US 20210364004A1

(19) United States
(12) Patent Application Publication
Combs et al.
(10) Pub. No.: US 2021/0364004 A1
(43) Pub. Date: Nov. 25, 2021

(54) PRODUCT FAN SYSTEM AND RELATED METHODS

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(21) Appl. No.: **17/396,923**

(22) Filed: **Aug. 9, 2021**

Related U.S. Application Data

(62) Division of application No. 14/823,495, filed on Aug. 11, 2015, now Pat. No. 11,085,455.

(60) Provisional application No. 62/035,667, filed on Aug. 11, 2014.

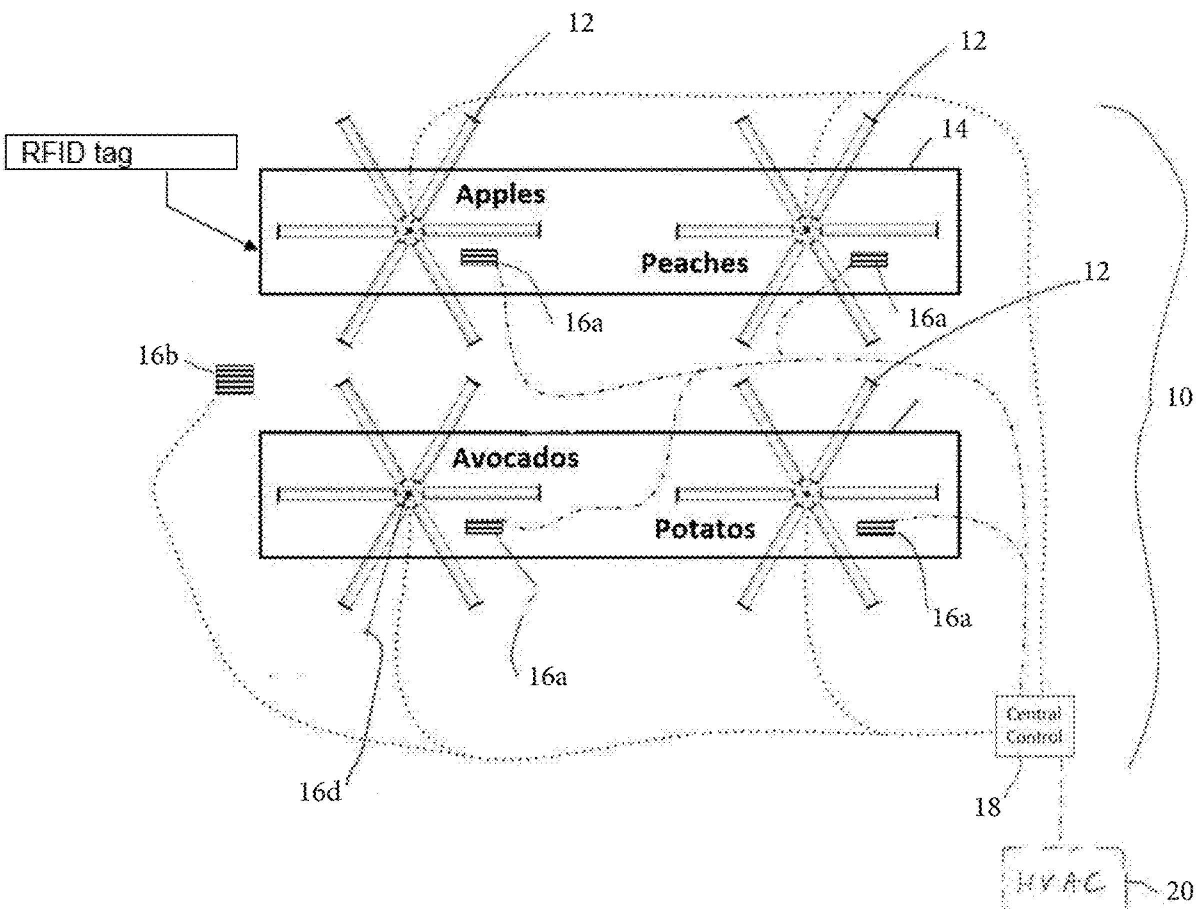
Publication Classification

(51) Int. Cl.
F04D 27/00 (2006.01)
F04D 19/00 (2006.01)

(52) U.S. Cl.
CPC *F04D 27/006* (2013.01); *F04D 19/002* (2013.01)

(57) ABSTRACT

A system uses one or more fans to regulate airflow associated with products, such as to assist in retarding the spoilage of produce on display for sale in a space. The system includes a display in the space for displaying the produce for sale and at least one sensor for sensing a parameter associated with the display and generating an output representative of the parameter. The fan may be an overhead fan located in the space above the display for regulating the airflow over the display. A controller is provided for controlling the fan based on the output of the sensor. Related aspects and methods are also disclosed.



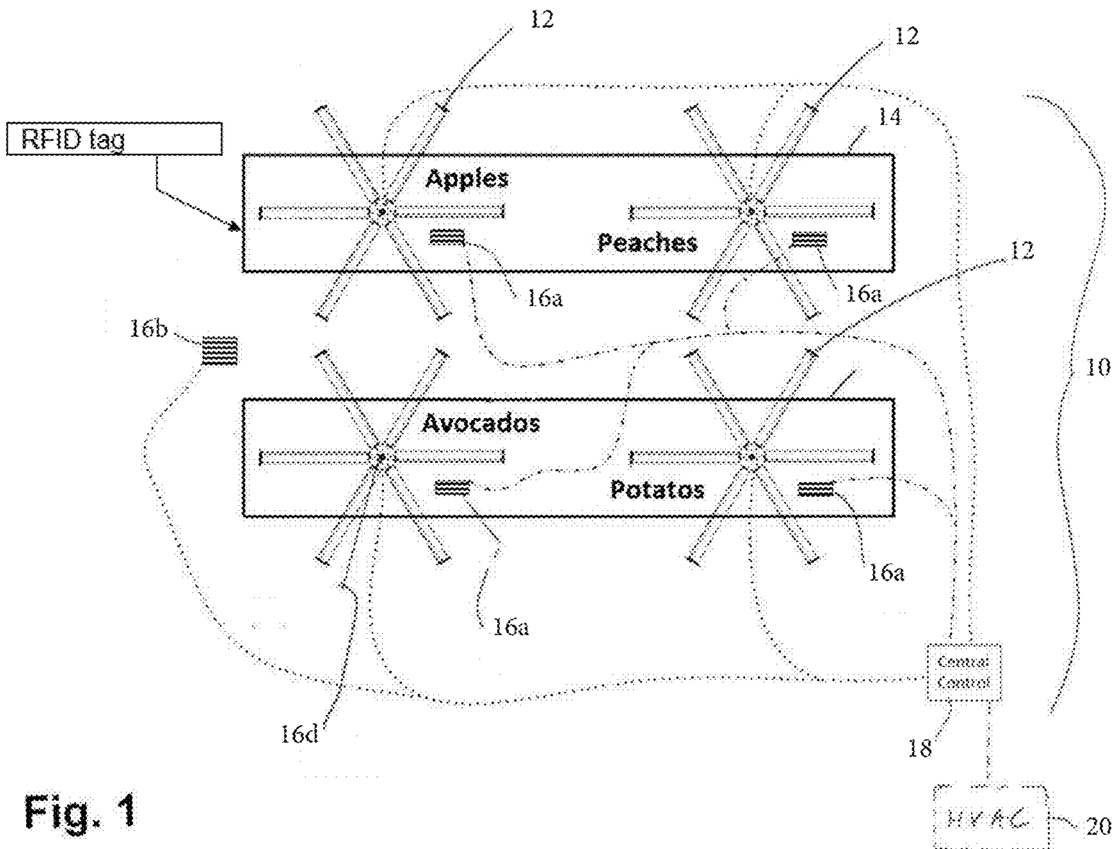

12
12
14
RFID tag
Apples
Peaches
16a
16a
12
16b
10
Avocados
Potatos
16a
16a
16d
Central Control
18
HVAC
20

Fig. 1

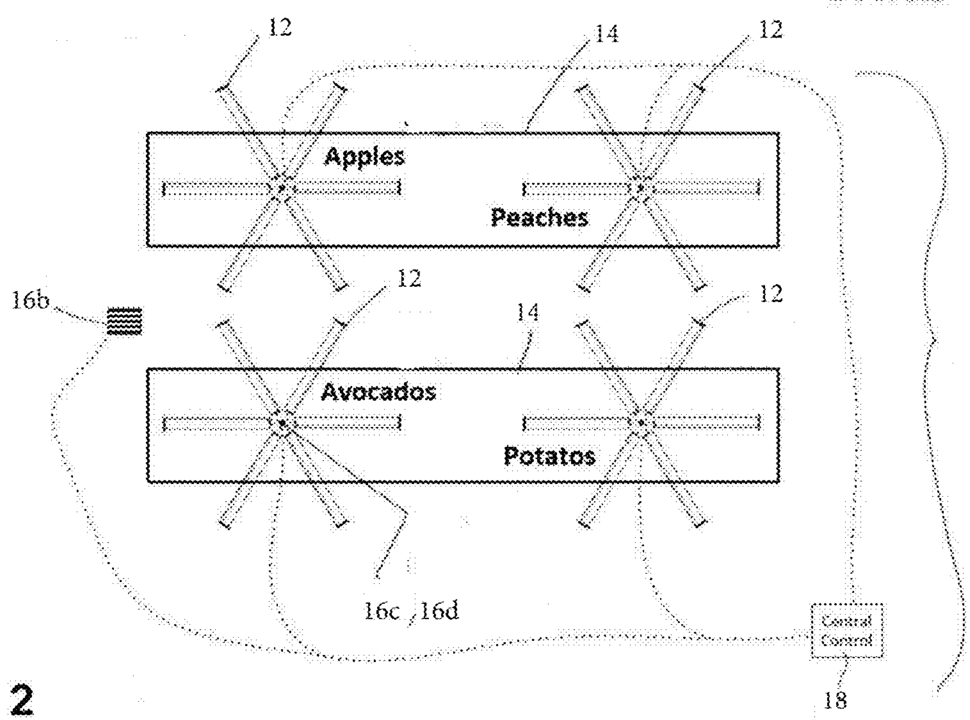

12
14
12
Apples
Peaches
16b
12
14
12
Avocados
Potatos
16c
16d
Central Control
18

Fig. 2

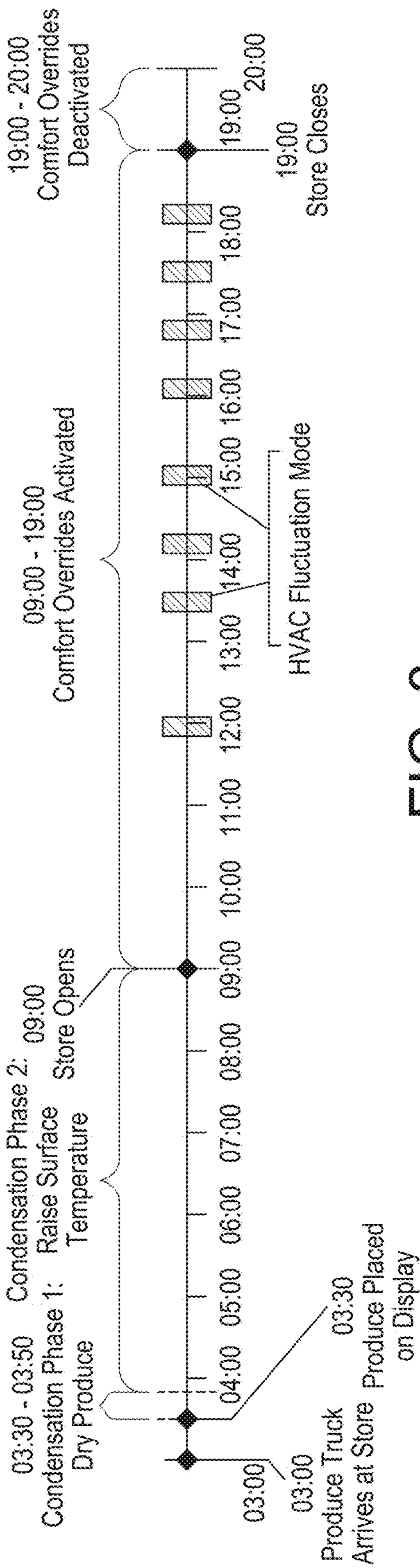

03:30 - 03:50
Condensation Phase 1:
Dry Produce
03:50 - 09:00
Condensation Phase 2:
Raise Surface
Temperature
09:00
Store Opens
09:00 - 19:00
Comfort Overrides Activated
19:00 - 20:00
Comfort Overrides
Deactivated
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
03:00
Produce Truck
Arrives at Store
03:30
Produce Placed
on Display
HVAC Fluctuation Mode
19:00
Store Closes

FIG. 3

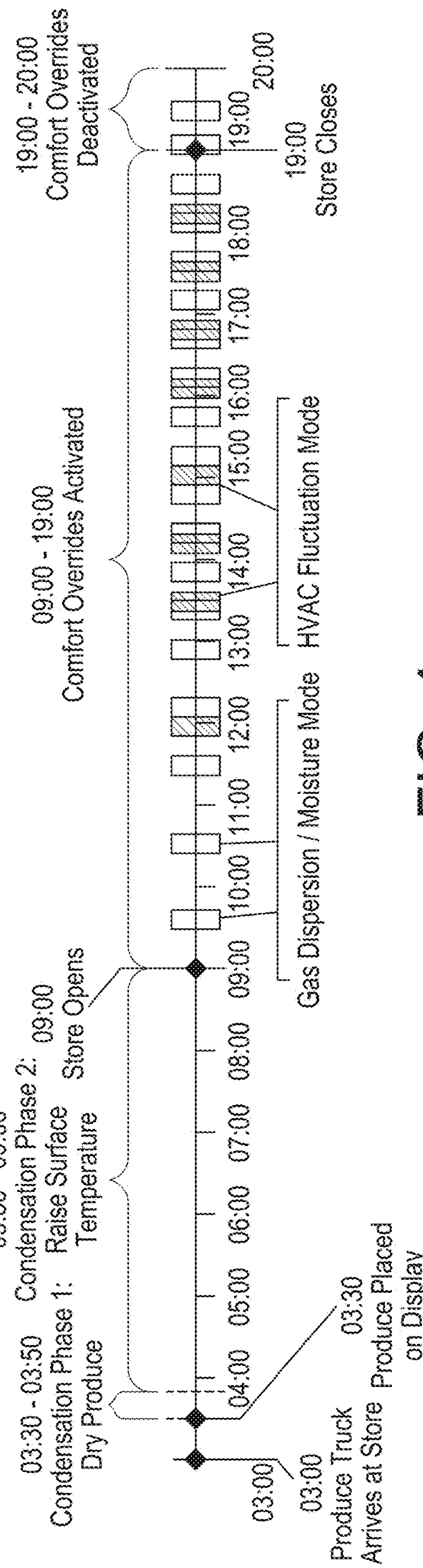

03:30 - 03:50
Condensation Phase 1:
Dry Produce
03:50 - 09:00
Condensation Phase 2:
Raise Surface
Temperature
09:00
Store Opens
09:00 - 19:00
Comfort Overrides Activated
19:00 - 20:00
Comfort Overrides
Deactivated
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
03:00
Produce Truck
Arrives at Store
03:30
Produce Placed
on Display
Gas Dispersion / Moisture Mode
HVAC Fluctuation Mode
19:00
Store Closes

FIG. 4

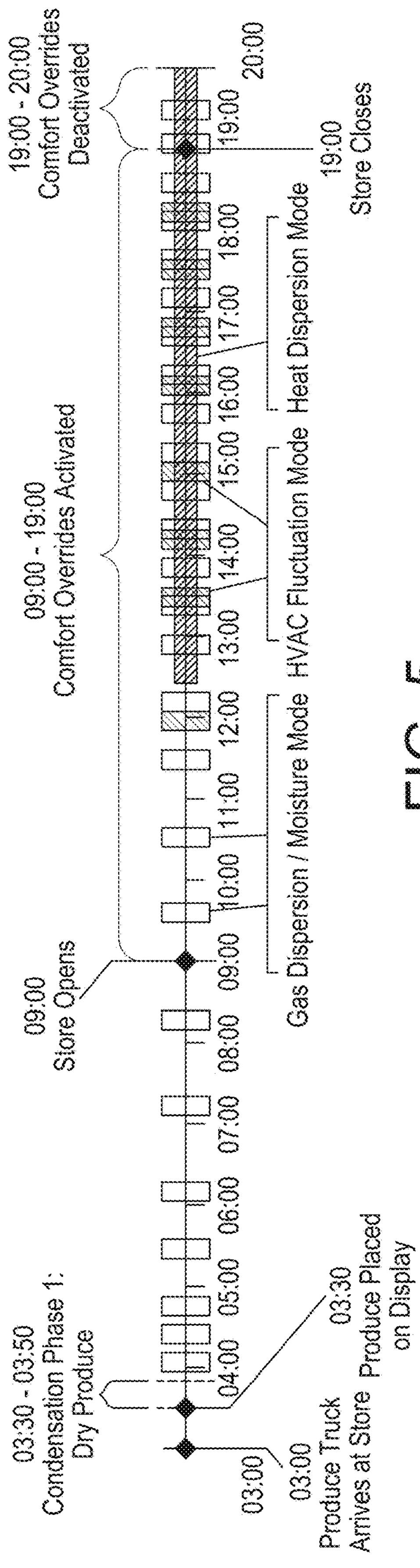

03:30 - 03:50
Condensation Phase 1:
Dry Produce
09:00
Store Opens
09:00 - 19:00
Comfort Overrides Activated
19:00 - 20:00
Comfort Overrides
Deactivated
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
03:00
Produce Truck
Arrives at Store
03:30
Produce Placed
on Display
Gas Dispersion / Moisture Mode
HVAC Fluctuation Mode
Heat Dispersion Mode
19:00
Store Closes

FIG. 5

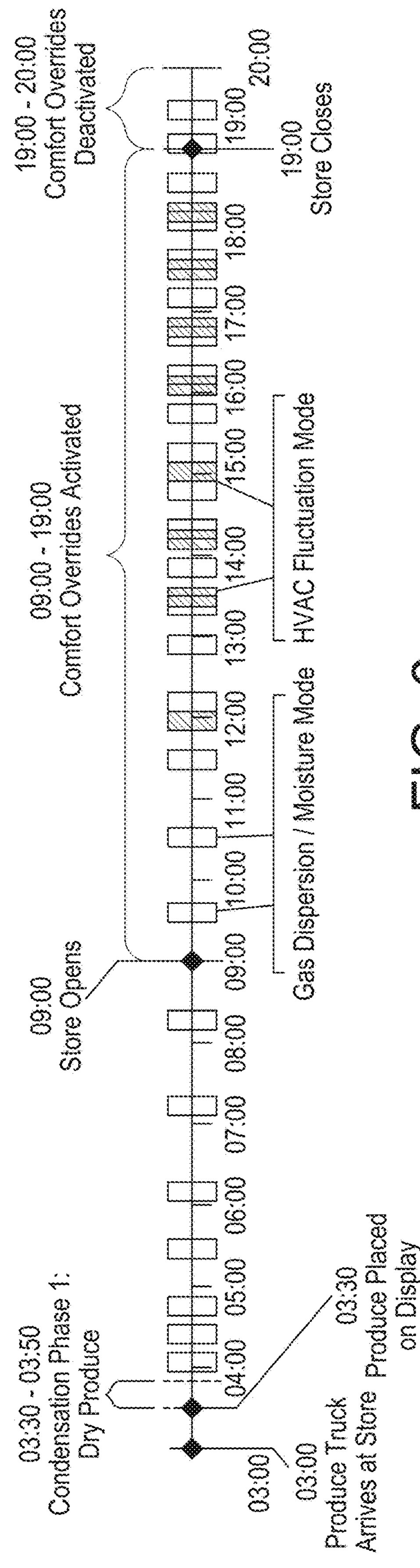

03:30 - 03:50
Condensation Phase 1:
Dry Produce
09:00
Store Opens
09:00 - 19:00
Comfort Overrides Activated
19:00 - 20:00
Comfort Overrides
Deactivated
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
03:00
Produce Truck
Arrives at Store
03:30
Produce Placed
on Display
Gas Dispersion / Moisture Mode
HVAC Fluctuation Mode
19:00
Store Closes

FIG. 6

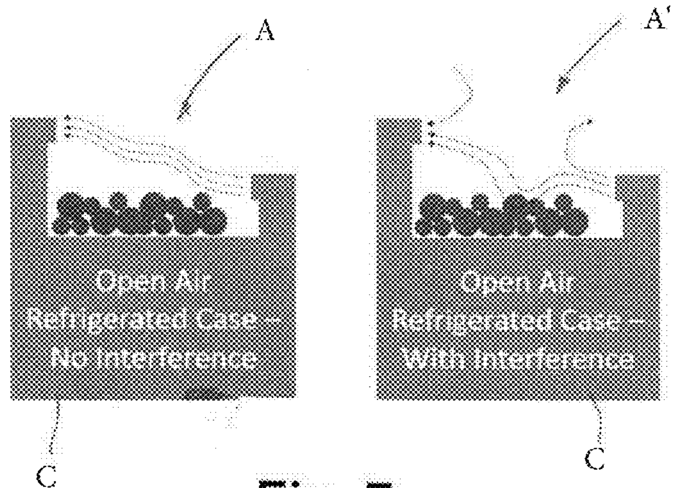

A
A'
Open Air
Refrigerated Case –
No Interference
Open Air
Refrigerated Case –
With Interference
C
C

Fig. 7

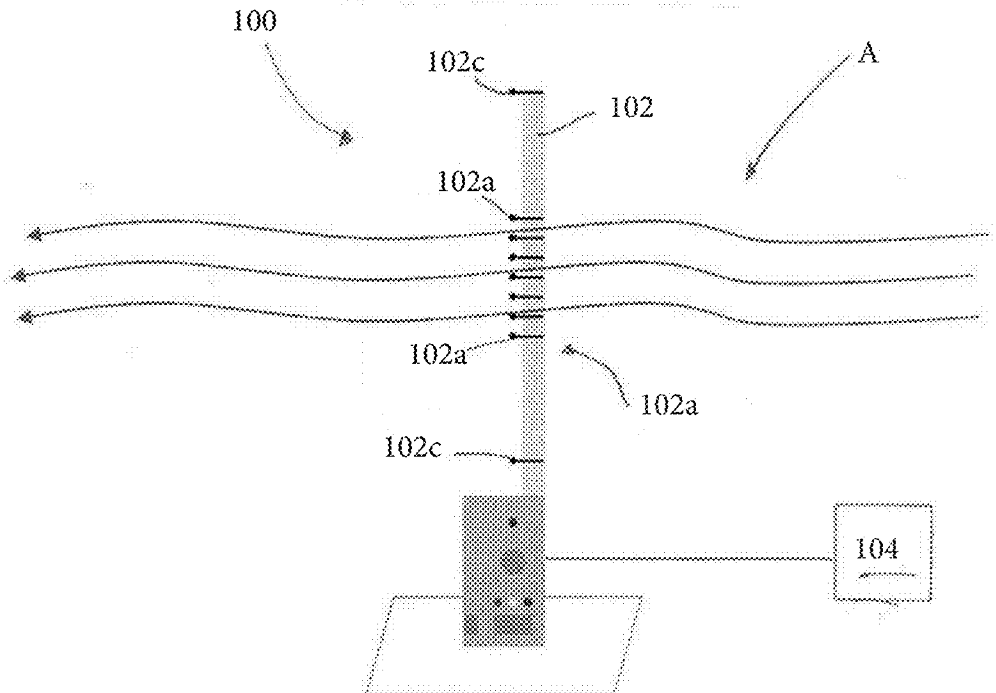

100
102c
102
A
102a
102a
102a
102c
104

Fig. 8

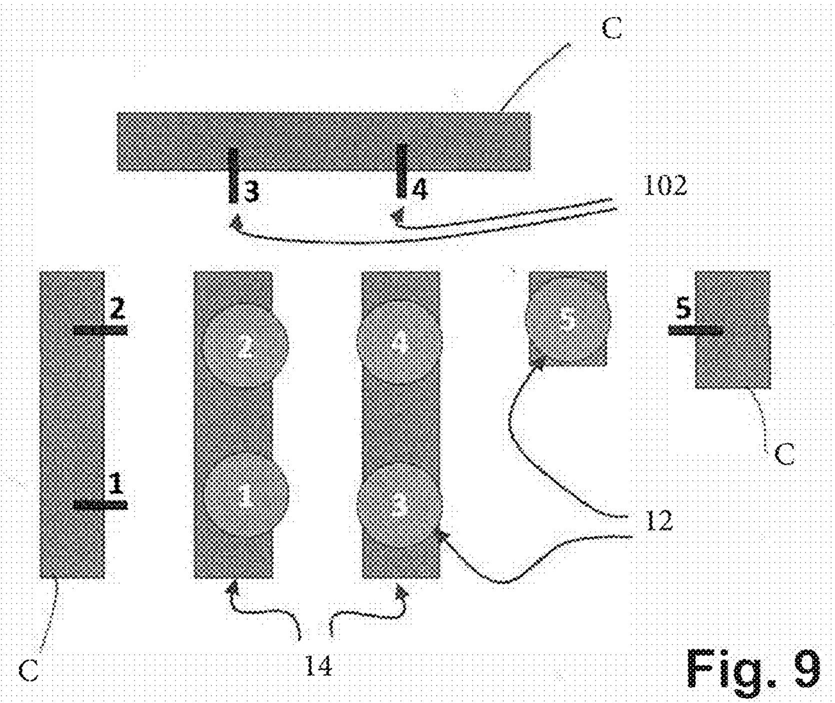

C
3
4
102
2
1
2
4
5
5
1
3
C
12
C
14

Fig. 9

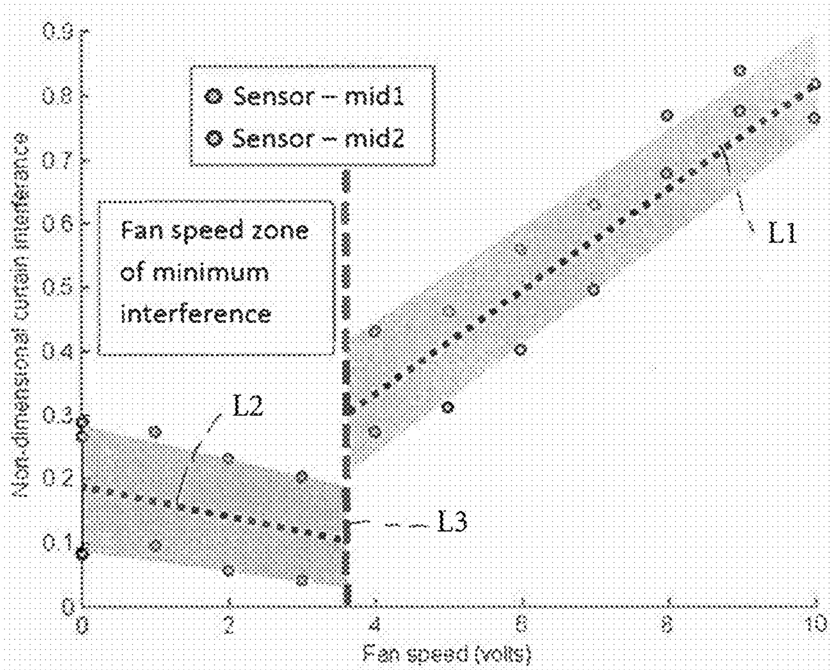

Sensor – mid1
Sensor – mid2
Fan speed zone
of minimum
interference
L1
L2
L3
Non-dimensional curtain interference
Fan speed (volts)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
2
4
6
8
10

Fig. 10

PRODUCT FAN SYSTEM AND RELATED METHODS

[0001] This is a divisional of Ser. No. 14/823,495 the disclosure of which is incorporated by reference. This patent application claims the benefit of U.S. Provisional Patent Application Ser. No. 62/035,667, the disclosure of which is incorporated herein by reference. The disclosure of U.S. patent application Ser. No. 14/685,897 is incorporated herein by reference.

TECHNICAL FIELD

[0002] This application relates generally to the air handling arts and, more particularly, to a system and method involving the regulated use of a fan to control airflow associated with product offered for sale, such as for example produce subject to spoilage.

BACKGROUND OF THE INVENTION

[0003] The respiration and microbial activity associated with certain types of products, such as fruit, increases dramatically with increasing temperature. Certain types of produce generate heat as they ripen, which in turn increases respiration and microbial activity. Increased microbial activity causes spoilage, while increased respiration causes the commodity to produce more ethylene which in turn causes the fruit to ripen quicker.

[0004] Moisture is also a consideration. Produce stored in an environment that has a relative humidity of less than 100% (vapor pressure deficit) will release moisture to the surrounding air. At low temperatures (refrigeration), high humidity is beneficial to produce life because it prevents moisture loss, which is a key component in quality degradation of produce. However, high humidity at higher temperatures is not necessarily beneficial to shelf life. High humidity combined with room temperatures creates ideal conditions for microbial growth and spoilage.

[0005] Surface moisture can also be created by condensation, such as when a cold object moves from a cold space with a low absolute humidity to a thermally comfortable space. Surface moisture on produce encourages microbial growth even more than high relative humidity, since it hydrates and activates dormant microbes and makes nutrients available in an aqueous solution for microbial growth.

[0006] Accordingly, a need is identified to address the foregoing issues and thereby prolong the useful life of the produce by retarding spoilage by regulating the operation of one or more fans for circulating air in a space including the produce. A related need is to avoid causing discomfort to consumers and/or disrupting air curtains associated with open air refrigeration cases in the space.

SUMMARY

[0007] In accordance with one aspect of the disclosure, a system for regulating airflow associated with product in a space is provided. The system comprises a display in the space for displaying the product for sale. At least one sensor is provided for sensing a parameter associated with the display and generating an output representative of the parameter. An overhead fan is located in the space adjacent to the display, and a controller is provided for controlling the fan based on the output of the sensor.

[0008] In one embodiment, the sensor is supported by the display or connected to the fan. The parameter sensed by the sensor may be selected from the group consisting of air temperature, surface temperature of the product, relative humidity, and CO_2 concentration. The system may further include a sensor node with the at least one sensor, which node is adapted for sensing air temperature, surface temperature, relative humidity, and CO_2 concentration. An occupancy sensor may be provided for determining the presence of a person adjacent to the display, and the controller may be adapted to override the control based on a sensor output when occupancy is detected. An HVAC system for conditioning air in the space may also be in communication with the controller.

[0009] The display may comprise a pallet including an electronic tag for identifying at least the location of the pallet relative to the fan. The sensor may be adapted for sensing a surface temperature of the product, and the controller may be adapted for predicting a temperature within a pile of product based on the sensed surface temperature and for using the predicted temperature to regulate the fan. The display may alternatively comprise a refrigerated open air case including an air curtain and the controller may be adapted to control the fan to avoid disrupting the air curtain. In one embodiment, the sensor comprises a temperature sensor for positioning at least partially within the air curtain, and the controller is adapted to regulate the fan based on the output of the temperature sensor. The system may further include a refrigerated open air case including an air curtain, and wherein the controller is adapted to control the fan to avoid disrupting the air curtain.

[0010] Another aspect of the disclosure relates to a method of assisting in regulating airflow in connection with a product. The method involves displaying the product for sale on a display in a space, and regulating an overhead fan in the space adjacent to the product based on at least one condition associated with the product display. The condition may comprise a condition of the product determined by sensing a parameter selected from the group consisting of air temperature, surface temperature, relative humidity, and CO_2 concentration.

[0011] The method may further include the step of regulating the fan based on the detection of a person adjacent to the display. The regulating step may be performed based on a condition selected from the group consisting of a type of product, a time of day, a concentration of CO_2, a relative humidity, or any combination of the foregoing. The regulating step may be performed by predicting a temperature within a pile of product based on a sensed surface temperature of the pile.

[0012] Additionally, the step of regulating the fan may comprise operating the fan at a first speed based on a detected difference in a temperature associated with the product at the at least one condition associated with the display and an ambient dewpoint temperature. The method may further include the step of regulating the fan at a second speed lower than the first speed when the temperature of the product exceeds the ambient dewpoint temperature. The second speed may comprise a minimum speed not to cause discomfort if occupancy is detected adjacent to the display.

[0013] The regulating step may comprise regulating the fan at a speed necessary to maintain a sensed surface temperature of the product within a predetermined amount above an ambient air dew point temperature. Alternatively,

the regulating step may comprise regulating an HVAC system. The method may further include the step of overriding the regulating step if one of a person or an air curtain is located adjacent to the display. In a further aspect of the method, the condition comprises a sensed temperature of an air curtain associated with a refrigerated open air case serving as the display, and the regulating step comprises regulating the fan to avoid disrupting the air curtain.

[0014] Still another aspect of the disclosure pertains to a system for regulating airflow associated with product on display for sale. The system comprises a plurality of displays in the space, each for displaying a different type of product for sale. At least one sensor is provided for sensing a parameter associated with each display and generating an output representative of the parameter. At least one overhead fan may be associated with each display for regulating an airflow adjacent thereto. A controller is also provided for controlling the fans based on the output of the sensors.

[0015] In one embodiment, the controller is adapted to regulate the at least one fan based on the type of product on the display associated with the at least one fan. The system may further include an interface for allowing a user to communicate to the controller an identification relating to the type of product on the display. The product is associated with an electronic identifier used by the controller to control the associated fan.

[0016] At least one of the displays may comprise a refrigerated open air case including an air curtain. The controller may be adapted for controlling the at least one overhead fan to avoid disrupting the air curtain. The at least one sensor may comprise a temperature probe for positioning within the air curtain.

[0017] Still another aspect of the invention relates to a system for regulating airflow in a space. The system comprises a fan for circulating air within the space. A first sensor for sensing CO_2 within the space and generating a first output is also provided, as is a controller for controlling the operation of the fan based on the first output of the first sensor. The space may include a display for supporting produce for sale. The system may further include a second sensor for detecting one of temperature or humidity and generating a second output signal used by the controller to regulate the fan.

[0018] Yet another aspect of the disclosure relates to a method of regulating airflow in a space. The method comprises regulating a fan based on a sensed amount of CO_2 within the space. The method may further include the step of providing produce in the space, and wherein the sensed CO_2 is representative of ethylene gas emanating from the produce.

[0019] Another aspect of the disclosure relates to a method of retarding the spoilage of produce. The method comprises regulating the operation of a fan based on the type of produce influenced by an airflow generated by the fan.

[0020] A system for providing airflow in a space is also disclosed. The system comprises a first display in the space for displaying a first type of produce, a first fan for providing airflow to the first type of produce, a second display in the space for displaying a second type of produce, a second fan for providing airflow to the second type of produce, and a controller for controlling the operation of the first fan and the second fan based on the first and second types of produce.

[0021] The disclosure also pertains to a system for regulating airflow. The system comprises a display in the space including an air curtain. A sensor for positioning within the air curtain is also provided, along with an overhead fan located in the space above the display for regulating the airflow. A controller is provided for controlling the fan based on the output of the sensor.

[0022] Also, this disclosure relates to a method for regulating airflow for a product display in association with an air curtain of a refrigerated open air case. The method comprises regulating an overhead fan to provide airflow for the product display while avoiding disrupting the air curtain of the refrigerated open air case. The method further includes the step of sensing a temperature of the air curtain using a sensor associated with the case, and regulating the fan based on the sensed temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1** is a top schematic view of one embodiment of the system;

[0024] FIG. **2** is a top schematic view of another embodiment of the system;

[0025] FIGS. **3-6** are timelines illustrating possible uses of the disclosed methods and systems;

[0026] FIG. **7** is a schematic illustration of an open air refrigerated case to which this disclosure may apply;

[0027] FIG. **8** is a schematic illustration of a sensor probe for use in connection with an air curtain;

[0028] FIG. **9** is a top schematic view of a system used to regulate the operation of fans in spaces with open air refrigerated cases; and

[0029] FIG. **10** is a graph illustrating one manner in which the optimal level of fan regulation may be determined.

DETAILED DESCRIPTION OF THE INVENTION

[0030] In accordance with one aspect of the invention, one or more fans may be used to regulate airflow delivered to one or more products, such as in connection with the regulation of an HVAC system and/or one or more sensors for sensing conditions associated with the product. In one exemplary embodiment, a system **10** is provided that uses one or more fans **12**, which may be provided adjacent to the product under consideration. In the example shown in the figures, the fan **12** comprises an overhead fan (i.e., a ceiling fan, even though it need not be mounted directly to the ceiling) mounted above a collection of product, which may be of any type or possibly a variety of types, including for instance produce in the form of fresh fruit or vegetables.

[0031] The fan(s) **12** need not be of any particular type, but there is a preference for high volume, low speed fans, as disclosed in U.S. Pat. No. 7,284,960, entitled "Fan Blades," issued Oct. 23, 2007; U.S. Pat. No. 6,244,821, entitled "Low Speed Cooling Fan," issued Jun. 12, 2001; U.S. Pat. No. 6,939,108, entitled "Cooling Fan with Reinforced Blade," issued Sep. 6, 2005; and U.S. Pat. No. D607,988, entitled "Ceiling Fan," issued Jan. 12, 2010, U.S. Pat. Pub. No. 2008/0008596, entitled "Fan Blades," published Jan. 10, 2008; U.S. Pat. Pub. No. 2009/0208333, entitled "Ceiling Fan System with Brushless Motor," published Aug. 20, 2009; and U.S. Pat. Pub. No. 2010/0278637, entitled "Ceiling Fan with Variable Blade Pitch and Variable Speed Control," published Nov. 4, 2010, the disclosures of which are all incorporated by reference herein.

[0032] As illustrated, the product may be provided on display for sale by way of a display **14**. The display **14** may comprise a stand, table, bin, pallet, or like structure for supporting the product, usually in a stacked or pile form. While exposed to the ambient environment and not fully contained, the product may in some situations be located in shipping boxes or cartons, which as a result of display **14** may be located above the floor of an associated space (which may for example be the produce section of a retail grocery or warehouse store, but could also be a storage area for holding the produce prior to display for sale). The display **14** may be an elongated structure, and may support different types of product in different zones, as will be understood upon reviewing the following description. The term display may also be considered to include separate structures used to support a type of product for sale, and need not comprise a single unitary structure.

[0033] The system **10** may operate such that one or more parameters relating to one or more conditions of the product are sensed and used to regulate the operation of the associated fan(s) **12**. For instance, one or more sensors may be provided adjacent to the product (such as by being embedded within the product arranged in a stack or pile form or otherwise connected to the display **14**) for sensing one or more of air temperature, surface temperature, relative humidity, and CO_2 concentration (which correlates to ethylene production by produce). The output from the sensor(s) may then be used to regulate the operation of the fan(s) **12**.

[0034] As an example, and as shown in FIG. **1**, one or more sensors may be provided as a sensor node **16*a*** supported by the display **14** for detecting conditions of the product, while sensors may also be provided as part of a more remote node **16*b*** for sensing ambient conditions. As can be appreciated from FIG. **1**, more than one sensor or sensor node **16*a*** may be associated with each display **14**, including for sensing conditions relative to more than one type of product associated with the display.

[0035] In some arrangements (such as in warehouse stores without fixed displays), direct sensing of temperature of the product, such as using an embedded sensor, may not be practicable or create the desired results. In such situation, a predictive model of temperature may be used in lieu of a sensor node **16*a*** at the display **14**. The temperature prediction within a pile of product may be based on a detection of surface temperature of the exposed items in the pile of product. As shown in FIG. **2**, the surface temperature may be obtained using a remote sensor, such as an IR sensor **16*c*** associated with the fan **12** or otherwise in communication with the control **18** to provide the information necessary to model the temperature within the pile and react accordingly.

[0036] Because this system **10** is typically located in a sensitive consumer environment, it may also be desirable to obtain occupancy information in order to prevent discomfort or any adverse impacts on sales psychology. Thus, an occupancy sensor **16*d*** (which may be connected to each fan **12**) may be used to determine when customers are in the fan's area of influence. Whenever customer motion is detected, the maximum allowable air velocity generated by the fan **12** may be controlled to help ensure comfort is achieved. As noted below, a scheduling input interface to the system **10** may be used to provide information to the system to differentiate between customer motion and employee motion outside of regular business hours.

[0037] Part of the system **10** may comprise a central control **18**, which may receive the input from the sensor(s) **16** (such as by wired or wireless communication) and control the fan(s) **12** accordingly. As shown in FIG. **1**, the central control **18** may also communicate with the HVAC system **20** for regulating the temperature of the associated space. In this manner, the regulation of fan(s) may be coordinated with the operation of the HVAC system **20** in order to achieve the maximum effect on the product from any corresponding regulation of the ambient temperature (which may be by way of a local thermostat, or may be done by central control **18**).

[0038] The central control **18** may include a user interface that allows for the conditions of the space to be viewed and changed depending on the particular arrangement used or desired. For example, the interface may provide an interactive map preconfigured to replicate the specific product arrangement for a given period of time, such as a typical business day. The user may then indicate the produce varieties to chosen locations under and around fans **12**, and the control **18** would respond accordingly by regulating the associated fan(s) **12** based on the type of produce (see, e.g., Examples 1-4 set out below). The control **18** may also make suggestions for layout changes based on similar airflow preferences for the varieties of produce selected. After accepting a final produce layout, the interface may generate a communication to the person who directs the placement of the product on the displays in the space, such as the produce manager. Optionally, the system **10** may include the automated locating of product using electronic (RFID) tags (which may be provided on the pallets associated with the produce) and floor mounted electronic (e.g., RFID) detectors, which may be used by the control **18** to determine the location of the product adjacent to the associated fan and regulate it accordingly.

[0039] The system **10** may be programmed to operate in various modes depending on the sensed parameters. For example, in a "Condensation" mode, the system **10** may operate to use the fan(s) **12** to dry off accumulated condensation that occurred in transit between refrigeration (truck or cooler) and a display location. The trigger for this mode may be the system **10** detecting a difference in the display area surface temperature (such as may be read by a sensor **16**, including an IR sensor associated with the fan **12**) to reading less than a predetermined amount (such as 5° C. above ambient dew point temperature). Upon being triggered, the system **10** may regulate the fan(s) **12** to create the maximum possible air flow for a predetermined time (e.g., 20 minutes).

[0040] A related aspect is to operate the system **10** in a second phase of the condensation mode following the first phase described above that seeks to increase surface temperature of product deep within display pile to prevent condensation from forming. This may be done by sensing the inner temperature of the product, such as by using a sensor **16** associated with the display **14** or within a pile of product. When the sensed temperature of the product reaches a predetermined amount (e.g., 1.5° C.) over the ambient dew point temperature, then the speed of the fan **12** may be regulated depending on the occupancy conditions. For example, if it is before the store opening time, the system **10** may operate the fan(s) at a minimum level in order to allow the temperature to increase as desired. If during a time when occupancy is expected, the fan(s) **12** may be set to the minimum speed when no occupancy is detected and set fan to maximum not to cause discomfort whenever occupancy is detected.

[0041] Another mode of operation relates to the thermal characteristics of the produce. In a "Heat Dispersion" mode, the purpose is to convectively remove heat generated by respiration and thus decrease over-ripening and microbial growth, which is especially desirable for any produce prone to generating heat and when the air temperature is below produce surface temperature. The trigger for this mode may be a produce surface temperature, which may be directly sensed or predicted, and the system **10** may then regulate the fan(s) to operate at a constant velocity necessary to maintain the sensed temperature within a predetermined range (e.g. 1° C.) over ambient air temperature.

[0042] A further "HVAC Fluctuation" mode of operation will involve using information learned from monitoring HVAC usage. For instance, by using temperature drops caused by the HVAC system **20**, the system **10** may be operated to use this to cool produce and decrease respiration and microbial activity. This may be done by sensing an ambient temperature in the space where the fan **12** is located, such as in the upper part of the room, and determining if it is less than the produce temperature (whether directly or indirectly determined). If it is determined that the ambient temperature is less than the produce temperature, the fan **12** may be operated at a maximum speed. Likewise, in a related mode, if the system **10** detects a temperature of the produce that is likely to cause spoilage, it may also cause the HVAC system and fan(s) to activate to reduce the temperature.

[0043] The system **10** may also operate in a "Gas Dispersion" mode that seeks to prevent over-ripening and associated quality degradation by dispersing ethylene build-up. If a produce type is sensitive to ethylene buildup, produce surface temperature is above a predetermined amount (e.g., 5° C.), and CO_2 concentration as sensed by an associated sensor **16** has trended to a peak plateau, then the fan(s) **12** may be operated for a particular time to disperse the ethylene. The operation may be halted after a predetermined time or the detected CO_2 concentration is reduced to a particular level.

[0044] In a "Moisture" mode of operation, the goal of the system **10** is to maintain a relative humidity level that is detrimental to microbial growth without causing an increased amount (e.g., more than a 2%) of loss in produce moisture. The trigger for this mode may be a sensed relative humidity in the produce that is greater than a target (which may vary depending on the type of produce) plus a predetermined amount (e.g., 10%), or may be done without direct measurements according to a produce-specific predetermined schedule. The system **10** would operate to cycle the fan(s) **12** to a gas dispersion velocity at a duty cycle necessary to limit moisture loss in specific produce variety to 2% in one business day.

[0045] The following examples are provided as non-limiting discussions of how the above-identified technology might be applied in connection with particular types of produce.

Example 1

[0046] This example pertains to potatoes, and is best understood with reference to FIG. **3**. Root crops such as potatoes (and onions) have a very large thermal mass and thus resist changes in temperature. For this reason, condensation abatement needs to be especially aggressive, as can be seen in the diagram provided. However, after condensation is avoided, shelf life is reasonably stable and there is no sensitivity or production of ethylene. This is why the example system behavior only includes HVAC Fluctuation Mode after condensation.

Example 2

[0047] This example pertains to peaches, and is best understood with reference to FIG. **4**. Soft skin varieties such as peaches and berries will be strongly affected by condensation due to the permeability of the skin and the availability of nutrients to microbes once hydrated. More care must also be taken with soft skin varieties to avoid over-drying.

Example 3

[0048] With reference to FIG. **5**, this example pertains to avocados, which have very thick and fairly moisture tolerant skin. For this reason, condensation is not a major concern. Also, low temperature prevents ethylene off-gassing and slows ripening; thus, it is beneficial to maintain the initial cold temperature of the produce as long as possible. Accordingly, as can be seen in FIG. **5**, initial condensation is dried off at the very beginning and then periodic Moisture Mode is used to prevent liquid buildup without excessively heating the avocados with ambient air. Once the avocado does warm to the point where respiration begins and heat begins to build up, Heat Dispersion Mode is activated.

Example 4

[0049] This example relates to apples, which have a similar (but not as extreme) moisture resistance compared to avocados. However, apples do not generate significant amounts of heat and thus a Heat Dispersion Mode is not needed. Otherwise, the treatment is similar, as shown in FIG. **6**.

[0050] Certain overrides may also be applied to any of the foregoing modes when conditions have been met within the specified time range. For instance, a customer comfort override may be provided during business hours when occupancy is detected. This override would cause system **10** to limit the maximum air velocity at occupant level created by fan(s) to that allowable by ASHRAE standard 55 such that no more than a particular percentage of occupants are dissatisfied and for a given time.

[0051] A further override may be provided if air curtains, such as associated with a refrigerated display for displaying product, are present within the area of influence of produce system fans **12**. In this override, fan speed may be restricted such that the temperature does not diverge more than a certain amount (e.g., 1° C.) from normal operating temperature (when no fans are present) during the current fan mode. The temperature may be sensed by a sensor associated with the display.

[0052] In this regard, and with reference to FIGS. **7-10**, the disclosure also pertains to a manner in which to minimize interference on refrigerated open air displays as a result of a fan for regulating the flow of air in an associated space. The situation of concern is illustrated in FIG. **7**, in which an airflow, such as an air curtain A, is used to create or contain refrigeration for produce or products P in an open air display, such as a case C. The use of fans, such as overhead fans, in an associated space, may cause a disruption in the airflow, such as disrupted air curtain A' indicated on the right hand side of FIG. **7**.

[0053] In order to account for this disruption and possibly avoid it, a commissioning system **100** is provided which includes a sensor in the form of a probe **102** for determining the influence of external airflow, such as that generated by a fan, on an air curtain. The probe **102** includes a plurality of spaced sensors **102***a* for sensing temperature, which may be strategically placed in the flow of air forming the air curtain A (vertical in the illustrated example). In this exemplary configuration, the probe **102** includes a first group of sensors **102***b* designed to be positioned within the normal air flow boundary forming the air curtain A, and a second group of sensors **102***c* outside of the normal boundary and spaced from the first group (such as, for instance, at a six inch interval). Variations in temperature as a result of fan operation may then be sensed and reported to a controller **104**, such as a portable computer, and used to then determine the optimal setting to minimize disruption as a result of fan operation.

[0054] One possible use of this system **100** is now described with reference to FIG. **9**, which illustrates a typical arrangement of displays **14** including cases C (also considered displays) and adjacent fans **12** (which as noted above may be arranged over displays for displaying produce). Each case C may be associated with one or more probes **102**. Each fan **12** is then incrementally adjusted simultaneously from a fan specific baseline speed to a maximum speed (which may be done by controller **104** or manually). Settling time will be provided after every speed adjustment before logging of temperature sensor data using controller **104**.

[0055] Using the collected data, an inflection point may be determined for each probe/fan/refrigerated case. The fan speed(s) may then be selected to minimize impact on all refrigerated cases under the influence of the fan or fans according to those results. Minimum and maximum fan speeds will be determined based on refrigerated case model specific criteria and the determined fan speed inflection point for that refrigerated case. Keeping fan speeds within these thresholds ensures that sufficient airflow can be provided to the produce while minimizing energy/operational interference on the refrigerated cases.

[0056] As an example of the data processing methods that may be used, the applicable sensors **102***a*-**102***c* for each probe **102** may be selected and the following methodology applied:

[0057] i. Probe(n).Sensor(1) is the most interior sensor to the cooler (where n is the probe number)

[0058] ii. Probe(n).Sensor(4) is the most exterior sensor to the cooler

[0059] iii. Extract the fan off data for analysis

[0060] iv. Probe(n).Sensor(2) is the sensor with an average temperature closest to 2° F. warmer than the average temperature of Probe(n).Sensor(1)

[0061] v. Probe(n).Sensor(3) is the sensor with an average temperature closest to 4° F. warmer than the average temperature of Probe(n).Sensor(1)

[0062] vi. Discard data from all other sensors on Probe (n)

[0063] vii. Repeat for each probe 1 through n

[0064] b. Convert continuous data set from each probe into discrete data

[0065] i. Average Probe(n).Sensor data for all timestamps corresponding to each fan speed. Example data:

Fan Speed	1	2	3	4	5	6	7	8	9
Proc-Sensor(1)	28.2	29.3	28.5	29.9	28.8	30	29.8	30.2	30.1
Proc-Sensor(2)	30.5	30.4	29.1	31.5	33.3	35.5	37.6	39.7	41.8
Proc-Sensor(3)	32.9	32.8	30.2	33.5	35.2	38.0	40.5	43.0	45.5
Proc-Sensor(4)	58.5	59.6	60.1	58.9	58.2	58.1	57.2	57.9	58.2

[0066] ii. Nondimensionalize the above data by applying the below equations on all fan speeds 1 through 9 (F):

$$\text{Probe}(n).ND(1) = \frac{\text{Probe}(n),\ ProcSensor(2) - \text{Probe}(n),\ ProcSensor(1)}{\text{Probe}(n),\ ProcSensor(4) - \text{Probe}(n),\ ProcSensor(1)}$$

$$\text{Probe}(n).ND(2) = \frac{\text{Probe}(n),\ ProcSensor(3) - \text{Probe}(n),\ ProcSensor(1)}{\text{Probe}(n),\ ProcSensor(4) - \text{Probe}(n),\ ProcSensor(1)}$$

Fan Speed	1	2	3	4	5	6	7	8	9
ND(1)	8%	4%	2%	6%	15%	20%	28%	34%	42%
ND(2)	16%	12%	5%	12%	22%	28%	39%	46%	55%

[0067] 1. Repeat for each probe 1 to n

[0068] c. Identify inflection point in Probe(n).ND data

[0069] i. Given F speed settings in Probe(n).ND data

[0070] ii. Split Probe(n).ND data into F-3 sequential pairs (1 to nPair, pair(k)), where each piece of the pair must have at least two data points. Probe(n).pair(k).S (1) to Probe(n).pair(k).S(2) and Probe(n).pair(k).S(3) to Probe(n).pair(k).S(4) for each pair k

[0071] 1. Example: For F=9 speeds, (pair=1) 1-2&3-9, (pair=2) 1-3&4-9 . . . (pair=6) 1-7&8-9. To tie this back to the above nomenclature, pair 1 for probe 2 would be:

[0072] Probe(2).pair(1).S(1)=1

[0073] Probe(2).pair(1).S(2)=2

[0074] Probe(2).pair(1).S(3)=3

[0075] Probe(2).pair(1).S(4)=9

[0076] iii. Find the equation of the best fit line for each half of all pairs

[0077] 1. pair(k).m(1) and pair(k).m(2) are the slopes for the first and second half of pair k respectively

[0078] 2. pair(k).b(1) and pair(k).b(2) are the intercepts for the first and second half of pair k respectively

[0079] iv. Sum the simple error of both halves of each pair k within probe(n) data

$$\text{probe}(n).\text{pair}(k).\text{error} =$$

$$\sum_{i=1}^{2}\left(\sum_{j=1}^{probe(n).pair(k).S(2)} |\text{probe}(n).ND(i)[j] - [\text{probe}(n).\text{pair}(k).m(j) *\right.$$

-continued

$$\text{probe}(n).\text{speed}(j) + \text{probe}(n).\text{pair}(k).b(j)]| + \sum_{m=probe(n)pair(k)S(3)} |\text{probe}(n).ND(i)[m] - \lceil \text{probe}(n).\text{pair}(k).m(m) * \text{probe}(n).\text{speed}(m) + \text{probe}(n).\text{pair}(k).b(m)]| \Big)$$

[0080] v. The pair k that results in the minimum simple error sum is the location of the inflection point for probe(n)

[0081] vi. Repeat for all probes, 1 to n

[0082] d. Identify inflection Speed {probe(n).Speedlnf}

[0083] i. Check for negligible/catastrophic influence: For a given probe(n), if the difference in intercepts (b) of the resulting inflection point pair are within 0.10 and the difference in the slopes (m) are within 10% per speed increment, then probe(n) is either experiencing negligible or catastrophic influence

[0084] 1. If the slope of the half pair with most data points is

[0085] a. less than 3% per speed increment, then fan influence is negligible and intersection speed {Speedlnt} should be the highest speed tested

[0086] b. else, the influence of the fan is catastrophic and intersection speed {SpeedInt} should be chosen to keep nondimentionalized influence to below 30%

[0087] ii. Else, find the inflection point of fan speed influence:

$$\text{probe}(n).SpeedInf = \frac{\text{probe}(n).\text{pair}(k).S(2) + \text{probe}(n).\text{pair}(k).S(3)}{2}$$

An exemplary output for a single probe **102** is shown in FIG. **10**. The combination of lines L**1** and L**2** provide the minimum fit error compared to the points. Line L**3** represents the fan speed that causes the minimum interference for the associated location.

[0088] Having shown and described various embodiments, further adaptations of the apparatuses, methods and systems described herein may be accomplished by appropriate modifications by one of ordinary skill in the art without departing from the scope of the disclosure. Several of such potential modifications have been mentioned, and others will be apparent to those skilled in the art. For instance, the examples, embodiments, geometries, materials, dimensions, ratios, steps, and the like discussed above are illustrative and are not required. Accordingly, the scope of the disclosure should be considered in terms of claims that may be presented, and is understood not to be limited to the details of structure and operation shown and described in the specification and drawings.

1. A method of assisting in regulating airflow in connection with a product displayed on a display for sale in a space, comprising:

regulating a fan in the space adjacent to the product based on at least one condition associated with the product display.

2. The method of claim **1**, wherein the regulating step is performed based on a condition selected from the group consisting of a type of product, a time of day, a concentration of CO_2, a relative humidity, or any combination of the foregoing.

3. The method of claim **1**, wherein the regulating step comprises regulating the ceiling fan based on a sensed amount of CO_2 within the space.

4. The method of claim **1**, wherein the regulating step comprises regulating the operation of the fan based on the type of produce influenced by an airflow generated by the fan.

5. The method of claim **1**, further including the step of regulating the fan based on the detection of a person adjacent to the display.

6. The method of claim **1**, wherein the regulating step is performed by predicting a temperature within a pile of product based on a sensed surface temperature of the pile.

7. The method of claim **1**, wherein the step of regulating the fan comprises operating the fan at a first speed based on a detected difference in a temperature associated with the product at the at least one condition associated with the display and an ambient dewpoint temperature.

8. The method of claim **7**, further including the step of regulating the fan at a second speed lower than the first speed when the temperature of the product exceeds the ambient dewpoint temperature.

9. The method of claim **8**, wherein the second speed comprises a minimum speed not to cause discomfort if occupancy is detected adjacent to the display.

10. The method of claim **1**, wherein the regulating step comprises regulating the fan at a speed necessary to maintain a sensed surface temperature of the product within a predetermined amount above an ambient air dew point temperature.

11. The method of claim **1**, further including the step of regulating an HVAC system.

12. The method of claim **1**, further including the step of overriding the regulating step if one of a person or an air curtain is located adjacent to the display.

13. The method of claim **1**, wherein the at least one condition comprises a sensed temperature of an air curtain associated with a refrigerated open air case serving as the display, and the regulating step comprises regulating the fan to avoid disrupting the air curtain.

14. A system for regulating airflow in a space, comprising:

a fan for circulating air within the space;

a first sensor for sensing CO_2 within the space and generating a first output; and

a controller for controlling the operation of the fan based on the first output of the first sensor.

15. The system of claim **14**, wherein the space includes a display for supporting produce for sale.

16. The system of claim **14**, further including a second sensor for detecting one of temperature or humidity and generating a second output signal used by the controller to regulate the fan.

17. The system of claim **14**, comprising:

a first display in the space for displaying a first type of produce;

the fan being a first ceiling fan for providing airflow to the first type of produce, and further including:

a second display in the space for displaying a second type of produce;

a second ceiling fan for providing airflow to the second type of produce; and wherein the controller for controlling the operation of the first ceiling fan and the second ceiling fan based on the first and second types of produce.

18. A system for regulating airflow, comprising:

a display in the space including an air curtain;

a sensor for positioning within the air curtain; and

a fan located in the space above the display for regulating the airflow; and

a controller for controlling the fan based on the output of the sensor.

* * * * *