ABSTRACT

A variable demand radiant heating system applies multi stage burner control technology to singular or multi-burner radiant heating systems. A radiant heater consists of a burner connected to an elongated heat exchanger tube. The combustion air is supplied to the burner via blower or draft inducer. Fuel is supplied to the burner via fuel regulator. Fuel and air are mixed in burner and communicated to the inlet end of the heat exchanger tube. Spent products of combustion are expelled from the heat exchanger at the outlet end. The burner controls provide gas supply pressure (volume), via a multi-stage or modulating gas regulator, and combustion air pressure (volume), via a combustion air blower with a plurality of operating speeds, communicated to the burner mixing chamber, which in turn, varies the burner input between two or more inputs that are stepped or staged within a pre-determined input range as heat demand varies.
Figure 5

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VARIABLE INPUT RADIANT HEATER

FIELD OF THE INVENTION

[0001] The present invention relates to controlling the thermal energy generated by a heating system.

BACKGROUND OF THE INVENTION

[0002] Presently, radiant heaters and radiant heating systems most commonly operate at a single preset input and space temperature is controlled by a thermostat by turning the heater or heating system on or off. In the early to mid-1990's, radiant heaters were developed to operate at two distinct preset inputs by varying the fuel pressure communicated to the burner via a two-stage fuel regulator. One radiant burner with a two-stage operation is described in U.S. Pat. No. 5,535,986, which was superseded by U.S. Pat. No. RE 37,636, titled “Demand Radiant Heating System” by Joseph B. Wortman, and assigned to Detroit Radiant Products Co. of Warren, Mich. In the '986 patent, Wortman describes a radiant heater with a single fuel control capable of dual regulation. The dual regulation is limited to only providing a high or low input rate to respond to a high or low heat demand. That is why the dual regulation radiant heater is referred to as a hi-lo radiant burner. Flow Detroit Radiant Products' hi-lo radiant burner operates is disclosed in the '986 patent and the '636 patents, which are hereby incorporated by reference in this application.

[0003] An alternative version of Detroit Radiant Products' hi-lo radiant burner is disclosed in United Kingdom patent number 2,189,314, which is hereby incorporated by reference in this application. The inventor of the '314 patent is Stephen Hall, and the last assignee of the now expired '314 patent is the assignee of the present application, Robert Gordon, Inc. of Buffalo, N.Y.

[0004] Further advances in radiant burner input control are described in U.S. Pat. No. 5,989,011 titled “Burner Control System” by Caruso et al. Caruso et al. in the '011 patent disclose a control system. Caruso et al. describe the control system as being capable of altering the fuel pressure to the burner by varying air pressure from a blower to the fuel regulator via an air regulator. By continuously varying the air pressure communicated to the fuel regulator, the discharge gas pressure to the burner is also varied allowing a continuously variable input.

[0005] None of the cited patents describes a hi-lo fuel regulator that has an air volume that fluctuates in relation to the fuel variation. The '314 patent alludes that the fan that provides the air pressure can be varied, but not in direct relation to the fuel variation.

[0006] Heater inputs are sized to satisfy building heat loss based on an outdoor design temperature that occurs approximately 1-5% of the time during the entire heating season. In other words, single-stage heating systems normally operate at an input that exceeds the demand. It is favorable to have the option of varying the heater input based on the heating demand to decrease the number of heater on/off cycles and to increase occupant comfort in the heated space.

[0007] In the cited patents, there are disadvantages to varying gas volume (or pressure) to the burner mixing apparatus without also varying combustion air volume (or pressure) to the burner’s mixing means. Without variation of the air flow to the burner simultaneously with variation of fuel flow, sacrifices are made in terms of heater performance and efficiency as well as combustion quality and efficiency. It is desirable to vary the heater’s input not only by controlling the gas flow to the burner, but also the combustion air flow. By varying both the combustion air and gas flows (pressure or volume); combustion efficiency, combustion quality, heater efficiencies and fume emissions can be more closely regulated for optimum infrared heater performance.

[0008] In commonly assigned U.S. Pat. No. 5,211,331 entitled “Control in Combination with Thermospatially Responsive Assembly”, Timothy Seel describes a variable input system of infrared burners-in-series. The infrared system of burners possesses the ability to vary fuel and combustion air to achieve modulating system input, but not for hi-lo systems. Seel does not disclose, teach or suggest any ability to control a single “unitary” style infrared heater with associated burner modulating controls and blower mounted internal to the burner housing.

[0009] Two-stage and modulating infrared heaters with fixed combustion air flow set the combustion air flow for the maximum input. In laboratory testing in accordance with the European Standard prEN 416-2 “Single Burner Gas-Fired Overhead Radiant Tube Heaters For Non-Domestic Use”, it has been shown that two stage heaters exhibit 9-10% lower radiant efficiency at low input due to the blower delivering an excess of combustion air, which is fixed to deliver a volume and pressure of air that is optimum only at maximum input. Besides a reduction in radiant efficiency, two-stage infrared heaters show an approximate 2% decrease in thermal efficiency at low input versus high input. By reducing the combustion air and fuel when input is reduced, an infrared heater with two or more input stages will maintain its optimum radiant efficiency at all inputs. That results in an exhibition of radiant efficiency at low fire that is 9-10% higher than a two-stage heater that does not alter air flow from hi stage to lo stage. That capability is not possible in current modulating or two-stage infrared heater design with single speed blowers. In addition, by maintaining heat exchanger temperature through varying fuel and combustion air flow with respect to burner pressure, the radiant efficiency of the heater can be maintained throughout the entire input range. Not only is radiant efficiency improved, but also thermal efficiency increases as input decreases, thermal efficiency increases at least 2-4% at minimum input versus maximum input.

SUMMARY OF THE INVENTION

[0010] The present invention relates to the use of apparatus that will change the amount of combustion air in relation to the changing amount of fuel available to burn. The radiant heater apparatus comprises (1) a burner housing having a combustion air and fuel inlet and (2) a burner assembly for (a) mixing the fuel and air and (b) conveying the mixture into a heat exchanger for combustion. Combustion takes place inside the heat exchanger and resulting hot products of combustion are moved through the heat exchanger to the exhaust end due to air pressure from a combustion air blower with a plurality of predetermined operating speeds providing either positive air pressure from the burner end of the heater or negative pressure from the exhaust end of the heater. At the exhaust end of the heat exchanger, the combustion gases are vented from the heater. A signal is conveyed simulta-
neously to a two stage, n-stage (multi-stage) or modulating gas valve and a corresponding two speed, n-speed (multi-speed) or variable speed blower. Based on the signal, the input is switched to any one of two or more preset stages to satisfy the heat demand.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 illustrates the present invention.

FIG. 2 illustrates a schematic of FIG. 12 and portion of element 14 of FIG. 1.

FIG. 3 illustrates an alternative embodiment of FIG. 1.

FIG. 4 illustrates an electrical schematic of the present invention.

FIG. 5 illustrates a chart graph of the gas valve and the air blower change simultaneously for a two-stage embodiment.

FIG. 6 illustrates a chart graph of the gas valve and the air blower change based on a time delay.

FIG. 7 illustrates a chart graph of the gas valve and the air blower change simultaneously for a multi-stage embodiment.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Generically, the present invention is directed to a single radiant heater or multi-burner radiant heating system. In particular, the present invention is directed to a single radiant heater or multi-burner radiant heating system that regulates the burner input by changing fuel flow and combustion air supply to any one of two or more distinct stepped or staged settings to the burner’s mixing apparatus. The apparatus continuously switches to any one of the distinct preset inputs of the radiant gas heater(s) that respond to heat demand. The multi-stage input radiant apparatus have (1) a burner housing with a combustion air and fuel inlet and (2) a burner assembly for (a) mixing the fuel and air, and (b) conveying the mixture into a heat exchanger for combustion. Combustion takes place inside the heat exchanger and resulting hot products of combustion are moved through the heat exchanger to the exhaust end due to air pressure from a combustion air blower providing either positive air pressure from the burner end of the heater or negative pressure from the exhaust end of the heater. At the exhaust end of the heat exchanger, the combustion gasses are vented from the heater. A signal is conveyed to (a) a gas valve and (b) a blower mounted in the burner housing from a heat demand control device. Based on the signal, the gas valve varies the input of the heater to satisfy the heat demand. The input of the burner is varied by a multi-stage or modulating gas valve. Combustion air is varied via blower speed changes and/or by varying the air volume via mechanical means such as a damper.

1. Objectives of the Present Invention

It is an object of the present invention to customize the operation and settings of the heater for the purpose of optimization of performance, efficiencies and safety unique to an infrared heater.

It is an object of the present invention that a modulating or multi-stage gas valve controls fuel supply. The gas valve may have either pneumatic or electronic control. The fuel volume and pressure issued from the outlet of the gas valve to the burner can be controlled by a heat demand control device such as a two stage thermostat or other device capable of multiple stage control.

An advantage of the present invention is that the motor may be DC, multi-speed permanent split capacitor (AC, single phase) or multi-speed shaded pole (AC, single phase). The option allows for the most economical choice as the motor market dictates. The AC motor speed is varied by removing or restoring power to part of the coil windings. The DC motor speed is varied by increasing or decreasing the voltage to the motor.

It is an object of the present invention to be able to control motor speed of a standard single speed, multi-speed, or variable speed motor that are commonly used in single, two-stage and modulating heaters. Achieving motor speed control by purchasing a more expensive DC motor is not required.

It is an object of the present invention to control the input to any one of two or more predetermined inputs within a range of inputs. The burner may operate between and including full rated input to a lower percentage of full rated input.

It is an object of the present invention to detect heated area conditions with a traditional mechanical thermostat, two-stage thermostat, temperature sensor, potentiometer or other heat demand control device.

2. Heater

The heater or multi-burner heating system 10, as illustrated in FIG. 1, in this invention includes a burner housing 12 to which a heat exchanger 14 or plurality of heat exchangers 14 is connected. The heat exchanger’s 14 length and shape may be various. By various, the shape can include and is not limited to straight, U-shaped, J-shaped, L-shaped, polygonal shaped and combinations thereof. The heat exchanger 14 is of conventional construction and will typically be mounted below a reflector 16 covering the length of the heat exchanger 14. The entire heater 10 including burner housing 12, heat exchanger 14 and reflector 16 is typically suspended (with conventional suspension instruments like cables, rods, cords and the like 102) from and/or attached (clamps, brackets, screws, bolts, nails and the like) to a ceiling 100 of a structure (as illustrated in FIG. 3).

In accordance with this invention, the housing 12 is provided with a single fuel delivery system 20, as illustrated in FIG. 2, including (1) a multi-stage or modulating gas valve 121 capable of regulating more than one gas outlet pressure setting, (2) a gas manifold 122 whose inlet side 122a is connected to the outlet side 121a of the gas valve 121 and (3) a burner assembly 123 whose inlet side 123a is connected to the outlet side 122b of the manifold 122.

The burner assembly 123 includes suitable apertures 123b, and an apertured stem 123c connected to the manifold outlet 122b fitted with a suitable gas orifice 124. Mounted either downstream of the burner 123 or inside the burner 123 is a flame igniter 123d and flame sensor 123e.
The burner assembly 123 is positioned at the inlet end 141 of the heat exchanger 14.

3. Blower

A blower 18 is provided for causing a draft through (1) the combustion air inlet 125 of the burner housing 12, (2) the burner assembly 123, and (3) then the heat exchanger 14. The blower 18 may be positioned between the combustion air inlet 125 of the burner housing 12 and the burner assembly 123, forcing air through the burner housing 12 and heat exchanger 14. Alternately, the blower (draft inducer) may be positioned at the outlet end 142 of the heat exchanger 14 as illustrated in FIG. 1, providing vacuum to pull air through the combustion air inlet 125 of the burner housing 12, through the burner assembly 123 then through the heat exchanger 14. An air restriction plate 20 is placed before or after the blower 18 to meter the combustion air delivered from the blower 18 to the burner assembly 123. The blower 18 can be any conventional single speed, multiple speed or variable speed blower capable of providing the above-described attributes for conventional heating systems.

4. Controller

In accordance with this invention, a single controller 22 (control board), as illustrated in FIG. 4, controls the operation and sequencing of the multi-stage or modulating gas valve 121, the blower 18 and the igniter 123d. The circuit board 22, is powered both from a line voltage source 220 and from a 24V transformer 221 mounted in the burner housing 12 connected to line voltage 220 as illustrated in FIG. 2. A pressure (or vacuum) switch 222 being sensitive to burner pressure via pressure lines 223 is electrically connected to the control board 22. The control board 22 monitors the opening and closing of the pressure switch 222 circuit to verify proper operation. Optionally, additional pressure switches 222 or a pressure transducer 224 will be used to verify air pressure and various inputs. A conventional two stage thermostat 225 can be used to communicate heat demand to the controller 22. The control board 22 can collect data relating to a thermostat 225 circuit closing and opening cycle timing.

5. Operation

At minimum input, the present invention achieves a thermal efficiency at least 2-4% higher than a conventional two-stage infrared heater at low input.

In operation, the heater 10 is operated in a similar fashion to other thermostatically controlled heating appliances. A two stage thermostat 225, on/off switch 227, potentiometer 228, temperature sensor 226 or other heat demand control device initiates the operation. Upon activation the blower 18 is energized and will run at either full speed or at a pre-selected lower speed depending on heat demand. Once the pressure switch 222 proves flow of air through the burner, the controller 22 allows an air purge period prior to ignition. After the purge period, the controller 22 energizes the igniter 123d then opens the gas valve 121. Gas flows through the gas valve 121, manifold 122 and orifice 124 then into the burner 123 where it mixes with the combustion air and the mixture is ignited by the igniter 123d. Ignition is detected by the flame sensor 123e, which signals the controller 22 to maintain the gas valve 121 in an open position. If the flame is extinguished at any time during operation, the flame sensor 123e will signal the controller 22 to close the gas valve 121 and stop the flow of gas to the manifold 122. Upon ignition, initial input is dictated by demand signal from the heat demand control device. The heater 10 will continue to operate at the initial input until the following conditions change the heater operation: 1) heat demand is satisfied and the heater will shut off; 2) if the heater is operating at a low input and more heat is demanded then the gas valve and blower will switch to a higher input; or 3) if the heater is operating on higher input and less heat is demanded then the gas valve and blower will switch to a lower input. Flow and when the switch occurs depends on the timing mechanism of the controller. The controller could have the gas valve and the air blower change simultaneously as illustrated in FIGS. 5 (two-stage) and 7 (multi-stage), or based on a time delay as illustrated in FIG. 6. The time delay can be any pre-set time in relation to the alteration of the status of the fuel and/or the air. Alternatively, the time delay could be based just on pre-set times.

The heat, fire and associated flue gasses are pushed or drawn downstream by the blower 18 through the heat exchanger 14, away from the burner 123 towards the exhaust end 142 of the heat exchanger 14. The fire and hot flue gasses heat up the heat exchanger 14. The heat exchanger 14 releases this energy through convective and radiant heat transfer from the tube’s outer surface in all directions. The reflector 16 over the heat exchanger helps contain the convective heat to maintain desired tube temperature, it also reflects and directs the radiant energy toward the heated space opposite the reflector; in most cases downward toward the heated space.

The heater described could also be grouped into a multi-burner heating system. In such a configuration, the exhaust ends 142 of multiple heat exchangers 14 are coupled together through a common draft inducer that is located at the exhaust end of the coupled heat exchanger. In this configuration, the draft inducer creates negative pressure through heating system drawing the flame and heated gasses toward the end of the coupled heat exchanger. All burners would be controlled simultaneously as a result of connection to the same draft inducer.

While a preferred form of this invention has been described above and shown in the accompanying drawings. It should be understood that the applicant does not intend to be limited to the particular details described above and illustrated, but intends to be limited only by the scope of the invention as defined by the following claims.

Moreover, the overall mechanics and the apparatus of the burner heater system, excluding the dynamic switch system of altering the fuel flow rate and air flow rate simultaneously and/or within a prescribed time differential, are disclosed in United Kingdom patent number 2,189,314 or for a less desired apparatus in U.S. Pat. No. 5,353,986, and U.S. Pat. No. RE 35,636, which supercedes the '986 patent.

What is claimed is:

1. A gas-fired radiant tube heater comprising:
   at least one unitary burner housing connected to at least one heat exchanger;
   a fuel outlet that delivers fuel to the burner housing;
a combustion air blower that delivers air to the burner housing;

a controller, in the burner housing, interconnected to the fuel outlet and the combustion air blower, the controller alters the output of the fuel outlet and the output of the combustion air blower, the output for the fuel outlet is a hi setting for high demand heating by providing greater fuel and a lo setting for low demand heating by providing lesser fuel, the output for the combustion air blower is a corresponding hi setting for high demand heating by providing greater air, and a corresponding lo setting for low demand heating by providing lesser air; and

a timing mechanism that switches the settings for the combustion air blower and fuel outlet (1) simultaneously or (2) with a time delay between the setting of (a) one of the combustion air blower and (b) the other the fuel outlet.

2. The gas heater of claim 1 wherein the at least one heat exchanger is configurable in a shape that is straight.

3. The gas heater of claim 1 wherein the at least one heat exchanger is configurable in a shape that is U-shaped.

4. The gas heater of claim 1 wherein the at least one heat exchanger is configurable in a shape that is selected from the group consisting of straight, U-shaped, J-shaped, L-shaped, polygonal shaped and combinations thereof.

5. The gas heater of claim 1 wherein the heat exchanger is coupled to heat exchangers of additional heaters and vented through a common exit.

6. The gas heater of claim 1 wherein the burner operates at an input within a preset range burner inputs.

7. The gas heater of claim 1 wherein the burner input responds to at least one demand control device.

8. The gas heater of claim 1 further comprising a blower.

9. The gas heater of claim 11 wherein the blower draws air into the heater.

10. The gas heater of claim 11 wherein the blower pushes air into the heater.

11. An apparatus for varying the input of at least one radiant gas heater that responds to heat demand comprising:

a burner housing having (1) a combustion air and fuel inlet and (2) a burner assembly for mixing the fuel and air and conveying the mixture into a heat exchanger for combustion;

at least one conduit in conjunction with a blower that directs at least the energy formed from the combustion of the fuel and the air from the burner housing to a heat exchanger;

the gasses formed from the combustion of the fuel and the air are vented from the heat exchanger;

a heat demand control device positioned in the heated space transmits a signal to a controller and based on the signal, the controller varies the input of the fuel and the air into the burner housing between hi settings and lo settings for the input of the fuel and the input of the air to satisfy the heat demand.

15. The apparatus of claim 14 wherein the blower provides positive air pressure from the burner end of the heater.

16. The apparatus of claim 14 wherein the blower provides negative pressure from the exhaust end of the heater.

17. The apparatus of claim 14 further comprising at least one pressure switch that completes or breaks an electrical circuit due to differential pressure of air in the burner housing.

18. The apparatus of claim 17 wherein if the air pressure meets a predetermined pressure switch setpoint parameter, the controller allows an air purge period prior to ignition.

19. The apparatus of claim 17 wherein if the air pressure does not meet predetermined parameters, the blower will adjust to a higher or lower setting or terminate the flow of air and/or fuel into the burner housing.

20. The apparatus of claim 17 wherein the energy generated by the fuel and the air is radiant and convective heat.

21. The apparatus of claim 1 wherein additional settings between the high setting and the low setting are optional.