

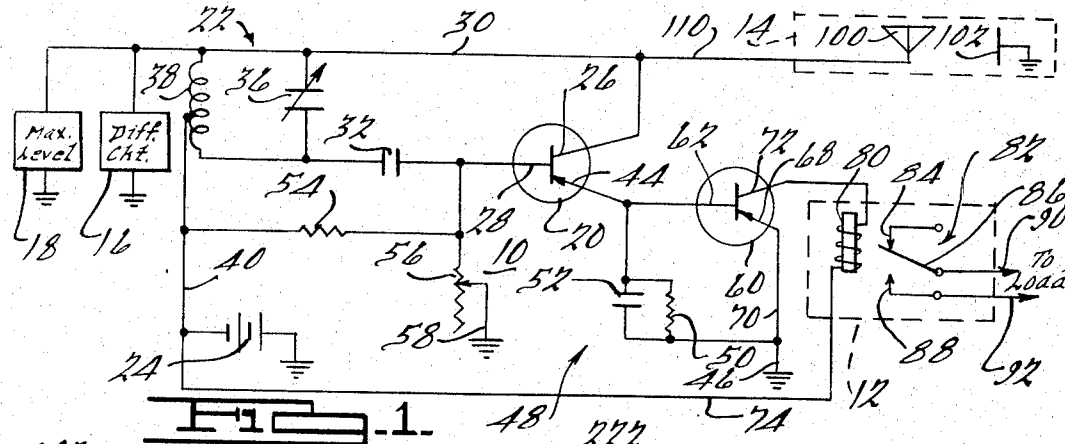
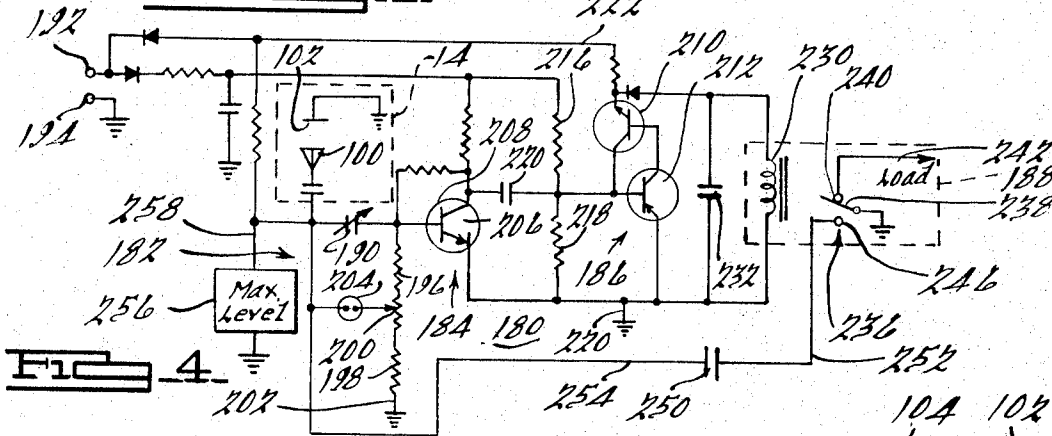
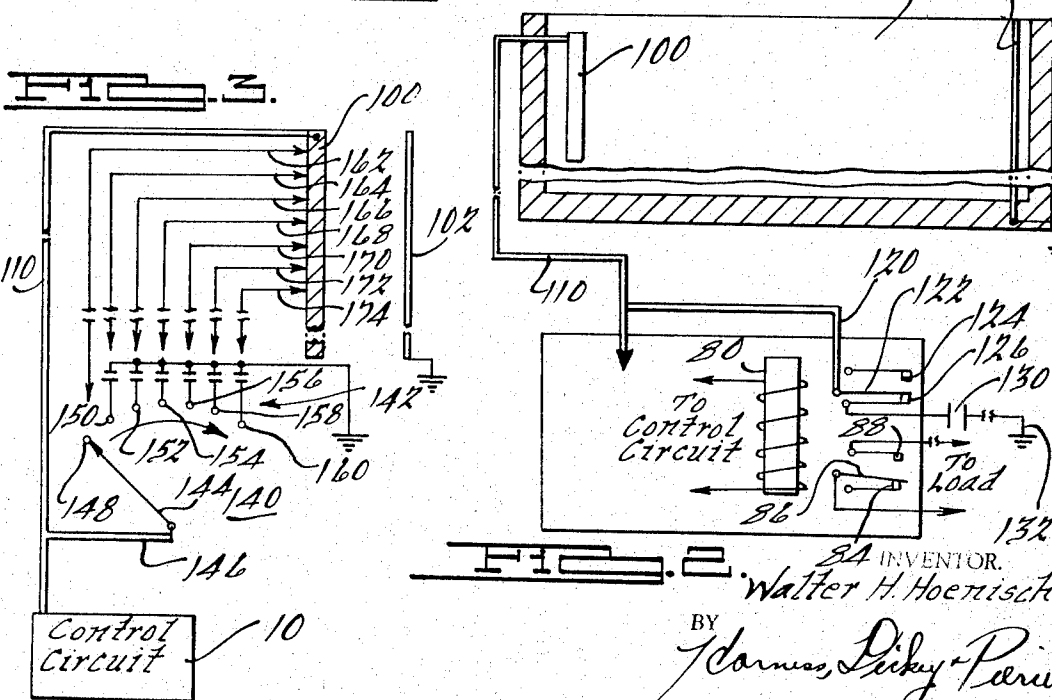
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ICE LEVEL CONTROL FOR REFRIGERATION MECHANISM

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ICE LEVEL CONTROL FOR REFRIGERATION MECHANISM

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ABSTRACT OF THE DISCLOSURE

An ice making apparatus including a refrigerating apparatus and an ice level sensing circuit for controlling the refrigerating apparatus, the ice level sensing circuit being responsive to a change in capacitance between a low level of ice stored in the ice making apparatus and a high level of ice stored therein, the control circuit starting or stopping the refrigerating apparatus at low levels and high levels of ice storage, respectively.

Background and summary of the invention

This invention relates generally to control systems for refrigerating apparatus, and more specifically to an ice level sensing circuit for use in controlling the energization of a refrigerating apparatus wherein provision has been made to vary the level to which ice will accumulate and also providing a differential in the operation of the refrigerating apparatus.

Certain prior art refrigerating systems are known which incorporate temperature actuated devices for controlling the ice level in an ice generating apparatus. However, certain of the temperature actuated systems have shortcomings which make their continued use undesirable. Accordingly, it has been discovered that an ice level system utilizing a capacitance actuated sensing system will eliminate these shortcomings while at the same time retaining the features of simplicity of operation, low cost and reliability.

In the use of a capacitance control circuit in an automatic refrigerating apparatus, it has been found to be desirable to provide means for varying the amount of ice buildup which will actuate the refrigerating apparatus cutoff mechanism. In this way the user of the system may vary the amount of ice storage of the apparatus to suit particular and variable needs by increasing or decreasing the storage capabilities of the system.

In utilizing a capacitance sensitive ice bank control, certain conditions arise which tend to upset the balance of the sensing circuit thereby causing what may be termed "chattering" in the operation of the control circuit. This chattering may not be tolerated for any great length of time due to the wearing of parts in both the output circuit connected to the sensing circuit and in the refrigerating apparatus controlled thereby. Certain of these changing conditions arise due to the fact that in the process of making ice, the ice product of the refrigerating apparatus is dropped into the storage area and falls between the sensing plates of the capacitive unit.

In this manner, the capacitance of the sensing circuit is changed due to the passage of ice therethrough to cause the chattering of the circuit described above. Also the ice lying in a stored state within the storage compartment of the unit may change both in position and characteristic to further change the capacitive value of the sensing probes. For example, ice formed adjacent the probe may melt away thereby changing its position, and subsequently the capacitance of the probe. Similarly, unfrozen water present in the ice or surface water thereon will drain from the ice to a point below the sensing level of the probe thereby changing the capacitance of the ice due to the

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change in dielectric constant. Thus, an incipient on-off condition in the control circuit will result.

Accordingly, it is one object of the present invention to provide an improved control system for a refrigerating apparatus.

It is another object of the present invention to provide an improved capacitive ice level control having a high degree of reliability in operation.

It is still a further object of the present invention to provide an improved capacitive ice level control having substantially chatter-free characteristics.

It is still another object of the present invention to provide an improved capacitive responsive ice level control circuit including means for varying the upper level to which the ice level will reach.

It is still a further object of the present invention to provide an improved capacitive ice level control having differential operating characteristic wherein the refrigerating apparatus is turned off once the ice level reaches a predetermined maximum and will not turn on again until such time as the ice level has dropped a predetermined level below the said maximum level.

It is still another object of the present invention to provide an improved capacitive ice level control which is simpler in construction, more reliable in operation and less expensive to manufacture than heretofore known refrigerating apparatus controls.

Further objects, features and advantages of this invention will become apparent from a consideration of the following description, the appended claims and the accompanying drawing in which:

FIGURE 1 is a schematic diagram of a capacitive sensitive ice level control incorporating certain principles of the present invention;

FIGURE 2 is a schematic diagram of a circuit illustrating a preferred embodiment of a system for providing a differential operation in the capacitive ice level control of FIGURE 1;

FIGURE 3 is a schematic diagram representatively illustrating circuitry utilized in providing a variable maximum ice level; and

FIGURE 4 is a schematic diagram of a modified capacitive ice level control illustrating the features of the present invention.

Referring now to FIGURE 1 there is illustrated one preferred form of a capacitance sensitive control circuit which may be utilized in taking advantage of the features of the present invention. Specifically, an oscillator type control circuit 10 is connected in controlling relation with an output circuit 12, herein illustrated as a relay circuit. The energization and deenergization of the relay circuit 12 is controlled by the operation of the control circuit 10, the latter being utilized in controlling the operation of the load apparatus. In the particular situation illustrated, the load apparatus includes the compressor of a refrigerating system. The operation of the circuit 10 is varied in response to the change in capacitance of a capacitive probe circuit 14 which is placed in sensing relation within a storage bin or the like of an ice producing apparatus.

As was stated above, the presence of ice in the proximity of or within the capacitor probe gap causes a change in the dielectric constant thereof, thereby reflecting a change in capacitance of the probe circuit 14. The operation of the oscillator circuit 10 may be varied by the addition of circuits 16 and 18, to be described in conjunction with FIGURES 2 and 3, respectively. The operation of the circuits 16 and 18 vary the effective capacitance of the probe circuit 14 in accordance with certain operations of the relay circuit 12.

Referring specifically to the details of the oscillator circuit 10, there is illustrated a PNP type transistor 20

having its conductive state controlled by an oscillator circuit 22, the transistor 20 and oscillator circuit 22 being supplied with electrical energy from a suitable direct current source 24. The transistor 20 is provided with a collector electrode 26 and a base electrode 28 which are connected to the oscillator circuit 22 by means of a conductor 30 and a coupling capacitor 32. The oscillator circuit 22 includes a parallel combination of a variable trimmer capacitor 36 connected in parallel circuit arrangement with an inductive coil 38, wherein the inductor 38 is connected to the source of electrical energy 24 in an auto transformer configuration by means of a conductor 40.

The transistor 20 further includes an emitter electrode 44 which is connected to ground potential at ground conductor 46 by means of a coupling network 48. The coupling network includes a resistor 50 which provides a controlled potential at the emitter electrode 44 in response to the conductive or nonconductive condition of the transistor 20. A capacitor 52 is connected in shunt relation to the resistor 50 to provide an alternating current bypass or filter for the network 48. The base-emitter biasing potential for the base-emitter circuit of transistor 20 is provided by means of a series combination of a resistor 54 and a potentiometer 56, the latter of which is connected at one end to ground potential by means of conductor 58 and at the other end of the resistor 54 is connected to the source of DC potential 24 by means of the conductor 40.

With the foregoing circuitry and a proper combination and adjustment of inductor element 38 and capacitor 36, an oscillatory operation of the transistor 20 will be created thereby rendering the transistor 20 conductive during the period that the circuit is oscillating. The conduction of transistor 20 causes the lowering of the potential at the emitter 44 thereby providing a proper biasing signal to drive an output transistor 60 to the conductive state.

The voltage at emitter 44 is fed to a base electrode 62 of transistor 60 by means of a conductor 64 and an emitter electrode 68 is connected to ground potential at 46 by means of conductor 70. The collector electrode 72 is connected through the load circuit 12 to the source of DC potential 24 by means of a conductor 74 whereby the conduction of the emitter collector circuit of transistor 60 will tend to energize the load circuit 12. While the above description has been rendered on the basis that an oscillation of circuit 22 and transistor 20 will cause the output circuit 12 to be energized, it is to be understood that the opposite effect could be achieved by the proper selection of elements and polarities. Similarly, the output circuit may incorporate semiconductor switching elements rather than the relay illustrated, or other known elements.

The output circuit 12, in the preferred embodiment, generally comprises an output relay 80 which is connected in series relation with the emitter-collector circuit of transistor 60 whereby the conduction of transistor 60 causes the energization of the relay 80. The relay 80 is connected in magnetic controlling relation with a switch 82 having a normally closed contact 84 in contacting relation with a switch armature 86 at such time as the relay is deenergized. Upon energization of the relay 80, the armature 86 is connected to a transfer contact 88 thereby completing the circuit to the load connected to output conductors 90, 92.

The load circuit may comprise a motor compressor combination of a refrigerating apparatus whereby the compressor is energized or operated in response to the completion of the circuit between conductors 90 and 92 through switch armature 86 and transfer contact 88. Thus, the oscillation of the circuit 22 in conjunction with the transistor 20 will cause the operation of the refrigerating apparatus to produce ice therein. The control circuit described above is adapted to be utilized in conjunction with an ice storage bin which has been provided with a

pair of capacitive probes 100 and 102 which are situated in spaced relation, one from the other, within the confines of a storage bin 104. It has been found that the variation in dielectric strength between air and ice is sufficiently different to control the operation of an oscillator circuit, such as that described above, wherein the level of ice in the storage bin 104 may be sensed by sensing the amount of ice disposed between the capacitor plates 100 and 102.

Thus the capacitance of the plates 100 and 102 has been found to vary between .4 picofarad (pf.), wherein the dielectric constant of air is at 1.0, to approximately 31 pf. at an ice level which approximates a full storage bin 104, wherein the dielectric constant of ice has been found to be approximately 70. Utilizing this phenomenon, the level of ice between the probes 100 and 102 may be sensed by means of sensing the change in capacitance between the probes as the level of ice varies from a condition wherein the ice is remote from either of the electrodes or capacitor plates 100 and 102 to a position wherein the total area of the plates is covered up.

It will be noted that the capacitance between the probe plates 100 and 102 will vary in accordance with the amount of the area of the plates which is covered or masked by the buildup of ice therebetween. The dielectric constant of the ice may further vary in accordance with the situation of whether the ice is dry or wet, etc., and the amount of air between plates 100, 102.

Thus it is that the operation of the oscillator circuit may be varied in accordance with the sensed conditions within an ice bin wherein the probes 100, 102 are representatively illustrated in probe circuit 14 (FIGURE 1). The capacitance of the plates 100, 102 is sensed to alter the operation of the oscillator circuit 22 by means of a conductor 110 wherein the capacity of circuit 14 is fed in parallel relation to the oscillator circuit 22, the capacitor 32 and the potentiometer 56. Accordingly, it is seen that the operation of the oscillator circuit 22 may be varied in response to the sensed capacitance between probes 100 and 102 whereby the circuit 22 may be caused to cease oscillations at a preselected amount of total capacitance of the oscillator circuit, including the capacitance added by the circuit 14.

In the use of the circuit, the oscillator 22 is caused to commence oscillation and the bin 104 is filled to the desired level. The trimmer capacitor 36 is then adjusted to such a value that the circuit ceases oscillation at the desired fill point of the storage bin 104. The transistor 60 will be rendered nonconductive due to the cessation of oscillations and the refrigerating apparatus will be deenergized in response to the filing of the bin 104. However, it will be noted that the removal of ice from the bin or the other conditions described above may start oscillations occurring in the circuit 22, thereby permitting the incipient action of the relay 80 for the reasons discussed above. Accordingly, it is desirable to maintain the oscillator circuit 22 in the nonoscillating state until such time as the level of ice in the bin reaches a predetermined minimum level.

It has been found that, by the addition of capacitance to the oscillator circuit 22 at such time as the refrigerating apparatus is deenergized, a differential effect will be achieved. This differential action permits the ice level within the bin 104 to drop to a level below the maximum level of ice before the oscillations in circuit 22 again commence.

This feature may be provided by the additional switching circuitry illustrated in FIGURE 2 wherein a conductor 120 is connected at one end to the capacitor input conductor 110 and at the other end thereof to a switch armature 122. The switch armature 122 is adapted to be controlled by the operation of the relay 80 wherein the deenergization of the relay 80 causes the armature 122 to transfer from a transfer contact 124 to a normal contact 126 with the armature 122 in the deenergized posi-

tion illustrated in FIGURE 2. In this way, a capacitor 130 is connected in parallel with the capacitance between plates 100 and 102 by means of conductor 120, armature 122, contact 126, capacitor 130 and a ground connection 132. At the same instant, the electrical circuit to the load is interrupted due to the fact that the armature 86 is transferred from transfer contact 88 to normal contact 84.

With the capacitor 130 connected in circuit with the oscillator circuit 22 and the probe circuit 14, the effective capacitance of the oscillator circuit will be greater than that permitted for oscillation due to the additional capacitance of element 130 and the fact that the capacitance of the probe circuit 14 is approximately equal to that permitted for oscillation. Accordingly, the ice level within the storage bin 104 may drop to a level sufficient to decrease the capacitance of the probe circuit 14 by an amount equal to the added capacitance due to the connection of capacitor 130 into circuit. At such time as the ice level reaches the minimum to commence oscillation, the capacitor 130 will be disconnected from the circuit and the ice level will be permitted to build up to the maximum described with probe 14 and without the capacitance of capacitor 130.

In utilizing circuits of the capacitive sensing type, it has been found desirable to enable the user to vary the maximum level to which the ice will reach by a simple switching of a level switch without necessitating the re-balancing of the oscillator circuit by means of variable capacitor 36. Accordingly, a level circuit 140 has been provided as illustrated in FIGURE 3 wherein a variable amount of capacitance may be switched into parallel circuit with the oscillator circuit 22 in accordance with a desired decreasing level of ice within the bin 104. Thus a capacitor bank 142 has been provided with a plurality of capacitors which are adapted to be switched into circuit with the capacitance between plates 100 and 102 by means of a switch armature 144 and a conductor 146.

The switch armature 144 is adapted to be transferred through a plurality of contacts 148 to 160 to provide an addition of a zero capacitance for terminal 148 and a finite amount of capacitance which increases from terminal 150 to terminal 160. The levels to which the terminals 148 to 160 will limit the ice are representatively illustrated by lines 162 to 174 corresponding to switch contacts 148 to 160, respectively.

Thus, if the circuit 10 is initially adjusted such that oscillations will cease at the maximum indicated by line 162 with switch armature 144 in contact with terminal 148, this level may be consecutively decreased by the successive switching of the armature 144 through contacts 150 to 160. Accordingly if the armature 144 is switched into contact with terminal 156 after the circuit 10 is initially adjusted, the level of ice within the bin 104 will reach a point approximately as indicated by line 170. If it is desired to further decrease the level to which the ice reaches the armature 144 may be switched into contact with terminal 158 or 160.

Referring now to FIGURE 4, there is illustrated a modification of the control circuit described in conjunction with FIGURE 1 which may be utilized in providing the control functions described above. Specifically, a control circuit 180 generally includes a pulse producing oscillator 182 which is connected in controlling relation with a driver circuit 184. The driver circuit 184 is adapted to provide driving current for a control circuit configuration 186 connected in controlling relation with an output circuit 188. As was the case with FIGURE 1, the output signal of the oscillator circuit 182 is modified by means of a probe circuit 14 which is connected in level sensing relation with a storage bin such as storage bin 104.

Specifically, the oscillator circuit 182 is of the relaxation oscillator type wherein a variable capacitor 190 is charged from a source of alternating current potential at input terminals 192, 194 through a plurality of resistors 196, 198 including a voltage divider resistor 200, all of

which are connected to ground potential by means of a ground connection 202. The charging voltage across variable capacitor 190 is sensed by means of a neon tube 204 which ignites when the voltage across the capacitor 190 reaches a preselected value. The effective capacitance in the oscillator circuit 182 is varied in accordance with the capacitance of probe circuit 14 wherein the capacitance is increased as the level of ice builds up between capacitor plates 100, 102 as was described in conjunction with FIGURE 1.

The output signal of the oscillator 102 is fed to a transistor 206 by means of a base electrode 208 wherein the transistor is maintained in what will be referred to as the nonconductive state during the period when the capacitance of probe circuit 14 is at a low level or during the period when the ice in the storage bin 104 is below the predetermined maximum. The output signal from capacitor 206 is fed to the circuit 186 including transistors 210 and 212, which are connected in a Darlington configuration, through a resistive biasing circuit including resistors 216, 218 and a coupling capacitor 220. The nonconductive state of transistors 206 maintains transistors 210 and 212 in the conductive state thereby providing a current path from ground circuit 220 to an output conductor 222. The transistors 210, 212 are interconnected in such a manner as to continue conduction after the control signal is removed provided the voltage thereacross does not drop to or go through zero.

The conduction of transistors 210 and 212 shunts any current which would tend to flow through circuit 188, thereby deenergizing a relay 230 contained within the circuit. A filter capacitor 232 is connected in shunt relation with the relay 232 to filter the current across relay 230. The deenergized condition of relay 230 causes a switch 236 to assume its normal state wherein an armature 238 is in contact with a normal contact 240, thereby energizing the load connected to output conductor 242. At such time as the relay is energized, the armature 238 is moved into contact with a transfer contact 246. The transferring of armature 238 into contact with transfer contact 246 connects a differential capacitor 250 into circuit with the probe circuit 14 by means of conductors 252 and 254 whereby the effective capacitance of the probe circuit 14 is increased by a predetermined amount.

The capacitor 250 would correspond to capacitor 130 described in conjunction with FIGURE 2 wherein the refrigerating apparatus is maintained in the deenergized state once it has been deenergized until such time as the ice level in the storage bin 104 drops to a predetermined minimum. A maximum level control circuit 256 is connected to the probe circuit 14 by means of conductor 258 and permits the user to vary the maximum level to which the ice will reach as was the situation described in conjunction with FIGURE 3.

While it will be apparent that the embodiments of the invention herein disclosed are well calculated to fulfill the objects of the invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope of fair meaning of the subjoined claims.

What is claimed is:

1. A refrigerating apparatus comprising refrigerating means for producing ice, a storage means for storing ice produced by the refrigerating means, and a control circuit for controlling the operation of the refrigerating means in response to the level of ice in the storage means including a first reactive element, an output circuit having first and second states of operation wherein said circuit operates in said first state in response to a characteristic value of said first element, capacitive circuit means operatively connected to said first reactive element for altering the effective characteristic value of said first reactive element and transferring said output circuit to said second state of operation including probe circuit means having first and second spaced plate means in the storage

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means, said plate means being positioned in said storage apparatus a substantial distance, one from the other, such that the ice in the storage means is positioned at least partially in the space between said plate means, said capacitive circuit means acting on said output circuit to cause the transfer of said output circuit to said second state of operation when the ice in the storage means reaches a predetermined height thereby altering the capacitive value of said capacitive circuit means.

2. The control circuit of claim 1 wherein said reactive elements is a capacitor.

3. The control circuit of claim 1 further including additional circuit means for varying the effect of said capacitive circuit means on said reactive element including additional capacitance means connected in circuit with said capacitive circuit means.

4. The control circuit of claim 1 wherein said reactive element is a capacitor and the buildup of ice in the storage means increases the effective capacitive value of said capacitor on said output circuit to transfer the output circuit of the second state of operation in response to the attainment of a preselected buildup of ice.

5. The control circuit of claim 3 wherein said additional circuit means is connected in circuit with said probe circuit means when said control circuit transfers to said second state of operation to increase the effective capacitive value of said probe circuit on said reactive element for a differential operation of said control circuit and permitting said control circuit to remain in said second state of operation until said ice level drops below a predetermined minimum.

6. The control circuit of claim 5 wherein said control circuit transfers back to said first state of operation in response to the level of ice dropping below said predetermined minimum.

7. The control circuit of claim 6 wherein said additional circuit means is disconnected from said probe circuit when said control circuits transfers from said second to said first state of operation.

8. The control circuit of claim 3 wherein said additional circuit includes fixed capacitive circuit means connected in circuit with said probe circuit means during said first and second states of operation of said control circuit, said fixed capacitive circuit means coacting with said probe circuit means to limit the maximum ice buildup in the storage means.

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9. In a refrigerating apparatus having refrigerating means and a storage means for storing ice produced by the refrigerating means, a control circuit for controlling the operation of the refrigerating means in response to the level of ice in the storage means comprising a first reactive element, an output circuit having first and second states of operation wherein said circuit operates in said first state in response to a characteristic value of said first element, capacitive circuit means operatively connected to said first reactive element for altering the effective characteristic value of said first reactive element and transferring said output circuit to said second state of operation including probe circuit means having first and second spaced plate means in the storage means, the ice in the storage means being adapted to be positioned at least in the proximity of the space between said plate means, said capacitive circuit means causing the transfer of said output circuit to said second state of operation when the ice in the storage means reaches a predetermined height thereby altering the capacitive value of said capacitive circuit means, said fixed capacitive circuit means including a plurality of fixed capacitors of varying values, and switch means for selectively interconnecting selected ones of said fixed capacitors in circuit with said probe circuit means for varying the maximum ice buildup in the storage means.

10. The control circuit of claim 9 wherein said selected fixed capacitor is connected in parallel circuit with said probe circuit to vary the effective capacitance of said probe circuit on said control circuit and vary the maximum buildup of the ice to a maximum below that caused by said probe circuit independently.

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