March 24, 1953 R. L. ENGELHARDT 2,632,308

ICE DETECTING SYSTEM

Filed April 24, 1950

Fig. 1

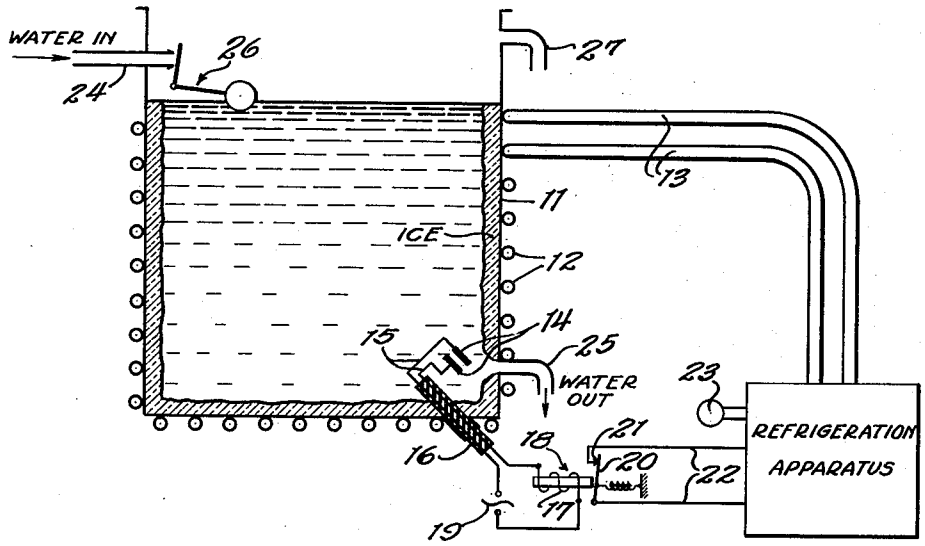


Fig. 2

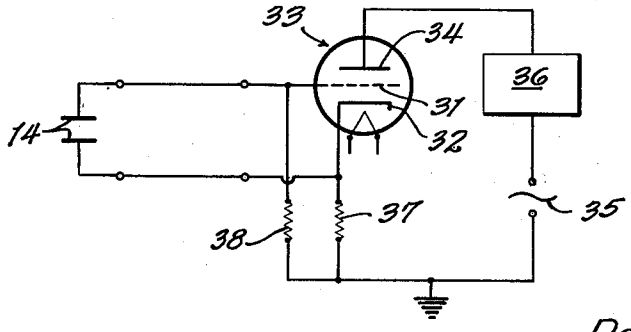
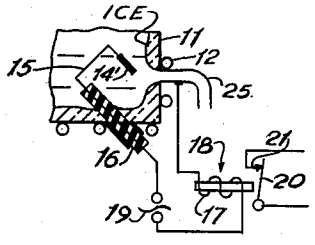


Fig. 3



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ICE DETECTING SYSTEM

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2 Claims. (Cl. 62—7)

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This invention relates to a system for detecting formation of ice in ordinary water having an appreciable degree of electrical conductivity. While not so limited, the invention has particular utility in connection with control of the extent of formation of ice on the inner surfaces of a refrigerated tank of ordinary water into which containers of milk or other substances are placed for cooling.

An object of this invention is to provide a simple but effective electrical system for the purpose described, and I accomplish this object by taking advantage of the fact that when ice is formed by freezing of ordinary water having even a relatively high degree of electrical conductivity, the ice so formed is virtually non-conductive.

For full understanding of the invention, and further appreciation of its features and advantages, reference is to be had to the following detailed description and accompanying drawing, and to the appended claims.

In the drawing:

Figure 1 is a schematic view of an ice-formation detecting and controlling system embodying the invention;

Figure 2 is a diagram of an electronic circuit adapted for use in the system shown in Fig. 1; and

Figure 3 is a view of a portion of Fig. 1 showing a modified arrangement of the electrodes.

Referring first more particularly to Fig. 1, the numeral 11 indicates a metallic tank which is open at its top and is filled with ordinary water, indicated by the broken lines. Around the outside of the tank is a coil 12 through which evaporating refrigerant can be passed by conventional refrigeration apparatus, indicated by the legend, connected to the coil by pipes 13. The coil 12 may optionally be arranged on the inner surfaces of the tank.

The tank 11 is of a size suitable for receiving large containers of warm milk, freshly obtained from the cows, which is to be chilled to a temperature of about 38–40° F. The tank is used only immediately after milking times, and during the several-hour intervals between these times the tank is conditioned for the next cooling operation. In order to increase the cooling capacity of the tank, refrigeration is continued until a coating of ice, indicated by the legend, is deposited on the inner surfaces of the tank. This coating, commonly known as an "ice-bank," may have a thickness of about six inches.

If refrigeration is not interrupted soon after an ice-bank of proper thickness has been formed,

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there is the probability that the whole tank of water will suddenly freeze-over, so that it is impossible to place the milk containers in the tank. It has therefore been necessary heretofore to watch the formation of ice and interrupt refrigeration when the formation reached proper thickness.

According to the present invention the extent of formation of the ice-bank is determined by electrical means controlling the operation of the refrigeration apparatus. These means comprise a pair of electrodes or metallic plates 14, within the tank, whose leads or wire conductors 15 extend through a member 16 of insulating material sealingly and adjustably mounted in an opening through the bottom wall of the tank. At the exterior of the tank the conductors 15 are connected respectively to the opposite ends of the coil 17 of a sensitive electromagnetic relay 18; a source of electrical energy being inserted in one of the conductors as is indicated by the alternating-current symbol 19. While direct current may be employed, with alternating current the effect of electrolysis is minimized. The voltage of the source is dependent mainly on the degree of sensitivity of the relay. The portions of conductors 15 within the tank should be insulated.

The contact-arm or armature 20 and cooperating fixed-contact 21 of the relay are connected by wires 22 to the refrigeration apparatus, in any suitable and well-known manner, so that the same is operated when the relay is energized, as shown; deenergization of the relay effecting stoppage of refrigeration. Instead of controlling the refrigeration apparatus automatically, the system may be arranged merely to operate an alarm 23 if desired.

The energization of relay 18 is due to the electrically conductive path provided by the water between the electrodes 14 when the same are free from ice. Ordinary water, obtained from rivers or from underground, contains in solution salts in an amount sufficient to render the water electrically conductive to a relatively high degree. However, when such water is frozen, the salts are separated or precipitated out, so that the resulting ice is substantially non-conductive. It follows that when, as the ice-bank thickens, it reaches or is near to the electrodes, the ice then formed on the electrodes effects obstruction of the conductive path of water between them, so that flow of current through the relay ceases and its armature is released to effect stoppage of the refrigeration apparatus or sounding of the alarm.

Obstruction of the conductive water-path oc-

curs when only one of the electrodes is coated with even a thin film of ice, but the whole surface of that electrode must be covered by the ice since a substantial amount of current can still flow when only a small area of the electrode (even on its surface away from the other electrode) is exposed to the water. For that reason the drop-out of the relay is abrupt and hence positive.

Particularly in the intervals between use of the tank and while the same is being conditioned for use by formation of the ice-bank, it is advisable to circulate the water continuously through the tank to ensure formation of the ice only on the refrigerated surfaces of the tank; the water preferably being supplied at the top of the tank by a pipe 24 and withdrawn from a point near its bottom by pipe 25. The level of the water in the tank is controlled by a float valve 26 cooperating with pipe 24; an overflow pipe 27 also being provided near the top of the tank through which the water can drain when its level is raised by placement of the milk containers.

When the water is circulating, the outlet of the tank is the point at which freezing occurs latest. The electrodes 14 are therefore positioned adjacent that point, as shown, so that they are in the path of the water flowing to the outlet and remain free from ice until the growing ice-bank reaches or is very near them. The angular mounting of the electrodes, as shown, permits better adjustment of the electrodes relative to the outlet.

Inasmuch as the flow of current ceases when only one of the electrodes is covered by ice, as was described, it is not necessary to provide a pair of adjacent electrodes; the showing of such a pair in the drawing being to facilitate understanding of the invention by mere inspection of the drawing. In practice, a single electrode can be mounted in place of the pair shown in Fig. 1, the other electrode then being formed by any suitable metallic part exposed to the water, such as the outlet pipe 25, which is then connected in the electric circuit in the same manner as the plate-electrode of which it takes the place. This practical arrangement is shown in Fig. 3 wherein the single adjustable electrode is indicated by numeral 14'. The conductivity of the water path between the electrodes is not substantially reduced when, by this arrangement, the electrodes are more-widely spaced from each other. Since the electrode formed by the inside of pipe 25 is at a point where formation of ice occurs subsequently to that at the single plate-electrode, the position of the latter can be adjusted more accurately to determine the desired thickness of the ice-bank.

In Fig. 2 of the drawing there is shown an electronic circuit which may be substituted for the simple series circuit of Fig. 1. The electrodes 14 are shown in Fig. 2 connected respectively to the grid 31 and cathode 32 of a vacuum tube 33 of the triode type. The plate 34 of the tube is connected to one terminal of a source of alternating current, indicated by the symbol 35, in series with a controlling or indicating device 36 which may be of any suitable and known construction. The other, or grounded, terminal of source 35 is connected through a bias resistor 37 to the cathode 32; grid 31 being returned to ground through another resistor 38. The circuit is of the self-rectifying type, and the source 35 may be the ordinary 117 volt 60 cycle service. During the half-cycle when the plate is positive with respect to the cathode the tube conducts and the amount of current flowing in its plate circuit is determined by the grid-cathode potential. When a conductive path of water is between the electrodes 14 the grid is at zero potential with respect to the cathode (it being assumed that the value of grid resistor 38 is very high relative to the effective resistance of the water path) so that a large amount of plate current flows through the device 36 to maintain it in a condition corresponding to that of the relay 18 as shown in Fig. 1. When at least one of the electrodes 14 is covered by ice, so that the water path between the electrodes is thereby obstructed, the grid is at negative potential with respect to the cathode (due to the voltage drop across resistor 37 when current flows in the plate-cathode circuit) so that the plate current is substantially reduced and the condition of device 36 altered correspondingly.

While this invention has been described in connection with the control of an ice-bank, it is obviously applicable to the detection of ice-formation in any body of ordinary water. Further, the specific arrangements herein shown and described are obviously susceptible of modification without departing from the spirit of the invention. I intend therefore that my invention be limited only by the scope of the appended claims.

I claim as my invention:

1. In a system for determining the extent of formation of ice on the inner surface of a wall of a refrigerated tank through which ordinary water, having an appreciable degree of electrical conductivity, is flowing to an outlet in said wall: a pair of electrodes exposed to said water, said electrodes being so constructed and arranged that the water between them provides an electrically conductive path only when the whole surface of at least one of the electrodes is free from ice, one of said electrodes being located adjacent said outlet and at a predetermined distance from said tank-wall surface; and electrical means connected to said electrodes, and responsive to the degree of conductivity of said water path, for indicating obstruction of said path and thereby the covering of at least one of said electrodes by ice.

2. A system as defined in claim 1, and wherein said outlet is of electrically conductive material and forms the other of said pair of electrodes.

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