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Display assembly using air characteristic data to verify display assembly operating conditions, systems and methods for the same

Abstract

Display assemblies utilizing air characteristic data to verify internal operating conditions and related systems and methods are disclosed. The display assembly includes a side assembly, including an electronic display, is connected to a structural framework. Sensor(s) are provided, at least one of which is located at, or fluidly connected to, a closed airflow pathway. A controller receives data from the sensor(s) and determines whether an initial indication of an operating condition exists. If so, a testing routine is initiated, additional data is received from the sensor(s) during and/or thereafter. The controller confirms whether the operating condition exists based on the additional data.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application claims the benefit of U.S. provisional patent application Ser. No. 63/574,559 filed Apr. 4, 2024, the disclosures of which are hereby incorporated by reference as if fully restated herein.

TECHNICAL FIELD
(1) Exemplary embodiments relate generally to display assemblies which use air characteristic data to verify operating conditions as well as systems and methods for the same.
BACKGROUND AND SUMMARY OF THE INVENTION
(2) Electronic displays are used in a wide variety of applications, such as digital out of home (DOOH) advertising, by way of example. DOOH advertising is an increasingly popular way to reach potential customers, or the public more generally. Generally, such DOOH advertising units include electronic displays placed within at least partially ruggedized enclosures to protect the sensitive electronics from the elements, vandals, general wear and tear, and the like.
(3) Display assemblies are known which utilize various sensors to monitor operating conditions of the assembly. Where sensor values indicate a problem with the unit, a team may be dispatched to service the unit. Sometimes, false positive or false negative alerts are encountered. This may be, at least in part, due to the large variety of operating conditions for such units, especially DOOH advertising units which operate in a wide variety of environments (e.g., climates, seasonal conditions, weather, diurnal fluctuations, urban environments, and the like). Sensor failure, sensor error, or other factors may also cause such false alerts. What is needed is a display assembly which can better verify the existence and/or nature of operating conditions of the display assembly.
(4) Display assemblies are provided which utilize certain air characteristic data to verify indicated operating conditions of the assembly. Such air characteristic data may be derived from one or more sensors and may include, by way of example and without limitation, pressure, humidity, and/or temperature. In an exemplary embodiment, a door open indication is received, such as from a door and/or latch sensor. Pressure and/or humidity check routines are initiated, such as leak down testing and/or dew point spread (DPS) calculations. Where pressure and/or humidity test data indicates significant changes, such as significantly lower leak down times and/or significantly decreased DPS calculations, the door open indication may be verified. In another exemplary embodiment, a condition alert is indicated, such as a likely leak, condensation likely present, or the like. Pressure and/or humidity check routines are initiated, such as leak down testing and/or DPS calculations. Where pressure and/or humidity test data indicates significant changes, such as significantly lower leak down times and/or significantly decreased DPS calculations, the condition alert may be verified. In yet another exemplary embodiment, a condition alert is indicated, such as a door open, likely leak, condensation likely present, or the like. Testing routines are initiated, which may include commanding operations which cause a sudden, temporary increase in internal temperature (e.g., activating/increasing backlight levels, slowing/stopping fans, combinations thereof, or the like). Pressure response may be analyzed. Where the pressure changes outside of expected parameters, the condition alert may be confirmed. Essentially, where the pressure response is relatively minimal, this may indicate a not well sealed condition which may be used to verify the initially indicated condition, such as a door open, likely leak, condensation likely present, or the like.
(5) A wide variety of operating conditions may be verified by using some or all of the aforementioned techniques. Upon verification, an electronic notification may be generated, which may be an initial notification or a confirmatory notification, by way of non-limiting example.
(6) Further features and advantages of the systems and methods disclosed herein, as well as the

structure and operation of various aspects of the present disclosure, are described in detail below with reference to the accompanying figures.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) In addition to the features mentioned above, other aspects of the present invention will be readily apparent from the following descriptions of the drawings and exemplary embodiments, wherein like reference numerals across the several views refer to identical, similar, or equivalent features, and wherein:

(2) FIG. **1** is a perspective view of an exemplary display assembly;

(3) FIG. **2** is another perspective view of the display assembly of FIG. **1** with a side assembly in an opened position;

(4) FIG. **3** is the display assembly of FIG. **2** with the side assembly in a closed position;

(5) FIG. **4** is a detailed, top, sectional view of the side assembly of FIGS. **1-3**, taken along section line A-A of FIG. **3**;

(6) FIG. **5** is a flow chart with logic for operating the display assembly of FIGS. **1-3**;

(7) FIG. **6** is a flow chart with other exemplary logic for operating the display assembly of FIGS. **1-3**; and

(8) FIG. **7** is a flow chart with other exemplary logic for operating the display assembly of FIGS. **1-3**.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENT(S)

(9) Various embodiments of the present invention will now be described in detail with reference to the accompanying drawings. In the following description, specific details such as detailed configuration and components are merely provided to assist the overall understanding of these embodiments of the present invention. Therefore, it should be apparent to those skilled in the art that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the present invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

(10) Embodiments of the invention are described herein with reference to illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

(11) FIG. **1** through FIG. **3** illustrate an exemplary display assembly **10**. The display assembly **10** may comprise a structural framework **12**, such as for mounting to a ground surface (e.g., sidewalk, parking lot, etc.), wall, item of street furniture (e.g., bus shelter, lamp post, railing, etc.), combinations thereof, or the like. The structural framework **12** may comprise one or more members, cladding, paneling, grills, combinations thereof, or the like.

(12) One or more side assemblies **14** may be connected (directly or indirectly) to a side of the structural framework **12**. For example, without limitation, a first and second side assembly **14** may be positioned on opposing sides of the structural framework **12**. However, other number and/or arrangement may be utilized (e.g., one sided, triangular, multiple displays on a given side, displays on four sides, etc.).

(13) The side assemblies **14** may each be configured for movement between a closed position (e.g., FIG. **3**) where the side assembly **14** is proximate to the structural framework **12** and an opened position (e.g., FIG. **2**) where the side assembly **14** is moved away from the structural framework **12**. However, this feature is optional. For example, without limitation, a bottom edge of the side

assembly **14** may be capable of swinging outward, such as by way of hinges located along an upper edge thereof where the side assembly **14** connects to the structural framework **12**. As another example, without limitation, a first side edge (e.g., left side) of the side assembly **14** may be capable of swinging outward, such as by way of hinges located a second side edge (e.g., right side) thereof where the side assembly **14** connects to the structural framework **12**. Gas struts, hinges, springs, counterweights, cables, combinations thereof, or the like.

(14) FIG. **4** illustrates an exemplary side assembly **14** in more detail. The side assemblies **14** may each comprise one or more electronic displays **15** (hereinafter also a "digital side assembly"), preferably set behind a cover **17**. The cover **17** may form part of the side assembly **14** or the structural framework **12**. The electronic displays **15** may be of various type, such as a liquid crystal display (LCD), organic light emitting diodes (OLED) display, light emitting diodes (LED, direct LED) display, combinations thereof, or the like. The cover **17** may comprise one or more layers. The electronic displays **15** and/or covers **17** may comprise various optical layers, such as polarizers, antireflective films, optically clear adhesives, combinations thereof, or the like. The electronic displays **15** may include a display layer **11** and a backlight **13**, in exemplary embodiments, without limitation. In other exemplary embodiments, a separate backlight **13** is not required (e.g., OLED). An air gap **19** may be provided between the cover **17** and the electronic display **15**, though such is not necessarily required. The air gap **19** may provide an airflow pathway into and out of the side assembly **14**, and/or within the side assembly **14**. The electronic display **15** may optionally be touch sensitive and may include related components at the electronic display **15** and/or cover **17**.

(15) An airflow channel **21** may optionally be provided rearward of, or form a rear portion of, the electronic display **15**. For example, without limitation, the airflow channel may extend along all or substantially (e.g., 80% or more) of the backlight **13**, where utilized. The airflow channel **21** may be part of the side assembly **14**.

(16) The side assemblies **14** need not necessarily include an electronic display **15**. The side assemblies **14** may comprise a static poster cavity (hereinafter also a "poster side assembly"), an access panel (hereinafter also a "door side assembly"), and/or panel (hereinafter also a "panel side assembly"), by way of non-limiting example. For example, a digital side assembly **14** may be positioned at a first side of the structural framework **12** and a door side assembly at a second side of the structural framework **12**. These examples are by way of illustration and are not intended to be limiting.

(17) The display assembly **10** may include one or more heat exchangers **23**, such as multi-layer, ducted passageways providing cross-flow, counterflow, and/or parallel flow. The heat exchanger(s) **23** may, in exemplary embodiments, be provided rearward of the side assembly **14**, and may be attached to the structural framework **12**.

(18) The display assembly **10** may comprise one or more airflow pathways. The airflow pathways may form open pathways for ambient air ingested/exhausted to the ambient environment and/or closed pathways within the display assembly **10** for circulating gas. The open pathway(s) may include the airflow channel **21**. The open pathway(s) may include at least certain layers and/or portions of the heat exchanger(s) **23**. One or more of the closed pathway(s) may optionally include, without limitation, the air gap **19** of any of the one or more the side assemblies **14** and/or at least certain layers of or portions of the heat exchanger(s) **23**.

(19) Fans **29** and/or intakes/exhausts **16** may be provided, such as at a respective one of the one or more side assemblies **14** and/or the structural framework **12**, for ingesting, exhausting, and/or moving such ambient air and/or circulating gas. The fan(s) **29** may be provided as part of the side assembly **14**, or separate therefrom.

(20) The open and/or closed pathways may be provided entirely within a respective one of the one or more side assemblies **14**, between the side assemblies **14** (where multiple are provided) of a respective display assembly **10**, within the display assembly **10** but outside of a respective one of

the one or more side assemblies **14**, combinations thereof, or the like. In exemplary embodiments, without limitation, any closed pathway(s) may be separated from the ambient environment and/or any open pathway(s) in accordance with at least ingress protection code IP 55 or higher (e.g., 56, 57, 65, 66, 67, etc.) as defined by the International Electrotechnical Commission at least as of the filing date of this application (https://www.iec.ch/ip-ratings).

(21) A space between the side assemblies **14** and/or structural framework **12** of the display assembly may define, at least in part, a cavity **18** for circulating gas. The cavity **18** may form part of one or all of any closed pathway(s) for the display assembly **10**. Preferably, some or all of the electronics **31** (e.g., network connectivity devices, power modules, video players, controllers, processors, non-transitory electronic storage devices, circuit boards, computing devices, sensors, etc.) for operating the units **10** are located along or within the closed pathway(s), such as within the cavity **18**. The some or all of the electronics **31** may, alternatively or additionally, be located along a rear surface of the airflow channel **21**.

(22) The heat exchanger(s) **23** may be located within the cavity **18**. The heat exchanger(s) **23** may facilitate thermal interaction between the closed and open pathway(s).

(23) At least some of the fan(s) **29**, differential pressure sensor(s) **20**, controller **28**, humidity sensor(s) **22**, temperature sensor(s) **32** may be located within the cavity **18** and/or within one or more of the one or more side assemblies **14**.

(24) The airflow pathways may be, for example, without limitation, as shown and/or described in one or more of: U.S. Pat. No. 9,629,287 granted Apr. 18, 2017 entitled SYSTEM FOR USING CONSTRICTED CONVECTION WITH CLOSED LOOP COOLING SYSTEM AS THE CONVECTION PLATE, U.S. Pat. No. 10,506,738 granted Dec. 10, 2019 entitled CONSTRICTED CONVECTION COOLING FOR AN ELECTRONIC DISPLAY, U.S. Pat. No. 11,540,418 granted Dec. 27, 2022 entitled ELECTRONIC DISPLAY WITH COOLING, and/or U.S. Pat. No. 11,032,923 granted Jun. 8, 2021 entitled FIELD SERVICEABLE DISPLAY ASSEMBLY, the disclosures of each of the foregoing being hereby incorporated by reference as if fully restated herein. Other types and/or kinds of airflow pathways may be utilized. The display assemblies **10** may include some or all of the components of the foregoing disclosures incorporated by reference.

(25) Various types and kinds of sensors for detecting various types and kinds of conditions of the display assembly **10** and/or side assemblies **14** may be provided at various locations at the assembly **10**. In exemplary embodiments, without limitation, such sensors comprise at least one differential pressure sensor **20** located at, or fluidly connected to, one of the closed pathway(s) (e.g., cavity **18**, associated portions/layers of heat exchanger(s) **23**, air gap **19**) and the ambient environment (directly or by way of connection to one of the open pathway(s) or components thereof (e.g., airflow channel **21**, associated portions/layers of heat exchanger(s) **23**)), at least one humidity sensor **22**, preferably located at, or fluidly connected to, the closed pathway(s), and at least one door sensor associated with each of the one or more side assemblies **14** (e.g., at one or more contact points between structural framework **12** and side assembly **14**). The differential pressure sensor **20** and/or humidity sensor **22** may be in electronic communication with a controller **28** of the display assembly **10**, which is local to the display assembly **10** and/or remote therefrom.

(26) The door sensor(s) may comprise a switch **24** located where a respective one of the side assemblies **14** is located when in the closed positioned so as to detect movement of the respective side assembly **14** into the closed position. Alternatively, or additionally, the door sensor(s) may comprise a proximity sensor **26** located at a position of the display assembly **10** to detect a distance of the side assembly **14** to the structural framework **12** (e.g., at a respective one of the side assemblies **14** and/or the structural framework **12**). The proximity sensor **26** may comprise a magnet and magnetic field sensor, ultrasonic sensor, RFID tag, laser and optical sensor, combinations thereof, or the like. The door sensor(s) may be configured to determine if a respective one of the side assemblies **14** is located in a closed position or an opened position. While sometimes discussed as used with the side assemblies **14**, the door sensors may be used with access

panels/door assemblies, static posters, or the like, where such components are utilized. The switch **24** and/or proximity sensor **26** may be provided at the structural framework **12** and/or the side assembly **14**.

(27) FIG. **5** illustrates an exemplary flow chart for operating the display assembly **10**. Where an initial indication is received that one of the side assemblies **14** (or other door/access panel type component) is in the opened position, air characteristic check routines may be initiated. The air characteristic check routines may check pressure, humidity, combinations thereof, or the like. The air characteristic check routines may comprise pressure check routines, humidity check routines, combinations thereof, or the like. The indication that the side assembly **14** is in the opened position may be determined based on data received from one or both of the switch **24** and/or the proximity sensor **26**. For example, without limitation, where the proximity sensor **26** indicates that the side assembly is at least a predetermined distance (e.g., more than 0.5 inches, without limitation) from the structural framework **12**, the side assembly **14** may be considered open. Alternatively, or additionally, where the switch **24** is in a given position (e.g., open from no longer being in contact with the structural framework **12** or a latch mechanism within one or both of the side assembly **14** or the structural framework **12**), then the side assembly **14** may be considered open. Such an initial determination may be made by way of the controller **28**.

(28) The pressure check routine may be performed in accordance with some or all of the disclosures of PCT Pub. No. WO 2023/009477 the entirety of which is hereby incorporated by reference as if fully restated herein. For example, without limitation, field deployed leak down testing in accordance with the '477 PCT Pub. may be performed. The display assembly **10** may comprise some or all of the components, programming routines, and/or arrangements shown and/or described in the '477 PCT Pub. patent by way of non-limiting example. The humidity check routine may be performed in accordance with some or all of the disclosures of US Pub. No. 2023/0333423 the entirety of which is hereby incorporated by reference as if fully restated herein. For example, without limitation, a dew point spread (DPS) may be in accordance with the '432 Pub. The display assembly **10** may comprise some or all of the components, programming routines, and/or arrangements shown and/or described in the '432 Pub. patent by way of non-limiting example. The DPS may be determined by way of the controller **28**.

(29) Where the pressure check routine and/or humidity check routines indicate a change in pressure and/or humidity levels, respectively, during or following the routine(s) outside of certain predetermined parameters (e.g., significant changes), the initial indication may be considered confirmed and/or an electronic notification may be generated and/or transmitted, such as by way of the controller **28**. Optionally, an electronic notification may also be generated and/or transmitted for the initial indication and the second electronic notification may include a confirmation of the initial indication. One or both routines may be performed. Where more than one routine is performed, changes outside of certain predetermined parameters (e.g., significant changes) in one or both may be required to perform generating and/or transmitting the electronic notification. A significant pressure change may be determined where the display assembly **10** changes in leak down time by at least a predetermined threshold (e.g., 1 second, 3 seconds, or a wide variety of user determined thresholds), by way of non-limiting example. A significant humidity change may be determined where the DPS drops by more than at least a predetermined threshold (e.g., 1 degree Celsius, 3 degrees Celsius, or a wide variety of user determined thresholds), by way of non-limiting example.

(30) In exemplary embodiments, without limitation, the parameters may include pressure and/or humidity categories. The category parameters or thresholds may be stored at the controller **28**. The categories may be universal or display unit **10** specific. For example, without limitation, a leak down time above a first threshold may indicate generally well-sealed unit **10**, a leak down time below the first threshold but above a second threshold may indicate average sealed unit **10**, and a leak down time below the second threshold may indicate poorly sealed unit **10**. As another

example, without limitation, a DPS above a first threshold may indicate condensation not likely present, a DPS below the first threshold but above a second threshold may indicate condensation possibly present, and a DPS below the second threshold may indicate condensation likely present.
(31) Where a certain category is reached and/or when the unit **10** changes categories (e.g., from a last test), the initial indication may be considered confirmed. A wide variety of number and type of categories may be utilized for pressures and/or humidity, such as but not limited to a respective 1-5 category/classification. Where the display assembly **10** changes categories, a significant humidity change may be determined.
(32) Alternatively, or additionally, a check may be made to see if leak down time and/or DPS has reached a certain category, is decreasing, has decreased (e.g., dropped one category, dropped multiple categories) to determine if the alert should be generated and/or transmitted.
(33) Alternatively, or additionally, a check may be made to see if pressure readings are outside a typical daily pressure range, daily pressure high, daily pressure low, outside a daily pressure average, combinations thereof, or the like. Some or all of the foregoing may include a predetermined margin, such as to account for routine errors or other conditions, minimize alerts for temporary or transient conditions, combinations thereof, or the like. Such a margin may be particularly useful for the daily pressure average. The margin for the daily pressure average may be at least one, two, or three standard deviations of the daily pressure average (in the upward and/or downward direction from the average), by way of non-limiting example. The margin may, alternatively or additionally, be temporal, such as to allow a period of time (e.g., 1 second, 3 seconds, 1 minute, etc.) to see if the value continues to remain outside of the respective parameter. The typical daily pressure range, daily pressure high, daily pressure low, and/or daily pressure average may be predetermined data points, such as based on testing results, idealized calculations, expected parameters, combinations thereof, or the like. Alternatively, or additionally, the typical daily pressure range, daily pressure high, daily pressure low, and/or daily pressure averages may be derived data points, such as from some or all historic operations data for the unit **10**, such as using known statistical analysis techniques. For example, without limitation, data from the prior 24 hours or some other time period (e.g., some test case or baseline time period) may be used to derive such data points.
(34) Such derivations or determinations of parameters may be made locally, such as at the controller **28**, or remotely. Such derivations or determinations of parameters may optionally be made updated over time, such as using one or more machine learning techniques. Such derivations or determinations of parameters may be user determined variables which may be updated from time to time, such as based on instructions received from one or more remote electronic devices.
(35) Alternatively, or additionally, the routines shown and/or described herein may provide the initial indication as well as the confirmation. For example, without limitation, the controller **28** may be configured to perform a leak down test or DPS calculation may be run from time-to-time (e.g., periodically). Where a certain parameter is reached (e.g., threshold, rate of change, category change, category reached, combinations thereof, or the like), the initial determination may be made (and optionally alert generated). The controller **28** may be configured to automatically run an additional leak down test or DPS calculation may be run thereafter, such as after a predetermined period of time, at a different time of day, at the same time the next day, combinations thereof, or the like. Where a certain parameter is reached (e.g., threshold, rate of change, category change, category reached, combinations thereof, or the like), the initial determination may be confirmed and/or alert generated.
(36) The determinations and/or alerts shown and/or described herein may be determined and/or generated locally to the display assembly **10** and/or remotely (e.g., at the controller **28**).
(37) The electronic alert/notification may be an initial alert/notification and/or a confirmatory type of alert/notification.
(38) As illustrated in FIG. **6**, similar approaches may be applied to verifying other conditions of the

display assembly **10**, such as but not limited to, ability to hold pressure (e.g., how well sealed the unit is), condensation conditions (e.g., condensation likely present), combinations thereof, or the like. An initial indication of a likely leak or condensation, such as by way of a low pressure reading, a low leak down time, a high humidity reading, a low DPS reading, change in pressure and/or humidity classification, combinations thereof, or the like may be used as a preliminary indication to trigger verification, by way of non-limiting example. A testing routine, such as but not necessarily limited to, a leakdown test and/or humidity test, may be performed. Where a significant change is determined, this may indicate that the unit **10** has changed state, which may confirm the initial indication. Where no change and/or an insignificant change is determined, this may indicate that the unit **10** has not changed state, and therefore the initial indication may be discarded, ignored, and/or left unconfirmed/unverified.

(39) As illustrated in FIG. **7**, alternatively, or additionally, after a condition alert is triggered, one or more testing routines may be initiated for verifying the existence of the condition which triggered the alert. In exemplary embodiments, without limitation, such testing routines may include issuing one or more commands which are intended to cause an increase of heat generated within the unit **10**. For example, without limitation, the commands may include commands to increase illumination levels of the electronic display **15** (e.g., backlight **13**), decrease certain speed levels of the fan(s) **29** (e.g., those associated with some or all of any open pathways), such as down to zero, combinations thereof, or the like. These actions may cause internal temperature within the units **10** to increase, such as measured by one or more temperatures sensors **32**. In exemplary embodiments, without limitation, these routines may be performed to increase heat, in particular, within closed pathway(s) or areas (e.g., channel **21**, cavity **18**, heat exchanger **23**), though the heat may be increased in other areas, such as the open pathway(s).

(40) With a relatively well sealed unit **10**, increasing heat within the closed areas may be expected to result in a significant pressure increase. With a less well sealed or leaky unit **10**, increasing heat within the closed areas may be expected to result in no to an insignificant pressure increase.

(41) Some or all of the temperature sensor(s) **32**, pressure sensor(s) **20**, humidity sensor(s) **22**, combinations thereof, or the like, may be provided within, and/or in fluid connection with, some or all of any closed pathways within the units **10**, such as to detect air characteristic changes to the air within the same.

(42) The commands may also include commands to increase the speed level of certain other fans **29** (e.g., those associated with some or all of any closed pathways), and/or at least be maintained at a minimum level. This may assist with preventing overheating and/or ensuring sufficient uniformity of heat to provide sufficiently accurate readings at the temperature sensor(s) **32**.

(43) Where a measured pressure change (e.g., by way of the pressure sensor(s) **20**) during some or all of the testing routine is significant, that may indicate that the unit **10** remains relatively well sealed such that the condition is considered unverified and/or no alert is issued. For example, if a door were open (an exemplary condition that may initially be detected), thereby exposing the closed and/or other sealed or partially sealed area to ambient, little or no pressure response may be expected due to the lack of sufficient sealing. Thus, where no significant pressure change is found under such automated testing routines, it may be concluded that the door is actually shut and/or that the sensor(s) indicating the door is opened are faulty. An alert or other indication of the same may optionally be generated and/or transmitted.

(44) Where a measured pressure change during some or all of the testing routine is not significant, that may indicate that the unit **10** is no longer relatively well sealed and the condition may be considered verified and/or an alert may be generated. A significant pressure change may be some predetermined threshold, such as but not necessarily limited to, a minimum pressure change level, a minimum pressure rate of change level, a minimum pressure level, an acceptable pressure range, combinations thereof, or the like. Such parameter(s) may be pre-programed or derived from certain historical and/or testing information (e.g., automatically, manually by user set parameters,

combinations thereof, or the like). By way of non-limiting example, the temperature change may be implemented relatively rapidly, such as over a one minute period. The rate or amount of pressure change may be monitored over that minute period against an expected rate or amount of change. The expected rate or amount of change may be determined, for example without limitation, from earlier testing. Other time periods may be utilized.
(45) As used herein, the “condition” being verified may be leaking, door or other access panel or component open status, and/or need for service, by way of non-limiting example.
(46) As used herein, “checks” or “routines” may refer to software instructions which, when executed, provides the stated functionality in a fully or at least partially automated fashion.
(47) As used herein, the side assembly **14** or other normally moveable component may be in an “open” (e.g., non-closed) state where it is moved away from the structural framework **12** or in another configuration which reduces or removes the pressure barrier and/or provides access to an interior of the unit **10**. This may include swinging part of the side assembly **14** away from the structural framework **12**, such as on hinges, by way of non-limiting example. Contrary, these component(s) may be in a closed state where they are adjacent to the structural framework **12** or in another configuration which provides or enhances the pressure barrier and/or prevents normal access to the interior of the unit **10**. This may include moving the side assembly **14** towards the structural framework **12** and/or lacking the same to the structural framework **12**, by way of non-limiting example.
(48) While alerts are sometimes shown and/or described, various types of notification and/or indications may be provided.
(49) Where conditions are initially found which trigger some or all of the routines and/or checks shown and/or described herein, but those initially triggering conditions are considered unverified after the checks and/or routines are completed, the controller **28** may be configured to generate an alert or other indication that a sensor or other component associated with the initial triggering condition or event is faulty, in exemplary embodiments, without limitation. For example, without limitation, if a door sensor initially indicates that a door is open, but the testing routine indicates that significant pressure changes are found with temperature changes (and thus the unit remains relatively well sealed), an alert may instead be generated indicating that the door sensor is likely faulty.
(50) The controller **28** may be configured to automatically generate one or more repair orders, tickets, combinations thereof, or the like and transmit such items to appropriate parties to initiate repair or remedy of any detected conditions, such as following verification of the same. Such repair orders, tickets, combinations thereof, or the like may be dispatched to teams specific to the type of condition detected and/or may comprise information identifying the unit **10** and/or the condition(s) detected.
(51) The data used for verifying the display assembly **10** condition does not have to be the same data which triggered the analysis. For example, if a low DPS indication is generated, an analysis may be made of pressure to see if pressure has changed significantly (e.g., dropped one or more categories of leak down time, thereby indicating that the unit is less well sealed) to verify the condition and/or need for servicing. Similarly, if indication of a likely leak is made, the DPS may be analyzed to verify the condition. Such cross-referencing may be preferred to enhance verification.
(52) While the alert/notifications shown and/or described herein are sometimes referred to as being triggered by an indication (e.g., likely leak, low DPS), the display assemblies **10** may be programmed, and/or may be programmable, to perform such analysis without the need for an initial indication, such as in response to a command to provide such an analysis, which may be triggered manually, automatically (e.g., periodically, randomly, etc.), or the like. In such instances, the alerts/notifications may be the first or original indication that such conditions may be present (e.g., instead of verifying already indicated conditions).

(53) The illustrated size, shape, and/or location of at least certain components shown and/or described herein, such as but not limited to, the differential pressure sensor(s) **20**, controller(s) **28**, humidity sensor(s) **22**, temperature sensor(s) **32**, fan(s) **29**, electronic(s) **31**, switch **24**, proximity sensor(s) **26**, and/or heat exchanger(s) **23** are exemplary and not intended to be limiting.
(54) Various size and/or shape side assemblies **14**, electronic displays **15**, and/or structural frameworks **12** may be utilized.
(55) Any embodiment of the present invention may include any of the features of the other embodiments of the present invention. The exemplary embodiments herein disclosed are not intended to be exhaustive or to unnecessarily limit the scope of the invention. The exemplary embodiments were chosen and described in order to explain the principles of the present invention so that others skilled in the art may practice the invention. Having shown and described exemplary embodiments of the present invention, those skilled in the art will realize that many variations and modifications may be made to the described invention. Many of those variations and modifications will provide the same result and fall within the spirit of the claimed invention.
(56) Certain operations described herein may be performed by one or more electronic devices. Each electronic device may comprise one or more processors, electronic storage devices, executable software instructions, combinations thereof, and the like configured to perform the operations described herein. The electronic devices may be general purpose computers or specialized computing devices. The electronic devices may comprise personal computers, smartphones, tablets, databases, servers, or the like. The electronic connections and transmissions described herein may be accomplished by one or more wired or wireless connectively components (e.g., routers, modems, ethernet cables, fiber optic cable, telephone cables, signal repeaters, and the like) and/or networks (e.g., internets, intranets, cellular networks, the world wide web, local area networks, and the like). The computerized hardware, software, components, systems, steps, methods, and/or processes described herein may serve to improve the speed of the computerized hardware, software, systems, steps, methods, and/or processes described herein. The electronic devices, including but not necessarily limited to the electronic storage devices, databases, controllers, or the like, may comprise and/or be configured to hold, solely non-transitory signals.

Claims

1. A display assembly utilizing air characteristic data to verify internal operating conditions, said display assembly comprising: a structural framework; a side assembly connected to the structural framework and comprising an electronic display; a closed airflow pathway; one or more sensors, at least one of which is located at, or fluidly connected to, the closed airflow pathway; and a controller in electronic communication with the electronic display, and the one or more sensors, said controller comprising one or more non-transitory electronic storage devices comprising software instructions, which when executed, configure one or more processors to: receive data from at least one of the one or more sensors; determine, based on the data, whether an initial indication of an operating condition exists, and if so: initiate a testing routine; receive additional data from at least one of the one or more sensors during and/or following initiation of the testing routine; and confirm, based on the additional data, whether the operating condition exists.
2. The display assembly of claim 1 wherein: the one or more sensors comprise at least one humidity sensor or temperature sensor; the testing routine comprises determining a dew point spread based, at least in part, on the additional data from the at least one humidity sensor or temperature sensor; and the operating condition is confirmed where the dew point spread is within a predetermined margin of zero.
3. The display assembly of claim 1 wherein: the one or more sensors comprise at least one differential pressure sensor fluidly connected to an ambient environment; the testing routine comprises determining a differential pressure reading based on the additional data from the at least

one differential pressure sensor; and the operating condition is confirmed where the differential pressure reading is within a predetermined margin of zero.

4. The display assembly of claim 1 wherein: the one or more sensors comprise at least one differential pressure sensor fluidly connected to an ambient environment; the testing routine comprises determining an initial differential pressure reading based on the data from the at least one differential pressure sensor, at least one of: commanding increase of an illumination level of the electronic display and commanding Assembly Operating Conditions, Systems and Methods for the Same decrease of an operating speed of a fan located along an open airflow pathway of the display assembly, and determining a time elapsed until subsequent differential pressure readings based on the additional data from the at least one differential pressure sensor return to a predetermined margin of the initial differential pressure reading; and the operating condition is confirmed where the time is less than a predetermined threshold value.

5. The display assembly of claim 4 wherein: the testing routine comprises commanding increase of the illumination level of the electronic display and commanding decrease of the operating speed of the fan located along the open airflow pathway of the display assembly.

6. The display assembly of claim 1 wherein: the one or more sensors comprises at least one differential pressure sensor fluidly connected to an ambient environment; the testing routine comprises at least one of: commanding increase of an illumination level of the electronic display and commanding decrease of an operating speed of a fan located along an open airflow pathway of the display assembly, and determining a time elapsed until subsequent differential pressure reading based on the additional data from the at least one differential pressure sensor return to a predetermined margin of a historical differential pressure reading; and the operating condition is confirmed where the time is less than a predetermined threshold value.

7. The display assembly of claim 6 wherein: the historical differential pressure value comprises a baseline differential pressure reading for the display assembly.

8. The display assembly of claim 1 wherein: the one or more sensors comprises at least one differential pressure sensor fluidly connected to an ambient environment; the testing routine comprises determining an initial differential pressure reading based on the data from the at least one differential pressure sensor, at least one of: commanding increase of an illumination level of the electronic display and commanding decrease of an operating speed of a fan located along an open airflow pathway of the display assembly, and determining a subsequent differential pressure reading based on the additional data from the at least one differential pressure sensor; and the operating condition is confirmed where a change between the initial differential pressure reading and the subsequent differential pressure reading is less than a predetermined threshold value.

9. The display assembly of claim 1 wherein: the one or more sensors comprises at least one differential pressure sensor fluidly connected to an ambient environment; the testing routine comprises at least one of: commanding increase of an illumination level of the electronic display and commanding decrease of an operating Assembly Operating Conditions, Systems and Methods for the Same speed of a fan located along an open airflow pathway of the display assembly, and determining a differential pressure reading based on the additional data from the at least one differential pressure sensor; and the operating condition is confirmed where a change between the differential pressure reading and a historical differential pressure value for the display assembly is less than a predetermined threshold value.

10. The display assembly of claim 1 wherein: the one or more sensors comprises at least one of: a switch and a proximity sensor for the side assembly; the initial indication of the operating condition is determined, at least in part, based on the data from the at least one of: the switch and the proximity sensor; the side assembly is movable relative to the structural framework; and the operating condition comprises the side assembly in an open state where the side assembly is moved away from the structural framework.

11. The display assembly of claim 10 wherein: the controller comprises additional software

instructions stored at the one or more non-transitory electronic storage devices, which when executed, configure the one or more processors to: determine that the at least one of: the switch and the proximity sensor is faulty where the operating condition is not confirmed based on the additional data from the one or more sensors.
12. The display assembly of claim 1 wherein: the operating condition comprises a leaky unit.
13. The display assembly of claim 12 wherein: the one or more sensors comprises at least one differential pressure sensor fluidly connected to an ambient environment; and the initial indication of the operating condition is determined where the data from the at least one differential pressure sensor is below a predetermined threshold.
14. The display assembly of claim 12 wherein: the one or more sensors comprises at least one humidity sensor or temperature sensor; and the initial indication of the operating condition is determined where a dew point spread determined, at least in part from the data from the at least one humidity sensor or temperature sensor, is below a predetermined threshold.
15. The display assembly of claim 1 wherein: the one or more sensors comprise a first sensor of a first type and a second sensor of a second type; the initial indication of the operating condition is determined, at least in part, from the data from the first sensor and without data from the second sensor; and the operating condition is confirmed from the additional data from the second sensor and without data from the first sensor.
16. The display assembly of claim 1 wherein: the controller comprises additional software instructions stored at the one or more non-transitory electronic storage devices, which when executed, configure the one or more processors to: generate and transmit an electronic notification comprising the operating condition following confirmation of the operating condition.
17. The display assembly of claim 1 wherein: the electronic display comprises a liquid crystal display and a backlight.
18. A display assembly utilizing air characteristic data to verify internal operating conditions, said display assembly comprising: a structural framework; a side assembly connected to the structural framework and comprising an electronic display; a closed airflow pathway; a first sensor of a first type; a second sensor of a second type, wherein said second sensor is located at, or fluidly connected to, the closed airflow pathway; and a controller in electronic communication with the electronic display, and the one or more sensors, said controller comprising one or more non-transitory electronic storage devices comprising software instructions, which when executed, configure one or more processors to: receive data from the first sensor; determine, at least in part from the data received from the first sensor, an initial indication of an operating condition; initiate a testing routine; receive data from the second sensor during and/or following initiation of the testing routine; and confirm, based at least in part on the data received from the second sensor, whether the operating condition exists.
19. The display assembly of claim 18 wherein: the data from the second sensor is not used to determine the initial indication of the operating condition; and the data from the first sensor is not used to confirm the operating condition.
20. A method for verifying internal operating conditions of a display assembly using air characteristic data, said method comprising: receiving, at a controller of the display assembly, data from a first sensor of a first type of the display assembly; determining, at the controller and based at least in part on the data received from the first sensor, an initial indication of an operating condition of the display assembly; initiating, by way of the controller, a testing routine at the display assembly; receiving, at the controller, data from a second sensor of the display assembly of a second type during and/or following initiation of the testing routine; and confirming, at the controller and based at least in part on the data received from the second sensor, whether the operating condition exists.