

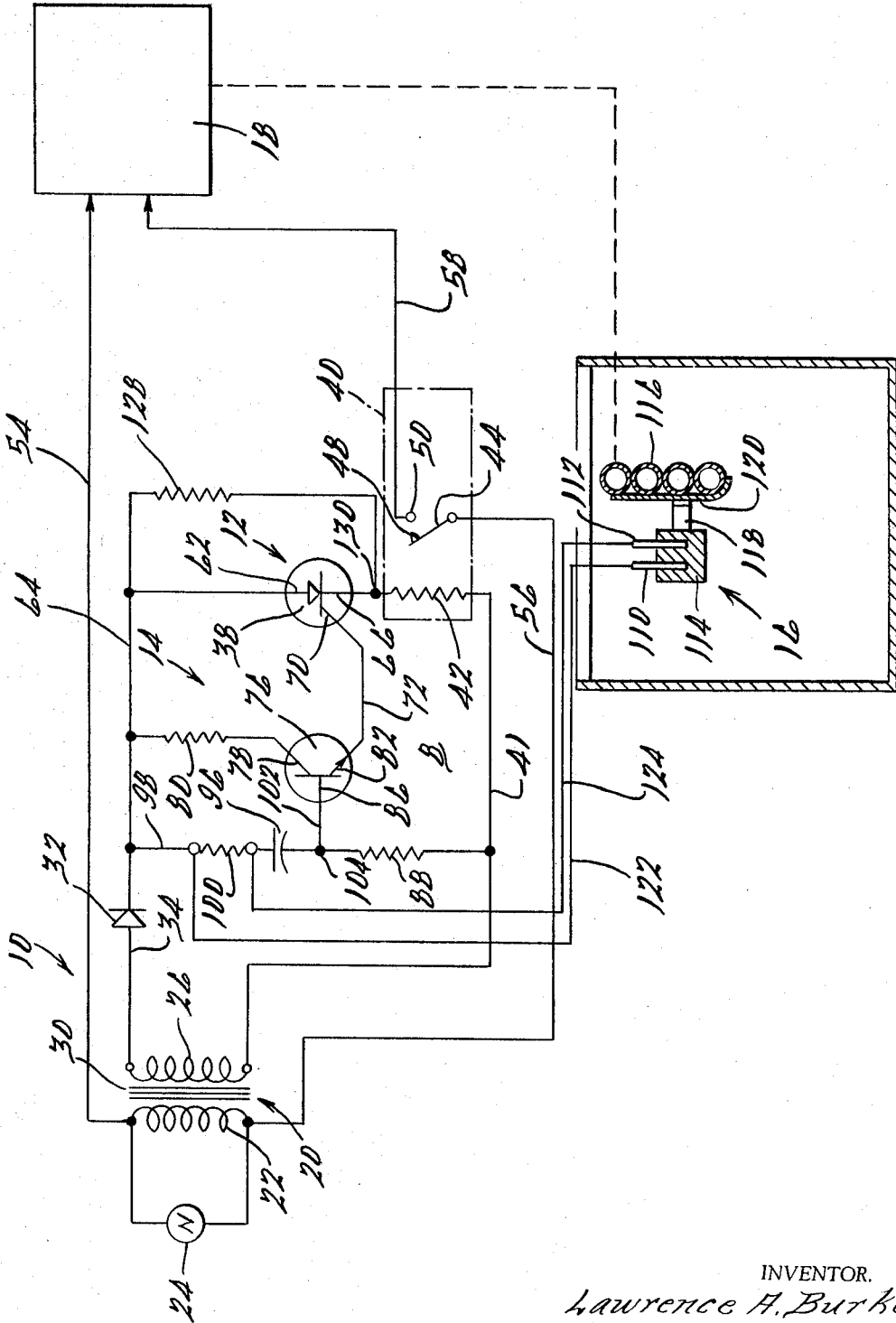
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SOLID STATE ICE BANK CONTROL

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SOLID STATE ICE BANK CONTROL

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The present invention relates generally to a control system for refrigerating apparatus and more specifically to a control system which is adapted to control the operation of a compressor mechanism of the refrigerating system wherein the control system is responsive to a change in an electrical characteristic of a transfer medium, as for example, the difference in an impedance characteristic between the medium in one state as compared to an impedance characteristic of the medium in another state.

The invention is particularly adapted for use in conjunction with a refrigerating apparatus of the type incorporating an ice forming means, such as a set of evaporator coils which receive a cooling fluid under pressure from a compressor unit. The evaporator coils are normally submerged in a cooling medium, such as water, in proximity to a set of dispensing coils containing the material to be cooled. Accordingly, the extraction of heat from the cooling medium adjacent the evaporator coils is transmitted to the dispensing coils by the cooling medium, thus extracting heat from the dispensing coils.

In certain applications of the refrigerating apparatus, as for example, in a beverage dispensing application, it is desirable to maintain a predetermined thickness of ice on the set of evaporator coils connected to the compressor. A primary reason for building up a bank of ice on the evaporator coils within predetermined limits is to increase the average effective heat absorption capacity of the refrigerating mechanism by storing refrigeration capacity within the apparatus, in the form of ice, during the times in which the beverage dispensing machine is not being used. Accordingly, when the machine is at its peak load and beverage is being dispensed at a rapid rate, the stored refrigeration capacity of the system will be utilized by melting the ice bank. Thus, the latent heat of fusion of ice, as it is melted, is utilized while effecting the desired temperature of the beverage passing through the coils submerged in the water bath.

However, it is important that the ice bank not be permitted to build up beyond a predetermined maximum to insure that the material contained within the dispensing coils or the medium adjacent the dispensing coils does not fall below the freezing temperature. Obviously, the freezing of the beverage contained within the submerged cooling coils would render the beverage dispenser inoperable due to its clogging by ice. Accordingly, it is necessary that the ice bank be limited to a predetermined maximum thereby permitting the dispensing coils to be surrounded by the cooling medium at a temperature as close to 32° as is feasible without freezing.

The principles of the present invention are adapted to be utilized in various types of dispensing apparatus and is particularly capable of being utilized in the type of beverage dispensing apparatus which basically consists of an insulated water tank in which an ice forming means, the evaporator coils, are submerged proximate with the dispensing coils which carry the beverage to be cooled. In this type of beverage dispensing apparatus, it is the usual practice to include a water agitating means to effect an efficient heat transfer between the coils of the ice forming means and the beverage containing dispensing coils through the water or other cooling transfer medium. In carrying out the principles of the present

invention, a control circuit is provided which generates a control signal in response to a sensed electrical condition of the cooling medium, as for example, the change of resistance between water and ice as the cooling medium is frozen about the ice forming means.

The output signal of the control signal is connected in controlling relation to a compressor circuit which controls the operation of the compressor in the refrigerating apparatus. More particularly, the control circuit includes a source of electrical energy which is fed to a switching element, as for example, a silicon controlled rectifier. The switching element is adapted to control the flow of current through an output means which acts as a transducer between the controlling circuit and the controlled circuit. While the term switching element is utilized in describing the control element, it is to be considered generic to amplitude control elements, as for example, inter alia, a transistor which is either slightly conducting or saturated, and an on-off device, as for example, a transistor operated in the conducting or non-conducting state or a silicon controlled rectifier.

The switching operation of the switch means is controlled, in the preferred form of the invention, through a firing circuit which comprises a transistor, the collector-emitter circuit current of which forms the firing current for the gate electrode of the silicon controlled rectifier. The conduction of the transistor is controlled by means of a variable impedance connected in the base circuit, the magnitude of the impedance varying in accordance with the electrical characteristic being sensed. In the illustrated embodiment, the variable impedance means takes the form of the resistance between a pair of probes, through the cooling medium. The probes are spaced, one from the other and one probe is placed closely spaced from the evaporator coils. Thus, the resistance varies in accordance with the amount of ice forming adjacent the ice forming means and between the probes.

The control circuit has been provided with a capacitor in the base circuit which provides a block for any direct current which may flow through the probes adjacent the ice forming means. This direct current block is utilized to prevent electrolytic action of the probes, this electrolytic action eroding the probes and decreasing the life thereof. The circuit has been so designed that it is voltage compensated or voltage insensitive, that is, variations in the source voltage will not produce variations in the output signal in the presence of identical sensed conditions.

Accordingly, it is one object of the present invention to provide an improved control circuit which is responsive to a change of conditions of a medium.

It is a further object of the present invention to provide an improved control circuit which is responsive to a change of electrical conditions of a medium.

It is another object of the present invention to provide an improved control circuit for a refrigerating apparatus.

It is still another object of the present invention to provide an improved control circuit for a refrigerating system, the control circuit being responsive to a change of electrical conditions in the cooling medium.

It is still a further object of the present invention to provide an improved control apparatus for a refrigerating system which is responsive to the difference in impedance between the refrigerating medium in one state as compared to the impedance of the medium in another state.

It is another object of the present invention to provide an improved control system for a refrigerating apparatus which will maintain a coating of ice on an ice forming means between predetermined maximum and minimum limits in thickness.

It is still a further object of the present invention to provide an improved control system for a refrigerating apparatus which is voltage compensated and includes means for preventing electrolytic action by blocking direct current from the probes in the cooling medium.

It is a further object of the present invention to provide an improved control system for a refrigerating apparatus which is compact, has a long life, low heat generating characteristics and is inexpensive to manufacture.

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:

The single figure of the drawing is a schematic illustration of one preferred embodiment of the invention, as used in conjunction with a refrigerating apparatus.

Referring now to the single figure of the drawing, there is illustrated a control circuit 8, as applied to a refrigerating apparatus and is adapted to perform the functions described above. The control circuit 8, in broad terms, generally comprises a source of power 10, an output controlling means 12, a condition responsive control circuit 14 for controlling the operation of the output controlling means 12, a condition sensing circuit means 16 for controlling the operation of the condition responsive control circuit 14, and the device to be controlled 18, as for example, a compressor circuit of a refrigerating apparatus.

The source of supply 10 generally comprises an input transformer 20 having a primary winding 22 connected to a source of alternating current potential 24, and a secondary winding 26 magnetically coupled to the primary winding 22 through a transformer core 30. The transformer is provided to isolate the control circuit 8 from the source of electrical energy and also to provide the proper operating voltage for the control circuit 8 and the controlled device 18, both the control circuit 8 and the controlled device 18 being energized from the same source.

The output of the secondary winding is fed to a half wave rectifying means 32, in the form on a semiconductor diode, by means of a conductor 34, and the output of the diode 32 is fed through the output controlling means 12, in the form of a silicon controlled rectifier 38. The output of the silicon controlled rectifier 38 is fed through a circuit controller 40 and back to the secondary winding 26 by means of a conductor 41. The circuit controller 40, in the preferred embodiment, is illustrated as consisting of a thermal relay which includes a resistance heating element 42 and a normally open switch 44 in thermal proximity to the heating element 42. The normally open switch 44 is thermally responsive to the resistance heating element 42 and may be formed of a bimetal or other thermally responsive configuration whereby the contacts 48, 50 are closed in response to a heating of the heating element 42. It is to be understood that other types of circuit controllers may be utilized.

The switch 44 is in series circuit with the source of alternating current potential 24 by means of a pair of conductors 54, 56 and a conductor 58 connects the switch 44 to the controlled refrigerating assembly 18. Thus, as the switch 44 is closed, the compressor contained in the controlled system 18 will be energized thereby providing heat removal from the fluid contained in the condenser coils. On the other hand, as the silicon controlled rectifier 38 ceases conduction and the switch 44 opens, the compressor will be deenergized.

Thus, the heating and cooling of resistance heating element 42 is controlled by the conduction and nonconduction of the silicon controlled rectifier 38. The anode 62 of the silicon controlled rectifier 38 is connected to a conductor 64 which forms the positive conductor of the control system 8, and the cathode 66 is connected to the negative conductor 41 through the resistance heating element 42. The gate electrode 70 is connected to the condition responsive or firing circuit 14 by means of a conductor 72. The firing circuit generally comprises an NPN trans-

sistor 76 having a collector electrode 78 connected to the positive conductor 64 through a collector load resistance 80 and an emitter electrode 82 connected to the gate electrode 70 through the conductor 72. A base electrode 86 is connected to the negative conductor 41 through a voltage divider resistor 88. While an NPN transistor is illustrated, it is to be understood, that by proper polarity modifications, a PNP transistor may be utilized. Also, the control means may take a form including other elements known in the art, as for example, tunnel diodes, hyperconductive diodes, unijunction transistors and the like.

The base electrode 86 is connected to the positive conductor 64 through a blocking capacitor 96, a conductor 98 and a representative variable resistance 100. The variable resistance 100 and the fixed resistance 88 form a voltage divider network, with the base electrode connected therebetween by a conductor 102. Accordingly, as the magnitude of the variable resistance 100 drops in value, a greater current will flow through the circuit, thereby raising the voltage at a node 104. This increased voltage at node 104 causes the transistor to conduct or become more conductive, as the case may be depending on the value chosen for the resistance 88. Contrarywise, as the resistance 100 increases, the current flow through the voltage divider will decrease and the voltage node 104 will be drawn closer to the voltage of conductor 41, thereby decreasing the base-emitter current to transistor 76. Thus, the transistor 76 ceases conduction.

When the transistor 76 is in the nonconductive state, the gate current to the silicon controlled rectifier 38 is cut off and the silicon controlled rectifier 38 ceases conduction. Accordingly, the resistance heating element will cool down and the contacts 48, 50 will be opened. It is to be understood that while the controller 40 has been illustrated as a resistance heating element and a normally open switch, a relay element may be utilized in lieu thereof, or any other type of switching means which may be controlled by the interruption of current therethrough or voltage thereacross. As was stated above, the probe circuit 16 controls the value of the reflected impedance 100 in response to the buildup of ice on the evaporator coils.

The probe circuit includes a pair of probe elements 110, 112 which are suitably mounted in an inert support structure 114 and supported relative to the set of evaporator coils 116 by means of a bracket 118 and evaporator coil support member 120. Thus, as the compressor is energized and cooling fluid flows through the evaporator coils 116, a layer of ice will be built up around the coils 116 due to the lowering of the temperature around the coils 116 below the freezing point. As the ice builds up to a point adjacent the probe structure 16, the electrode 112 closest to the condenser coil 116 will be enveloped with ice. As the ice continues to build up and fully covers the electrode 112, the resistance between the electrodes 110, 112 will increase substantially over the resistance between the electrodes through the water when the electrode 112 is uncovered.

This impedance between electrodes 110 and 112 is fed into series circuit with resistance 88 by means of a pair of conductors 122, 124 and is representatively illustrated as the impedance 100. It is to be understood, in the preferred embodiment, impedance 100 does not actually exist as illustrated in the drawing, but rather the impedance 100 is merely representative of the impedance between the probes 110 and 112. Thus, as the ice covers the electrode 112, the impedance 100 will increase substantially, thereby decreasing the current flow to the base emitter circuit of transistor 76 and switching the transistor 76 to the nonconductive state.

As stated above, the control circuit 8 is voltage compensated, that is, it is substantially insensitive to voltage fluctuations at the supply source 24. This voltage compensation is accomplished by means of a second voltage divider

network in the output stage of the control circuit. This voltage divider has been formed by providing a resistor 128 in parallel circuit relation with the silicon controlled rectifier 38 and in series circuit with the resistance portion of the resistance heating element 42. The juncture of resistance 128 and 42, forming node 130 increases and decreases its voltage in accordance with the increase and decrease of the supply voltage, respectively.

Accordingly, as the supply voltage increases, the voltage at node 130 will also increase thereby making the cathode 66 of silicon controlled rectifier 38 more positive with respect to its anode 62. However, as stated above, the representative impedance 100 and the resistance 88 form a first voltage divider circuit wherein the node 104 also increases and decreases its potential in accordance with the increase and decrease of the source potential 24. Thus, as the voltage at node 104 increases for a given ice formation on electrode 112, the increase being due to a rise in source potential 24, the node 130 will also increase a corresponding amount thereby increasing the positive potential at cathode 66.

In this way the circuit is voltage compensated by offsetting the increase in the amount of gate current supplied to the gate electrode 70 by simultaneously raising the cathode potential 66 to a more positive level, thereby decreasing the amount of conduction of the silicon controlled rectifier 38 for any given gate current. On the other hand, if the supply voltage decreases, thereby decreasing the potential at node 104, the conduction of transistor 76 is decreased thereby decreasing the gate firing current. Also, the voltage at the cathode 66 will be made less positive thereby increasing the conduction characteristics of the silicon controlled rectifier 38 for any given gate current. Thus, while the gate current may decrease, the silicon controlled rectifier 38 will be rendered capable of conducting the same amount of current at the decreased gate current, thus compensating for a decrease in voltage at the source 24.

This voltage compensation of the circuit is desirable due to the fact that the transistor 76 is highly sensitive to voltage variations at the base electrode 86. Thus, while the amount of ice may not increase or decrease, the voltage at node 104 may rise or fall to increase or decrease the conduction of transistor 76. Without voltage compensation, the silicon controlled rectifier 38 will conduct more or less, depending upon the increase or decrease of the supply voltage 24.

Further, experience has illustrated that the starting of the refrigerating apparatus 18 tends to lower the voltage across the primary winding 22 in the situation where the apparatus 18 and the control circuit are supplied from the same source due to the increased loading on the windings. Without the voltage compensation feature, the voltage available at the secondary winding 26 would accordingly decrease for an increased load, thereby decreasing the voltage at node 104. This lowering of the voltage would decrease the conduction of transistor 76 and also the conduction of silicon controlled rectifier 38 to turn off the refrigerating apparatus 18. However, as soon as the refrigerating apparatus 18 turns off, the supply voltage at primary winding 22 would immediately rise thereby increasing the voltage at node 104. The net effect of this increased voltage would cause the refrigerating apparatus to again turn on. The final result would be that the refrigerating apparatus would be incipiently energized and deenergized in accordance with a frequency determined by the inertia of the controller 40. The voltage divider compensating networks described above tend to alleviate this problem.

While the foregoing concepts have been described in an environment of a refrigerating apparatus, it is to be understood that other uses for a control circuit may be provided. For example, if the probe resistance 100 were replaced by a temperature responsive resistor and the resist-

ance 88 made adjustable, the circuit may be utilized as a voltage compensated thermostat wherein the environmental temperature would vary the effective resistance 100 and the silicon controlled rectifier 38 would be utilized in controlling a heating circuit. Similarly, the probe resistance 100 could be replaced by both a thermally responsive resistance having a positive or negative temperature coefficient and a potentiometer in series. Resistor 88 is then replaced by a temperature responsive resistance with a temperature coefficient which is opposite to that of the above temperature responsive resistance. The result is a solid state thermostat with an auxiliary freeze detection, this apparatus having been heretofore supplied with two mechanical thermostats. Further, the thermoelectric relay 40 and the compressor mechanism 18 may be replaced by a thermoelectric module comprising a series of thermoelectric cells or a single cell for the extraction of heat from the media.

While it will be apparent that the embodiment of the invention herein disclosed is 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 or fair meaning of the subjoined claims.

What is claimed is:

1. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of the freezing media, a pulsating direct current source of electrical energy and impedance means varying the magnitude of its impedance in accordance with predetermined freezing and nonfreezing conditions of the media comprising output controlling means, controller means connected in circuit with said output control elements and operatively connected with the apparatus for controlling the operation of the apparatus in response to an electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to the predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means connected to the impedance means for producing a condition signal in response to variations of the impedance means, signal producing circuit means for producing a control signal in response to said condition signal, said signal producing means varying the conductive conditions of said controlling means in response to said controlling means, and reactive impedance means in circuit between said condition sensing circuit means and said signal producing circuit means for blocking direct current components of the pulsating source of electrical energy from said condition sensing circuit means.

2. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of the freezing media, and impedance means varying the magnitude of its impedance in accordance with predetermined freezing and nonfreezing conditions of the media comprising a pulsating direct current source of electrical energy, output controlling means, controller means connected in circuit with said output control elements and operatively connected with the apparatus for controlling the operation of the apparatus in response to an electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to the predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means connected to the impedance means for producing a condition signal in response to variations of the impedance means, signal producing circuit means for producing a control signal in response to said condition signal, said signal producing means varying the conductive conditions of said controlling means in response to said controlling means, and capacitive reactive impedance means in circuit between said condition sensing circuit means and said signal producing circuit means for block-

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ing direct current components of the source of electrical energy from said condition sensing circuit means.

3. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of the freezing media comprising a unidirectional semiconductor controlling means having first, second and third electrode means, relay switching means connected in circuit with said first and second electrodes of said controlling means, said relay switching means being operatively connected with the apparatus for controlling the apparatus in response to a change in electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means having impedance means, said impedance means varying the magnitude of its impedance in accordance with the freezing and nonfreezing conditions of the media and a signal producing circuit means having semiconductor means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance means, said semiconductor means having an electrode connected at one end of said impedance means and the other end of said impedance means being connected to a source of electrical energy, said signal producing means varying the conductive condition of said controlling means in response to said control signal.

4. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of the freezing media comprising a unidirectional output controlling means having first and second electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means having a plurality of probes positioned in the environment of the media and varying the magnitude of the impedance between the probes in accordance with the freezing and nonfreezing conditions of the media and a signal producing circuit means for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance, said signal producing means varying the conductive condition of said controlling means in response to said control signal.

5. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of the freezing media comprising a unidirectional output controlling means having first and second electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means having a plurality of probes positioned in the environment of the media and varying the magnitude of the impedance between the probes in accordance with the freezing and nonfreezing conditions of the media and a signal producing circuit means having semiconductor means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance, said semiconductor means having an electrode connected to one of said probes, another of said probes being connected to a source of electrical energy whereby a condition of said electrical energy as impressed on said semiconductor means is varied in accordance with the impedance between said electrodes, said signal producing means varying the con-

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ductive condition of said controlling means in response to said control signal.

6. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of a freezing media comprising a unidirectional semiconductor controlling means having first, second and third electrodes, current responsive relay means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to variation of current through said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means having a plurality of probes positioned in the environment of the media and varying the magnitude of the impedance between the freezing and nonfreezing probes in accordance with the conditions of the media and a signal producing circuit means including control semiconductor means having a first electrode connected to said third electrode of said controlling means for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance, said semiconductor means having a second and third electrode, one of said second and third electrodes being connected to one of said probes, another of said probes being connected to a source of electrical energy whereby current from said electrical energy fed to a circuit comprising two of said first, second and third electrodes of said control semiconductor means is varied in accordance with the impedance between said electrodes, said signal producing means varying the conductive condition of said controlling means in response to said control signal.

7. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of a freezing media comprising a silicon controlled rectifier having first, second and gate electrodes, current responsive relay means connected in circuit with said first and second electrodes of said silicon controlled rectifier and operatively connected with the apparatus for controlling the apparatus in response to current flow through said silicon controlled rectifier, and condition responsive control circuit means coupled in controlling relation with said silicon controlled rectifier in response to predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means having a plurality of probes positioned in the environment of the media and varying the magnitude of the impedance between the probes in accordance with the freezing and nonfreezing conditions of the media and a signal producing circuit means including transistor means having an emitter-collector circuit connected to said gate electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance, said transistor means having a base electrode connected to one of said probes, another of said probes being connected to a source of electrical energy whereby current from said electrical energy fed to the base-emitter circuit is varied in accordance with the impedance between said electrodes, said signal producing means varying the conductive condition of said silicon controlled rectifier in response to said control signal.

8. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control the amount of freezing of a media between predetermined approximate maximum and minimum limits comprising a unidirectional output controlling means having first and second electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to a predetermined degree of freezing of the media including condition sensing circuit means

having a plurality of probes so positioned in the media that at least the predetermined maximum of frozen media falls between said probes, the magnitude of the impedance between said probes varying in accordance with the amount of freezing of the media and a signal producing circuit means for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance between said probes, said signal producing means varying the conductive condition of said controlling means in response to said control signal.

9. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control the amount of freezing of a media between predetermined approximate maximum and minimum limits comprising output controlling means having first, second and third electrode means, controller means connected in circuit with said first and second electrodes of said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to a predetermined degree of freezing of the media including condition sensing circuit means having a plurality of probes so positioned in the media that at least the predetermined maximum of frozen media falls between said probes, the magnitude of the impedance between said probes varying in accordance with the amount of freezing of the media and a signal producing circuit means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance between said probes, said signal producing means varying the conductive condition of said controlling means in response to said control signal.

10. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control the amount of freezing of a media between predetermined approximate maximum and minimum limits comprising a unidirectional semiconductor controlling means having first, second and third electrode means, relay switching means connected in circuit with said first and second electrodes of said controlling means, said relay switching means being operatively connected with the apparatus for controlling the apparatus in response to a change in electrical condition of said controlling means, and condition responsive control circuit means coupled in controlling relation with said controlling means in response to a predetermined degree of freezing of the media including condition sensing circuit means having a plurality of probes so positioned in the media that at least the predetermined maximum of frozen media falls between said probes, the magnitude of the impedance between said probes varying in accordance with the amount of freezing of the media and a signal producing circuit means having semiconductor means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance between said probes, said semiconductor means having an electrode connected at one end of said impedance means and the other end of said impedance means being connected to a source of electrical energy, said signal producing means varying the conductive condition of said controlling means in response to said control signal.

11. A control system for use with an apparatus adapted to control conditions of a media and a source of input electrical energy comprising a unidirectional output controlling means having electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined conditions of the media including condition sensing circuit means having first impedance means, said first impedance means varying

the magnitude of its impedance in accordance with the conditions of the media and a signal producing circuit means for producing a control signal which varies in magnitude in accordance with the variation in magnitude of said first impedance means, said signal producing means varying the conductive condition of said controlling means in response to said control signal, and voltage compensation circuit means including said impedance means and second and third impedance means, said first and second impedance means forming a voltage divider connected between the input source and said signal producing circuit means for varying the voltage of said input source fed to said signal producing circuit means in a first direction, said third impedance means being connected between said input source and said electrode means for varying the voltage of said input source impressed on said third electrode in said first direction.

12. A control system for detecting the condition of a freezing media and controlling an apparatus adapted to control conditions of a freezing media and a source of input electrical energy comprising a unidirectional output controlling means having first and second electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined freezing and nonfreezing conditions of the media including condition sensing circuit means having first impedance means, said first impedance means varying the freezing and nonfreezing magnitude of its impedance in accordance with the conditions of the media and a signal producing circuit means having semiconductor means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of said first impedance means, said semiconductor means having an electrode connected at one end of said impedance means and the other end of said impedance means being connected to a source of electrical energy, said signal producing means varying the conductive condition of said controlling means in response to said control signal.

13. A control system for use with an apparatus adapted to control conditions of a media comprising a unidirectional output controlling means having first and second electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined conditions of the media including condition sensing circuit means having a plurality of probes positioned in the environment of the media and varying the magnitude of the impedance between the probes in accordance with the conditions of the media and a signal producing circuit means having semiconductor means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance, said semiconductor means having an electrode connected to one of said probes, another of said probes being connected to a source of electrical energy whereby a condition of said electrical energy as impressed on said semiconductor means is varied in accordance with the impedance between said electrodes, said signal producing means varying the conductive condition of said controlling means in response to said control signal, and voltage compensation circuit means including said impedance means and second and third impedance means, said first and second impedance means forming a voltage divider connected between the input

source and said signal producing circuit means for varying the voltage of said input source fed to said signal producing circuit means in a first direction, said third impedance means being connected between said input source and said electrode means for varying the voltage of said input source impressed on said third electrode in said first direction.

14. A control system for use with an apparatus adapted to control conditions of a media comprising a unidirectional semiconductor controlling means having first, second and third electrodes, current responsive relay means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to variation of current through said controlling means, condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined conditions of the media including condition sensing circuit means having a plurality of probes positioned in the environment of the media and varying the magnitude of the impedance between the probes in accordance with the conditions of the media and a signal producing circuit means including control semiconductor means having a first electrode connected to said third electrode of said controlling means for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance, said semiconductor means having a second and third electrode, one of said second and third electrodes being connected to one of said probes, another of said probes being connected to a source of electrical energy whereby current from said electrical energy fed to a circuit comprising two of said first, second and third electrodes of said control semiconductor means is varied in accordance with the impedance between said electrodes, said signal producing means varying the conductive condition of said controlling means in response to said control signal, and voltage compensation circuit means including said impedance means and second and third impedance means, said first and second impedance means forming a voltage divider connected between the input source and said signal producing circuit means for varying the voltage of said input source fed to said signal producing circuit means in a first direction, said third impedance means being connected between said input source and said electrode means for varying the voltage of said input source impressed on said third electrode in said first direction.

15. A control system for use with an apparatus adapted to control the amount of freezing of a media between predetermined approximate maximum and minimum limits comprising a unidirectional output controlling means having first and second electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, condition responsive control circuit means coupled in controlling relation with said controlling means in response to a predetermined degree of freezing of the media including condition sensing circuit means having a plurality of probes so positioned in the media that at least the predetermined maximum of frozen media falls between said probes, the magnitude of the impedance between said probes varying in accordance with the amount of freezing of the media and a signal producing circuit means for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance between said probes, said signal producing means varying the conductive condition of said controlling means in response to said control signal, and voltage compensation circuit means including said impedance means and second and third impedance means, said first and second impedance means forming a voltage divider connected between the input source and said

signal producing circuit means for varying the voltage of said input source fed to said signal producing circuit means in a first direction, said third impedance means being connected between said input source and said electrode means for varying the voltage of said input source impressed on said third electrode in said first direction.

16. A control system for use with an apparatus adapted to control the amount of freezing of a media between predetermined approximate maximum and minimum limits comprising a unidirectional semiconductor controlling means having first, second and third electrode means, relay switching means connected in circuit with said first and second electrodes of said controlling means, said relay switching means being operatively connected with the apparatus for controlling the apparatus in response to a change in electrical condition of said controlling means, condition responsive control circuit means coupled in controlling relation with said controlling means in response to a predetermined degree of freezing of the media including condition sensing circuit means having a plurality of probes so positioned in the media that at least the predetermined maximum of frozen media falls between said probes, the magnitude of the impedance between said probes varying in accordance with the amount of freezing of the media and a signal producing circuit means having semiconductor means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance between said probes, said semiconductor means having an electrode connected at one end of said impedance means and the other ends of said impedance means being connected to a source of electrical energy, said signal producing means varying the conductive condition of said controlling means in response to said control signal, and voltage compensation circuit means including said impedance means and second and third impedance means, said first and second impedance means forming a voltage divider connected between the input source and said signal producing circuit means for varying the voltage of said input source fed to said signal producing circuit means in a first direction, said third impedance means being connected between said input source and said electrode means for varying the voltage of said input source impressed on said third electrode in said first direction.

17. A control system for use with an apparatus adapted to control the amount of freezing of a media between predetermined approximate maximum and minimum limits comprising a unidirectional output controlling means having first and second electrode means, controller means connected in circuit with said controlling means and operatively connected with the apparatus for controlling the apparatus in response to an electrical condition of said controlling means, condition responsive control circuit means coupled in controlling relation with said controlling means in response to predetermined amount of freezing of the media including condition sensing circuit means having a plurality of probes so positioned in the media that at least the predetermined maximum of frozen media falls between said probes, the magnitude of the impedance between the probes varying in accordance with the amount of freezing of the media and a signal producing circuit means having semiconductor means connected to said third electrode for producing a control signal which varies in magnitude in accordance with the variation in magnitude of the impedance, said semiconductor means having an electrode connected to one of said probes, another of said probes being connected to a source of electrical energy whereby a condition of said electrical energy as impressed on said semiconductor means is varied in accordance with the impedance between said electrodes, said signal producing means varying the conductive condition of said controlling

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means in response to said control signal, and voltage compensation circuit means including said impedance means and second and third impedance means, said first and second impedance means forming a voltage divider connected between the input source and said signal producing circuit means for varying the voltage of said input source fed to said signal producing circuit means in a first direction, said third impedance means being connected between said input source and said electrode means for varying the voltage of said input source impressed on said third electrode in said first direction.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,298,191

January 17, 1967

Lawrence A. Burke

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 44, after "action" insert -- normally --;
column 3, line 25, for "respective" read -- responsive --;
column 4, line 24, for "Contrarywise" read -- Contrariwise --;
column 10, lines 31 and 32, strike out "freezing and nonfreezing"
and insert the same in line 33, after "the", first occurrence;
column 12, line 31, for "ends" read -- end --.

Signed and sealed this 24th day of October 1967.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents

Disclaimer

3,298,191.—*Lawrence A. Burke*, Royal Oak, Mich. SOLID STATE ICE
BANK CONTROL. Patent dated Jan. 17, 1967. Disclaimer filed Nov.
6, 1968, by the assignee, *Temprite Products Corporation*.
Hereby enters this disclaimer to claims, 1, 2, 3, 4, 5, 6, 8, 9, 10 and 12 of
said patent.
[*Official Gazette February 4, 1969.*]