HUMIDIFIER CONTROL SYSTEM

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ABSTRACT
An example humidifier controller for operation in conjunction with an air conditioning/furnace unit is presented. The humidifier controller may include a control circuit to generate a fan control output for the air conditioning/furnace unit. The fan control output may be equal to a fan control input in response to any of a heating control signal, an air conditioning control signal, and the fan control input being active. Also, the fan control output may be based on a humidistat output in response to each of the heating control signal, the air conditioning control signal, and the fan control input being inactive.

ENVIRONMENTAL CONTROL SYSTEM

THERMOSTAT 110

HUMIDIFIER CONTROLLER 102

AC/FURNACE 120
FAN 122

HUMIDIFIER 140
SOLENOID 142
HUMIDIFIER CONTROL SYSTEM
RELATED APPLICATIONS

[0001] This non-provisional application claims the benefit of priority to U.S. Provisional Application No. 61/982,586, titled “HUMIDITY CONTROL SYSTEM,” filed Apr. 22, 2014, and which is hereby incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

[0002] Aspects of the present disclosure generally involve environmental control systems and more specifically involve a humidifier controller for environmental control systems, such as heating, ventilation, and air conditioning systems that include a central humidifier.

BACKGROUND

[0003] Humidification of a whole house and other living spaces may have several desirable effects, such as, for example, a reduction in floating particulates in the air and a reduction in static electricity on household animals, carpet, and electrical devices. Accordingly, heating, ventilation (or circulation), and air conditioning (HVAC) systems often include humidifiers and humidistats to maintain a desired level of humidity in an interior or enclosed space. HVAC systems may include a furnace with a heating element, an air conditioner (AC) with a cooling element, a blower fan, a condensing unit, a humidistat, and a humidifier with a water solenoid and one or more water-absorbent pads or control steam systems. The blower fan may be configured to blow air across the heating and cooling elements of the furnace and AC as well as through the humidifier and into the interior space, and also may recirculate the air through the interior space without heating or cooling of the air. The humidifier may operate by way of the humidistat actuating the water solenoid to wet the pads, which are positioned in the flow of air being moved by the blower fan.

[0004] Traditionally, a humidifier is activated in conjunction with a furnace or air humidifier. The thermostat and humidistat may allow a user to set a target temperature and a target humidity level. Whenever the thermostat activates the furnace or air handler and the blower fan, the humidifier also may be activated depending on the target humidity level. Once the target temperature is reached, the thermostat may deactivate the furnace or air handler and blower fan, and the humidifier also may be deactivated regardless of whether the target humidity level is reached. Typically, the humidistat may only activate the humidifier while the furnace is operating and/or the blower fan is running, as controlled by the thermostat. If the target humidity level is reached while the furnace is running, the humidistat may deactivate the humidifier by closing the water solenoid. Often times, such operation causes the desired humidity level to not be reached unless the temperature is set uncomfortably high or the blower fan is set to run continuously by the user. The continuous running of the blower fan often leads to the user forgetting to deactivate the system, thus wasting electricity. Furthermore, most HVAC systems are not configured to operate the humidifier while the AC is operating to prevent the additional humidity from causing ice to form on the cooling element, thus potentially damaging the AC.

[0005] Moreover, in some HVAC systems, the thermostat may be at least partially incompatible with the AC/furnace. Many HVAC systems include an AC/furnace that uses six wires for power and controlling the AC/furnace. Many thermostats, however, have connections for only four or five wires. For example, the AC/furnace may have connections for a 24 VAC (volts alternating current) wire, a common wire, a heater control wire, an air conditioner control wire, a medium fan speed wire, and a low fan speed wire, while a thermostat might only include connections for a 24 VAC wire, a common wire, a heater control wire, an air conditioner control wire, and a medium fan speed wire. Using such a thermostat with the six-wire AC/furnace thus may lead to the low fan speed never being utilized.

[0006] In another example, a four-wire thermostat may only include a 24 VAC wire, a heater control wire, an air conditioner control wire, and a medium fan speed wire. For these thermostats to function correctly with the AC/furnace, one or more additional wires may be routed between the AC/furnace and the thermostat, or digital techniques may be used.

[0007] In some cases, the operation of a humidifier may cause a buildup of water in HVAC ducts. Humidifiers may be placed in a number of locations in an HVAC system, but are typically placed next to a furnace. This placement of the humidifier often results in water buildup in angled ducts located near the humidifier.

[0008] It is with these and other concepts in mind that aspects of the present disclosure were conceived.

SUMMARY

[0009] At least some implementations of the present disclosure involve a humidifier controller that facilitates humidifier operation without operation of the corresponding furnace. In an example, the humidifier controller may sense the current state of the AC/furnace and allow the humidifier to operate normally while the furnace is heating or the blower fan is recirculating air, as well as while the AC, furnace, and blower fan have each been turned off by the thermostat unit. In an embodiment, the humidifier controller may also facilitate operation of the humidifier with a previously unused low-speed setting of the blower fan while the AC and the furnace are not operating. The humidifier controller may also include a timer circuit that allows for continued operation of the blower fan after the water solenoid of the humidifier has been closed, thus allowing the air to dry the pads of the humidifier as well as the air ducts of the HVAC system without operating the AC or furnace.

BRIEF DESCRIPTION OF THE FIGURES

[0010] Aspects of the present disclosure may be better understood and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The drawings depict only typical embodiments of the present disclosure and, therefore, are not to be considered limiting in scope.

[0011] FIG. 1 is a block diagram of an environmental control system including an example humidifier controller.

[0012] FIG. 2A is a block diagram of an environmental control system including an example humidifier controller in which control signals from a thermostat are passed to an air conditioner/furnace through the humidifier controller.

[0013] FIG. 2B is a block diagram of an environmental control system including an example humidifier controller in which some control signals from a thermostat are passed....
directly to an air conditioner/furnace, and in which those control signals are provided to the humidifier controller for monitoring.

**FIG. 3** is a flow diagram of an example method of controlling a blower fan of an AC/furnace unit.

**FIG. 4** is a flow diagram of an example method of enabling a humidistat.

**FIG. 5** is an electrical schematic of an example humidifier controller for an environmental control system.

**FIG. 6** is an electrical schematic of an example electronic switch employable in the humidifier controller of Fig. 5 for monitoring control signals from a thermostat unit.

**FIG. 7** is an electrical schematic of an example AC-to-DC converter employable in the humidifier controller of Fig. 5 for providing power to the humidifier controller.

**FIG. 8** is an electrical schematic of an example timer circuit employable in the humidifier controller of Fig. 5 for operating the blower fan.

**FIG. 9** is an electrical schematic of an example status indicator employable in the humidifier controller of Fig. 5.

**DETAILED DESCRIPTION**

**[0021]** Aspects of the present disclosure involve an environmental control system that may operate a humidifier at least partially independently of a thermostat unit. More specifically, a humidifier controller interfaces with existing HVAC components, such as an AC/furnace unit and air handler (including a blower fan), a thermostat unit, a humidistat, and a humidifier (including a water solenoid valve). The humidifier controller may operate the humidifier and blower fan either conventionally or unconditionally. Conventional operation of the humidifier may involve operating the humidifier while the furnace and associated blower fan are operating, or while the blower fan is set to recirculate. Unconventional operation of the humidifier may involve operating the humidifier while the air conditioner and blower fan are running, or operating the humidifier in conjunction with the blower fan when the heater, air conditioner, and blower fan are not currently running. Stated differently, the humidifier controller allows for the humidifier to operate at least somewhat independently from the operation of the furnace, AC, and blower fan as determined by the thermostat unit.

**[0022]** The humidifier controller may also facilitate the connection of a four-wire, five-wire, or six-wire thermostat to an AC/furnace system. In addition, the humidifier controller may include an adjustable timer delay for operating the blower fan after a desired humidity level has been reached and the water solenoid has been closed. Moreover, the humidifier controller may be configured to operate the blower fan at a relatively low speed while the humidifier is being operated but the furnace and AC are not operating.

**[0023]** **FIG. 1** is a block diagram of an environmental control system 100 including an example humidifier controller 102. As shown, the humidifier controller 102 may be coupled with any of a number of HVAC devices or equipment, including an AC/furnace 120 that includes a blower fan 122, a humidifier 140 that includes a solenoid 142 configured to introduce water into one or more evaporative pads of the humidifier 140, a thermostat 110 configured to control the operation of the AC/furnace 120 including the blower fan 122, and a humidistat 130 configured to operate the solenoid 142 of the humidifier 140 based on a detected humidity level. In some examples, each of the AC/furnace 120, the thermostat 110, the humidistat 130, and the humidifier 140 may be conventional HVAC components or equipment configured to operate in a home, office building, or other enclosed space. The environmental control system 100 may also include any associated infrastructure for regulating the temperature and humidity of an enclosed space. For example, the environmental control system 100 may include ducting, electrical wiring, water connections, drainage connections, water pumps, and other equipment used in an HVAC system.

**[0024]** The thermostat 110 may include any conventional thermostat that is configured to regulate the temperature in an indoor space, such as a house, a room, a building, or other enclosed area. The thermostat 110 may include a temperature sensor and an input that allows a user to input a temperature setting and mode of operation (e.g., heat, cool, and/or recirculate). In operation, the thermostat 110 may measure the current temperature using the temperature sensor and compare the measured temperature to the temperature setting. If the temperature is greater than the temperature setting and the thermostat 110 is set to a cooling mode, the thermostat 110 may send a control signal to the AC of the AC/furnace 120 to begin operation until the temperature falls below the temperature setting. Similarly, if the temperature is less than the temperature setting and the thermostat 110 is set to a heating mode, the thermostat 110 may send a control signal that causes the furnace of the AC/furnace 120 to activate and heat the space until the temperature rises above the temperature setting. In recirculate mode, the thermostat 110 may cause a blower fan 122 of the AC/furnace 120 to operate without activating either the heating element or cooling element of the AC/furnace 120.

**[0025]** The AC/furnace 120 may include any heating and cooling system designed for an enclosed space. The AC/furnace 120 may also include a multi-speed blower fan 122 capable of operating at least at two different fan speeds. The AC/furnace 120 may also include a transformer that connects to the electrical system of a building and converts a standard voltage (e.g., 120 VAC) to an operating voltage (e.g., 24-27 VAC, nominally 24 VAC) for the environmental control system 100.

**[0026]** The blower fan 122 may be any multi-speed fan configured to move air across the heating and/or cooling elements of the AC/furnace 120, through ductwork, and into an enclosed space. In one example, the blower fan 122 may be a three-speed fan configured for a high speed mode, a medium speed mode, and a low speed mode of operation. In one example, the AC/furnace 120 may be configured to run the blower fan 122 at a high speed during AC operation and at a medium speed during furnace operation, and may not utilize the low speed.

**[0027]** The humidistat 130 may include a humidity sensor and an input device for setting the target humidity. The humidistat 130 may be configured to compare the humidity measured by the humidity sensor to a target humidity level set by a user and provide a control signal to the humidifier 140 to operate the humidifier 140 when the sensed humidity level drops below the target humidity level. Conversely, when the sensed humidity level subsequently rises above the target humidity level, the humidistat 130 may then alter the control signal to the humidifier 140 to cease operation of the humidifier 140.

**[0028]** The humidifier 140 may be configured to increase the humidity in the enclosed space when activated. In one example, the humidifier 140 may include one or more
humidifier pads and a water solenoid valve (or solenoid) 142. The water solenoid 142 may be configured to receive a control signal from the humidistat 130 to open and provide water to the pads. The pads may be positioned so that air moved by the blower fan 122 of the AC/furnace 120 is pushed through or along the pads, causing the water to evaporate and humidify the air. The humidifier 140 may be configured to operate when either the blower fan 122 is active. In one example, the humidifier 140 is configured to operate when either the furnace is operating or the AC/furnace 120 is set to recirculating mode by running the fan 122 without activating any heating or cooling elements. In the embodiments discussed herein, the humidifier 140 operates according to the opening of the water solenoid 142. In other embodiments, humidifiers that do not include a water solenoid or that utilize addition inputs may be employed.

[0029] In various embodiments discussed herein, the humidifier controller 120 may be configured to interface with the humidistat 110, the AC/furnace 120, the humidistat 130, and the humidifier 140 to decouple the operation of the humidifier 140 from the operation of the AC/furnace 120 from time to time. For example, the humidifier controller 102 may pass signals between the humidistat 110 and the AC/furnace 120 to utilize those signals, as well as signals provided by the humidistat 130, to activate and deactivate the humidifier 140 and/or the blower fan 122. The humidifier controller 102 may be added to existing HVAC systems by interconnecting the humidifier controller 102 between the wires connecting between the humidistat 110 and the AC/Furnace 120, as well as between the wires connecting the humidistat 130 and the humidifier 140. In other examples, as depicted using dashed lines in FIG. 1, at least some of the control signals between the thermostat 110 and the AC/Furnace 120, and between the humidistat 130 and the humidifier 140, may be routed directly between those units without passing through the humidifier controller 102. In those examples, the humidifier controller 102 may accept those signals as inputs to generate control signals for the humidistat 130 and the blower fan 122 of the AC/Furnace 120.

[0030] In each example, the signals to and from the humidifier controller 102 may be carried over wires and connected to the humidifier controller 102 by way of standard connectors attachable to connector headers located at the humidifier controller 102, or by other types of hardware. Moreover, signals to or from each of the humidifier 140, the AC/Furnace 120, the humidistat 130, and the humidifier 140 may be connected to the humidifier controller 102 by way of a separate connector or header associated with each of these components 110, 120, 130, and 140. In yet other examples, signals of two or more of the components, such as, for example, the humidistat 130 and humidifier 140, may be connected at the humidifier controller 102 via a single combined connector or header.

[0031] FIG. 2A is a block diagram of an environmental control system 100A including an example humidifier controller 102A in which control signals from the humidistat 110 are passed to the AC/Furnace 120 through the humidifier controller 102A. More specifically, the thermostat 110 may include a four-wire, five-wire, or six-wire connection for receiving power and controlling the AC/Furnace 120. A four-wire configuration of an example thermostat 110 may include: (1) a 24 VAC wire (VAC 200) (which may be a different AC or DC voltage in other embodiments) for receiving power from the AC/Furnace 120; (2) a heater control wire (HEAT 1 CTL 210) for activating the furnace; (3) an air conditioner control wire (AC CTL 220) for activating the AC; and (4) a medium fan speed control wire (MS FAN CTL IN 230) for activating the medium speed of the blower fan, either with or without activation of the heater control wire 210 or the air conditioner control wire 220. In the four-wire configuration, the AC and furnace each may activate the blower fan 120 whenever the AC/Furnace 120 runs using a blower control wire coming from AC/Furnace 120. A thermostat 110 with a five-wire configuration may include each of the wires listed in the four-wire configuration, as well as a common wire (VAC COM 202). Further, in a six-wire configuration, the thermostat 110 may include a second heater control signal (HEAT 2 CTL 212) for operating a second heating element in the AC/furnace 120, which may be configured to heat a separate enclosed physical space or zone separate from the enclosed space served by the first heating element. In these examples, each of the control wires 210, 212, 220, and 230 received from the thermostat 110 may provide a 24 VAC signal when active.

[0032] In one example, the AC/furnace 120 may include six input/output terminals for forming six connections between the AC/furnace 120 and the thermostat 110, including (1) the 24 VAC wire (VAC 200) for providing power to the thermostat 110; (2) the heater control wire (HEAT 1 CTL 210) for activating the furnace; (3) the air conditioner control wire (AC CTL 220) for activating the AC; (4) a medium fan speed control wire (MS FAN CTL OUT 240) for activating the medium speed of the blower fan 122; (5) a low fan speed control wire (MS FAN CTL OUT 242) for activating the blower fan 122 at a low speed; and (6) the common wire (VAC COM 202) to provide a return current path from the thermostat 110 to the AC/furnace 120. In some examples, the AC/furnace 120 may include a seventh terminal for the second heat control signal wire (HEAT 2 CTL 212) from the thermostat 110. Again, in these examples, each of the control wires 210, 212, 220, 240, and 242 may provide a 24 VAC signal when active.

[0033] In this example, each of the signals typically routed directly between the thermostat 110 and the AC/furnace 120 (e.g., the 24 VAC 200, the 24 VAC common 202, the heat 1 control signal 210, the heat 2 control signal 212, the AC control signal 220, and the medium speed fan control input signal 230) pass through the humidifier controller 102A to the AC/Furnace 120, with the power voltage, the common line, the furnace control signals, and the AC control signal provided to the AC/Furnace 120 being essentially the same as received at the humidifier controller 102A from the thermostat 110. Further, the humidifier controller 102A may accept the medium speed fan control input signal 230 from the thermostat 110, and generate the medium speed fan control output signal 240 and the low speed fan control output signal 242 for the AC/Furnace 120 based on the medium speed fan control input signal 230 and other signals from the thermostat 110.

[0034] In addition, the humidifier controller 102A may use the signals received from the thermostat 110 to generate a humidistat enable signal 250 (HUM EN 250) for the humidistat 130 to control the operation of the humidistat 130. The humidifier controller 102A may also receive a humidistat output signal 252 (HUM OUT 252) of the humidistat 130 to generate a solenoid control signal 260 (SOL CTL 260) to operate the solenoid 142. The humidifier controller 102A may also provide a solenoid common line 262 (SOL COM
(0035) In this and other examples, the humidifier controller 102A may perform its various operations described herein by utilizing the power bus between the thermostat 110 and the AC/furnace 120 (e.g., the 24 VAC power line 200 and the 24 VAC common line 202).

(0036) FIG. 2B is a block diagram of an environmental control system 100B including an example humidifier controller 102B in which some of the control signals between the thermostat 110 and the AC/furnace 120 (e.g., the 24 VAC 200, the 24 VAC common 202, the heat 1 control signal 210, the heat 2 control signal 212, and the AC control signal 220) are passed directly therewithin. In this example, these signals are provided for use as inputs by the humidifier controller 102B to generate the medium speed fan control output signal 240 and the low speed fan control output signal 242 for the AC/furnace 120. Further, the humidifier controller 102B, in a similar manner as the humidifier controller 102A, may use the control signals received from the thermostat 110 to generate the humidistat enable signal 250, receive the humidistat output signal 252, provide the solenoid control signal 260 based on the humidistat output signal 252, and provide the solenoid common line 262. In other embodiments related to the embodiments of FIG. 1, FIG. 2A, and FIG. 2B, the humidistat 130 may provide humidistat output signal 252 directly to the solenoid 142 of the humidifier 140 as the solenoid control signal 260 without that signal being routed through the humidifier controller 102A.

(0037) FIG. 3 is a flow diagram of an example method 300 of controlling the blower fan 122 of the AC/furnace 120. In the method 300, if any of the heat control signals (heat 1 control signal 210 and/or heat 2 control signal 212), the AC control signal 220, or the medium speed fan control input signal 230 from the thermostat 110 are active (operations 302, 304, and 306, respectively), indicating that the heater, AC, and/or fan 122 are currently operating, the humidifier controller 102 may provide a medium speed fan control output signal 240 that essentially equals or follows the received medium speed fan control input signal 230 (operation 310), thus allowing the thermostat 110 to continue to control the blower fan 122 of the AC/furnace 120 normally. If, instead of all of the heat control signals (heat 1 control signal 210 and/or heat 2 control signal 212), the AC control signal 220, and the medium speed fan control input signal 230 are inactive, the humidifier controller 102 may produce either the medium speed fan control output signal 240 or the low speed fan control output signal 242 based on the humidifier output signal 252 (operation 308). Consequently, under these circumstances, the humidifier controller 102 may operate the blower fan 122 independently of the medium speed fan control input signal 230 from the thermostat 110. In some examples, the humidifier controller 102 may activate the medium speed fan control output signal 240 or the low speed fan control output signal 242 when the input fan control input signal 230 from the thermostat 110 becomes active, and then either deactivate the output fan control output signal 240 or 242 when the input fan control signal 230 is deactivated, or extend the output fan control output signal 240 or 242 for some period of time to ensure the pads of the humidifier 140 are dried sufficiently. In one example, a user may select whether or not this extra time is added to the activation of the output fan control output signal 240 or 242 by way of a switch, jumper, or other selection means at the humidifier controller 102. Similarly, the user may determine which of the medium speed fan control output signal 240 or the low speed fan control output signal 242 is generated by way of a switch, jumper, or the like.

(0038) As shown in FIG. 3, the humidifier controller 102 may continuously or repeatedly monitor the incoming heat control signal 210 and/or 212, the AC control signal 220, and the medium speed fan control input signal 230 from the thermostat 110 and adjust the medium speed or low speed fan control signals 240 or 242 to the AC/furnace 120 accordingly. Also, while the various input control signals are shown in FIG. 3 as being monitored in operations 302, 304, and 306 in a particular order, other orders of operation, including simultaneous or concurrent performance of these operations, are also possible.

(0039) FIG. 4 is a flow diagram of an example method 400 of enabling the humidistat 130. In the method 400, if the AC control signal 220 from the thermostat 110 is inactive (operation 402), or the user has not indicated (via a jumper, switch, or other selection means) that the humidifier 140 is to be disabled while the AC is running (operation 404), the humidifier controller 102 may activate the humidistat enable signal 250 (operation 408) to allow the humidistat 130 to operate, thus providing the humidistat output signal 252 indicating whether the current humidity level has dropped below a target humidity level, thereby activating the humidifier 140 via the solenoid control signal 260. Otherwise, if both the AC control signal 220 is active (operation 402) and the user has indicated that the humidifier is to be disabled while the AC is running (operation 404), the humidifier controller 102 may inactivate the humidistat enable signal 250, thus preventing the humidistat output signal 252 from becoming active, thereby preventing the humidifier 140 from operating during that time. In one example, by setting the jumper or switch, the user may indicate that the humidifier 140 is not permitted to be active while the AC is operating to prevent the formation of ice in the AC/furnace 120 or associated ductwork.

(0040) As a result, the enabling or disabling of the humidistat enable signal 250, as performed in the method 400, may then affect the operation of the method 300, specifically when the humidifier controller 102 generates the medium speed fan control output signal 240 or the low speed fan control output signal 242 based on the humidifier output signal 252 (operation 308 of method 300) during times when the AC and heating functions of the AC/furnace 120 are not being activated. Further, the user may select which of the medium or low speeds of the blower fan 122 may be used for such humidifier-only operation by way of an additional jumper or switch. For example, a user may select to utilize the low speed of the blower fan 122 for humidifier-only operations to reduce potential noise caused by the blower fan 122 in comparison to a medium or high setting.

(0041) Similar to the method 300, the monitoring operations 402 and 404 of method 400 may be performed in another order other than that specifically shown in FIG. 4, including simultaneous or concurrent operation. Also, the humidifier controller 102 may perform the monitoring operations 402 and 404 repeatedly or continuously. Additionally, in other embodiments, the humidifier controller 102 may not provide an option to allow the user to disable the humidistat 130 while the AC is operating, and may thus base its activation of the humidistat enable signal 250 strictly on the state of the AC control signal 220 (operation 402).
By taking methods 300 and 400 in combination, the humidifier controller 102 may allow the humidistat 130 to open the solenoid 142 to provide additional humidity via the humidifier 140 and concurrently operating the blower fan 122 at a low or medium speed while the thermostat 110 is not operating the AC/furnace 120 in a heating, cooling, or recirculating mode.

FIG. 5 is an electrical schematic of an example humidifier controller 500 for the environmental control system 100. In at least some examples, the humidifier controller 500 of FIG. 5 may serve as any of the humidifier controllers 102, 102A, and 102B of FIGS. 1, 2A, and 2B. In the humidifier controller 500, an AC-to-DC converter 502 may convert the received 24 VAC voltage 200 to a DC (direct current) voltage VDC 501 so that the humidifier controller 500 may perform the various operations described below. In one example, the DC voltage at VDC 501 is 5 volts DC (VDC), although other DC voltages may be utilized for power at the humidifier controller 500 in other embodiments. In addition, a power indicator 504 may be included to indicate to the user when the 24 VAC voltage is being received at the humidifier controller 500.

In the humidifier controller 500, a first relay 520 (e.g., an Omron® single-pole, double-throw (SPDT) relay) and a second relay 522 (e.g., an Omron® double-pole, double-throw (SPDT) relay) may be employed to provide fan control signals to the AC/furnace 120 according to the method 300 of FIG. 3. Each of the heat control signal 210 and the second heat control signal 212, if available, the AC control signal 220, and the medium speed fan control input signal 230 received from the thermostat 110 is provided to a separate electronic switch 510, 512, 514, and 516, respectively. If any of the control signals 210, 212, 220, or 230 is active, the electronic switch or switches 510, 512, 514, and 516 correspond to the active control signal or signals are closed, thus pulling the output of the corresponding switch 510, 512, 514, and 516 to ground, thereby activating the first relay 520. When the first relay 520 is activated, any activation voltage to a second relay 122 via an internal relay control signal 521 is disconnected, thus deactivating the second relay 522. As a result, the medium speed fan control input signal 230 from the thermostat 110 is directed to the medium speed fan control output signal 240 for the AC/furnace 120.

If, instead, none of the control signals 210, 212, 220, or 230 is active, none of the electronic switches 510, 512, 514, and 516 is closed, thus preventing the activation of the first relay 520. Consequently, the first relay 501 remains in a state in which the humidifier output signal 252, possibly conditioned by way of a timer circuit 530, is forwarded to the second relay 522 via the internal relay control signal 521. In this case, the second relay 522 is activated when the humidifier output signal 252 is active, thus directing the 24 VAC voltage 200 to either the medium speed fan control output signal 240 or the low speed fan control output signal 242 to the AC/furnace 120, depending on a user selection. In this example, the user may set a jumper 538 to a medium speed fan enable position 534 or a low speed fan enable position 536, as shown in FIG. 5, to direct the 24 VAC 200 from the second relay 522 to the desired fan control output signal 240 or 242.

As illustrated in FIG. 5, one or more diodes 544, 546 (e.g., a 1 N4148 diode) may be employed between the electronic switches 510-516 and the first relay 520 to prevent current flow from the electronic switches 510-516 back to the first relay 520. Also, a capacitor 540 (e.g., a 100 microfarad (µF) electrolytic capacitor) may be placed across the coil of the first relay 520 to stabilize the voltage across the coil when the first relay 520 is activated.

A third relay 524 (e.g., an Omron® single-pole, double-throw (SPDT) relay) may be employed in the humidifier controller 500 to perform the method 400 of FIG. 4. For example, the AC control signal 220 may be applied to the coil of the third relay 524 depending on the state of a second jumper 526 that determines whether the humidistat 130 is to be enabled while the AC is operating. If the user places the jumper 526, the user indicates that the humidistat 130 is to be disabled while the AC is operating. More specifically, when the AC control signal 220 is active, its corresponding electronic switch 516 closes, thus activating the third relay 524. Consequently, the humidistat enable signal 250 is disconnected from the 24 VAC 200 applied to the third relay 524, thus disabling the humidistat 130 by preventing a voltage from being applied thereto, thereby preventing the humidistat output signal 252 from becoming active. If, instead, the AC control signal 220 is inactive, or if the jumper 526 has not been inserted by the user, the third relay 524 is inactivated, thus causing the 24 VAC 200 to be applied via the humidistat enable signal 250 to enable the humidistat 130 to operate.

When enabled, the humidistat 130 may then cause the humidistat output signal 252 to be active when the current humidity level detected by the humidistat 130 falls below a target humidity level set at the humidistat 130. When active, the humidistat output signal 252 drives the solenoid control signal 260, thus opening the solenoid valve 14 to wet the evaporative pads therewithin to humidify the air driven by the blower fan 122 of the AC/furnace 120. Further, when the humidistat output signal 252 is active, possibly extended via the timer circuit 530, either the medium speed fan control output signal 240 or the low speed fan control output signal 242 is activated via the first relay 520 and the second relay 522 if none of the input control signals 210, 212, 220, and 230 received from the thermostat 110 is active, as described above. In some examples, the state of the humidistat output signal 252, and thus the state of the solenoid 140, may be provided to the user via a humidistat indicator 532.

As with the first relay 520, the voltage across the coil of the third relay 524 may be stabilized using a capacitor 542 (e.g., a 68 µF electrolytic capacitor).

While the humidifier controller 500 employs a number of electronic components, such as the switches 510-516; relays 520, 522, and 524; and other analog components, as control circuitry to perform the various operations discussed above, other embodiments of the humidifier controller 102 may employ other components, including, for example, one or more integrated hardware components, such as application specific integrated circuits (ASICs), and/or a programmable digital processor, such as a microprocessor or microcontroller executing instructions stored in a readable memory device or unit, to perform the same operations.

FIG. 6 is an electrical schematic of an example of the electronic switches 510, 512, 514, and 516 employed in the humidifier controller 500 of FIG. 5 for monitoring control signals from the thermostat 130. In this example, an n-channel enhancement mode metal-oxide-semiconductor field effect transistor (MOSFET) 602 (e.g., a T2N2504 MOSFET) may be employed as a switch in conjunction with two resistors 604, 606 employed as a voltage divider for an input 610, such as any of the control signals 210, 212, 220, 230 from the
thermostat 110 to drive the gate of the MOSFET 602. When the input 610 is driven to a positive voltage when the input 602 is active, the MOSFET 602 conducts, thus pulling an output 612 at the drain of the MOSFET 602 close to the voltage at the source of the MOSFET 602, which is tied to ground. Accordingly, when the input 610 is active, the output 612 is pulled toward ground, thus activating the first relay 520 of FIG. 5, as described above. In other examples, other types of electronic components may be employed as each of the switches 510, 512, 514, and 516 of FIG. 5.

[0052] FIG. 7 is an electrical schematic of an example of the AC-to-DC converter 502 employed in the humidifier controller 500 of FIG. 5 for providing power to the humidifier controller 500. In this example, the 24 VAC 200 is rectified using a diode 704 (e.g., a 1N4001 diode) and low-pass-filtered using a resistor 706 (e.g., a 470 ohm (Ω) resistor) and a capacitor 708 (e.g., a 100 μF electrolytic capacitor). In addition, the resulting rectified and filtered voltage may be clipped using a Zener diode 710 (e.g., a Zener diode with a 30V reverse breakdown voltage) before being provided to a DC-to-DC converter 702 (e.g., an R78S5.0-0.5 DC-to-DC converter) to protect the DC-to-DC converter 702 from an over-voltage condition. The output of the DC-to-DC converter 702 may then convert the resulting voltage to 5 VDC output as VDC 501, possibly stabilized by an output capacitor 712 (e.g., a 180 μF electrolytic capacitor). Other types of converters, including integrated AC-to-DC converters, may be employed as the AC-to-DC converter 502 in other embodiments.

[0053] FIG. 8 is an electrical schematic of an example of the timer circuit 530 employed in the humidifier controller 500 of FIG. 5 for operating the blower fan 122. In this example, the humidistat output signal 252 received from the humidistat 130 may be provided by way of a rectifying diode 804 (e.g., a 2N4148 diode) across a capacitor 806 (e.g., a 4.7 μF capacitor) and in series with a resistor 808 (e.g., a 10 kilohm (kΩ) resistor) such as shown in FIG. 5. The resistor 808 and capacitor 804 may be provided using a Zener diode 810 (e.g., a Zener diode with a 5.1V reverse breakdown voltage) to produce an approximately 5 VDC signal when the humidistat output 252 is active (operating at 24 VAC). The resulting 5 VDC voltage is then applied to a second diode 812 (e.g., a 1N4148 diode) to a parallel pair of capacitors 814 and a resistor 816 providing a time delay to that DC voltage when the timer enable jumper 802 is inserted by the user to enable the timer circuit 530. Consequently, when the DC voltage at the capacitor 814 and the resistor 816 drops in response to the humidistat output signal 252 becoming inactive, the charge in the capacitor 814 drains through the resistor 816 according to the time constant represented by their values. Otherwise, if the timer enable jumper 802 is not present, the capacitor 814 is removed from the circuit, and no delay is imposed in the deactivation of the DC voltage resulting from the humidistat output signal 252 becoming inactive. In one example, the capacitor 814 may be a 220 μF capacitor and the resistor 816 may be a 1 megohm (MΩ) resistor, thus resulting in a time delay of approximately three minutes, during which an input to a first logic inverter 816 (e.g., a 74HC14 inverter) remains active after the humidistat output signal 252 becomes inactive. In other examples, the timer circuit 530 may be configured to provide an additional five minutes, ten minutes, fifteen minutes, or any other period of time to operate the blower fan 122 after the water solenoid 142 has been closed in order to dry the ductwork and pads. The output of the first inverter 816 is then provided as input to one or more second inverters 820 (e.g., also 74HC14 inverters) to drive the signal being passed by the first relay 520 to activate the second relay 522, as described more fully above. In this example, multiple second inverters 820 are employed to ensure sufficient current-drawing capacity to activate the second relay 522. While five second inverters 820 are utilized in FIG. 8, other numbers of second inverters 820 may be employed in other embodiments. Moreover, other examples of the timer circuit 530 may be utilized in other embodiments.

[0054] FIG. 9 is an electrical schematic of an example status indicator employable as the power indicator 504 and the humidistat on indicator 532 in the humidifier controller 500 of FIG. 5. In this example, an input 902, such as the 24 VAC 200 or the humidistat output 252, is provided via a current-limiting resistor 808 (e.g., a 3 KΩ resistor) to a light-emitting diode (LED) 808 so that the LED 808 emits light when the input 902 is active (e.g., operating at 24 VAC). Other methods or means of providing such indications may be employed in other embodiments of the humidifier controller 500.

[0055] The foregoing merely illustrates principles of operation of example humidifier controllers for an environmental control system. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. It will thus be appreciated that those skilled in the art will be able to devise numerous systems, arrangements, and methods that, although not explicitly shown or described herein, embody the principles of the example humidifier controllers and are thus within the scope of the present disclosure. From the above description and drawings, it will be understood by those of ordinary skill in the art that the particular embodiments shown and described are for purposes of illustration only and are not intended to limit the scope of the present disclosure. Further, references to details of the particular embodiments are not intended to limit the scope of the disclosure.

What is claimed is:

1. A humidifier controller comprising:
   a control circuit to generate a fan control output for an air conditioning/furnace unit;
   the fan control output being equal to a fan control input in response to any of a heating control signal, an air conditioning control signal, and the fan control input being active;
   and the fan control output being based on a humidistat output in response to each of the heating control signal, the air conditioning control signal, and the fan control input being inactive.

2. The humidifier controller of claim 1, the control circuit to enable the humidistat output based on the air conditioning control signal being inactive.

3. The humidifier controller of claim 1, the control circuit to forward the humidistat output to a water solenoid of a humidifier unit to control the water solenoid.

4. The humidifier controller of claim 1, the control circuit comprising a timer circuit to extend an active state of the fan control output for a predetermined period of time in response to the humidistat output transitioning from an active state to an inactive state while each of the heating control signal, the air conditioning control signal, and the fan control input is inactive.

5. The humidifier controller of claim 3, the predetermined period of time being at least three minutes.
6. The humidifier controller of claim 1, wherein:
the fan control output comprises a first fan control output and a second fan control output;
the first fan control output, when active, causes a fan of the air conditioning/furnace unit to operate at a first speed;
the second fan control output, when active, causes the fan of the air conditioning/furnace unit to operate at a second speed less than the first speed;
the control circuit to cause the first fan control output to be equal to the fan control input in response to any of the heating control signal, the air conditioning control signal, and the fan control input being active; and
the control circuit to cause the second fan control output to be based on the humidistat output in response to each of the heating control signal, the air conditioning control signal, and the fan control input being inactive.

7. The humidifier controller of claim 1, wherein:
the heating control signal comprises a first heating control signal for a first physical zone and a second heating control signal for a second physical zone; and
the heating control signal is active in response to at least one of the first heating control signal being active and the second heating control signal being active.

8. The humidifier controller of claim 1, the control circuit to receive the fan control input, the heating control signal, and the air conditioning control signal from a thermostat unit.

9. The humidifier controller of claim 8, the control circuit to forward the fan control input, the heating control signal, and the air conditioning control signal to the air conditioning/furnace unit.

10. The humidifier controller of claim 1, the control circuit comprising:
a first electronic switch activated by the heating control signal;
a second electronic switch activated by the air conditioning control signal;
a third electronic switch activated by the fan control input;
a first relay activated by any of the first electronic switch, the second electronic switch, and the third electronic switch to relay an internal relay control signal based on the humidistat output; and
a second relay controlled by the internal relay control signal, the second relay to relay the fan control input to the fan control output in response to the internal relay control signal being inactive, and the second relay to activate the fan control output in response to the internal relay control signal being active.

11. The humidifier controller of claim 10, the control circuit comprising:
a third relay activated by the second electronic switch to provide a humidistat enable signal.

12. A method of providing humidifier control, the method comprising:
receiving a heating control signal, an air conditioning control signal, and a fan control input for an air conditioning/furnace unit from a thermostat unit;
receiving a humidistat output from a humidistat; and
generating a fan control output for the air conditioning/furnace unit, the fan control output being equal to the fan control input in response to any of the heating control signal, the air conditioning control signal, and the fan control input being active, and the fan control output being based on the humidistat output in response to each of the heating control signal, the air conditioning control signal, and the fan control input being inactive.

13. The method of claim 12, further comprising:
activating the humidistat output based on the air conditioning control input being inactive.

14. The method of claim 12, further comprising:
generating a water solenoid control signal equal to the humidistat output.

15. The method of claim 12, further comprising:
activating an active state of the fan control output for a predetermined period of time in response to the humidistat output transitioning from an active state to an inactive state while each of the heating control signal, the air conditioning control signal, and the fan control input is inactive.

16. The method of claim 12:
the fan control output comprising a first fan control output and a second fan control output;
the first fan control output, when active, causing a fan of the air conditioning/furnace unit to operate at a first speed;
the second fan control output, when active, causing the fan of the air conditioning/furnace unit to operate at a second speed less than the first speed; and
the method further comprising:
cining the first fan control output to be equal to the fan control input in response to any of the heating control signal, the air conditioning control signal, and the fan control input being active; and
cining the second fan control output to be based on the humidistat output in response to each of the heating control signal, the air conditioning control signal, and the fan control input being inactive.

17. A humidifier controller comprising:
an input interface to receive, from a thermostat unit, a heating control signal, an air conditioning control signal, and a fan control input for an air conditioning/furnace unit;
an output interface to provide a fan control output for the air conditioning/furnace unit;
an output interface to provide a humidistat enable signal to a humidistat, and to receive a humidistat output from the humidistat; and
a control circuit to generate the fan control output for the air conditioning/furnace unit, the fan control output being equal to the fan control input in response to any of the heating control signal, the air conditioning control signal, and the fan control input being active, and the fan control output being based on the humidistat output in response to each of the heating control signal, the air conditioning control signal, and the fan control input being inactive.

18. The humidifier controller of claim 17, the control circuit to generate the humidistat enable signal based on the air conditioning control signal being inactive.

19. The humidifier controller of claim 17, the control circuit comprising:
a first electronic switch activated by the heating control signal;
a second electronic switch activated by the air conditioning control signal;
a third electronic switch activated by the fan control input;
a first relay activated by any of the first electronic switch, the second electronic switch, and the third electronic switch to relay an internal relay control signal based on the humidistat output;
a second relay controlled by the internal relay control signal, the second relay to relay the fan control input to the fan control output in response to the internal relay control signal being inactive, and the second relay to activate the fan control output in response to the internal relay control signal being active.

20. The humidifier controller of claim 19, the control circuit further comprising:
a third relay activated by the second electronic switch to generate the humidistat enable signal.

21. The humidifier controller of claim 17, further comprising:
a humidifier interface to provide the humidifier output to a water solenoid of a humidifier unit to control the water solenoid.

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