US 20070277542A1

(19) United States

(12) Patent Application Publication

Rao

(10) Pub. No.: US 2007/0277542 A1

(43) Pub. Date: Dec. 6, 2007

(54) AUTO-BALANCING DAMPER CONTROL

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(21) Appl. No.: **11/442,933**

(22) Filed: **May 30, 2006**

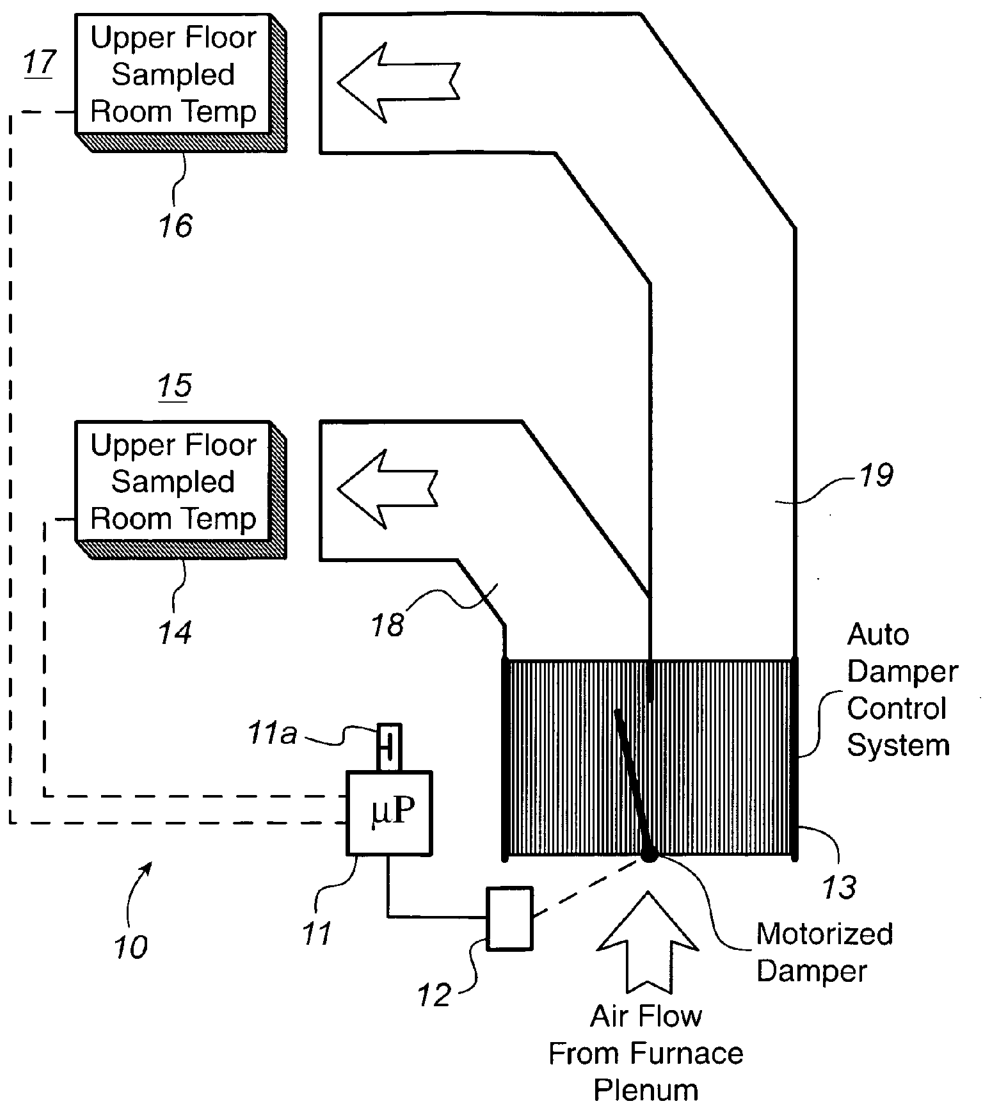
Publication Classification

(51) Int. Cl.
F24D 19/10 (2006.01)
F24F 7/00 (2006.01)
F25D 17/04 (2006.01)

(52) U.S. Cl. .... **62/186**; 236/1 B; 236/49.3

(57) ABSTRACT

A control system for a heating, ventilating and air conditioning system is provided. The control system regulates a temperature of a multi-zone building using only a single thermostat or set point, and a temperature element in each of the zones. The control system receives inputs from the temperature elements and uses the inputs and a control algorithm to control temperature according to the set point and to minimize the differences between the temperature elements in the different zones. In a two-zone building, a single damper is used. In a building with a larger number of zones, the number of dampers required is the same as the number of zones, less one damper.



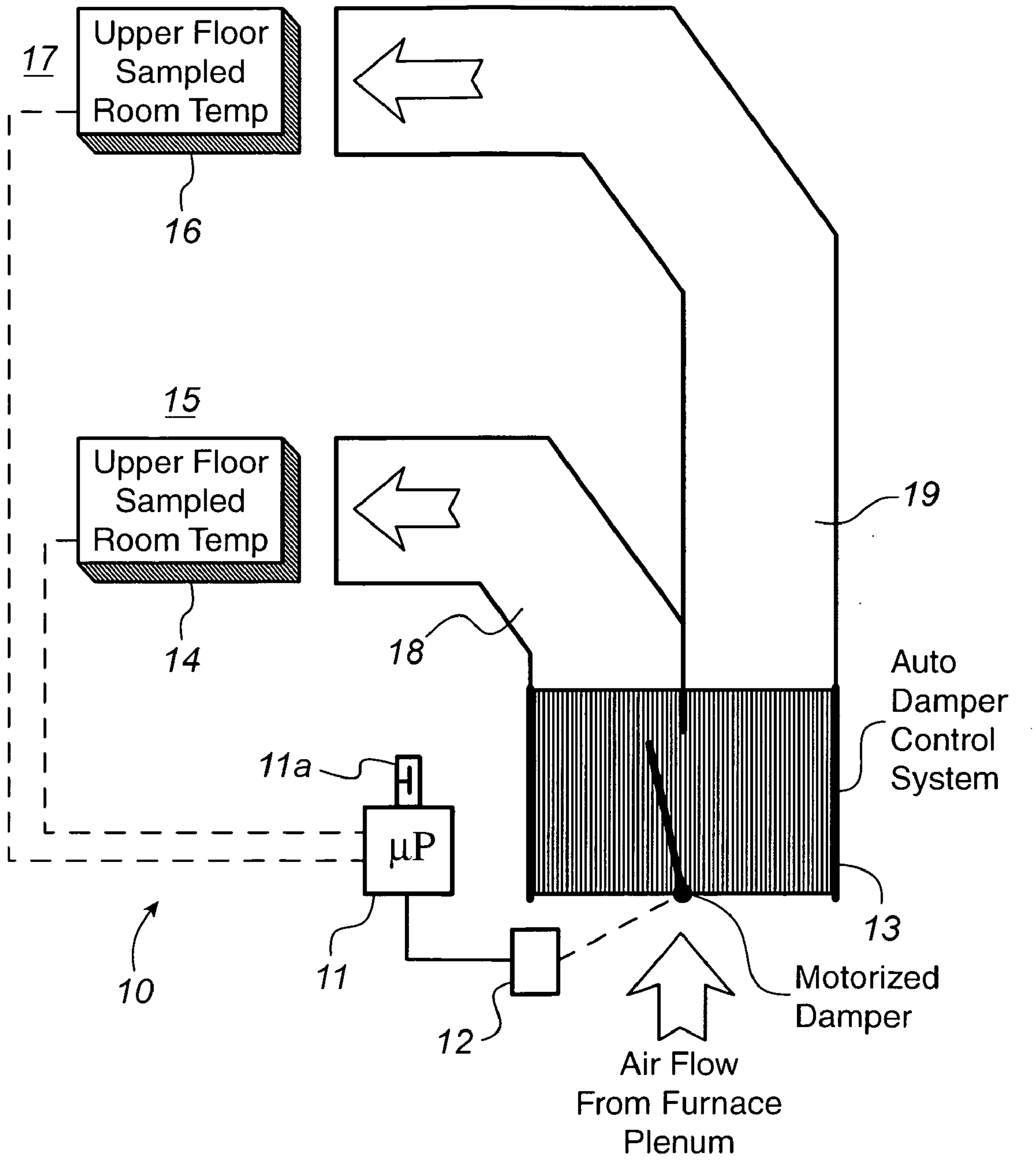

Upper Floor
Sampled
Room Temp
17
16
15
Upper Floor
Sampled
Room Temp
14
18
19
Auto
Damper
Control
System
11a
μP
13
10
11
12
Motorized
Damper
Air Flow
From Furnace
Plenum

FIG. 1

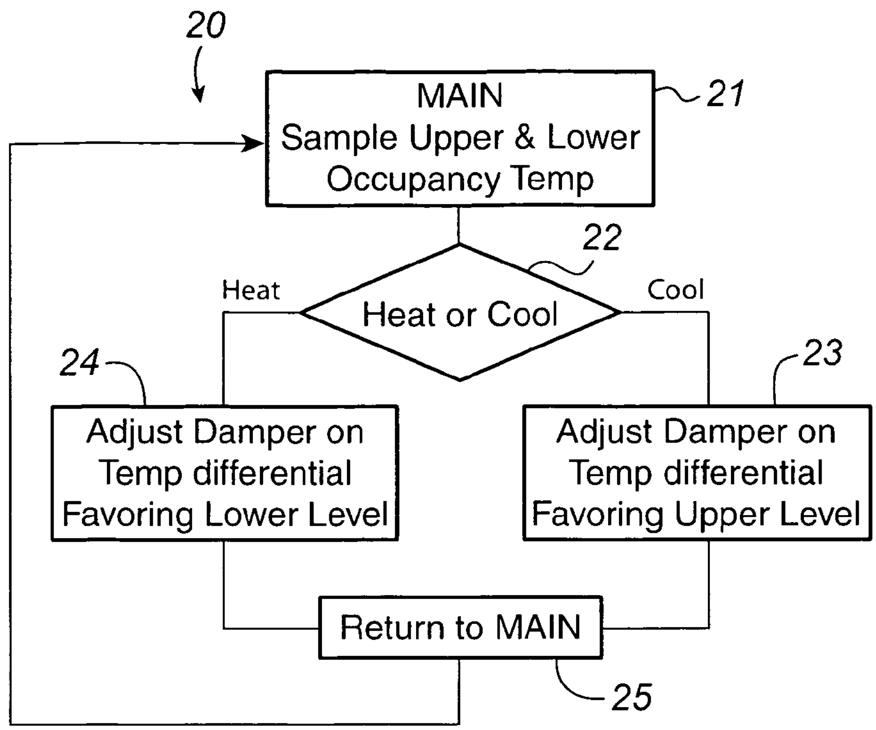

20
MAIN
Sample Upper & Lower
Occupancy Temp
21
22
Heat
Heat or Cool
Cool
24
23
Adjust Damper on
Temp differential
Favoring Lower Level
Adjust Damper on
Temp differential
Favoring Upper Level
Return to MAIN
25

FIG. 2

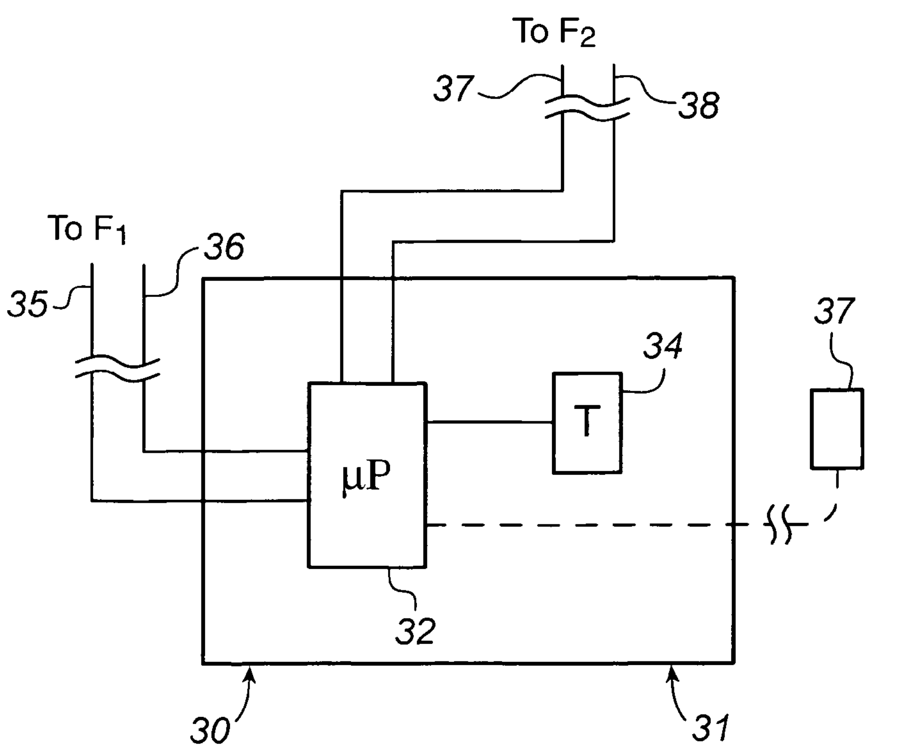

To F2
37
38
To F1
36
35
37
34
T
μP
32
30
31

FIG. 3

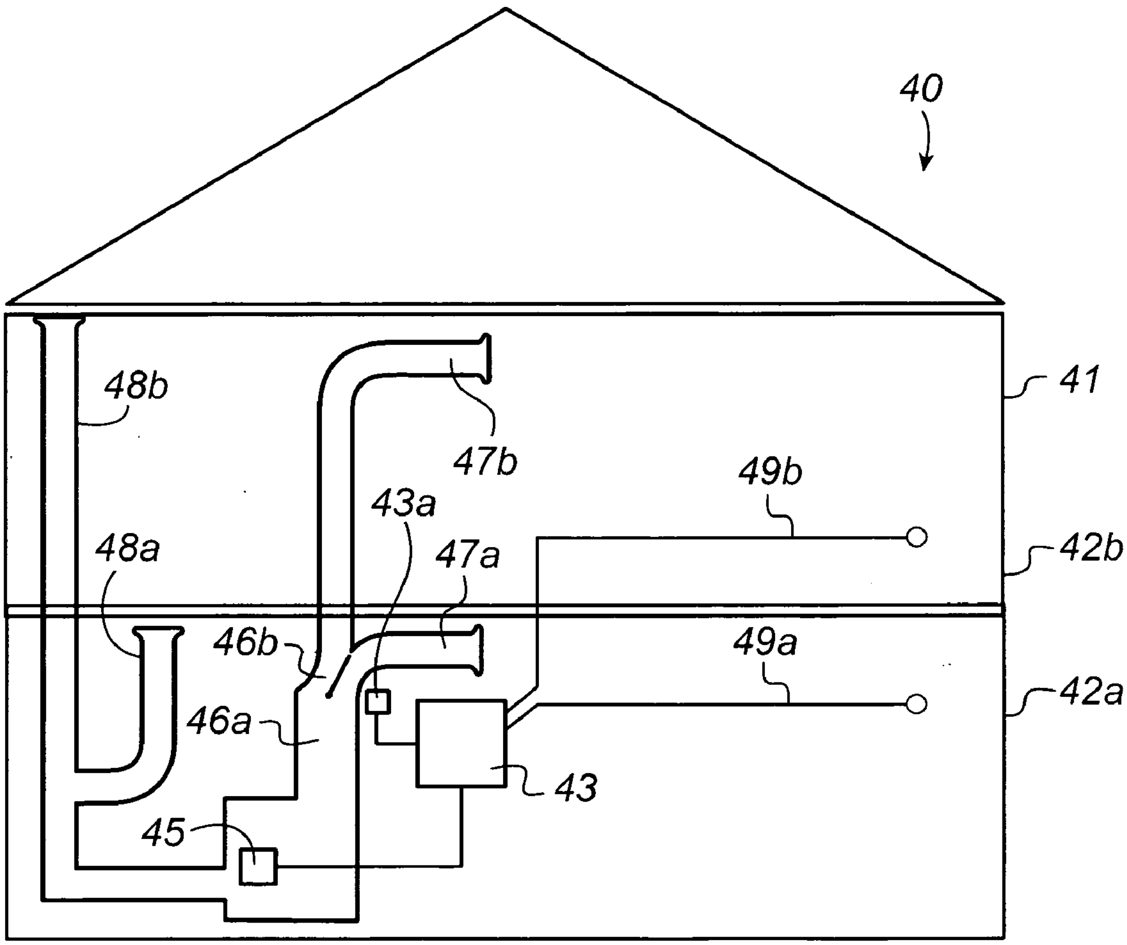


FIG. 4

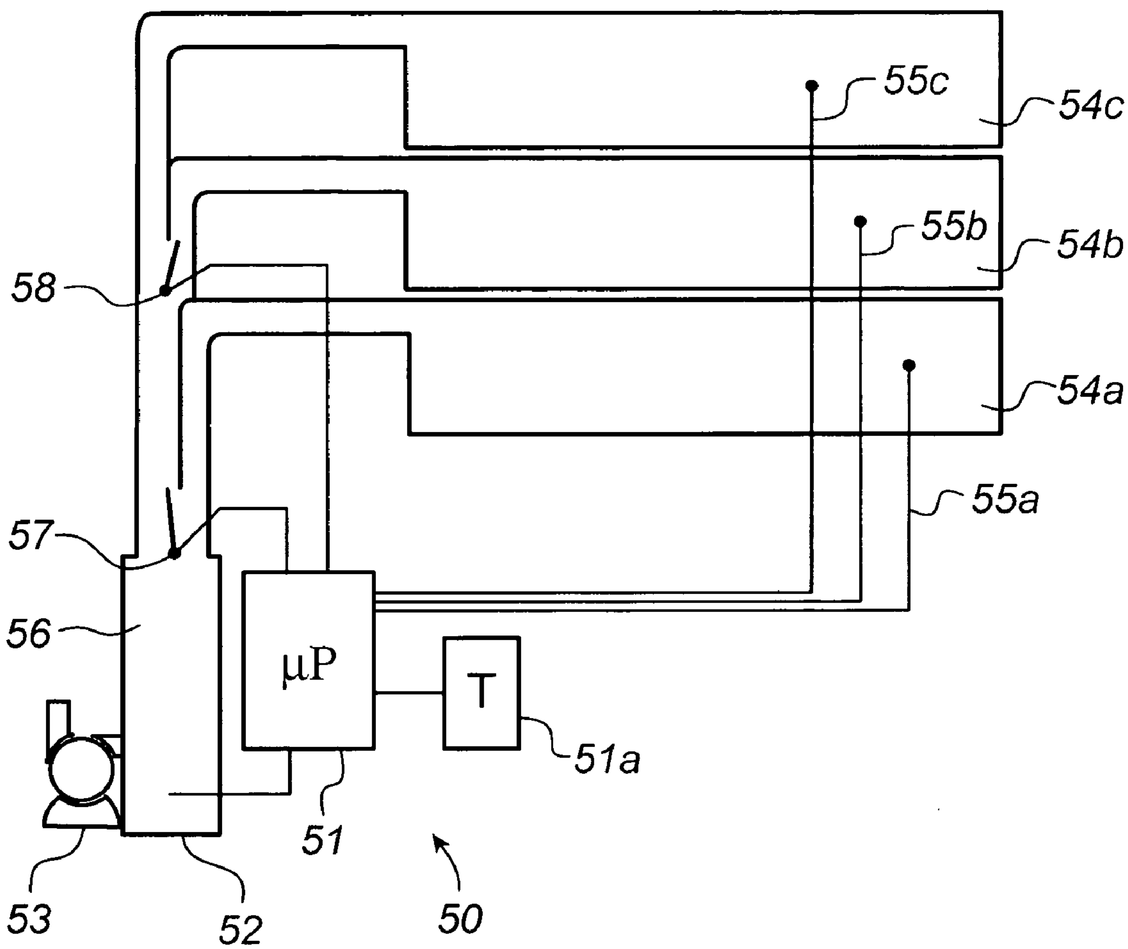


FIG. 5

AUTO-BALANCING DAMPER CONTROL

FIELD OF THE INVENTION

[0001] This invention generally relates to control systems for heating and air conditioning, and for methods of operating heating, ventilating, and air conditioning systems for multi-zone control.

BACKGROUND OF THE INVENTION

[0002] Heating, ventilating, and air conditioning (HVAC) systems provide comfort and convenience for persons using modern residential, commercial and industrial buildings. This comfort and convenience comes with a cost, of course, for installing and operating the fans, furnaces, and air conditioners that make possible such comfort and convenience. There is a great variety of controls for operating these systems, but there may be room for improvement in any of them.

[0003] A common occurrence in many multiple floor dwellings is that comfort is sacrificed for cost in providing for HVAC comfort control and efficiency. This sacrifice in efficiency usually equates to less than desirable performance for the temperatures of the upper and lower floors. The traditional method of improving these symptoms is to control or balance the airflow to a favored area. This can be done at additional cost by using automated controlled ducting vents to achieve improved temperature balance.

[0004] One example is U.S. Pat. No. 5,179,524, which describes a complicated HVAC system. In this patent, a fan-powered mixing box with a master damper supplies air from a heating or cooling unit and sends a variable amount of air to each of a plurality of zones. Each zone has its own thermostat and damper for controlling the flow or air, and thus the temperature of the zone. While effective, this is a complicated and expensive system to install. In addition, the needs of the zones must be balanced since each has its own controlling thermostat.

[0005] Another way to control temperature and ventilation in a multi-zone facility is shown in U.S. Pat. No. 5,413,165. Heating and cooling to an upper and a lower floor are adjusted by multiple dampers and a thermostat on each level. Temperature differences between the upper and lower levels may be evened out by directing air from the upper level to the lower level. However, there may be high temperature differentials between the floors.

[0006] In another example, U.S. Pat. No. 5,860,473 discloses a climate control system with separate zones, a separate damper for each zone, and interlocking controls. Each zone has its own thermostat and can individually call for heating or cooling. In this disclosure, however, if one zone is being heated, the other zones are not allowed to call for cooling; or if one zone is being cooled, the other zones are not allowed to call for heating. This system provides good control for each zone, but has a very high cost of equipment and installation. In U.S. Pat. No. 5,944,098, each zone also has its own thermostat and sets of contacts for calling for heating and cooling. The control system, which does not allow simultaneous heating and cooling, requires a separate damper for each zone. This will also be an expensive system to operate.

[0007] What is needed is a heating, ventilating, and air conditioning system that is simple and economical to operate, and which is also effective to control the temperature in at least two zones of a building.

BRIEF SUMMARY OF THE INVENTION

[0008] One embodiment is an automatic balancing damper control system. The damper control system includes a single set point environmental controller, at least two temperature elements, each temperature element located in a separate zone and in communication with the environmental controller, and a control output for a motorized damper, the damper responsive to the controller and configured to control a flow of air to the separate zones, wherein the controller is configured to accept temperature inputs from the at least two temperature elements and to send the control output for adjusting a position of the damper in accordance with the single set point and inputs from the at least two temperature elements.

[0009] Another embodiment is an automatic balancing damper control system. The damper control system includes a single set point environmental controller, two temperature elements, each temperature element located in a separate zone and in communication with the environmental controller, and a control output for a motorized damper, the damper responsive to the controller and configured to control a flow of air to the separate zones, wherein the controller is configured to accept temperature inputs from the two temperature elements and to adjust a position of the damper in accordance with the single set point and inputs from the two temperature elements.

[0010] Another embodiment of the invention is a method for automatically controlling a temperature in a building. The method includes setting a single set point for an environmental control system, measuring a temperature of each of two zones controlled by the environmental control system, and adjustably controlling a flow of air to the two zones by adjusting a position of a damper.

[0011] Through the various embodiments of the present invention, value of improved energy conservation is realized. That is, by improving airflow and waste from over heating or cooling other zones, an energy value can be realized. Embodiments of the system of the present invention also brings value by operating independently as an improved air circulatory system. Further, embodiments of the present invention provides value of when used to balance or offset natural convection airflow currents.

[0012] Other aspects, objectives and advantages of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

[0014] FIG. **1** is a schematic view of a first embodiment;

[0015] FIG. **2** is an embodiment of a control scheme for operating a HVAC embodiment;

[0016] FIG. **3** is a schematic view of controls for operating an HVAC system according to the present invention;

[0017] FIG. **4** is an elevational view of a dwelling with an HVAC embodiment; and

[0018] FIG. **5** is a schematic view of a building with multiple zones to control.

[0019] While the invention will be described in connection with certain preferred embodiments, there is no intent to limit it to those embodiments. On the contrary, the intent is to cover all alternatives, modifications and equivalents as included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

[0020] HVAC systems according to the present invention have a variety of advantages over conventional systems. Not only do these systems provide for better control of a two-zone or multi-zone space, these systems are less expensive to install than conventional systems. In addition, retrofits of existing systems are also possible by merely adding a damper and a desired number of temperature detecting elements.

[0021] A temperature detecting element, also known as a temperature element, is typically a thermocouple or a thermistor. A thermocouple or thermistor may be placed in each zone and wired back to the HVAC controller. More than one thermocouple or thermistor may also be placed in each zone for closer control of the temperature in the zone. It is important to note that in various embodiments of the present invention, these temperature elements need not be thermostats, i.e., they need not be temperature controllers. They are merely detecting elements, detecting a nearby temperature and reporting the temperature to the HVAC controller. If it is desired, remote temperature elements in communication with the controller and not requiring wiring may be used instead. These temperature elements may communicate with the controller via an infrared link or a wireless radio-frequency (RF) link.

[0022] FIG. **1** depicts an HVAC system embodiment according to the present invention. HVAC system **10** includes a controller **11**, typically a microprocessor controller, and a thermostat **11***a*, for setting a temperature set point for the system. The system includes a motor **12** and a damper **13** controlled by controller **11**. Adjusting the position of the damper regulates or balances the flow of air from an HVAC system, such as a furnace with an air conditioning coil. The damper is preferably located at the outlet of the furnace plenum. This improved HVAC embodiment then has two separate outlet plenums, one to each zone. In this case, there is a lower plenum **18** for a lower floor of a dwelling or building, and an upper plenum **19** for an upper floor of the dwelling or building. The upper and lower floors each have a temperature sampling device **14**, **15**, such as a thermocouple, that is in communication with the controller **11**.

[0023] The controller receives signals from the temperature sampling devices and uses these signals, a temperature set point, and a control algorithm stored in the controller or in a memory attached to the controller, to automatically turn on heating or cooling from the HVAC system and to adjust the position of the damper. A variety of control algorithms may be used in deciding the position of the damper, and how the damper control is integrated with the furnace/air conditioning controls. For example, the purpose of having a two-zone control is to equalize the temperatures in the zones. That is, the control algorithm may attempt to equalize the temperatures in the zones within a certain range, e.g., ±two degrees F. In one embodiment, if the temperature elements within the two zones are within two degrees of each other, say 70° F. and 72° F., the controller will make no adjustments to the damper.

[0024] In this embodiment, the algorithm may be designed so that if the temperature difference is three degrees or more, and the HVAC fan is running, the damper position will adjust a certain amount to route more air to the level requiring additional heating or cooling. The algorithm should be integrated with the control system for the furnace/air conditioner, which will decide whether additional cooling or heating for both zones is required upon reaching a certain differential from the set point. Any desired algorithm, such as a proportional, integral and derivative (PID) algorithm, may be used to control the damper position and thus to adjust the relative temperatures of the zones.

[0025] A diagram outlining this HVAC control scheme is depicted in FIG. **2**. Control scheme **20** begins with a step **21** of sampling the temperatures of an upper and a lower floor of a building. Alternatively, the two zones may be on the same level of a building, such as a home, an office, or a retail store. The temperature information is sent to a HVAC controller with a control algorithm. The controller calculates the difference between the set point temperature and the temperatures indicated in the zones. The controller then calculates whether the zones require **22** heating or cooling. The control scheme then looks at the differential between the upper and lower temperatures to see whether the damper should be adjusted to favor (i.e., send more air to) the lower level **24** or the upper level **25**. If necessary, the controller directs a damper adjustment. For example, if the season requires heating and the lower level is cooler than the upper level, the damper position will move to allow more heated air to flow to the lower level. If the season requires cooling and the lower level is cooler than the upper level, the damper position will move to allow more cooled air to flow to the upper level. After this iteration, the control scheme will then return **25** to the main program **21** and the sampling and control cycle begins again.

[0026] Embodiments are not limited to the ones already described. For example, if the zones are large, or if one zone is large, more than one temperature element may be located in a zone. FIG. **3** depicts an embodiment in which each zone has two temperature elements. Environmental control system **30** includes a control housing **31** with a microprocessor controller **32** which may include a memory. This system includes a single thermostat **34** for controlling a temperature. Each zone may have two or more temperature elements, preferably located separately in the zone. In this zone, the first floor F**1** has two temperature elements **35**, **36** and the second floor F**2** also has two temperature elements **37**, **38**. The controller receives signals from the temperature elements and uses this information, the set point of thermostat **34**, and a control algorithm to determine and adjust a position of damper **37**.

[0027] The control algorithm may use the temperatures and the temperature differences in each zone in any desired manner. For instance, the algorithm may average the two temperatures on each floor or zone and make damper adjustments based on the averages. Control over the system temperature may be kept tighter if the algorithm uses the extremes of the temperature differences to adjust damper position. In such an embodiment, there is only one thermostat controlling the temperature set point. The temperature elements in this embodiment are not thermostats and do not independently control a temperature. The control system accepts inputs from a plurality of temperature elements and uses these inputs to calculate whether heating or cooling is required, and also to calculate a desired position of the damper. The control system then activates heating, cooling, or an adjustment of the damper position.

[0028] A preferred embodiment of an HVAC system is disclosed in FIG. **4**. HVAC system **40** is installed in a two-zone building **41** that includes a first floor or zone **42***a* and a second floor or zone **42***b*. Each zone has an HVAC air inlet plenum **47***a*, **47***b*, a cold air return **48***a*, **48***b*, and a temperature element **49***a*, **49***b*. The temperature elements are in communication with system controller **43**, which is also in communication with a thermostat **43***a* which determines a temperature set point for the building. The HVAC system includes a furnace **45** with an air conditioning coil which is used to heat and cool building **41**. Furnace with air conditioning coil **45** receives the cold air returns **48***a*, **48***b* and blows heated and cooled air outputs through outlet plenum **46***a*, which is located directly atop furnace **45** and is split into zone inlet plenums **47***a*, **47***b*. Motorized damper **46***b* is located directly atop plenum **46***a* for economy of installation.

[0029] Embodiments are not limited to two zones. The advantages of the present discovery may be embodied in systems with more than two zones. An example with three zones is depicted schematically in FIG. **5**. An HVAC system **50** for controlling more than two zones includes a controller **51**, preferably a microprocessor controller which may include a memory for storing at least an algorithm for operating the system. The system is controlled by a single thermostat **51***a* by which controller **51** receives a set point for heating or cooling. The heating and cooling, as well as ventilation, are provided by furnace **52** which includes heating elements and an air conditioning coil. A fan **53** moves air that is heated or cooled or ventilates the building using system **50**.

[0030] Furnace plenum **56** is preferably mounted atop furnace **52**. First damper **57**, mounted atop plenum **56**, splits the flow of air between first floor or zone **54***a* and second and third floors or zones **54***b*, **54***c*. Second damper **58** is mounted downstream and further splits the air stream between second and third floors **54***b*, **54***c*. The positions of the dampers are controlled by controller **51** using temperature signals received from temperature elements **55***a*, **55***b*, **55***c* located in each of the floors or zones. The position of damper **58** is controlled primarily by the difference between the temperatures of elements **54***b*, **54***c*. The position of damper **57** is controlled primarily by the difference between the temperature of element **55***a* and the remaining temperature elements.

[0031] System **50** uses only a single HVAC temperature setting to control multiple zones. System **50** controls the temperature of the multiple zones, automatically balancing the temperatures of the zones, by using at least one temperature element in each zone, and a number of dampers that is equal to the number of zones, less one damper. As noted above, more than one temperature element may be used if the individual zones are large, or if only one zone is large and a closer degree of control over the damper(s) that control the flow of air to that zone.

[0032] All references, including publications, patent applications, and patents cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically set forth in its entirety herein.

[0033] The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) is to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to practicing the invention.

[0034] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. A automatic balancing damper control system, comprising:

a single set point environmental controller;

at least two temperature elements, each temperature element located in a separate zone and in communication with the environmental controller; and

a control output for a motorized damper, the damper responsive to the controller and configured to control a flow of air to the separate zones, wherein the controller is configured to accept temperature inputs from the at least two temperature elements and to send the control output for adjusting a position of the damper in accordance with the single set point and inputs from the at least two temperature elements.

2. The damper control system of claim **1**, wherein the environmental controller comprises a thermostat.

3. The damper control system of claim **2**, wherein one of the at least two temperature elements is integral to the thermostat.

4. The damper control system of claim **1**, wherein the temperature elements are selected from the group consisting of thermocouples and thermistors.

5. The damper control system of claim **1**, wherein the at least one of the at least two temperature elements are in wireless communication with the environmental controller.

6. The damper control system of claim **1**, further comprising the motorized damper.

7. The damper control system of claim **6**, wherein an outlet of the damper is split into at least two portions corresponding to the at least two zones.

8. The damper control system of claim **1**, wherein the system comprises a plurality of temperature elements at least equal to a number of the zones, at least one temperature element in each zone, and further comprises a number of dampers equal to the number of zones less one damper.

9. An automatic balancing damper control system for regulating temperature in at least two different zones, comprising:

a thermostat positioned in one of the two zones;

a temperature sensor positioned in a different zone from the thermostat and in communication with the thermostat; and

a motorized damper operatively connected to the thermostat, the damper positioned in fluid communication with temperature regulating appliance at an inlet and with each of the at least two different zones at outlets thereof;

wherein the thermostat is configured to adjust a position of the damper in accordance with a single set point and temperature inputs from the at least two zones.

10. The system of claim **9**, wherein the thermostat comprises an integral temperature sensor for sensing ambient temperature.

11. The system of claim **9**, wherein the thermostat is configured to bias the damper to supply more fluid flow to one of the at least two zones when an operating mode calls for heating.

12. The system of claim **11**, wherein the thermostat is configured to bias the damper to supply more fluid flow to another of the at least two zones when an operating mode calls for cooling.

13. The system of claim **9**, wherein at least one of the temperature elements is in wireless communication with the controller.

14. A method for automatically controlling a temperature in a building, the method comprising the steps of:

setting a single set point for an environmental control system;

measuring a temperature of each of two zones controlled by the environmental control system;

adjustably controlling a flow of air between the two zones by adjusting a position of a damper.

15. The method of claim **14**, wherein the environmental control system is a heating and air conditioning system.

16. The method of claim **14**, wherein the step of setting the single set point comprises setting the single set point with a thermostat.

17. The method of claim **14**, wherein the step of adjustably controlling a flow of air between the two zones by adjusting the position of the damper comprises the step of adjusted the flow of air to minimize a difference between temperatures detected in the two zones and the set point.

18. The method of claim **14**, wherein the two zones comprise a plurality of zones, the flow of air comprises a same number of flows of air as the plurality of zones, and a number of dampers comprises the same number of dampers as the plurality of zones, less one.

19. The method of claim **14**, wherein the step of adjustably controlling a flow of air between the two zones by adjusting the position of the damper comprises the step of biasing the damper to supply more fluid flow to one of the at least two zones when an operating mode calls for heating.

20. The system of claim **19**, wherein the step of adjustably controlling a flow of air between the two zones by adjusting the position of the damper further comprises the step of biasing the damper to supply more fluid flow to another of the at least two zones when an operating mode calls for cooling.

* * * * *