the capillary 34 and the expansible element 35 form a sealed system which is filled with a suitable non-freezing motion transmitting liquid such as, xylene (ortho). The longitudinal passage 25 in the outer tube 20 is filled with a suitable liquid which preferably freezes at 32° F. such as pure water. The inner tube 21 does not extend the full length of the passage 25, a small space being provided at one end as indicated at 50 to permit communication between the spaces on opposite sides of the inner tube.

The concave sides 27 of the filler bar 26 are developed so as to permit normal deflection of the thin flat sides 22 of the inner tube under uniformly distributed load and to limit the deflection of any part of the tube to a point below the elastic limit of the material. The thin inner tube is preferably constructed of a high nickel chrome steel and has a wall thickness in the order of .002 to .004 of an inch. The inner wall surfaces 51 of the outer tube 20 which lie opposite the surfaces 27 of the filler 26 are developed so that expansion proportional to the distance which the walls 22 are permitted to flex at any point will occur.

A second form of feeler bulb as shown in Figs. 4, 5 and 6 comprises an outer tube 52 of circular cross section having a generally elliptical passageway 53 therethrough in which is fitted a thin walled inner tube 54 having substantially flat opposite walls 55 and rounded ends 56. The shape of the passage 53 in cross section is such that the rounded edges of the inner tube 54 are contiguous therewith for a full 180° as indicated. The inner tube 54 is closed at its ends by pinching together the flat sides as indicated at 57 in Fig. 6. The ends are further sealed by soldering or welding. The outer tube 52 is counterbored at each end at 58 and 59 to receive the round end closing plugs 60 and 61. The plugs 60 and 61 are soldered or welded to the tube 52. The plug 61 is perforated to receive one end of a capillary tube 34a, the other end of which may be attached to the expansible element 35. In this form of bulb, the passage 53 in outer tube 52 is therefore connected to the expansible element and together with the expansible element and capillary tube form a closed system which is filled with a suitable non-freezing liquid. The inner tube 54 being hermetically sealed is filled with a freezing liquid such as pure water.

The curved walls 62 of the passage 53 in outer tube 52 are likewise developed so as to permit normal deflection of the inner tube walls 55 under uniform load and to limit the deflection to a point below the elastic limit of the material. The end plugs of the outer tubes of both forms of feeler bulbs are provided with short pieces of capillary tubing 63 to facilitate filling the outer tubes. These capillary tubes are pinched and soldered closed after the outer tubes have been filled.

In operation

The feeler bulb is placed in the water filled cooler and spaced at the desired distance from the wall or the evaporator coils. If the ice bank is not thick enough to touch the bulb in this position, the temperature of the bulb and the water therein will be above the freezing point and under these conditions, the expansible element 35 is retracted by the return spring 46 and the bottom of the inner cup member 37 is contiguous with the bottom of the outer cup 36, permitting the switch 42 to close and complete an energizing

circuit for the operation of the compressor. As the ice bank thickens under operation of the compressor to a point wherein the feeler bulb is substantially encompassed thereby, the water within the bulb will begin to freeze.

As the water in the bulb starts to freeze, ice will generally form first on the walls of the water chamber and freezing will progress thereafter toward the center of the water mass. The exact pattern or progress of freezing will of course be unpredictable and unequal expansion and therefore unequal stresses on the thin flat walls of the tube would ordinarily result. The curved walls 27 of the filler bar 26 in the first form of bulb described and the curved walls 62 of the outer tube in the second form of bulb described, prevent undue deflection of the thin tube walls at any point and force the freezing mixture which is still sufficiently fluent to permit this, to uniformly deflect these walls both longitudinally and transversely. As hereinbefore stated, the curvature of walls 27 and 62 is such that the thin tube walls cannot be stressed beyond the elastic limit.

By the use of a sensitive switching device requiring only a slight actuating movement in the order of .002 or .003 inch and the use of a liquid motion transmission medium together with a metal diaphragm type expansible element which altogether results in a positive unyielding transmission of motion, the actuation of the switching device may be achieved by expansion resulting from only partial freezing of the water within the feeler bulb. In the present invention, I have proportioned the volumes of the freezing and non-freezing liquids within the bulb and the expansible element 35 so as to achieve switch actuation with not more than 25 per cent of the total expansion of the water in the bulb which would occur between water at 32° F. and solid ice at 32° F. Thus it will be seen that in normal operation the water within the bulbs does not completely solidify and the inner tube walls are not deflected to the permissible limit.

The device may however be subjected to temperatures considerably below 32° F. in shipment or in storage when not in use. The relation of the permissible displacement of the inner tube walls to the volume of water within the tube is made such therefore, as to permit total expansion of the water upon complete solidification and some additional expansion of the solid ice as may occur in atmospheric temperatures likely to be encountered. It will be understood that the principles set forth hereinabove may be applied to a design of feeler bulb employing a flat circular diaphragm as well as the preferred round, elongated tube design shown and described.

I claim:

1. In a device of the class described, a temperature sensitive bulb comprising a relatively thick walled outer tube of circular cross-section, a relatively thin walled inner tube flattened so as to have relatively extensive and substantially flat and parallel opposite side walls and rounded edges arranged within said outer tube, an elongated filler member within said inner tube extending substantially the full length thereof, said filler member having rounded edges contiguous with the rounded edges of said inner tube and having transversely concave surfaces opposite the flat walls of said inner tube, said outer tube having sealed ends and containing a freezing liquid, said inner tube being sealed at one end and containing a non-freezing motion transmission fluid, an outlet at the other end of said inner tube, and means

providing communication between the spaces lying on opposite sides of said filler member.

2. A temperature sensitive bulb as set forth in claim 1 in which the curvature of the concave surfaces of the filler member are such that deflection of the flat surfaces of said inner tube to the extent that they are contiguous therewith will not stress the walls of said metal inner tube beyond the elastic limit of the metal at any point.

3. For use in a fluid pressure operated refrigeration control device having an expansible chamber, an ice detecting bulb comprising a completely closed outer tube of circular cross section, and a relatively thin walled metal inner tube of non-circular cross section arranged therein, said inner tube having an elongated member disposed therein and extending substantially the full length thereof for limiting the extent to which said inner tube may be collapsed transversely, said inner tube having a conduit connected to one end thereof which extends exteriorly of said outer tube and is connected to said expansible chamber, said outer tube containing sealed therein a quantity of freezing liquid, and said inner tube, said connecting conduit and said expansible chamber being filled with a non-freezing motion transmitting liquid.

4. For use in a fluid pressure operated refrigeration control device having an expansible chamber, a remote sensitive bulb comprising a chamber having a relatively rigid surrounding wall and being divided by a relatively thin normally flat flexible metal wall, one of the divisions of said chamber being sealed and containing a freezing liquid, the other division having communication with said expansible chamber and being filled with a non-freezing motion transmitting liquid, said rigid bulb chamber wall defining said last mentioned division being arcuate and being subtended by said flat flexible metal wall, and the curvature of this wall being such that said flexible metal wall may be deflected at any point so as to be contiguous therewith without exceeding its elastic limit at any point.

5. In a device of the class described an expansible chamber, a remote temperature sensitive bulb comprising a chamber divided by a normally flat relatively thin flexible metal wall into first and second divisions, said bulb chamber walls forming relatively flat arcuate curves on both sides of said flexible metal wall and being subtended thereby, the curvature of the chamber wall defining said second division being such that said flexible metal wall may be deflected at any point sufficiently so as to be contiguous therewith without exceeding its elastic limit, said first chamber division being sealed and filled with a freezing liquid, and said second division having communication with said expansible chamber together with which it forms a sealed system filled with a non-freezing motion transmitting liquid.

6. For use in a fluid pressure operated refrigeration control device having an expansible chamber, an ice detecting bulb comprising a chamber divided into first and second divisions by a relatively thin flexible metal wall, said opposite chamber walls being curved so as to form relatively flat arches on both sides of said flexible metal dividing wall, said first chamber division being sealed and filled with a freezing liquid, said second chamber division having communication with said expansible chamber and being filled with a non-freezing motion transmitting liquid, the curvature of said second chamber division wall being such that stress and deflection is substan-

7

tially equal at all points on said flexible metal wall when deflected so as to be contiguous therewith, and the curvature of said first chamber division wall being such that the expansion at any point thereon acting normally to said flexible metal wall due to freezing of the freezing liquid is proportionate to the deflection permissible by the opposite curved chamber wall at that point.

CLIFTON A. COBB.

5

10

REFERENCES CITED

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

8

UNITED STATES PATENTS

Number	Name	Date
416,947	Powers	Dec. 10, 1889
554,398	Powers	Feb. 11, 1896
1,285,990	Halsey	Nov. 26, 1918
1,356,175	Swift	Oct. 19, 1920
2,066,235	Smilack	Dec. 29, 1936
2,187,258	Wood	Jan. 16, 1940
2,453,851	Miller	Nov. 16, 1948

FOREIGN PATENTS

Number	Country	Date
213,207	Great Britain	Mar. 27, 1924
510,721	Germany	Oct. 22, 1930