(57) **Abstract:**
Apparatus and methods are provided for compensating for high altitude reduction in the heating capacity of a gas heating appliance, illustratively a gas-fired heating furnace. In a representative embodiment of such apparatus and methods the regulated pressure of the furnace gas valve, and the speeds of its combustion and indoor blowers, are coordinately increased to provide the furnace with a substantially unchanged maximum heating output despite its new higher altitude location.
ABSTRACT

Apparatus and methods are provided for compensating for high altitude reduction in the heating capacity of a gas heating appliance, illustratively a gas-fired heating furnace. In a representative embodiment of such apparatus and methods the regulated pressure of the furnace gas valve, and the speeds of its combustion and indoor blowers, are coordinately increased to provide the furnace with a substantially unchanged maximum heating output despite its new higher altitude location.
COMPENSATING FOR GAS APPLIANCE DE-RATE AT HIGH ALTITUDES

BACKGROUND OF THE INVENTION

[0001] A known problem with a conventional gas-fired furnace, as well as with other types of gas-fired heating appliances, is that the furnace outputs considerably less heat (when using gas having the same heating value) when it is used at high altitudes. For example, above 5000 feet the heating capacity of a typical gas furnace will be reduced by about 20 percent compared to the heating capacity of the same furnace, using gas having the same heating value, at sea level (per the National Fuel-Gas Code Handbook; Section 8.1.2 High Altitude). Because of this, a consumer has heretofore been forced to buy a larger and thus more expensive furnace to obtain the same heating output at a high altitude location as a smaller furnace at a lower altitude. In view of this it would be desirable to provide a gas-fired furnace, or other type of gas-fired heating appliance, with the capability of increasing its heating output enough to compensate for a high altitude use of the furnace without having to upsize the furnace.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. 1 schematically depicts a representative gas-fired air heating furnace incorporating therein a high altitude heating capacity compensation system embodying principles of the present invention;

[0003] FIG. 2 is a schematic diagram of the heating capacity altitude compensation system;

[0004] FIG. 2A is a schematic diagram of an alternate embodiment of the heating capacity altitude compensation system; and

[0005] FIG. 3 is a schematic diagram of an input touchpad and lookup table portion of the heating capacity altitude compensation system.

DETAILED DESCRIPTION

[0006] Schematically depicted in FIG. 1 is a representative gas-fired heating appliance, representatively in the form of a fuel-fired air heating furnace 10, which incorporates therein a specially designed furnace control 12 embodying principles of the present invention and operative to uniquely provide the furnace 10 with a heating output adjustment system enabling
the furnace to output substantially the same total amount of heat at both sea level and high altitude.

[0007] The illustrative furnace 10 is of the draft-induced type, having an outer housing 14 within which a heat exchanger 16 is operatively disposed above a combustion chamber 18 having a gas burner 20 therein below the heat exchanger 16. Gas burner 20 is supplied with gas via a gas supply line 22 in which a modulating gas valve 24, operative to maintain a predetermined gas manifold pressure within the line 22, is connected. In common with conventional furnace gas valves, the illustrated gas valve 24 has a normal gas pressure control setting level of 3.5" W.C. However, according to an aspect of the present invention, the gas valve is operable, in manners subsequently described herein, to enable its gas pressure control setting to be selectively increased to magnitudes greater than 3.5" W.C. to thereby increase the high altitude heating capacity of the furnace.

[0008] During firing of the furnace 10, which is initiated and terminated under the control of a thermostat 26 disposed in a conditioned space served by the furnace 10 and operatively coupled to the furnace control 12 as shown, hot combustion gases 28 created by the burner flame 30 travel through the interior of the heat exchanger 16 into the interior of a vent structure 32 that is coupled to the upper side of the heat exchanger 16. Passage of the hot combustion gases 28 through the vent 32 is assisted by the operation of a variable speed combustion blower 34 operatively mounted in the vent 32. Also during firing of the furnace 10, return air 36a from the conditioned space served by the furnace 10 is forced by a variable speed indoor blower 38 exteriorly across the heat exchanger 16, for example through a duct structure 40, to receive combustion gas heat from the heat exchanger 16 and thereby create heated supply air 36b suitably conveyed to the conditioned space served by the furnace 10.

[0009] Turning now to FIG. 2, the furnace control 12 is part of an overall heating capacity altitude compensation system 13 and has a preprogrammed microprocessor portion 12a. In a subsequently described manner, the furnace control 12 is operative to uniquely regulate the gas valve 24, the combustion blower 34 and the indoor blower 38 in a manner such that the furnace 10 (FIG. 1) is provided with the same heating output at high altitude as it has at sea level, thereby desirably eliminating the previous necessity of upsizing the furnace 10 to compensate for a high altitude placement and use thereof. Basically, when the furnace 10 is installed and operated at a high altitude, the control 12 operates, in response to a later described furnace user input to the
furnace control 12 of altitude and gas heating value, to coordinately increase the regulated gas pressure of the gas valve 24 and the speeds of the combustion blower 34 and the indoor blower 38 to provide the furnace 10 with a substantially unchanged maximum heating output despite its new higher altitude location.

[0010] Referring now additionally to FIG. 3, a user input touchpad 42 (or, more simply, a push-button on the main furnace control) is operatively associated with the furnace control 12 and permits a user to input both an elevation and a gas heating value for the elevated location at which the furnace 10 is disposed. Alternatively, this user input device could only provide for elevation input.

[0011] User input of a desired elevation value responsively transmits identical selected elevation magnitude signals 44 to first and second lookup tables 46 and 48. Lookup table 46 charts indoor blower speeds against associated elevation values and is operative as shown to output to the furnace control 12 a desired indoor blower RPM signal 50 associated with the user selected elevation range value.

[0012] Lookup table 48 charts gas valve control pressure offsets (i.e., above the normal 3.5" W.C. regulated gas pressure) against selected combinations of elevation range and gas heating values (or against only an elevation value as the case may be). When a user, via the touchpad 42, selects a desired elevation value and a desired gas heating value, the elevation magnitude signal 44 and a selected gas heating value signal 52 are transmitted to the lookup table 48 which responsively transmits to the furnace control 12 a desired pressure offset signal 54.

[0013] During firing of the furnace 10, the furnace control 12 regulates the operation and speed of the variable speed indoor blower 38 by outputting to the indoor blower 38 (1) 115 volt AC electrical power via lead 56 and (2) a speed control signal via lead 58. The speed control signal causes the indoor blower 38 to run at an increased speed corresponding to the magnitude of the lookup table signal 50 received by the furnace control 12, thereby causing the indoor blower 38 to deliver its designed-for CFM of air to the conditioned space despite the high altitude placement of the furnace 10 and the resulting ambient air density decrease. Alternatively, the indoor blower 38 could be a single speed blower and its speed control signal could be eliminated.

[0014] At the same time, the furnace control 10 regulates the operation and pressure regulation level of the modulating gas valve 24 by outputting to the gas valve 24 (1) 24 volt ac
electrical power via electrical power lead 60, (2) a regulating pressure offset signal via lead 61, and (3) a gas flow regulating signal via lead 62. The regulating pressure offset signal elevates the maximum manifold pressure regulation magnitude of the valve (for example, beyond its normal 3.5” WC level) to a level indicated by the magnitude of the signal 54 received by the furnace control 12. This upward valve pressure regulation level adjustment increases the heating capacity of the furnace 10 to compensate for its high altitude placement without the previous necessity of upsizing the furnace. The flow regulating signal modulates the gas flow to the burner 20 as required by the heating demand.

[0015] It should be noted that the regulating pressure offset signal (lead 61) and the gas flow regulating signal (lead 62) may be the same signal with compensation calculated and adjusted at the furnace control instead of the gas valve. Such a signal would have a predefined relationship to the output of the gas valve (e.g., a 50% PWM signal that corresponds to 50% of the valve’s maximum capacity). In any case, the gas valve 24 would need to be pre-set during production to be capable of exceeding 3.5” W.C. which is the current maximum value of gas valves commonly utilized on residential gas furnaces. While the gas valve 24 has been representatively illustrated as being a modulatable gas valve, it could alternatively be a single stage gas valve, in which case the gas flow regulating signal (lead 62) could be replaced with a simple “on/off” signal.

[0016] Operatively coupled to the furnace control 12 by the indicated electrical leads 64, 66 and 68 as shown in FIG. 2 are two pressure/electric switches - a low pressure switch 70 and a high pressure switch 72 electrically coupled to the low pressure switch 70 by an electrical lead 74. The two pressure switches 70,72 are pneumatically coupled to the combustion blower 34 by a suitable pneumatic linkage structure 76 as indicated. In a conventional manner the speed of the variable speed combustion air blower (also commonly referred to as a draft inducer) is regulated by the pressure switches 70 and 72 via the pneumatic linkage structure 76.

[0017] The combustion air blower speed is changed, via a speed control signal output to the blower from the furnace control 12 via a lead 78, based on feedback from the pressure switches, the low pressure switch 70 being set to be just closed at the selected minimum blower speed (corresponding to the minimum heating capacity of the furnace), and the high pressure switch 72 being set to be just closed at the selected maximum blower speed (corresponding to the maximum heating capacity of the furnace). A lead 80 from the furnace control 12 transmits 115 AC electrical power to the combustion blower 34. In developing the present invention it has
been found that this combustion blower control technique automatically provides altitude compensation for combustion blower flow capacity by increasing the speed of such blower at higher altitudes. As in the case of the indoor blower 38, the combustion blower 34 could be a single speed blower if desired.

[0018] Schematically depicted in FIG. 2A is a portion of an alternate embodiment 13a of the previously described heating capacity altitude compensation system 13. System 13a is identical to the previously described system 13 with the exceptions that (1) a pneumatic branch valve control line 76a is added and interconnected as shown between the pneumatic linkage structure 76 and the gas valve 24, and (2) the gas flow regulating signal lead 62 interconnected between the furnace control 12 and the gas valve 24 is eliminated. In the system 13a the combustion blower pressure generated within the pneumatic linkage structure 76 during firing of the furnace is transmitted to the gas valve 24 and is used as a control signal to modulate the gas flow through the valve.

[0019] As can be seen, the present invention is operative to increase the manifold regulation pressure of a furnace gas valve beyond its normal 3.5" W.C. fixed setting, and to also correspondingly optionally increase the combustion and indoor blower flow rates (if these devices are variable on the system in question) to compensate for the placement of a furnace at a high altitude. In this manner, the same furnace can be used at varying altitudes without altering its heating output, thereby eliminating the previous necessity of upsizing the furnace. While this desirable and cost effective altitude compensation technique has been representatively described in conjunction with a furnace, it will be readily appreciated by those skilled in this particular art that principles of the present invention could also be advantageously employed in conjunction with other types of gas-fired heating appliances.

[0020] Additionally, while the present invention has been described as being implemented via an automatic heating capacity altitude compensation system, it will be appreciated that principles of the present invention could also be employed by the use of manual adjustment of gas valve and blower components of a gas-fired heating appliance. For example, the gas valve 24 could be provided with a manual high altitude adjustment structure permitting its pressure regulation setting to be manually increased above 3.5" W.C. Additionally, altitude compensation for the furnace 10 could be achieved simply by replacing its standard gas valve (having a fixed 3.5"
W.C. gas pressure regulation setting) with a high altitude gas valve with a fixed gas pressure regulation setting greater than 3.5” W.C.
WHAT IS CLAIMED IS:

1. A method of compensating for heating output de-rating in a gas-fired heating appliance due to high altitude use thereof, the heating appliance having a regulated set gas supply pressure, said method comprising the step of:
   upwardly adjusting said regulated set gas supply pressure to a magnitude sufficient to provide said heating appliance with a heating capacity equal to that of the unadjusted heating appliance when disposed at a lower altitude.

2. The method of Claim 1 wherein:
   said upwardly adjusting step is performed in a manner raising said regulated set gas supply pressure to a magnitude greater than 3.5” W.C.

3. The method of Claim 1 wherein:
   said heating appliance is a gas-fired furnace.

4. The method of Claim 1 wherein:
   said heating appliance further has a gas valve operative to provide said regulated set gas supply pressure at a fixed magnitude of 3.5” W.C., and
   said upwardly adjusting step is performed by replacing said gas valve with a gas valve having a regulated set gas supply pressure greater than 3.5” W.C.

5. The method of Claim 1 wherein:
   said heating appliance further has a gas valve with an adjustable regulated set gas supply pressure, and
   said upwardly adjusting step is performed by upwardly adjusting said regulated set gas supply pressure of said gas valve to a magnitude greater than 3.5” W.C.
6. The method of Claim 5 wherein:
said upwardly adjusting step is performed by manually adjusting said gas valve.

7. The method of Claim 5 wherein:
said heating appliance further has an automatic control portion, and
said upwardly adjusting step is performed in response to user input to said control portion
of at least an altitude value.

8. The method of Claim 7 wherein:
said upwardly adjusting step is performed in response to user input to said automatic
control portion of altitude and gas heating value magnitudes.

9. The method of Claim 1 wherein:
said heating appliance further has an air blower and a combustion blower.

10. The method of Claim 9 further comprising the step of:
upwardly adjusting the speed of said air blower to a magnitude coordinated in a
predetermined manner with the upwardly adjusted regulated set gas supply pressure.

11. The method of Claim 10 wherein:
said heating appliance further has an automatic control portion, and
said step of upwardly adjusting the speed of said air blower is performed in response to
user input to said automatic control portion of at least an altitude value.

12. The method of Claim 11 wherein:
said step of upwardly adjusting the speed of said air blower is performed in response to
user input to said automatic control portion of altitude and gas heating value magnitudes.
13. The method of Claim 9 further comprising the step of:
upwardly adjusting the speed of said combustion blower to a magnitude coordinated in a
predetermined manner with the upwardly adjusted regulated set gas supply pressure.

14. The method of Claim 13 wherein:
said heating appliance has an automatic control portion, and
said step of upwardly adjusting the speed of said combustion blower is performed in
response to user input to said automatic control portion of at least an altitude value.

15. The method of Claim 14 wherein:
said step of upwardly adjusting the speed of said combustion blower is performed in
response to user input to said automatic control portion of an altitude value and a gas heating
value.

16. The method of Claim 13 wherein:
said heating appliance has an automatic control portion including pressure/electric switch
apparatus, and
said step of upwardly adjusting the speed of said combustion blower includes the step of
linking said pressure/electric switch apparatus and said combustion blower.

17. The method of Claim 5 wherein:
said heating appliance has an automatic control portion including pressure/electric switch
apparatus, and
said step of adjusting said regulated set gas supply pressure includes the step of
pneumatically linking said pressure/electric switch apparatus and said gas valve.

18. The method of Claim 17 wherein:
said heating appliance further has a combustion blower, and
said method further comprises the step of pneumatically linking said pressure/electric
switch apparatus and said combustion blower.
19. The method of Claim 5 wherein:
said heating appliance further has an automatic control portion including a preprogrammed microprocessor, and
said step of upwardly adjusting said regulated set gas supply pressure includes the step of transmitting an electrical control signal from said automatic control portion to said gas valve.

20. The method of Claim 1 wherein:
said heating appliance has a variable speed air blower, a gas valve with an adjustable regulated set gas supply pressure, and an automatic control portion having a lookup table portion, and
said method further comprises the steps, performed in response to user input to said automatic control portion of a signal comprising a selected appliance elevation value, of:
outputting from said lookup table portion to said air blower an adjusted RPM value control signal, and
outputting from said lookup table portion to said gas valve an adjusted regulated set gas supply pressure value control signal.

21. An altitude adjustable gas-fired heating appliance comprising:
an air blower for flowing air to be heated; and
a fuel gas combustion system for creating hot combustion gases and utilizing said hot combustion gases to heat said air, said fuel gas combustion system including:
a combustion blower operative to discharge said hot combustion gases from said heating appliance, and
a gas supply valve with a regulated set gas supply pressure which is upwardly adjustable to a magnitude sufficient to provide said heating appliance with a heating capacity equal to that of the unadjusted heating appliance when disposed at a lower altitude.
22. The altitude adjustable gas-fired heating appliance of Claim 21 wherein:
said regulated set gas supply pressure of said gas supply valve is upwardly adjustable to a
magnitude greater than 3.5"W.C.

23. The altitude adjustable gas-fired heating appliance of Claim 21 wherein:
said gas-fired heating appliance is a furnace.

24. The altitude adjustable gas-fired heating appliance of Claim 21 further comprising:
automatic control apparatus adapted to receive user input comprising an appliance
altitude value and, in response to said user input, upwardly adjust said regulated set gas supply
pressure.

25. The altitude adjustable gas-fired heating appliance of Claim 24 wherein:
said automatic control apparatus is further operable, in response to said user input, to
upwardly adjust the speed of said air blower.

26. The altitude adjustable gas-fired heating appliance of Claim 24 wherein:
said automatic control apparatus is automatically operable to upwardly adjust the speed
of said combustion blower.

27. The altitude adjustable gas-fired heating appliance of Claim 26 wherein:
said automatic control apparatus includes pressure/electric switch apparatus
pneumatically linked to said combustion blower.

28. The altitude adjustable gas-fired heating appliance of Claim 24 wherein:
said automatic control apparatus includes pressure/electric switch apparatus
pneumatically linked to said gas supply valve.
29. The altitude adjustable gas-fired heating appliance of Claim 28 wherein:
said pressure/electric switch apparatus is further pneumatically linked to said combustion
blower.

30. The altitude adjustable gas-fired heating appliance of Claim 24 wherein:
said automatic control apparatus includes a preprogrammed microprocessor and is
operable to transmit an electrical control signal to said gas valve to upwardly adjust said
regulated set gas supply pressure.

31. The altitude adjustable gas-fired heating appliance of Claim 21 further comprising:
automatic control apparatus including a lookup table portion which, in response to user
input to said control apparatus of at least a selected appliance elevation value, outputs to said air
blower an adjusted RPM value control signal, and outputs to said gas supply valve an adjusted
regulated set gas supply pressure value control signal.
Fig. 2A

- PNEUMATIC LINKAGE BETWEEN PRESSURE SWITCHES AND COMBUSTION BLOWER
- COMBUSTION BLOWER
- PNEUMATIC BRANCH VALVE CONTROL LINE
- GAS VALVE
- INDOOR BLOWER
Fig. 3