This invention relates to heating systems. In particular, the invention relates to a heating system involving the use of a radiating panel and a control circuit for intermittently supplying energy to the panel.

It is an object of this invention to provide a heating system whereby the energy supplied to the panel will be in the form of rapidly repeated pulses, the duration of the pulses being a function of the temperature of the panel whereby the panel will be maintained at an average mean temperature which varies through a small temperature range, the mean temperature being a function of the temperature within the space heated by the panel.

Another object of the invention is to provide a pulsed heating system wherein the pulsing of the system is entirely independent of the frequency of the line supplying the energy to the heating system.

Still another object of the invention is to control the repetition rate of pulsing of the panel in accordance with the temperature existing within the space heated by the panel.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagram of a system including a circuit in accordance with the invention;

FIG. 2, a diagram of the system with a heating panel adapted for use therein; and,

FIG. 3, an enlarged section on the line 3--3 of FIG. 2.

Considering the drawings in greater detail at 10 in FIG. 2 is generally indicated a heating panel. Insofar as this invention is concerned, various forms of electric heating devices may be employed, said devices constituting the load controlled by the circuit. The heater here shown for illustrative purposes constitutes a panel including an electrically conductive film 12, such as a binder of conductive particles, of a cross section and material capable of carrying the heating current. This film is attached or mounted next to an insulating backing sheet 14 which is attached to or mounted on a protective and heat radiating sheet 16, preferably formed of sturdy material such as steel. The heat radiating surface may be mounted in a suitable frame and if desired covered by decorative paper, not shown. Conductive strips or terminals 18 are provided to connect the conductive film 12 to an electric source.

The terminals 18 are connected to a controller 28. Also electrically connected to the controller is a heat sensitive device 30 mounted in heat sensing relationship to the panel 10, the mounting being sufficiently close so that the device is sensitive to the temperature of the panel rather than the temperature of the space heated by the panel. Thus, the device 30 may be mounted directly on the panel for better heat conduction therefrom.

Also, if desired, but not necessary to the functioning of the invention, is a second heat sensitive device 32 mounted outside the heated space, this second device being connected with the controller and functioning as will be explained. The controller is furnished with power from a normal A.C. house supply, as by a power cord and plug 33 connected to a 240 volt source of supply capable of furnishing 5 kilowatts.

Mounted on the controller is a potentiometer control knob 34 operative to afford compensation for function-
istance of the transistor 60, that is to say, by varying the potential applied to the base of the transistor and so varying its current carrying capacity. This base potential is under control of the switch 96 operated by the knob 38, the outdoor sensitive device 32 and the panel heat sensitive device 30.

Voltage is applied to the base of the unijunction device as follows: When the switch 96 is in the "HI" position, as shown in FIG. 1, filtered direct current flows through the voltage divider network comprising the outdoor sensor 32, a potentiometer 98 under control of the knob 34, an empirically selected resistor 100 selected to be of a value such that the potentiometer 98 would be at center position for a predetermined room temperature. The resulting resistor 102 and a voltage divider resistor 104 to line 68.

The base of an amplifying transistor 106 is connected in between resistors 102 and 104 and the voltage on the base is therefore responsive to the response of device 32 which preferably is a non-sensitive heat sensor having a positive coefficient of resistance. Its sensitivity is much less than that of a thermistor and it is therefore more adaptable to outdoor temperature measurements which may vary sharply and rapidly. In lieu of the use of this sensor, the heat sensing device can be inserted in series with the resistance below the base of the transistor, but the sensing device would then have to be a non-linear resistance, such as a thermistor having a negative coefficient of resistance.

When the switch 96 is set to the "LO" position, an extra resistor 108 is placed in the voltage divider string, thus reducing the voltage at the base of transistor 106. The transistor is then biased to a less conductive state, reducing the power delivered to the load, as will be made clear. The switch 96 provides a given power setback such as might be desirable at night or if the enclosed space or room were not to be occupied for a given time, the value of this setback being determined by the ratio of the resistance of resistor 108 to the resistance of the remainder of the voltage dividing string.

Also controlling the transistor 106 and connected between the line 74 and the emitter of transistor 106 is the panel mounted thermistor 30. A bias generating resistance 110 connects the emitter and the line 68. Resistor 112 provides means whereby a variable voltage may be established at the collector depending on the voltages at the base, as determined by the outdoor thermal sensor, and at the emitter, as influenced by the panel heat thermal sensor, and at the emitter, as influenced by the panel heat thermal sensor. A line 114 connects the junction between the collector of the transistor 106 and the resistance 112 with the base of a second amplifying transistor 116 whose emitter is connected with line 74 via a resistor 118 and whose collector is connected via potential establishing resistor 120 to line 68.

A third transistor 122 has its emitter directly connected to line 74 and its collector connected to line 68 via a potential establishing resistor 124. The base of transistor 122 is connected via a line 126 to the junction between the collector of transistor 116 and the resistance 120.

The fourth transistor 60 has its emitter connected to line 74 via a resistor 128 and its collector connected to line 68 via a resistor 62, as heretofore described. The base of transistor 60 is connected via a line 130 to the junction between the collector of transistor 122 and the resistance 120.

The circuit values around transistor 106 are such that thermistor 30 vastly overcompensates for temperature changes and in so doing provides the measure of temperature sensitivity necessary for control. Transistors 116 and 60 are temperature-compensated by the use of the described emitter resistances. This stability is achieved at the expense of some gain, but this is compensated for by the use of four cascaded transistors, thereby achieving high heat stability and sensitivity of the circuit.

Transistor 122 has no compensating resistor in its emitter circuit because its action is opposite to that of transistors 116 and 60, and the combination of slightly overcompensated transistors 116 and 60 with uncompensated transistor 122, as an intermediate amplifying stage, provides overall compensation without costly selection procedures. The silicon unijunction transistor 50 is inherently temperature stable and its stability is further enhanced by the use of the resistor 72 in the base 2 circuit.

It should be noted that the gated rectifier 44 is turned off each time the unfiltered pulsating direct current reaches zero. In addition to the resistor 75, a diode 132 is provided which prevents a charge stored in filter capacitor 89 from cutting off the rectifier 44.

It will be noted that because of the filtered supply to the unijunction transistor, its frequency is entirely independent of the line supply frequency, and the pulses transmitted to the silicon controlled rectifier in the heater load circuit are independent of the frequency in practice, the frequency of the oscillator may operate anywhere from zero to more than ten times the frequency of the alternating current source. Thus where a large number of heater units are coupled into a single supply system there is very little likelihood of simultaneous demands of power on the supply line thereby improving the wave form characteristics and power factor over a system wherein the pulsing of the silicon controlled rectifier is synchronized with line frequency.

It will be obvious to one skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is illustrated in the drawings and described in the specification, but only as indicated in the accompanying claims.

What is claimed is:

1. A heating system comprising lines adapted to be coupled to an alternating current source, a rectifier connected to said source to convert the alternating current to a pulsating direct current, a gating device and a heater in series with said rectifier, said heater having a sensing element primarily receiving its heat from said heater, a filtered direct current supply independent of the frequency of the alternating current source an oscillator connected to said independent direct current supply, said oscillator being connected to said gating device to control its operation, and means connected to said sensing element to control the frequency of said oscillator.

2. A heating system comprising a heater, a direct current pulsating source feeding said heater, a first means sensitive to the temperature of said heater to control the repetition rate of the pulses applied to the heater, and other means of less sensitivity than the first means, sensitive to ambient temperatures uninfluenced by said heater to additionally control the average temperature of the heater.

3. A heating system as defined in claim 2 wherein said other means has a resistance in series therewith which may be by-passed to vary the average temperature which the heater may assume under control of the first heat sensitive means.

4. A heating system comprising a heater, a circuit furnishing pulsing direct current to said heater, a gating device in series with the heater, an oscillator whose output is connected to the gating device to control its operation, a heat sensitive device influenced mainly by ambient temperature connected to the oscillator and controlling the pulse repetition rate of said oscillator, and means controlling said heat sensitive device to vary the operating point of said heat sensitive device.

5. A heating system including a pulsating direct current source, a heater and gate in series with said source, an oscillator operating at a frequency ranging from zero to greater than ten times the frequency of the source connected...
controlling the operation of said gate, and means sensitive to temperature conditions to control the frequency of said oscillator.

6. A heating system comprising a source of alternating current, a full wave bridge circuit converting the alternating current into pulsed direct current, a series connected heater, silicon controlled rectifier and silicon rectifier across said bridge circuit, said silicon controlled rectifier having a gating electrode, a filtering circuit including a shunt capacitor across the output from said bridge circuit, an oscillator connected across the filtered direct current source and connected to the gating electrode to control the flow of current through the heater, means sensitive to temperature changes to control the frequency of said oscillator, and a filtering resistance-capacitor combination connected to the gating electrode to prevent spurious pulses from being applied to the gating electrode.

7. A heating system comprising a heater in a pulsed direct current circuit, a gating device having a control electrode in series with said heater, an oscillator connected with the control electrode, a heat sensitive device controlling the frequency of said oscillator and an amplifier interconnecting the heat sensitive device and the oscillator and comprising three cascaded transistors, a direct current potential source for the transistors, first and third transistors having the emitter connected to the positive source of potential via a resistor and the intermediate stage having its emitter directly connected to the positive potential source.

8. In a heating system, a heater, an oscillator controlling the application of current to said heater, a heat sensitive device controlling the frequency of said oscillator, and a transistorized amplifier between the heat sensitive device and the oscillator, said amplifier comprising a transistor the base of which is connected to a voltage divider in one leg of which there is a resistor and in the other leg of which is located said heat sensitive device said second leg also including a potentiometer to adjust the midpoint of operation of said heat sensitive device.

9. In a heating system, a heater, an oscillator controlling the application of current to said heater, a heat sensitive device controlling the frequency of said oscillator, and a transistorized amplifier between the heat sensitive device and the oscillator, said amplifier comprising a transistor the base of which is connected to a voltage divider in one leg of which there is a resistor and in the other leg of which is located said heat sensitive device, said oscillator comprising a unijunction transistor having an emitter and two base electrodes, a resistance connecting each base electrode with a respective terminal of the direct current source, a second transistor across the direct current source having a base electrode, emitter and collector, means responsive to the heat sensitive device for varying the potential of the base electrode, a resistance between one terminal of the direct current source and one of the emitter and collector electrodes, the other of the emitter and collector electrodes being connected to the emitter of the unijunction transistor, and a paralleled capacitor and resistance connected between the emitter of the unijunction transistor and the other terminal of the direct current source.

11. In a heating system as claimed in claim 10, the addition of another resistor in the connection from the emitter of the unijunction transistor to the other one of emitter and collector electrodes of the second transistor.

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