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(54) **SELF-CONTAINED DATA LOGGING AIR MEASUREMENT DEVICE**

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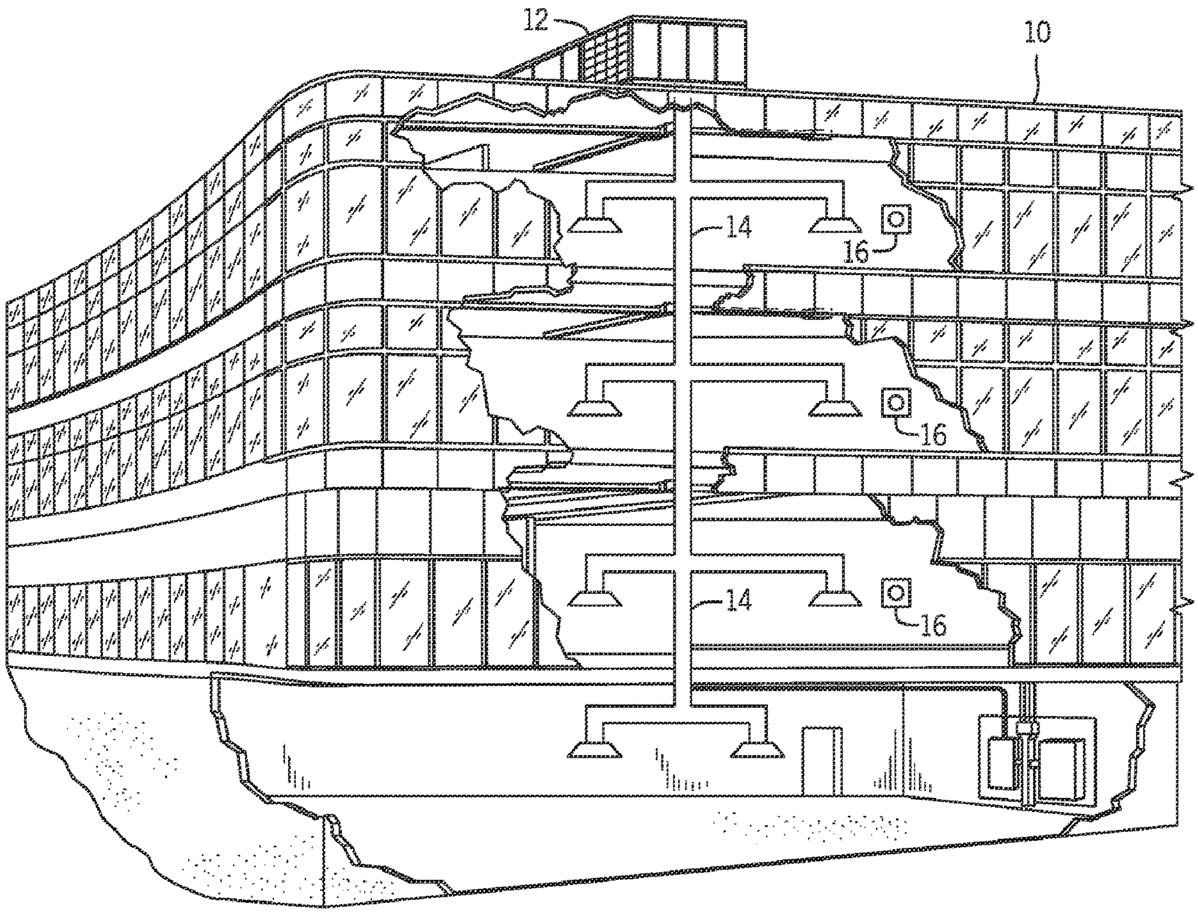
F24F 11/64 (2006.01)

(52) **U.S. Cl.**
CPC ***F24F 11/64*** (2018.01)

(57) **ABSTRACT**

Systems and methods of the present disclosure include heating, ventilation, and/or air conditioning (HVAC) air measurement devices configured to enable operators to select data relating to certain air flow parameters to be directly downloaded from the HVAC air measurement devices and/or to otherwise be transmitted directly from the HVAC air measurement devices in substantially real time during operation to enable operators to make analytical decisions quickly and to reduce design development timelines, among other things. In addition, the HVAC air measurement devices obviate the need for: (1) separate computing devices to be connected to the HVAC air measurement devices to extract the data from the HVAC air measurement devices, and/or (2) using specialized software to extract the data from the HVAC air measurement devices, as required by conventional HVAC air measurement devices.



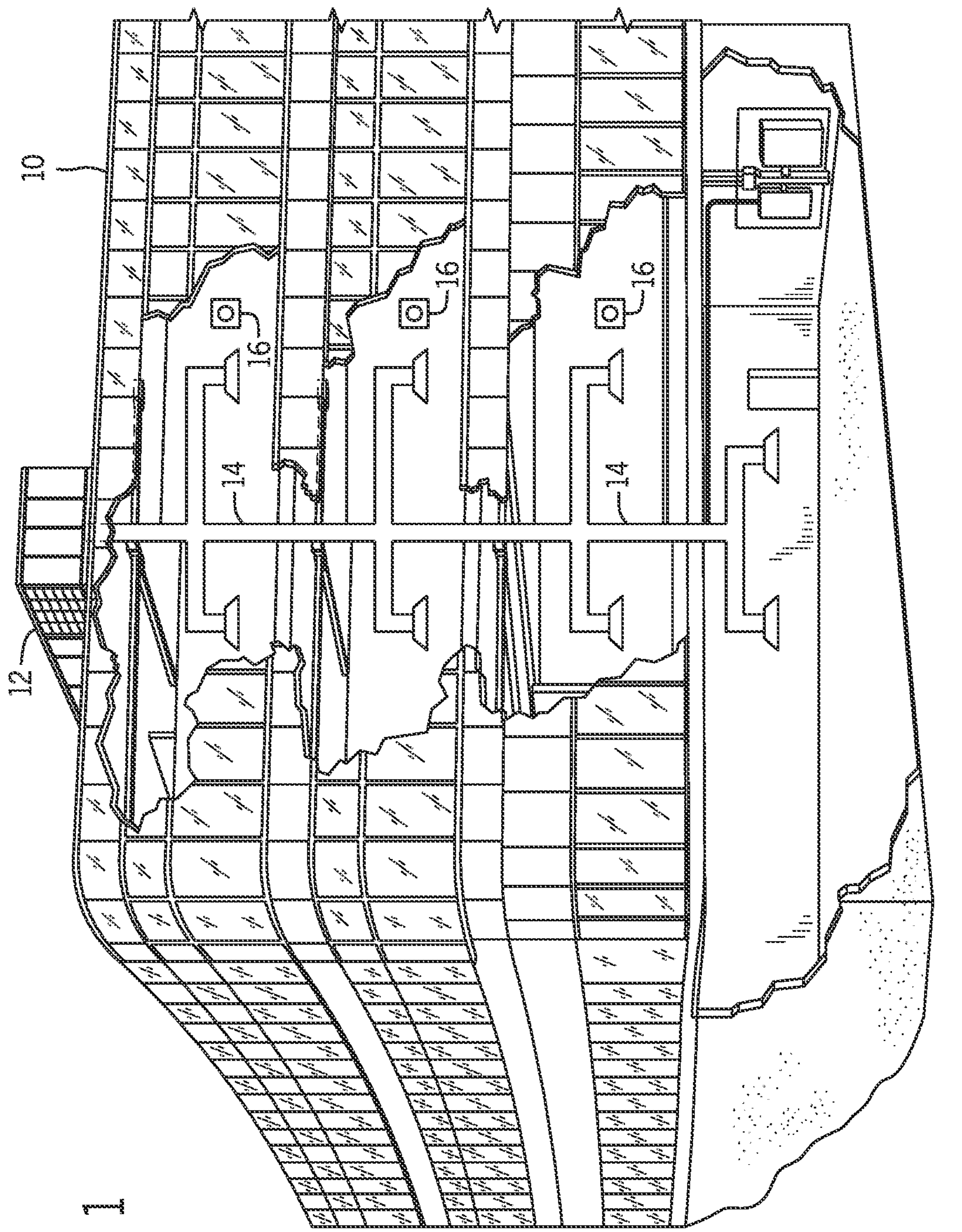


FIG. 1

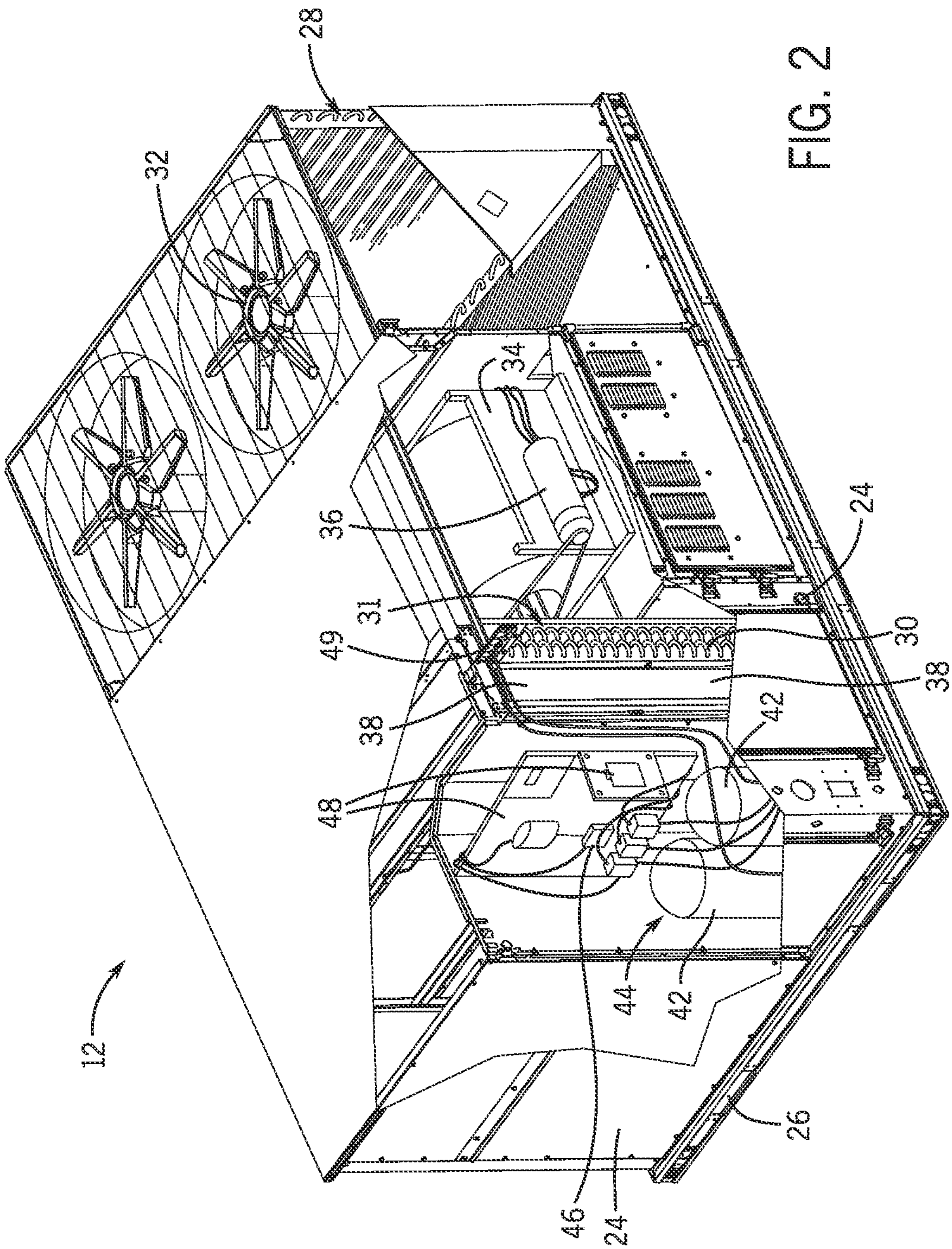


FIG. 2

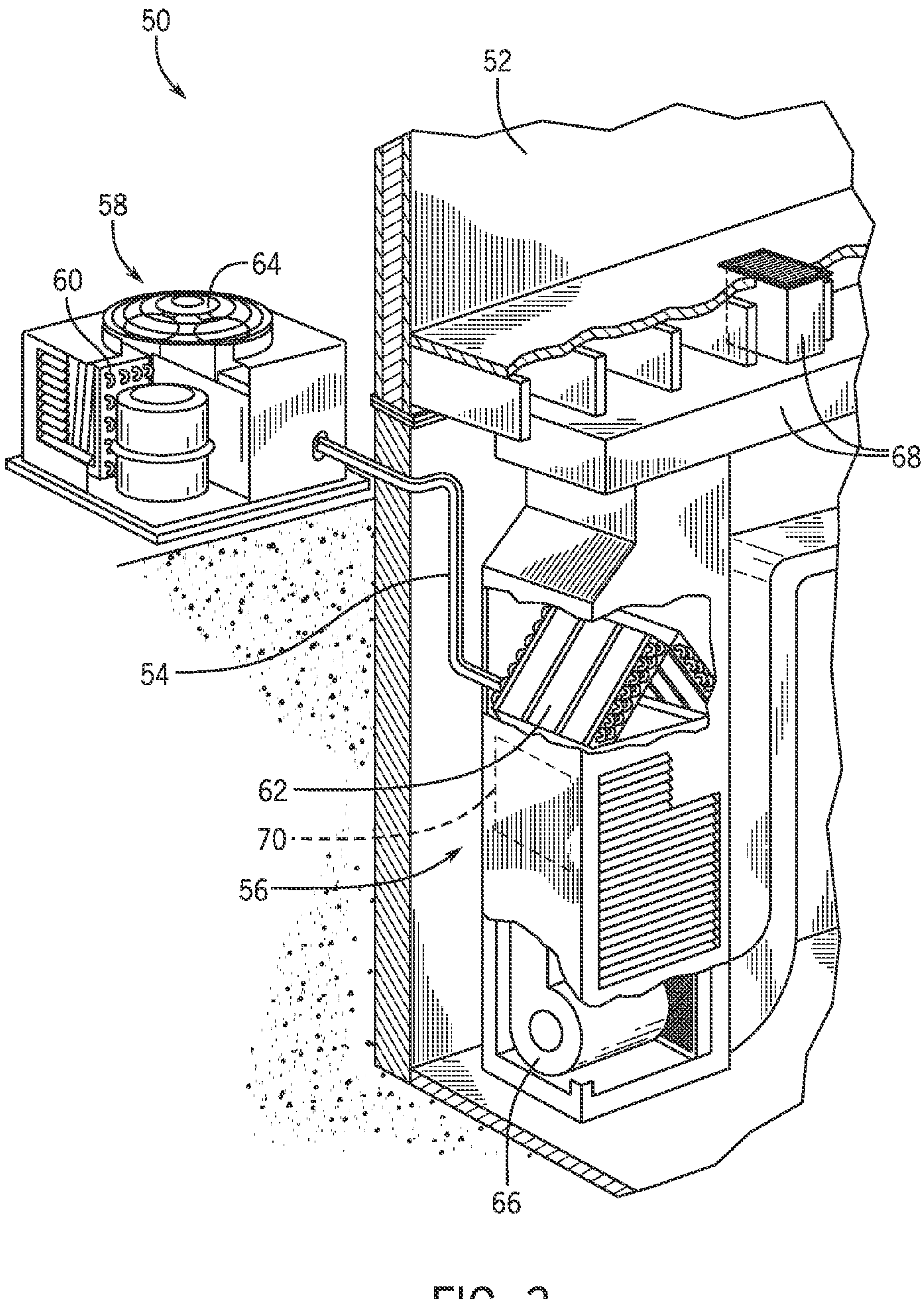


FIG. 3

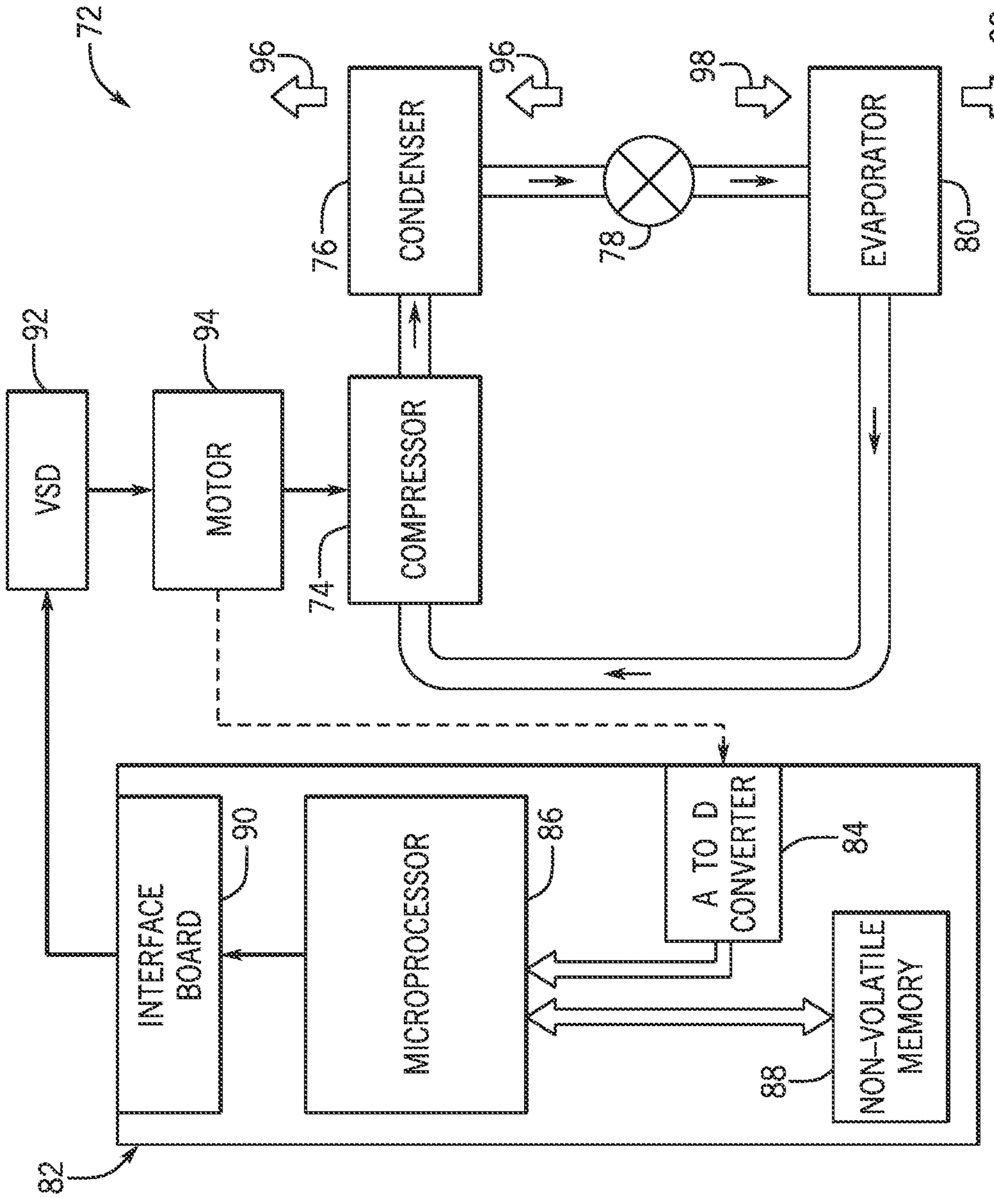

72
96
96
98
98
CONDENSER
76
78
EVAPORATOR
80
92
VSD
94
MOTOR
COMPRESSOR
74
INTERFACE BOARD
90
MICROPROCESSOR
86
A TO D CONVERTER
84
NON–VOLATILE MEMORY
88
82

FIG. 4

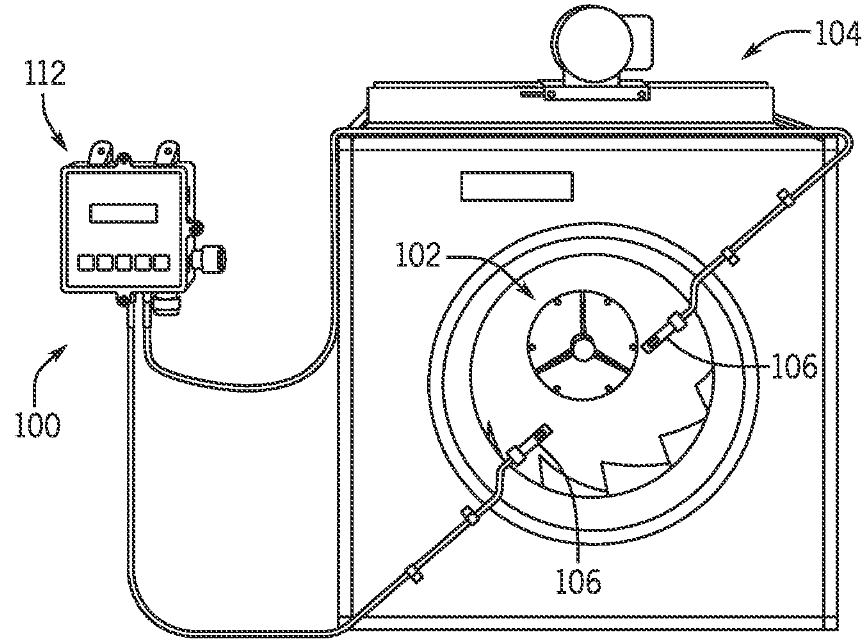


FIG. 5

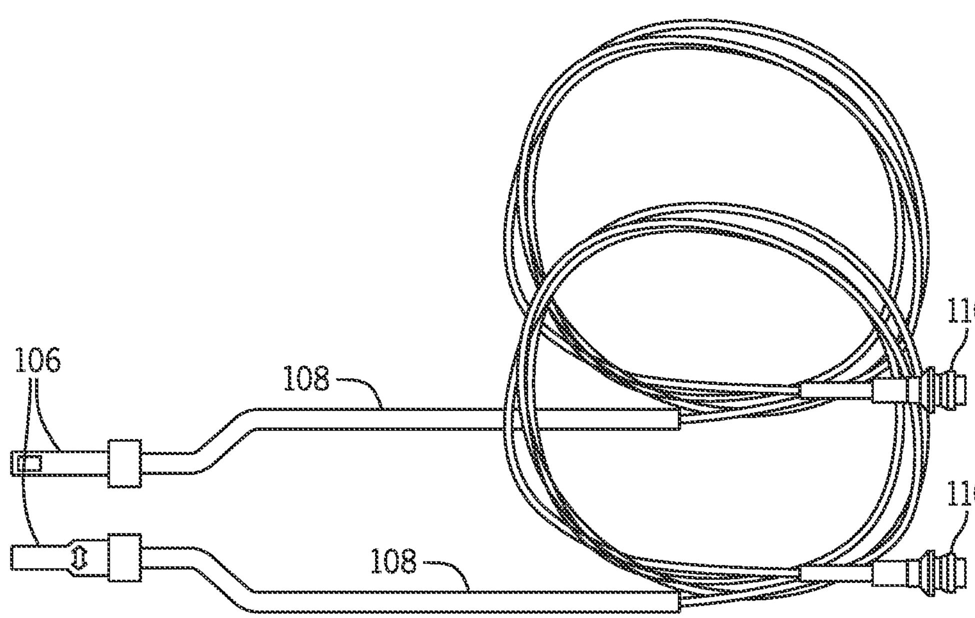
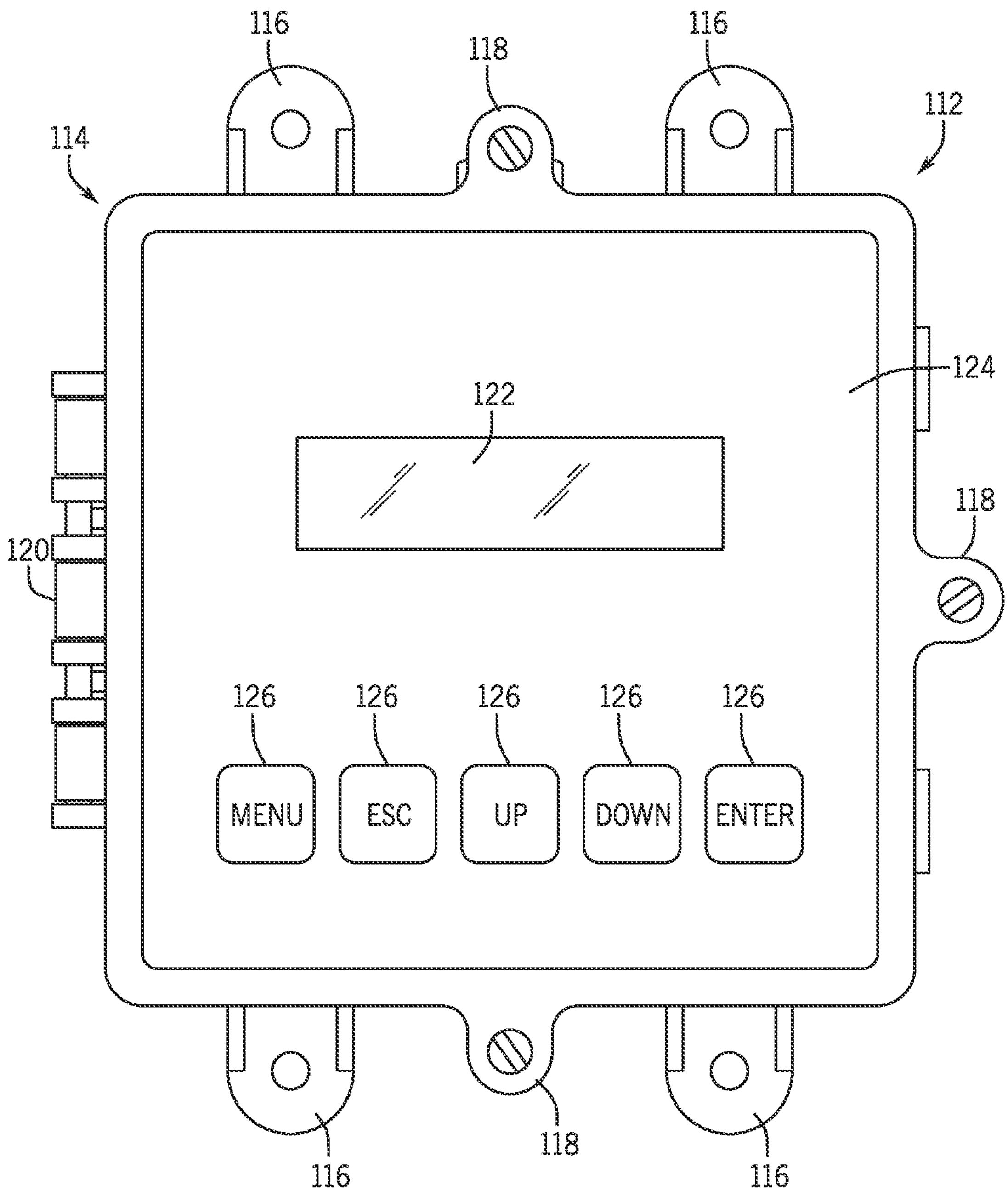


FIG. 6


116
118
116
112
114
124
122
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120
126
126
126
126
126
MENU
ESC
UP
DOWN
ENTER
116
118
116

FIG. 7

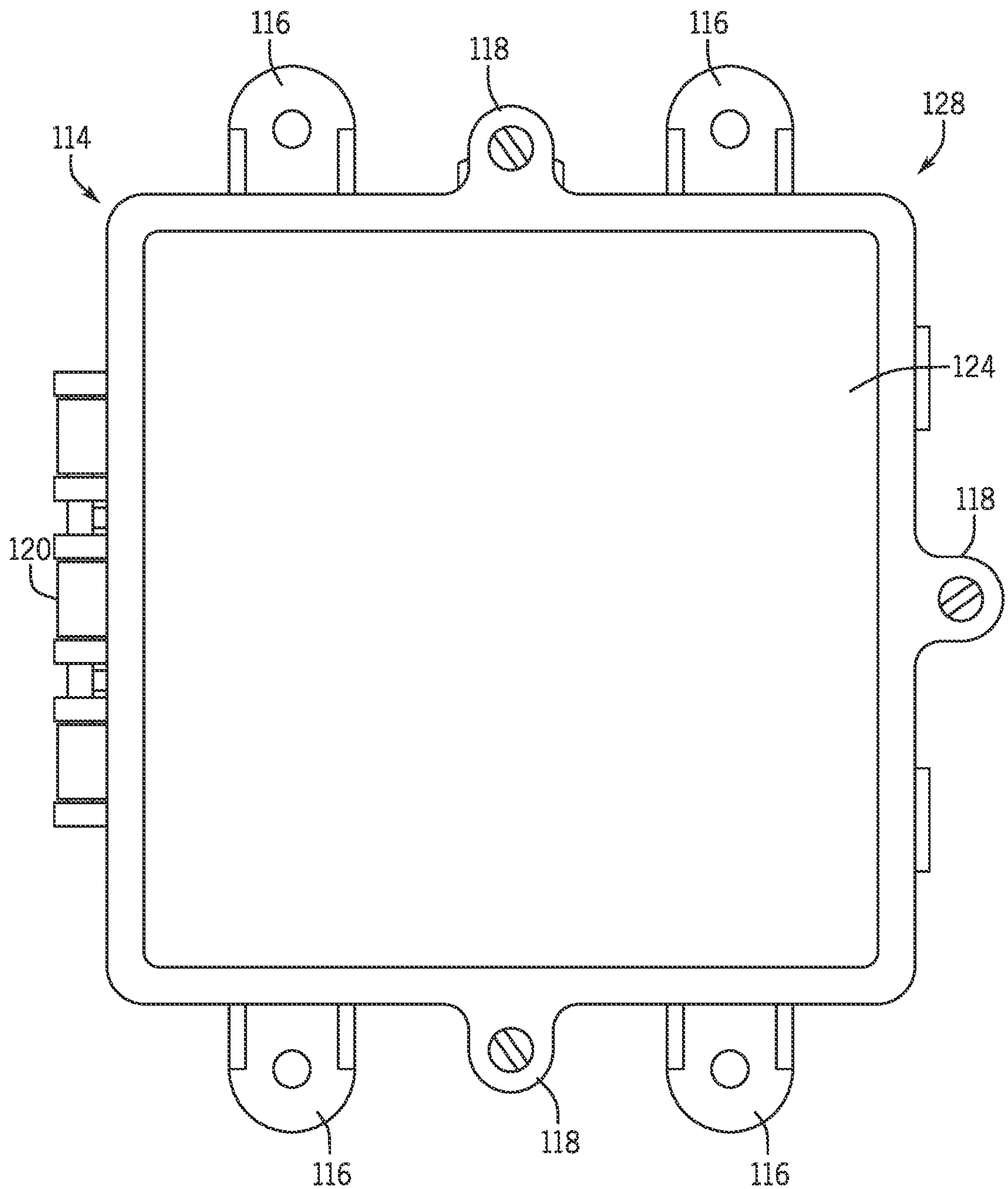

FIG. 8

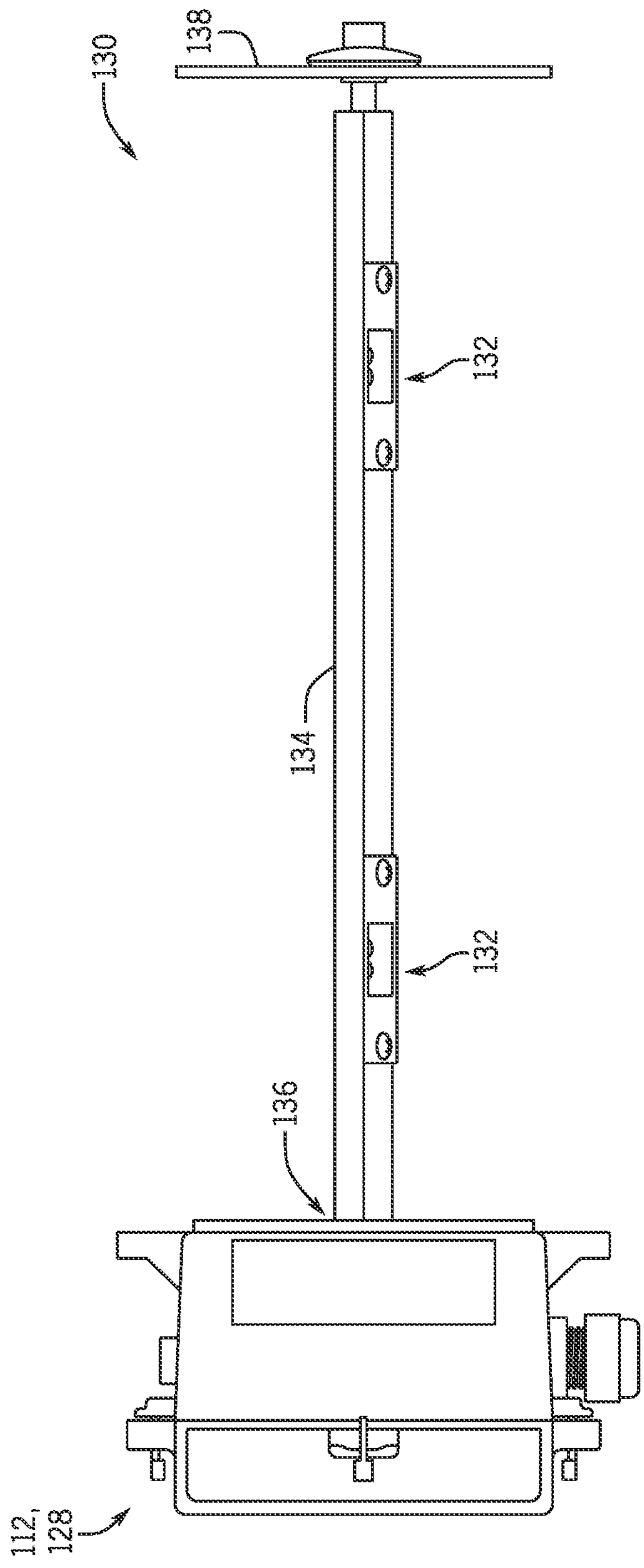

FIG. 9

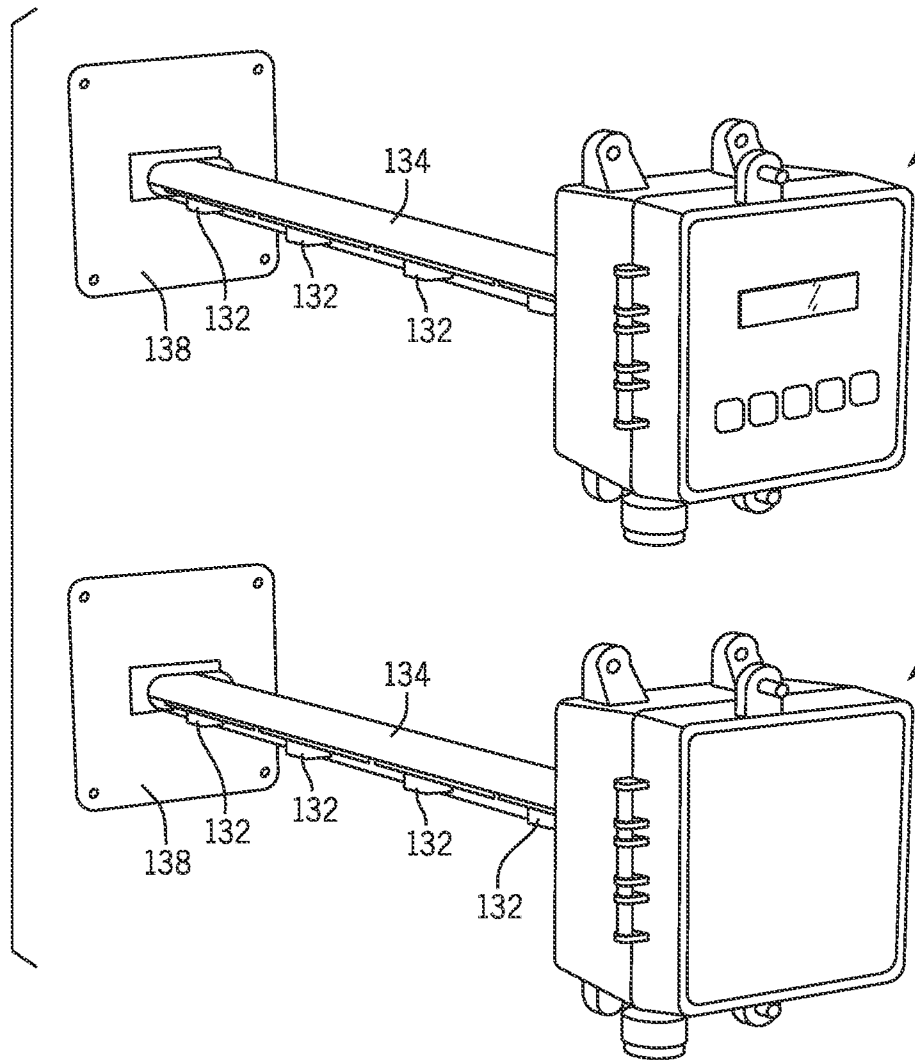

FIG. 10

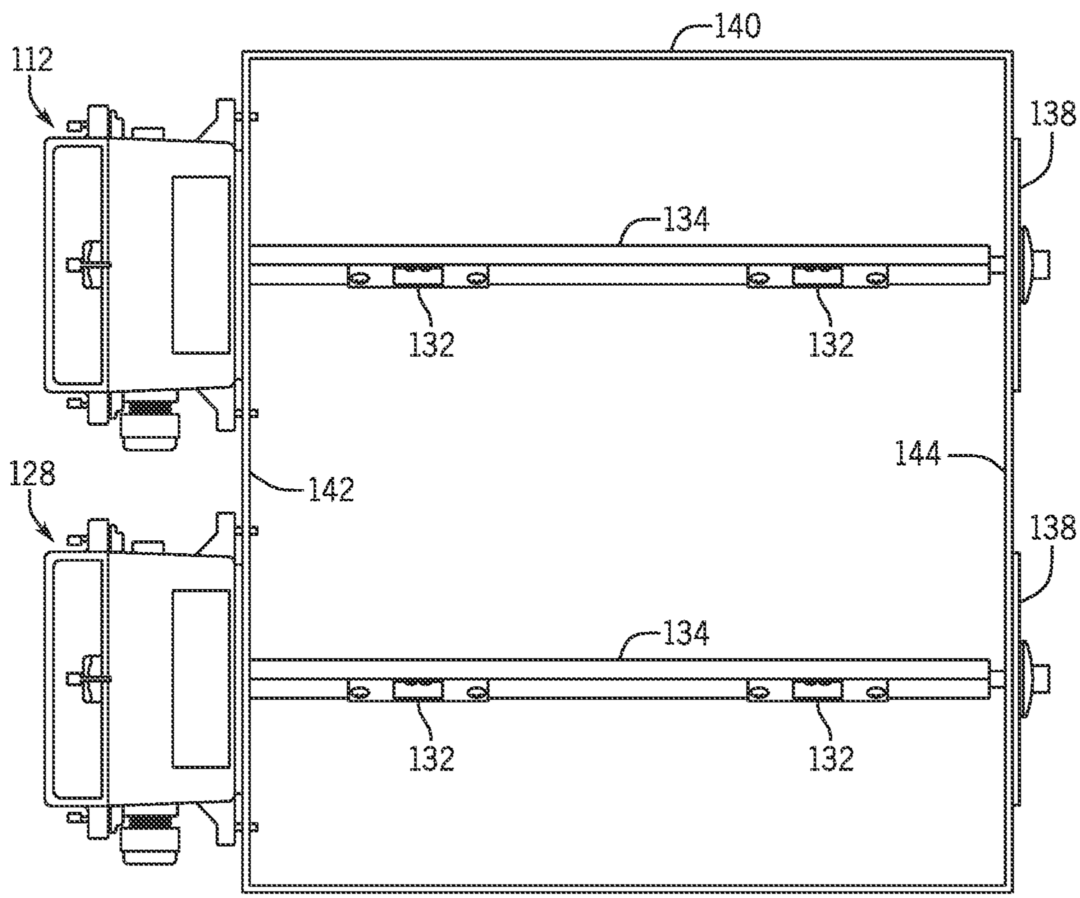

FIG. 11

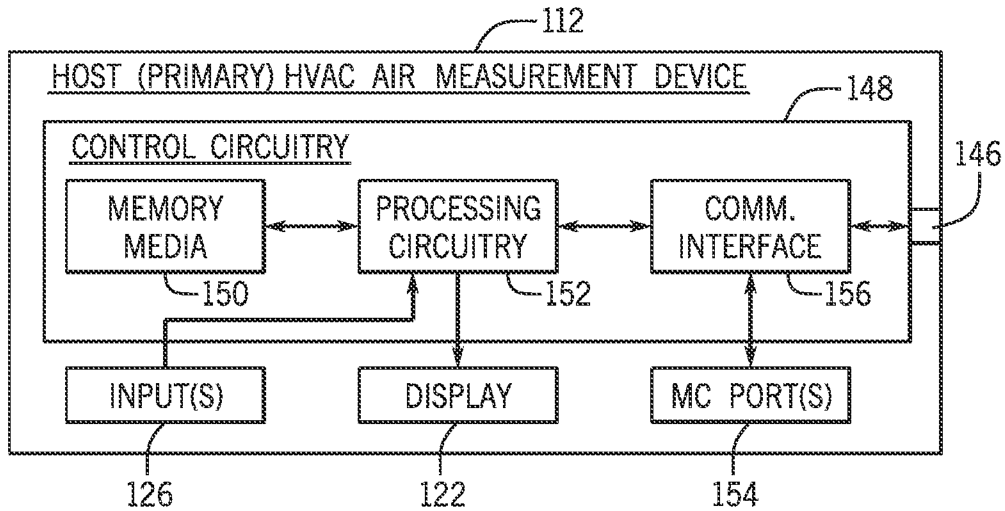
112
HOST (PRIMARY) HVAC AIR MEASUREMENT DEVICE
148
CONTROL CIRCUITRY
146
MEMORY MEDIA
PROCESSING CIRCUITRY
COMM. INTERFACE
150
152
156
INPUT(S)
DISPLAY
MC PORT(S)
126
122
154

FIG. 12

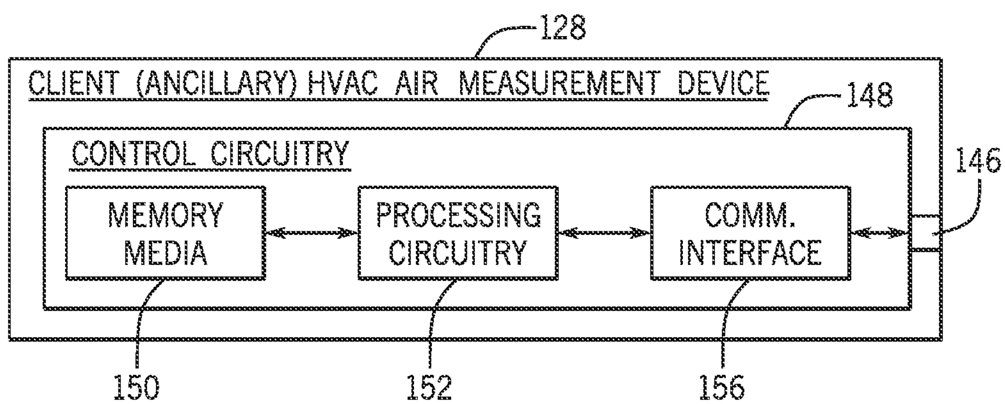
128
CLIENT (ANCILLARY) HVAC AIR MEASUREMENT DEVICE
148
CONTROL CIRCUITRY
146
MEMORY MEDIA
PROCESSING CIRCUITRY
COMM. INTERFACE
150
152
156

FIG. 13

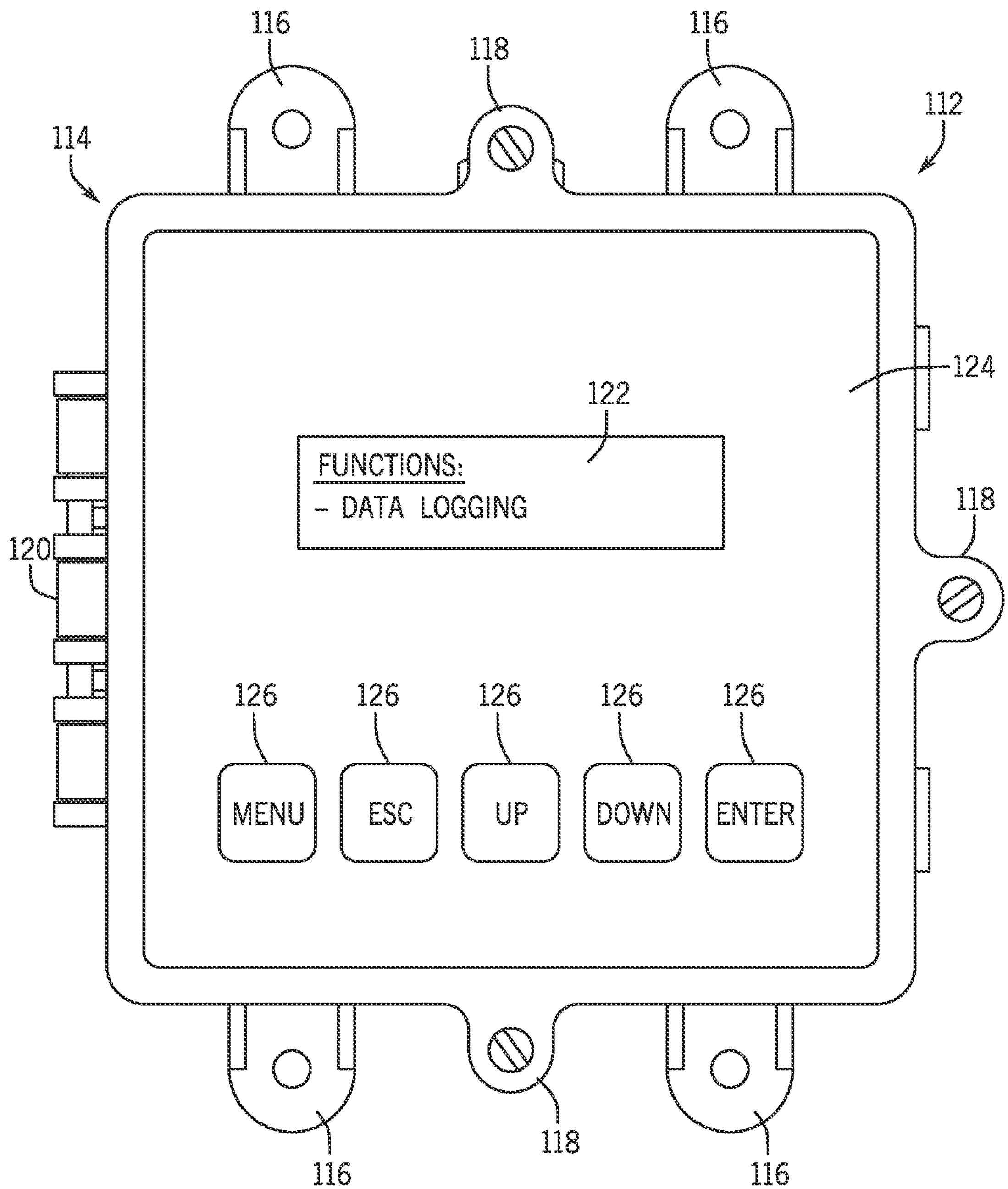
116
118
116
112
114
124
122
FUNCTIONS:
- DATA LOGGING
118
120
126
126
126
126
126
MENU
ESC
UP
DOWN
ENTER
116
118
116

FIG. 14

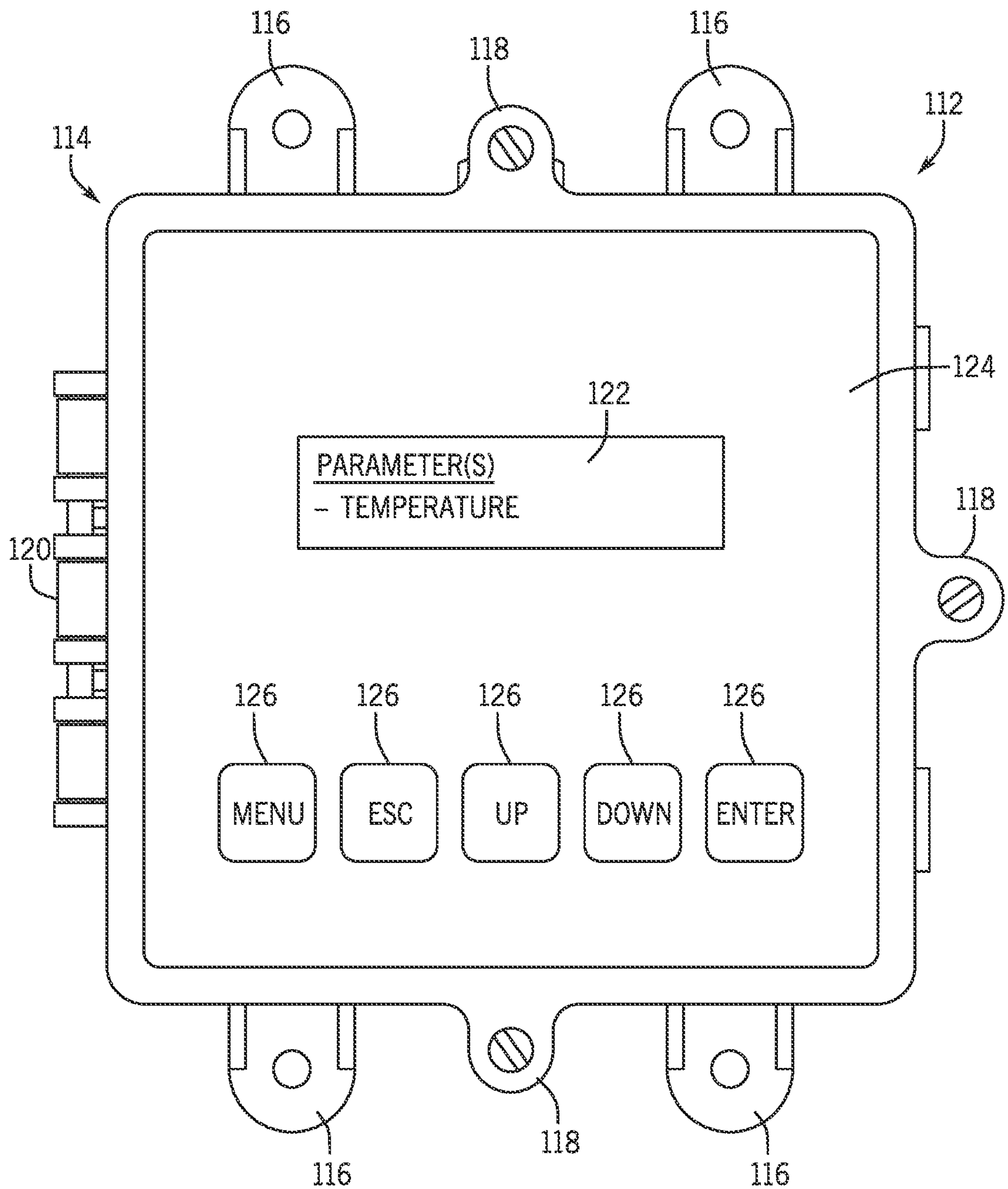
116
118
116
112
114
124
122
PARAMETER(S)
– TEMPERATURE
118
120
126
126
126
126
126
MENU
ESC
UP
DOWN
ENTER
116
118
116

FIG. 15

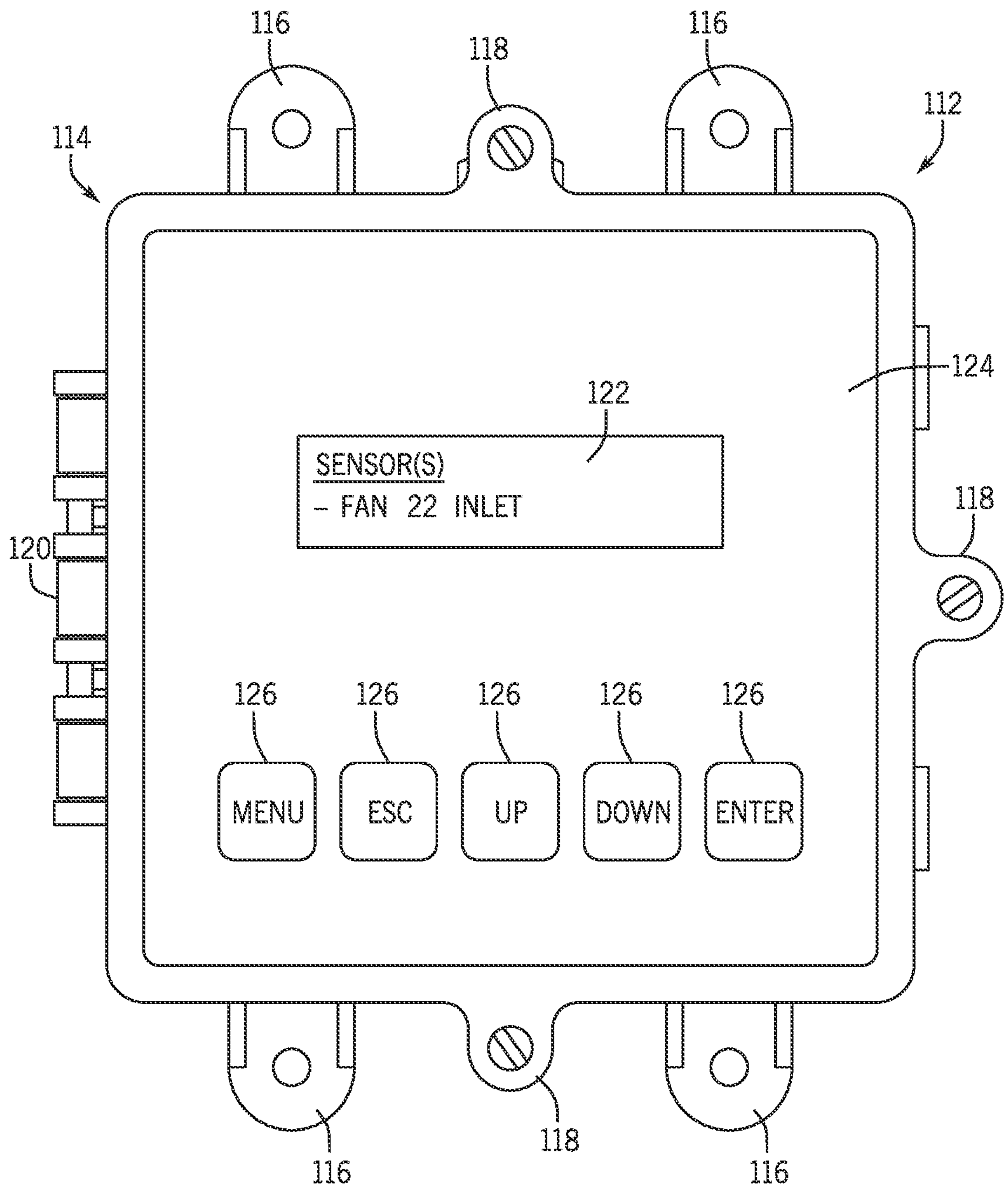
116
118
116
112
114
124
122
SENSOR(S)
- FAN 22 INLET
118
120
126
126
126
126
126
MENU
ESC
UP
DOWN
ENTER
118
116
116

FIG. 16

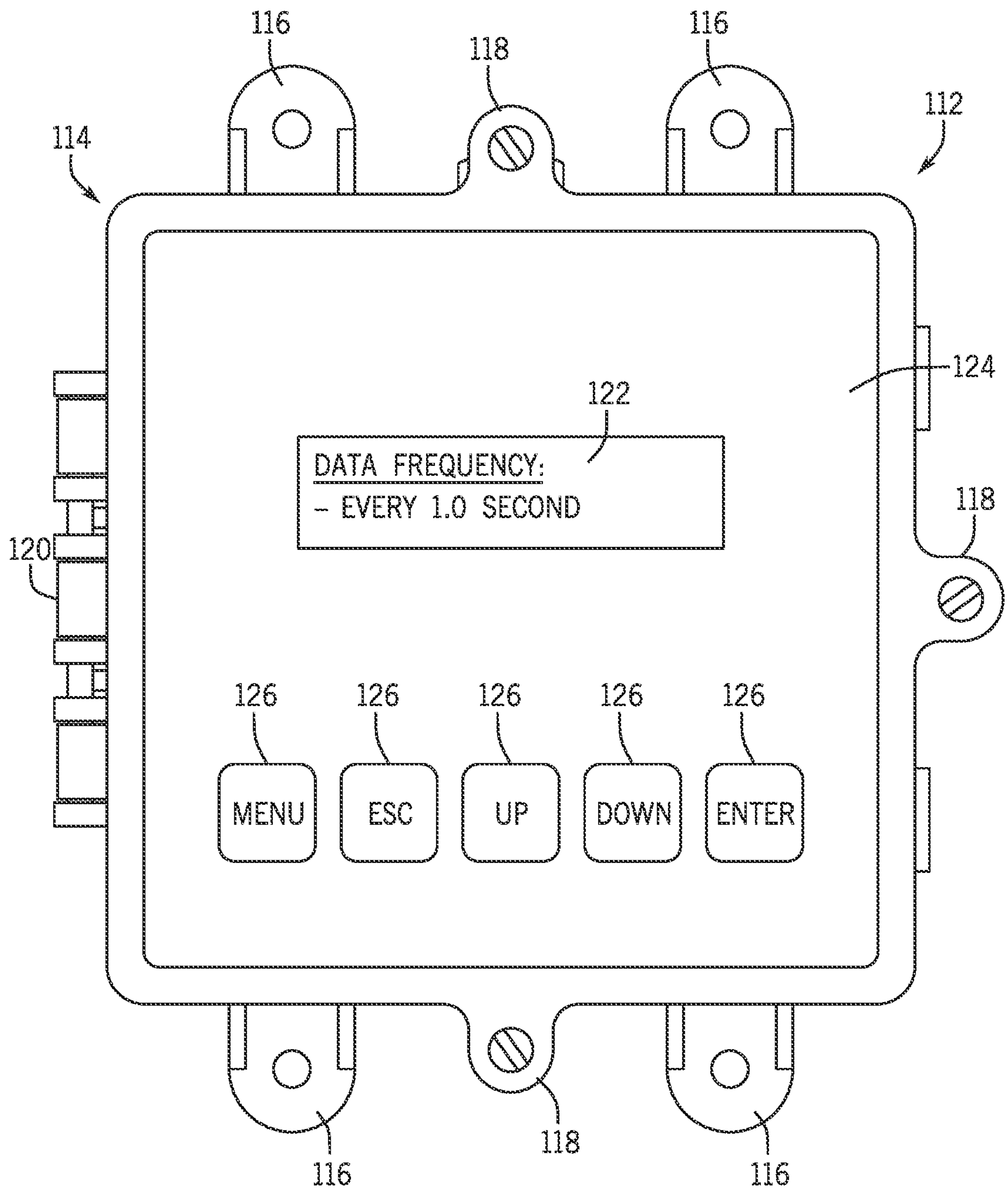
116
118
116
112
114
124
122
DATA FREQUENCY:
- EVERY 1.0 SECOND
118
120
126
126
126
126
126
MENU
ESC
UP
DOWN
ENTER
116
118
116

FIG. 17

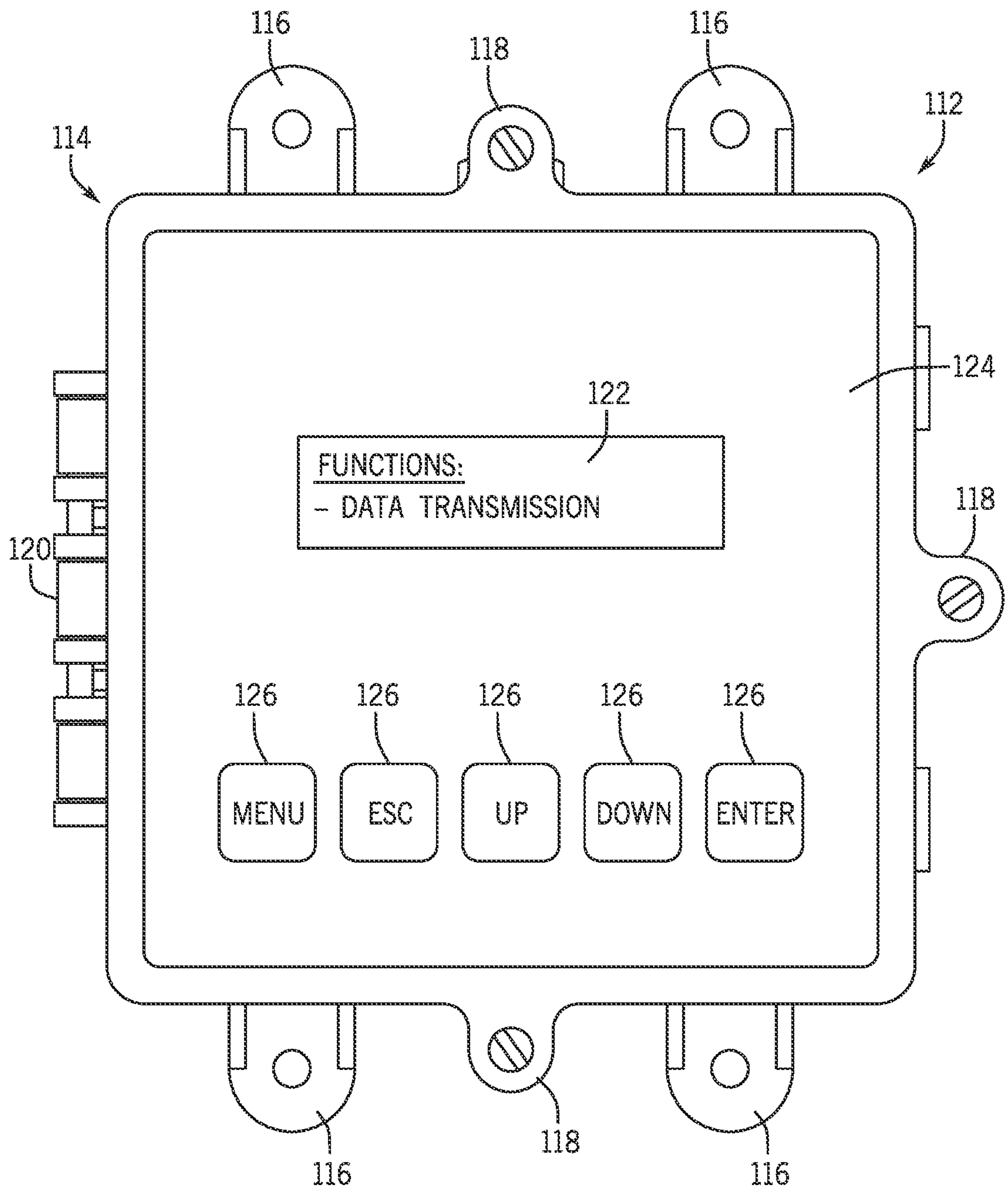
116
118
116
112
114
124
122
FUNCTIONS:
- DATA TRANSMISSION
118
120
126
126
126
126
126
MENU
ESC
UP
DOWN
ENTER
118
116
116

FIG. 18

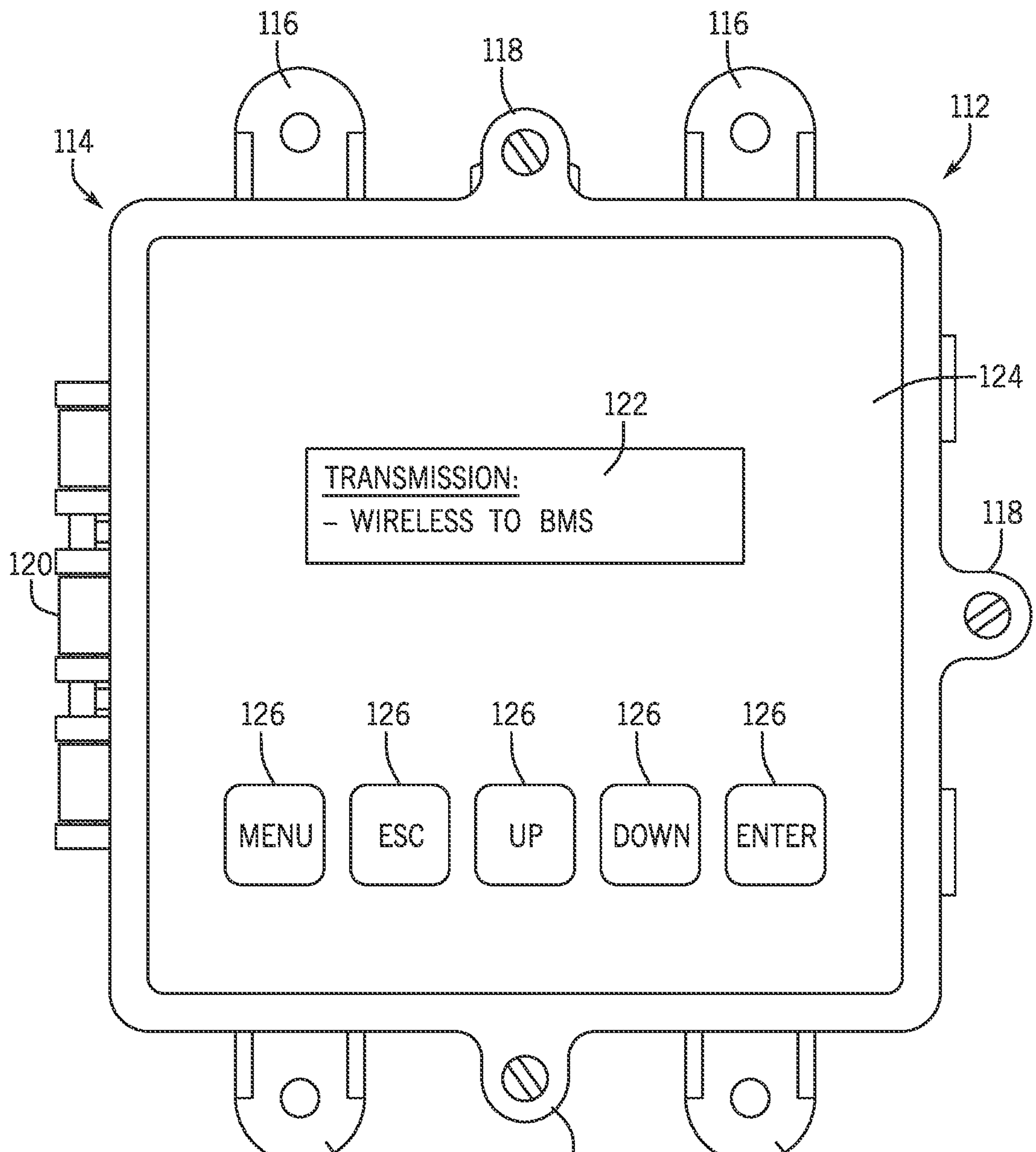
116
118
116
112
114
124
122
TRANSMISSION:
– WIRELESS TO BMS
118
120
126
126
126
126
126
MENU
ESC
UP
DOWN
ENTER
116
118
116

FIG. 19

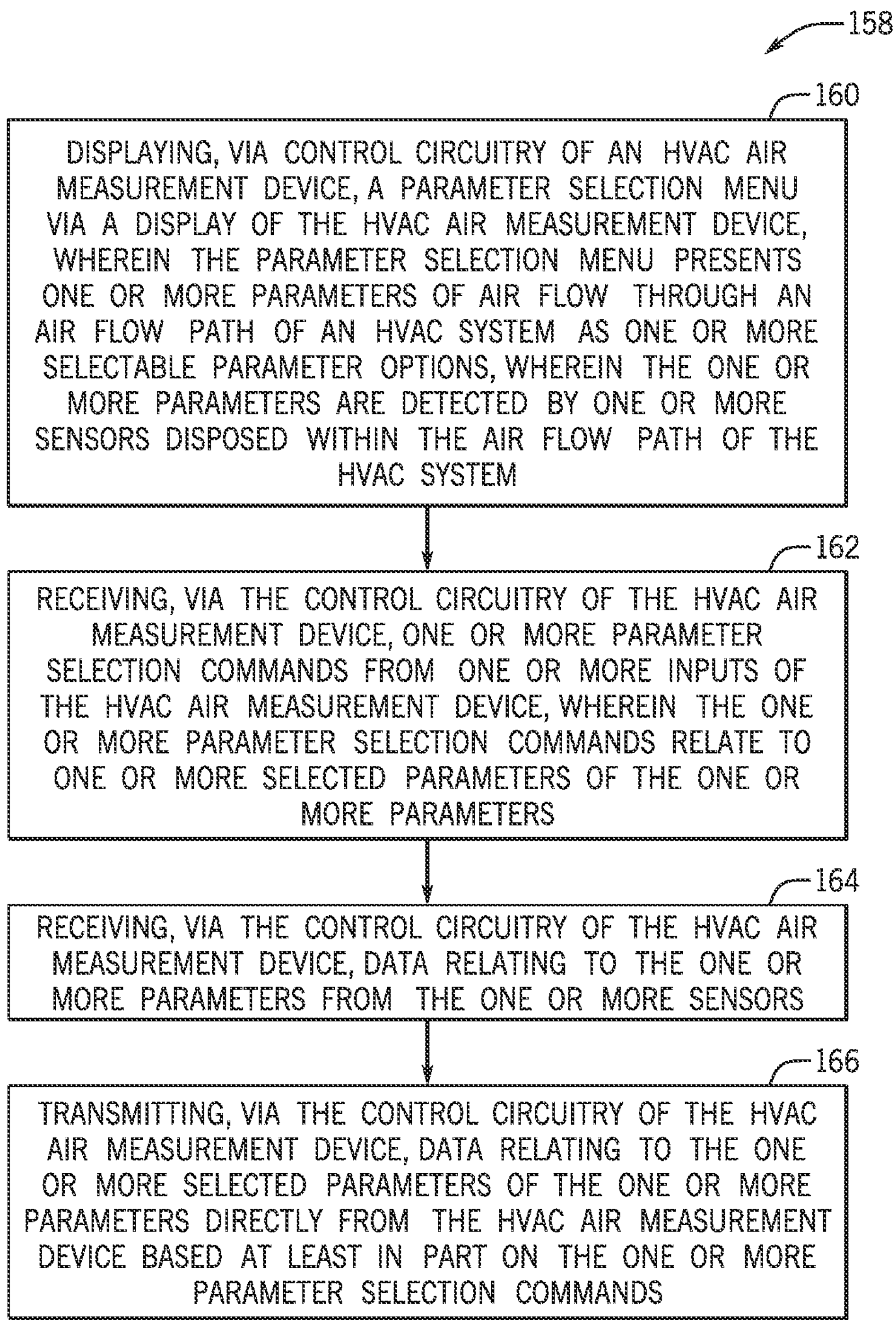
158
160
DISPLAYING, VIA CONTROL CIRCUITRY OF AN HVAC AIR MEASUREMENT DEVICE, A PARAMETER SELECTION MENU VIA A DISPLAY OF THE HVAC AIR MEASUREMENT DEVICE, WHEREIN THE PARAMETER SELECTION MENU PRESENTS ONE OR MORE PARAMETERS OF AIR FLOW THROUGH AN AIR FLOW PATH OF AN HVAC SYSTEM AS ONE OR MORE SELECTABLE PARAMETER OPTIONS, WHEREIN THE ONE OR MORE PARAMETERS ARE DETECTED BY ONE OR MORE SENSORS DISPOSED WITHIN THE AIR FLOW PATH OF THE HVAC SYSTEM
162
RECEIVING, VIA THE CONTROL CIRCUITRY OF THE HVAC AIR MEASUREMENT DEVICE, ONE OR MORE PARAMETER SELECTION COMMANDS FROM ONE OR MORE INPUTS OF THE HVAC AIR MEASUREMENT DEVICE, WHEREIN THE ONE OR MORE PARAMETER SELECTION COMMANDS RELATE TO ONE OR MORE SELECTED PARAMETERS OF THE ONE OR MORE PARAMETERS
164
RECEIVING, VIA THE CONTROL CIRCUITRY OF THE HVAC AIR MEASUREMENT DEVICE, DATA RELATING TO THE ONE OR MORE PARAMETERS FROM THE ONE OR MORE SENSORS
166
TRANSMITTING, VIA THE CONTROL CIRCUITRY OF THE HVAC AIR MEASUREMENT DEVICE, DATA RELATING TO THE ONE OR MORE SELECTED PARAMETERS OF THE ONE OR MORE PARAMETERS DIRECTLY FROM THE HVAC AIR MEASUREMENT DEVICE BASED AT LEAST IN PART ON THE ONE OR MORE PARAMETER SELECTION COMMANDS

FIG. 20

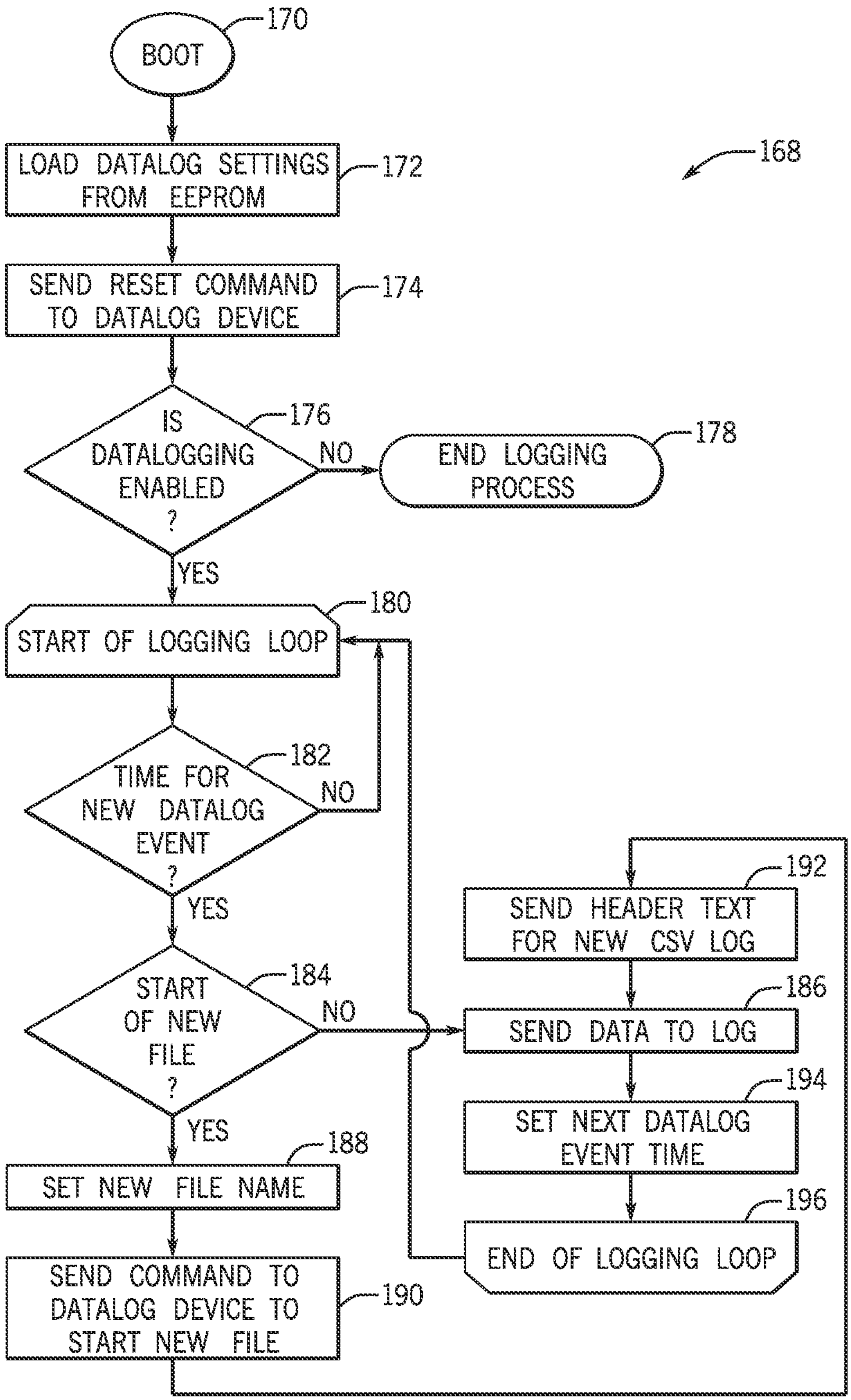
170
BOOT
LOAD DATALOG SETTINGS FROM EEPROM
172
168
SEND RESET COMMAND TO DATALOG DEVICE
174
IS DATALOGGING ENABLED ?
176
NO
END LOGGING PROCESS
178
YES
START OF LOGGING LOOP
180
TIME FOR NEW DATALOG EVENT ?
182
NO
YES
START OF NEW FILE ?
184
NO
YES
SET NEW FILE NAME
188
SEND COMMAND TO DATALOG DEVICE TO START NEW FILE
190
SEND HEADER TEXT FOR NEW CSV LOG
192
SEND DATA TO LOG
186
SET NEXT DATALOG EVENT TIME
194
END OF LOGGING LOOP
196

FIG. 21

SELF-CONTAINED DATA LOGGING AIR MEASUREMENT DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from and the benefit of U.S. Provisional Application No. 63/245,297, entitled "SELF-CONTAINED DATA LOGGING AIR MEASUREMENT DEVICE," filed Sep. 17, 2021, which is herein incorporated by reference in its entirety for all purposes.

BACKGROUND

[0002] This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure and are described below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be noted that these statements are to be read in this light, and not as admissions of prior art.

[0003] Heating, ventilation, and/or air conditioning (HVAC) systems are utilized in residential, commercial, and industrial applications to control environmental properties, such as temperature and humidity, for occupants of respective environments. An HVAC system may control the environmental properties through control of properties of an air flow delivered to and ventilated from spaces serviced by the HVAC system. For example, the HVAC system may transfer heat between the air flow and refrigerant flowing through the system (e.g., a heat exchanger) to provide cooled air for an indoor environment. Similarly, the HVAC system may heat the air flow to provide warmth to an indoor environment. In some situations, the HVAC system may even provide cooling of the air flow followed by heating of the air flow to limit humidity while providing air at a desired temperature to the indoor environment. The HVAC system may also control a flowrate of the air flow to manage (e.g., expedite transitioning between) environmental conditions. As such, air flow parameters of air flow through air flow paths of an HVAC system are often required to enable control of parameters of the HVAC system. In such situations, air measurement devices are often used to help collect data relating to such air flow parameters. However, conventional air measurement devices do not allow operators to extract specific types of data without the need for physically connected other computing devices to the air measurement devices and/or utilizing specialized software.

SUMMARY

[0004] A summary of certain embodiments disclosed herein is set forth below. It should be noted that these aspects are presented merely to provide the reader with a brief summary of these certain embodiments and that these aspects are not intended to limit the scope of this disclosure. Indeed, this disclosure may encompass a variety of aspects that may not be set forth below.

[0005] In one embodiment, a heating, ventilation, and/or air conditioning (HVAC) air measurement device includes a housing, a display disposed on an outer surface of the housing, and one or more inputs disposed on the outer surface of the housing. In addition, the HVAC air measurement device includes control circuitry configured to be electrically connected to one or more sensors disposed within an air flow path of an HVAC system. The one or more sensors are configured to detect one or more parameters of air flow through the air flow path. The control circuitry is configured to display a parameter selection menu via the display. The parameter selection menu presents the one or more parameters as one or more selectable parameter options. The control circuitry is also configured to receive one or more parameter selection commands from the one or more inputs. The one or more parameter selection commands relate to one or more selected parameters of the one or more parameters. The control circuitry is further configured to receive data relating to the one or more parameters from the one or more sensors. In addition, the control circuitry is configured to transmit data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more parameter selection commands.

[0006] In one embodiment, a method includes displaying, via control circuitry of an HVAC air measurement device, a parameter selection menu via a display of the HVAC air measurement device. The parameter selection menu presents one or more parameters of air flow through an air flow path of an HVAC system as one or more selectable parameter options. The one or more parameters are detected by one or more sensors disposed within the air flow path of the HVAC system. The method also includes receiving, via the control circuitry of the HVAC air measurement device, one or more parameter selection commands from one or more inputs of the HVAC air measurement device. The one or more parameter selection commands relate to one or more selected parameters of the one or more parameters. The method further includes receiving, via the control circuitry of the HVAC air measurement device, data relating to the one or more parameters from the one or more sensors. In addition, the method includes transmitting, via the control circuitry of the HVAC air measurement device, data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more parameter selection commands.

[0007] In one embodiment, an HVAC air measurement system includes one or more sensors configured to be disposed within an air flow path of an HVAC system. The one or more sensors are configured to detect one or more parameters of air flow through the air flow path. The HVAC air measurement system also includes an HVAC air measurement device that includes a housing, a display disposed on an outer surface of the housing, and one or more inputs disposed on the outer surface of the housing. The HVAC air measurement system further includes control circuitry configured to be electrically connected to the one or more sensors. The control circuitry is configured to display a parameter selection menu via the display. The parameter selection menu presents the one or more parameters as one or more selectable parameter options. The control circuitry is also configured to receive one or more parameter selection commands from the one or more inputs. The one or more parameter selection commands relates to one or more selected parameters of the one or more parameters. The control circuitry is further configured to receive data relating to the one or more parameters from the one or more sensors. In addition, the control circuitry is configured to transmit data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more parameter selection commands.

DRAWINGS

[0008] Various aspects of this disclosure may be better understood upon reading the following detailed description and upon reference to the drawings in which:

[0009] FIG. **1** is a perspective view of an embodiment of a heating, ventilation, and/or air conditioning (HVAC) system for environmental management that may employ one or more HVAC units, in accordance with an aspect of the present disclosure;

[0010] FIG. **2** is a perspective view of an embodiment of a packaged HVAC unit that may be used in the HVAC system of FIG. **1**, in accordance with an aspect of the present disclosure;

[0011] FIG. **3** is a cutaway perspective view of an embodiment of a residential, split HVAC system, in accordance with an aspect of the present disclosure;

[0012] FIG. **4** is a schematic of an embodiment of a vapor compression system that can be used in any of the systems of FIGS. **1-3**, in accordance with an aspect of the present disclosure;

[0013] FIG. **5** illustrates a first HVAC air measurement system that is configured to detect parameters of air flow at an inlet of a fan, in accordance with an aspect of the present disclosure;

[0014] FIG. **6** illustrates two sensors and associated sensor cables of the HVAC air measurement system of FIG. **5**, which may be electrically connected to an HVAC air measurement device, in accordance with an aspect of the present disclosure;

[0015] FIG. **7** is a front view of a host (primary) HVAC air measurement device, in accordance with an aspect of the present disclosure;

[0016] FIG. **8** is a front view of a client (ancillary) HVAC air measurement device, in accordance with an aspect of the present disclosure;

[0017] FIG. **9** is a side view of a second HVAC air measurement system that is configured to detect parameters of air flow through a duct, in accordance with an aspect of the present disclosure;

[0018] FIG. **10** are perspective views of two HVAC air measurement systems of FIG. **9**, in accordance with an aspect of the present disclosure;

[0019] FIG. **11** is a cutaway view of a duct having two HVAC air measurement systems of FIG. **9** mounted thereto, in accordance with an aspect of the present disclosure;

[0020] FIG. **12** is a schematic diagram of a host (primary) HVAC air measurement device, in accordance with an aspect of the present disclosure;

[0021] FIG. **13** is a schematic diagram of a client (ancillary) HVAC air measurement device, in accordance with an aspect of the present disclosure;

[0022] FIG. **14** illustrates a first level menu option relating to data logging being presented via a display of a host (primary) HVAC air measurement device **112**, in accordance with an aspect of the present disclosure;

[0023] FIG. **15** illustrates a second level menu option relating to data logging being presented via a display of a host (primary) HVAC air measurement device **112**, in accordance with an aspect of the present disclosure;

[0024] FIG. **16** illustrates a third level menu option relating to data logging being presented via a display of a host (primary) HVAC air measurement device **112**, in accordance with an aspect of the present disclosure;

[0025] FIG. **17** illustrates a fourth level menu option relating to data logging being presented via a display of a host (primary) HVAC air measurement device **112**, in accordance with an aspect of the present disclosure;

[0026] FIG. **18** illustrates a first level menu option relating to data transmission being presented via a display of a host (primary) HVAC air measurement device **112**, in accordance with an aspect of the present disclosure;

[0027] FIG. **19** illustrates a second level menu option relating to data transmission being presented via a display of a host (primary) HVAC air measurement device **112**, in accordance with an aspect of the present disclosure;

[0028] FIG. **20** is a flow diagram of a method for operating a host (primary) HVAC air measurement device, in accordance with an aspect of the present disclosure; and

[0029] FIG. **21** is a flow diagram of a data logging process that may be utilized using the host (primary) HVAC air measurement device, in accordance with an aspect of the present disclosure.

DETAILED DESCRIPTION

[0030] One or more specific embodiments will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be noted that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be noted that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0031] When introducing elements of various embodiments of the present disclosure, the articles "a," "an," and "the" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Additionally, it should be noted that references to "one embodiment" or "an embodiment" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features.

[0032] As used herein, the terms "real time" and "substantially real time" may refer to actions that are performed substantially simultaneously with other actions, without any human-perceptible delay between the actions. For example, two functions performed in substantially real time occur within seconds (or even within milliseconds) of each other. As but one non-limiting example, two functions performed in substantially real time occur within 1 second, within 0.1 second, within 0.01 second, and so forth, of each other.

[0033] The present disclosure is directed to heating, ventilation, and/or air conditioning (HVAC) air measurement devices configured to enable operators to select data relating to certain air flow parameters to be directly downloaded from the HVAC air measurement devices and/or to otherwise be transmitted directly from the HVAC air measurement devices in substantially real time during operation to enable operators to make analytical decisions quickly and to reduce design development timelines, among other things. In addition, the HVAC air measurement devices described herein obviate the need for: (1) separate computing devices to be connected to the HVAC air measurement devices to extract the data from the HVAC air measurement devices, and/or (2) using specialized software to extract the data from the HVAC air measurement devices, as required by conventional HVAC air measurement devices.

[0034] Turning now to the drawings, FIG. **1** illustrates an embodiment of an HVAC system for environmental management that may employ one or more HVAC units. As used herein, an HVAC system includes any number of components configured to enable regulation of parameters related to climate characteristics, such as temperature, humidity, air flow, pressure, air quality, and so forth. For example, an "HVAC system" as used herein is defined as conventionally understood and as further described herein. Components or parts of an "HVAC system" may include, but are not limited to, all, some of, or individual parts such as a heat exchanger, a heater, an air flow control device, such as a fan, a sensor configured to detect a climate characteristic or operating parameter, a filter, a control device configured to regulate operation of an HVAC system component, a component configured to enable regulation of climate characteristics, or a combination thereof. An "HVAC system" is a system configured to provide such functions as heating, cooling, ventilation, dehumidification, pressurization, refrigeration, filtration, or any combination thereof. The embodiments described herein may be utilized in a variety of applications to control climate characteristics, such as residential, commercial, industrial, transportation, or other applications where climate control is desired.

[0035] In the illustrated embodiment, a building **10** is air conditioned by a system that includes an HVAC unit **12**. The building **10** may be a commercial structure or a residential structure. As shown, the HVAC unit **12** is disposed on the roof of the building **10**; however, the HVAC unit **12** may be located in other equipment rooms or areas adjacent the building **10**. The HVAC unit **12** may be a single package unit containing other equipment, such as a blower, integrated air handler, and/or auxiliary heating unit. In other embodiments, the HVAC unit **12** may be part of a split HVAC system, such as the system shown in FIG. **3**, which includes an outdoor HVAC unit **58** and an indoor HVAC unit **56**.

[0036] The HVAC unit **12** is an air cooled device that implements a refrigeration cycle to provide conditioned air to the building **10**. Specifically, the HVAC unit **12** may include one or more heat exchangers across which an air flow is passed to condition the air flow before the air flow is supplied to the building. In the illustrated embodiment, the HVAC unit **12** is a rooftop unit (RTU) that conditions a supply air stream, such as environmental air and/or a return air flow from the building **10**. After the HVAC unit **12** conditions the air, the air is supplied to the building **10** via ductwork **14** extending throughout the building **10** from the HVAC unit **12**. For example, the ductwork **14** may extend to various individual floors or other sections of the building **10**. In certain embodiments, the HVAC unit **12** may be a heat pump that provides both heating and cooling to the building with one refrigeration circuit configured to operate in different modes. In other embodiments, the HVAC unit **12** may include one or more refrigeration circuits for cooling an air stream and a furnace for heating the air stream.

[0037] A control device **16**, one type of which may be a thermostat, may be used to designate the temperature of the conditioned air. The control device **16** also may be used to control the flow of air through the ductwork **14**. For example, the control device **16** may be used to regulate operation of one or more components of the HVAC unit **12** or other components, such as dampers and fans, within the building **10** that may control flow of air through and/or from the ductwork **14**. In some embodiments, other devices may be included in the system, such as pressure and/or temperature transducers or switches that sense the temperatures and pressures of the supply air, return air, and so forth. Moreover, the control device **16** may include computer systems that are integrated with or separate from other building control or monitoring systems, and even systems that are remote from the building **10**.

[0038] FIG. **2** is a perspective view of an embodiment of the HVAC unit **12**. In the illustrated embodiment, the HVAC unit **12** is a single package unit that may include one or more independent refrigeration circuits and components that are tested, charged, wired, piped, and ready for installation. The HVAC unit **12** may provide a variety of heating and/or cooling functions, such as cooling only, heating only, cooling with electric heat, cooling with dehumidification, cooling with gas heat, or cooling with a heat pump. As described above, the HVAC unit **12** may directly cool and/or heat an air stream provided to the building **10** to condition a space in the building **10**.

[0039] As shown in the illustrated embodiment of FIG. **2**, a cabinet **24** encloses the HVAC unit **12** and provides structural support and protection to the internal components from environmental and other contaminants. In some embodiments, the cabinet **24** may be constructed of galvanized steel and insulated with aluminum foil faced insulation. Rails **26** may be joined to the bottom perimeter of the cabinet **24** and provide a foundation for the HVAC unit **12**. In certain embodiments, the rails **26** may provide access for a forklift and/or overhead rigging to facilitate installation and/or removal of the HVAC unit **12**. In some embodiments, the rails **26** may fit onto "curbs" on the roof to enable the HVAC unit **12** to provide air to the ductwork **14** from the bottom of the HVAC unit **12** while blocking elements such as rain from leaking into the building **10**.

[0040] The HVAC unit **12** includes heat exchangers **28** and **30** in fluid communication with one or more refrigeration circuits. Tubes within the heat exchangers **28** and **30** may circulate refrigerant, such as R-410A, through the heat exchangers **28** and **30**. The tubes may be of various types, such as multichannel tubes, conventional copper or aluminum tubing, and so forth. Together, the heat exchangers **28** and **30** may implement a thermal cycle in which the refrigerant undergoes phase changes and/or temperature changes as it flows through the heat exchangers **28** and **30** to produce heated and/or cooled air. For example, the heat exchanger **28** may function as a condenser where heat is released from the refrigerant to ambient air, and the heat exchanger **30** may function as an evaporator where the refrigerant absorbs heat to cool an air stream. In other embodiments, the HVAC unit **12** may operate in a heat pump mode where the roles of the heat exchangers **28** and **30** may be reversed. That is, the heat exchanger **28** may function as an evaporator and the heat exchanger **30** may function as a condenser. In further embodiments, the HVAC unit **12** may include a furnace for heating the air stream that is supplied to the building **10**. While the illustrated embodiment of FIG. **2** shows the HVAC unit **12** having two of the heat exchangers **28** and **30**, in other embodiments, the HVAC unit **12** may include one heat exchanger or more than two heat exchangers.

[0041] The heat exchanger **30** is located within a compartment **31** that separates the heat exchanger **30** from the heat exchanger **28**. Fans **32** draw air from the environment through the heat exchanger **28**. Air may be heated and/or cooled as the air flows through the heat exchanger **28** before being released back to the environment surrounding the HVAC unit **12**. A blower assembly **34**, powered by a motor **36**, draws air through the heat exchanger **30** to heat or cool the air. The heated or cooled air may be directed to the building **10** by the ductwork **14**, which may be connected to the HVAC unit **12**. Before flowing through the heat exchanger **30**, the conditioned air flows through one or more filters **38** that may remove particulates and contaminants from the air. In certain embodiments, the filters **38** may be disposed on the air intake side of the heat exchanger **30** to prevent contaminants from contacting the heat exchanger **30**.

[0042] The HVAC unit **12** also may include other equipment for implementing the thermal cycle. Compressors **42** increase the pressure and temperature of the refrigerant before the refrigerant enters the heat exchanger **28**. The compressors **42** may be any suitable type of compressors, such as scroll compressors, rotary compressors, screw compressors, or reciprocating compressors. In some embodiments, the compressors **42** may include a pair of hermetic direct drive compressors arranged in a dual stage configuration **44**. However, in other embodiments, any number of the compressors **42** may be provided to achieve various stages of heating and/or cooling. Additional equipment and devices may be included in the HVAC unit **12**, such as a solid-core filter drier, a drain pan, a disconnect switch, an economizer, pressure switches, phase monitors, and humidity sensors, among other things.

[0043] The HVAC unit **12** may receive power through a terminal block **46**. For example, a high voltage power source may be connected to the terminal block **46** to power the equipment. The operation of the HVAC unit **12** may be governed or regulated by a control board **48**. The control board **48** may include control circuitry connected to a thermostat, sensors, and alarms. One or more of these components may be referred to herein separately or collectively as the control device **16**. The control circuitry may be configured to control operation of the equipment, provide alarms, and monitor safety switches. Wiring **49** may connect the control board **48** and the terminal block **46** to the equipment of the HVAC unit **12**.

[0044] FIG. **3** illustrates a residential heating and cooling system **50**, also in accordance with present techniques. The residential heating and cooling system **50** may provide heated and cooled air to a residential structure, as well as provide outside air for ventilation and provide improved indoor air quality (IAQ) through devices such as ultraviolet lights and air filters. In the illustrated embodiment, the residential heating and cooling system **50** is a split HVAC system. In general, a residence **52** conditioned by a split HVAC system may include refrigerant conduits **54** that operatively couple the indoor unit **56** to the outdoor unit **58**. The indoor unit **56** may be positioned in a utility room, an attic, a basement, and so forth. The outdoor unit **58** is typically situated adjacent to a side of residence **52** and is covered by a shroud to protect the system components and to prevent leaves and other debris or contaminants from entering the unit. The refrigerant conduits **54** transfer refrigerant between the indoor unit **56** and the outdoor unit **58**, typically transferring primarily liquid refrigerant in one direction and primarily vaporized refrigerant in an opposite direction.

[0045] When the system shown in FIG. **3** is operating as an air conditioner, a heat exchanger **60** in the outdoor unit **58** serves as a condenser for re-condensing vaporized refrigerant flowing from the indoor unit **56** to the outdoor unit **58** via one of the refrigerant conduits **54**. In these applications, a heat exchanger **62** of the indoor unit functions as an evaporator. Specifically, the heat exchanger **62** receives liquid refrigerant, which may be expanded by an expansion device, and evaporates the refrigerant before returning it to the outdoor unit **58**.

[0046] The outdoor unit **58** draws environmental air through the heat exchanger **60** using a fan **64** and expels the air above the outdoor unit **58**. When operating as an air conditioner, the air is heated by the heat exchanger **60** within the outdoor unit **58** and exits the unit at a temperature higher than it entered. The indoor unit **56** includes a blower or fan **66** that directs air through or across the indoor heat exchanger **62**, where the air is cooled when the system is operating in air conditioning mode. Thereafter, the air is passed through ductwork **68** that directs the air to the residence **52**. The overall system operates to maintain a desired temperature as set by a system controller. When the temperature sensed inside the residence **52** is higher than the set point on the thermostat, or the set point plus a small amount, the residential heating and cooling system **50** may become operative to refrigerate additional air for circulation through the residence **52**. When the temperature reaches the set point, or the set point minus a small amount, the residential heating and cooling system **50** may stop the refrigeration cycle temporarily.

[0047] The residential heating and cooling system **50** may also operate as a heat pump. When operating as a heat pump, the roles of heat exchangers **60** and **62** are reversed. That is, the heat exchanger **60** of the outdoor unit **58** will serve as an evaporator to evaporate refrigerant and thereby cool air entering the outdoor unit **58** as the air passes over the outdoor heat exchanger **60**. The indoor heat exchanger **62** will receive a stream of air blown over it and will heat the air by condensing the refrigerant.

[0048] In some embodiments, the indoor unit **56** may include a furnace system **70**. For example, the indoor unit **56** may include the furnace system **70** when the residential heating and cooling system **50** is not configured to operate as a heat pump. The furnace system **70** may include a burner assembly and heat exchanger, among other components, inside the indoor unit **56**. Fuel is provided to the burner assembly of the furnace **70** where it is mixed with air and combusted to form combustion products. The combustion products may pass through tubes or piping in a heat exchanger, separate from heat exchanger **62**, such that air directed by the blower **66** passes over the tubes or pipes and extracts heat from the combustion products. The heated air may then be routed from the furnace system **70** to the ductwork **68** for heating the residence **52**.

[0049] FIG. **4** is an embodiment of a vapor compression system **72** that can be used in any of the systems described above. The vapor compression system **72** may circulate a refrigerant through a circuit starting with a compressor **74**. The circuit may also include a condenser **76**, an expansion valve(s) or device(s) **78**, and an evaporator **80**. The vapor compression system **72** may further include a control panel **82** that has an analog to digital (A/D) converter **84**, a microprocessor **86**, a non-volatile memory **88**, and/or an interface board **90**. The control panel **82** and its components may function to regulate operation of the vapor compression system **72** based on feedback from an operator, from sensors of the vapor compression system **72** that detect operating conditions, and so forth.

[0050] In some embodiments, the vapor compression system **72** may use one or more of a variable speed drive (VSDs) **92**, a motor **94**, the compressor **74**, the condenser **76**, the expansion valve or device **78**, and/or the evaporator **80**. The motor **94** may drive the compressor **74** and may be powered by the variable speed drive (VSD) **92**. The VSD **92** receives alternating current (AC) power having a particular fixed line voltage and fixed line frequency from an AC power source, and provides power having a variable voltage and frequency to the motor **94**. In other embodiments, the motor **94** may be powered directly from an AC or direct current (DC) power source. The motor **94** may include any type of electric motor that can be powered by a VSD or directly from an AC or DC power source, such as a switched reluctance motor, an induction motor, an electronically commutated permanent magnet motor, or another suitable motor.

[0051] The compressor **74** compresses a refrigerant vapor and delivers the vapor to the condenser **76** through a discharge passage. In some embodiments, the compressor **74** may be a centrifugal compressor. The refrigerant vapor delivered by the compressor **74** to the condenser **76** may transfer heat to a fluid passing across the condenser **76**, such as ambient or environmental air **96**. The refrigerant vapor may condense to a refrigerant liquid in the condenser **76** as a result of thermal heat transfer with the environmental air **96**. The liquid refrigerant from the condenser **76** may flow through the expansion device **78** to the evaporator **80**.

[0052] The liquid refrigerant delivered to the evaporator **80** may absorb heat from another air stream, such as a supply air stream **98** provided to the building **10** or the residence **52**. For example, the supply air stream **98** may include ambient or environmental air, return air from a building, or a combination of the two. The liquid refrigerant in the evaporator **80** may undergo a phase change from the liquid refrigerant to a refrigerant vapor. In this manner, the evaporator **80** may reduce the temperature of the supply air stream **98** via thermal heat transfer with the refrigerant. Thereafter, the vapor refrigerant exits the evaporator **80** and returns to the compressor **74** by a suction line to complete the cycle.

[0053] In some embodiments, the vapor compression system **72** may further include a reheat coil in addition to the evaporator **80**. For example, the reheat coil may be positioned downstream of the evaporator relative to the supply air stream **98** and may reheat the supply air stream **98** when the supply air stream **98** is overcooled to remove humidity from the supply air stream **98** before the supply air stream **98** is directed to the building **10** or the residence **52**.

[0054] Any of the features described herein may be incorporated with the HVAC unit **12**, the residential heating and cooling system **50**, or other HVAC systems. Additionally, while the features disclosed herein are described in the context of embodiments that directly heat and cool a supply air stream provided to a building or other load, embodiments of the present disclosure may be applicable to other HVAC systems as well. For example, the features described herein may be applied to mechanical cooling systems, free cooling systems, chiller systems, or other heat pump or refrigeration applications.

[0055] The embodiments described herein relate to HVAC air measurement systems configured to enable operators to select data relating to certain air flow parameters to be directly downloaded from the HVAC air measurement devices and/or to otherwise be transmitted directly from the HVAC air measurement devices in substantially real time during operation to enable operators to make analytical decisions quickly and to reduce design development timelines, among other things. In addition, the HVAC air measurement devices described herein obviate the need for: (1) separate computing devices to be connected to the HVAC air measurement devices to extract the data from the HVAC air measurement devices, and/or (2) using specialized software to extract the data from the HVAC air measurement devices, as required by conventional HVAC air measurement devices.

[0056] The techniques described herein may be utilized in various types of HVAC air measurement systems. FIGS. **5** through **11** illustrate two exemplary types of HVAC air measurement systems. For example, FIG. **5** illustrates a first HVAC air measurement system **100** that is configured to detect parameters of air flow at an inlet **102** of a fan **104**. For example, as illustrated in FIG. **5**, one or more sensors **106** may be disposed in an air flow path defined by the inlet **102** of the fan **104** such that the sensors **106** can detect parameters of air flow through the air flow path defined by the inlet **102** of the fan **104** during operation of the fan **104**.

[0057] As illustrated in FIG. **6**, in certain embodiments, each of the sensors **106** may be connected to respective sensor cables **108** that have electrical connectors **110** disposed at opposite ends of the sensor cables **108** from the sensors **106**, wherein the electrical connectors **110** enable the sensors **106** to be electrically connected to a host (or "primary") HVAC air measurement device **112** via mating electrical connectors of the host (primary) HVAC air measurement device **112**, as illustrated in FIG. **5**. In certain embodiments, the sensors **106** (as well as the sensors **132** described below) may be thermal dispersion type sensors. However, any other suitable sensors may be used in conjunction with the data logging and transmission techniques described herein.

[0058] As illustrated in FIG. **7**, the host (primary) HVAC air measurement device **112** includes a housing **114** that, in certain embodiments, includes one or more mounting mechanisms **116** that enable the host (primary) HVAC air measurement device **112** to be mounted to a portion of an HVAC system. In addition, in certain embodiments, the housing **114** includes one or more release mechanisms **118** configured to release a front portion of the housing **114** from a back portion of the housing **114** to enable the front portion of the housing **114** to swing open via a hinge **120** that connects the front portion of the housing **114** from the back portion of the housing **114** such that control circuitry of the HVAC air measurement device **112**, which is enclosed within the housing **114**, may be accessible to operators. In addition, in certain embodiments, the housing **114** includes one or more electrical connectors that are configured to electrically connect the host (primary) HVAC air measurement device **112** to certain sensors **106**.

[0059] In addition, as also illustrated in FIG. **7**, the host (primary) HVAC air measurement device **112** includes a display **122** disposed on an outer surface **124** of the housing **114**. As described in greater detail herein, the display **122** may be used to present certain menu options to operators of an HVAC system, wherein the menu options relate to parameters of air flow through the HVAC system. In certain embodiments, the display **122** may be a liquid crystal display (LCD), however, any suitable display may be used in other embodiments. In addition, in certain embodiments, the host (primary) HVAC air measurement device **112** includes one or more inputs **126** disposed on the outer surface **124** of the housing **114**. As described in greater detail herein, the inputs **126** may be used by operators to select certain parameters of air flow through an HVAC system to be directly downloaded from the host (primary) HVAC air measurement device **112** and/or to otherwise be transmitted directly from the host (primary) HVAC air measurement device **112**, as described in greater detail herein.

[0060] In the illustrated embodiment, the inputs **126** include: (1) a “MENU” button that may be selected by an operator to cause menu options to be presented via the display **122** of the host (primary) HVAC air measurement device **112**, (2) an “ESC” button that may be selected by an operator to escape from the menu options (e.g., to cause the menu options to be removed from display via the display **122** of the host (primary) HVAC air measurement device **112**), (3) an “UP” button that may be selected by an operator to move up among a current level of menu options presented via the display **122** of the host (primary) HVAC air measurement device **112**, (4) a “DOWN” button that may be selected by an operator to move down among a current level of menu options presented via the display **122** of the host (primary) HVAC air measurement device **112**, and (5) an “ENTER” button that may be selected by an operator to select a menu option that is currently displayed via the display **122** of the host (primary) HVAC air measurement device **112**. Although illustrated in FIG. **7** as being buttons that may be selected by an operator, in other embodiments, the inputs **126** may take different forms. For example, in certain embodiments, the inputs **126** may be integrated into the display **122**, for example, in embodiments where the display **122** is a touch screen display.

[0061] As described in greater detail herein, the control circuitry of the host (primary) HVAC air measurement device **112** that is enclosed within the housing **114** of the host (primary) HVAC air measurement device **112** may be configured to be electrically connected to certain sensors **106**; to display a parameter selection menu via the display **122** of the host (primary) HVAC air measurement device **112**, wherein the parameter selection menu presents certain parameters detected by the sensors **106** as selectable parameter options; to receive parameter selection commands from the inputs **126** of the host (primary) HVAC air measurement device **112**, wherein the parameter selection commands relate to parameters selected via the parameter selection menu; to receive data relating to parameters from certain sensors **106**; and to transmit data relating to the selected parameters directly from the host (primary) HVAC air measurement device **112** based at least in part on the parameter selection commands.

[0062] As described in greater detail herein, in certain embodiments, the host (primary) HVAC air measurement device **112** may be electrically connected to, and receive data from, certain sensors **106**, whereas one or more client (or “ancillary”) HVAC air measurement devices **128** may be electrically connected to, and receive data from, other sensors **106**. In such embodiments, the host (primary) HVAC air measurement device **112** may function as a hub that collects data from the other client (ancillary) HVAC air measurement device(s) **128**, and processes both the data collected from the other client (ancillary) HVAC air measurement device(s) **128** as well as data received from its respective sensors **106**. In such embodiments, the menu selection commands that are received by the host (primary) HVAC air measurement device **112** may apply to data collected by the host (primary) HVAC air measurement device **112** as well as data collected by the client (ancillary) HVAC air measurement device(s) **128**. As illustrated in FIG. **8**, in certain embodiments, the client (ancillary) HVAC air measurement device(s) **128** may be substantially similar to the host (primary) HVAC air measurement device **112**. However, in certain embodiments, the client (ancillary) HVAC air measurement device(s) **128** do not include displays **122** or inputs **126** disposed on an outer surface **124** of a housing **114** of the client (ancillary) HVAC air measurement device(s) **128**.

[0063] FIGS. **5** through **8** illustrate a first type of HVAC air measurement system **100**, and FIGS. **9** through **11** illustrate a second type of HVAC air measurement system **130**. As illustrated, the host (primary) HVAC air measurement device **112** and the client (ancillary) HVAC air measurement device(s) **128** of the embodiments illustrated in FIGS. **9** through **11** may be substantially similar to the host (primary) HVAC air measurement device **112** and the client (ancillary) HVAC air measurement device(s) **128** of the embodiments illustrated in FIGS. **5** through **8**. However, as illustrated in FIG. **9**, sensors **132** may be mounted to an airfoil-shaped sensor array beam **134** that extends from the back portion **136** of the HVAC air measurement device(s) **112**, **128** at a first end of the sensor array beam **134** to a mounting plate **138** at a second, opposite end of the sensor array beam **134**.

[0064] As illustrated in FIG. **11**, the HVAC air measurement system(s) **130** may be mounted within a duct **140** of an HVAC system by, for example, mounting the HVAC air measurement device(s) **112**, **128** to a first wall **142** of the duct **140** (e.g., using the mounting mechanisms **116** of the HVAC air measurement device(s) **112**, **128** described above) and mounting the mounting plate(s) **138** to a second, opposite wall **144** of the duct **140**. In general, the airfoil-shaped sensor array beams **134** ensure that the HVAC air measurement system(s) **130** cause a relatively low pressure drop and relatively low noise levels during operation of the HVAC system of which the duct **140** is part.

[0065] The HVAC air measurement systems **100**, **130** illustrated in FIGS. **5** through **11** are merely exemplary, and not intended to be limiting, of the types of HVAC air measurement systems that may utilize the air measurement data logging and transmission techniques described herein. Indeed, any and all HVAC air measurement systems may leverage the air measurement data logging and transmission techniques described herein. In general, each of the HVAC air measurement systems **100**, **130** described herein include an HVAC air measurement device **112**, **128** that is configured to be electrically connected to one or more sensors **106**, **132** that are configured to detect parameters of air flow through air flow paths of HVAC systems. In addition, as described in greater detail herein, a host (primary) HVAC air measurement device **112** may be used to collect data relating to the parameters of air flow through air flow paths of an HVAC system from sensor(s) **106**, **132** that are directly electrically connected to the host (primary) HVAC air measurement device **112**, as well as collecting data relating to the parameters of air flow through the air flow paths of the HVAC system from one or more client (ancillary) HVAC air measurement devices **128** that are directly electrically connected to other sensor(s) **106**, **132**, in certain embodiments.

[0066] FIG. **12** is a schematic diagram of a host (primary) HVAC air measurement device **112**, as described herein. As described above, the host (primary) HVAC air measurement device **112** includes one or more inputs **126** configured to be manipulated by an operator to enable the operator to make menu selections from menu options presented via a display **122** of the host (primary) HVAC air measurement device **112**, wherein the menu options relate to parameters of air flowing through an air flow path of an HVAC system that are detected by one or more sensors **106**, **132** that are electrically connected to the host (primary) HVAC air measurement device **112**. For example, in certain embodiments, one or more sensors **106** of an HVAC air measurement system **100** may be electrically connected to the host (primary) HVAC air measurement device **112** via one or more electrical connectors **146** of the host (primary) HVAC air measurement device **112**, which may be directly coupled to mating electrical connectors **110** of sensor cables **108** associated with the one or more sensors **106**, as described above. In other embodiments, one or more electrical connectors **146** of the host (primary) HVAC air measurement device **112** may be directly connected to one or more sensors **132** of an HVAC air measurement system **130**, for example, via respective electrical wires that are disposed within an interior of a sensor array beam **134** of the HVAC air measurement system **130**, which is directly coupled to a back portion **136** of the host (primary) HVAC air measurement device **112**, as described above.

[0067] In addition, as described in greater detail herein, the host (primary) HVAC air measurement device **112** includes control circuitry **148** that enables the host (primary) HVAC air measurement device **112** to perform the data logging and transmission techniques described in greater detail herein. In certain embodiments, the control circuitry **148** includes memory media **150** and processing circuitry **152**. The memory media **150** may include a non-transitory computer-readable medium that may store instructions that, when executed by the processing circuitry **152**, may cause the processing circuitry **152** to perform the data logging and transmission techniques described in greater detail herein. In certain embodiments, the processing circuitry **152** may be any suitable type of computer processor or microprocessor capable of executing computer-executable code, including but not limited to one or more field programmable gate arrays (FPGA), application-specific integrated circuits (ASIC), programmable logic devices (PLD), programmable logic arrays (PLA), and the like.

[0068] In addition, in certain embodiments, the host (primary) HVAC air measurement device **112** may include one or more memory card ports **154**, each of which may receive a memory card (e.g., a secure digital (SD) card, a MicroSD card, a flash drive, a memory stick, or any other suitable memory card) such that data relating to parameters of air flow through air flow paths of an HVAC system that have been selected by an operator may be directly downloaded onto the memory card, as described in greater detail herein. In addition, in certain embodiments, the host (primary) HVAC air measurement device **112** may include a communication interface **156** that enables communication with other devices, such as the client (ancillary) HVAC air measurement devices **128** described herein as well as external computing devices. For example, in certain embodiments, the communication interface **156** may enable the host (primary) HVAC air measurement device **112** to receive data from one or more client (ancillary) HVAC air measurement devices **128** (e.g., to which the host (primary) HVAC air measurement device **112** is either directly electrically connected, or at least communicatively coupled with) and, in certain embodiments, to transmit data (e.g., either wired or wirelessly) to one or more external computing devices, such as a building management system, cloud storage service, and so forth, as described in greater detail herein. In certain embodiments, the communication interfaces **156** described herein may utilize customized universal asynchronous receiver-transmitter (UART) hardware to enable the HVAC air measurement devices **112**, **128** to communication with each other, and to enable the host (primary) HVAC air measurement device **112** to communicate with external computing devices, as described in greater detail herein. In addition, in certain embodiments, the host (primary) HVAC air measurement device **112** may be configured to automatically (e.g., without human intervention) convert the data into a data format that is specifically suitable for a particular external computing device to receive, for example, in the case of a third party computing device that uses a different data format than that used locally by the HVAC air measurement devices **112**, **128**.

[0069] FIG. **13** is a schematic diagram of a client (ancillary) HVAC air measurement device **128**, as described herein. As illustrated in FIG. **13**, in certain embodiments, the client (ancillary) HVAC air measurement device **128** may be substantially similar to the host (primary) HVAC air measurement device **112** of FIG. **12**. However, as described in greater detail herein, the client (ancillary) HVAC air measurement device **128** may not include inputs **126**, a display **122**, or memory card ports **154**. However, in certain embodiments, the client (ancillary) HVAC air measurement device **128** may include a communication interface **156** that enables communication with a host (primary) HVAC air measurement device **112** to enable the client (ancillary) HVAC air measurement device **128** to transmit data to an associated host (primary) HVAC air measurement device **112**, wherein the data relates to parameters of air flow through air flow paths of an HVAC system that have been selected by an operator via an associated host (primary) HVAC air measurement device **112**, and which has been collected by one or more sensors **106**, **132** that are electrically connected to the client (ancillary) HVAC air measurement device **128**, as described in greater detail herein.

[0070] As described in greater detail herein, the host (primary) HVAC air measurement device **112** is configured to present operators with menu options that may be used to select certain parameters of air flow through air flow paths of an HVAC system that are detected by one or more sensors **106**, **132** disposed within the air flow paths, and to transmit the data directly from the host (primary) HVAC air measurement device **112** (e.g., by downloading the data to a memory card received into a memory card port **154** of the host (primary) HVAC air measurement device **112** and/or by transmitting the data directly from the host (primary) HVAC air measurement device **112** to an external computing device such as a building management system, a cloud storage service, and so forth) without the need to directly connect other computing devices to the host (primary) HVAC air measurement device **112**, without the need to use additional software, and so forth. In addition, the menu options presented via the display **122** of the host (primary) HVAC air measurement device **112** may be presented as hierarchical menu options that enable relatively complex data logging and data transmission, as described in greater detail herein. For example, FIG. **14** illustrates an example first level menu option being presented via the display **122** of the host (primary) HVAC air measurement device **112** (in this instance, "Data Logging"), which may be scrolled to by manipulating the "MENU" button of the inputs **126** of the host (primary) HVAC air measurement device **112** and scrolling up or down by manipulating the "UP" or "DOWN" buttons of the inputs **126**, and may be selected by manipulating the "ENTER" button of the inputs **126**.

[0071] Then, once the first level "Data Logging" menu option is selected, as illustrated in FIG. **15**, second level menu options may be presented via the display **122** of the host (primary) HVAC air measurement device **112**, which may enable the selection of different parameters of air flow through air flow paths of an HVAC system that are detected by one or more sensors **106**, **132** disposed within the air flow paths. As illustrated in FIG. **15**, one example second level menu option may include "Temperature" of the air flow through the air flow paths of the HVAC system detected by the one or more sensors **106**, **132**. However, other second level menu options may include "Flow Rate" of the air flow through the air flow paths of the HVAC system detected by the one or more sensors **106**, **132**, "Relative Humidity" of the air flow through the air flow paths of the HVAC system detected by the one or more sensors **106**, **132**, "Barometric Pressure" of the air flow through the air flow paths of the HVAC system detected by the one or more sensors **106**, **132**, "Refrigerant Detection" of refrigerant within the air flow through the air flow paths of the HVAC system (e.g., due to refrigerant leaks) detected by the one or more sensors **106**, **132**, or any other parameter of air flow through the air flow paths of the HVAC system that are detected by one or more sensors **106**, **132**. In certain embodiments, an operator may select a particular parameter from the second level menu options by manipulating the "Enter" button of the inputs **126** of the host (primary) HVAC air measurement device **112** when the particular parameter is presented via the display **122** of the host (primary) HVAC air measurement device **112**, and then the operator may select other parameters from the second level menu options by again manipulating the "Enter" button of the inputs **126** when the other parameters are presented via the display **122**. As such, the host (primary) HVAC air measurement device **112** may enable the selection of multiple parameters by, in other words, enabling toggling of any of the second level menu options until a final "Finish Parameter Selections" second level menu option is selected by manipulating the "Enter" button of the inputs **126** when the "Finish Parameter Selections" second level menu option is presented via the display **122**.

[0072] Then, once the second level "Finish Parameter Selections" menu option is selected, as illustrated in FIG. **16**, third level menu options may be presented via the display **122** of the host (primary) HVAC air measurement device **112**, which may enable the selection of various sensors **106**, **132** disposed within the air flow paths of the HVAC system. As illustrated in FIG. **16**, the sensors **106**, **132** may have names that may be recognized by an operator (e.g., "Fan **22** Inlet" in the illustrated example). In certain embodiments, an operator may select a particular sensor **106**, **132** from the third level menu options by manipulating the "Enter" button of the inputs **126** of the host (primary) HVAC air measurement device **112** when the particular sensor **106**, **132** is presented via the display **122** of the host (primary) HVAC air measurement device **112**, and then the operator may select other sensors **106**, **132** from the third level menu options by again manipulating the "Enter" button of the inputs **126** when the other sensors **106**, **132** are presented via the display **122**. As such, the host (primary) HVAC air measurement device **112** may enable the selection of multiple sensors **106**, **132** by, in other words, enabling toggling of any of the third level menu options until a final "Finish Sensor Selections" third level menu option is selected by manipulating the "Enter" button of the inputs **126** when the "Finish Sensor Selections" third level menu option is presented via the display **122**.

[0073] Then, once the third level "Finish Sensor Selections" menu option is selected, as illustrated in FIG. **17**, fourth level menu options may be presented via the display **122** of the host (primary) HVAC air measurement device **112**, which may enable the selection of a data logging frequency at which data may be collected from the selected one or more sensors **106**, **132** disposed within the air flow paths of the HVAC system. As illustrated in FIG. **17**, one example fourth level menu option may include "Every 1.0 Second". However, other fourth level menu options may include "Every 5.0 Seconds", "Every 15 Seconds", "Every 30 Seconds", "Every 1.0 Minute", "Every 5.0 Minutes", "Every 15 Minutes", "Every 30 Minutes", "Every 1.0 Hour", or any other data logging frequency at which data may be collected from the selected one or more sensors **106**, **132**. In certain embodiments, an operator may select a particular data logging frequency from the fourth level menu options by manipulating the "Enter" button of the inputs **126** of the host (primary) HVAC air measurement device **112** when the particular data logging frequency is presented via the display **122** of the host (primary) HVAC air measurement device **112**. Once the particular parameters of air flow through the air flow paths of the HVAC system, the particular sensors **106**, **132** detecting the particular parameters of air flow through the air flow paths of the HVAC system, and the data logging frequency are selected by an operator, a data logging loop may be created by the host (primary) HVAC air measurement device **112**, as described in greater detail herein.

[0074] Then, at any time after the data logging loop has had an opportunity to run (e.g., and the data relating to the selected parameters of air flow through the air flow paths of the HVAC system has been collected and stored in the memory media **150** of the host (primary) HVAC air measurement device **112**), an operator may select to have the created data log to be transmitted directly from the host (primary) HVAC air measurement device **112**. For example, FIG. **18** illustrates another example first level menu option being presented via the display **122** of the host (primary) HVAC air measurement device **112** (in this instance, "Data Transmission"), which may be scrolled to by manipulating the "MENU" button of the inputs **126** of the host (primary) HVAC air measurement device **112** and scrolling up or down by manipulating the "UP" or "DOWN" buttons of the inputs **126**, and may be selected by manipulating the "ENTER" button of the inputs **126**.

[0075] Then, once the first level "Data Transmission" menu option is selected, as illustrated in FIG. **19**, second level menu options may be presented via the display **122** of the host (primary) HVAC air measurement device **112**, which may enable the selection of a transmission method by which a data log may be transmitted. As illustrated in FIG. **19**, one example second level menu option may include "Wireless to BMS" (e.g., meaning to wirelessly transmit the data log to a building management system associated with an HVAC system to which the data log relates). However, other second level menu options may include a list of different transmission options for the data log, such as wired communication to the building management system, wired or wireless communication to a cloud storage service, direct downloading into a memory card that is inserted into a memory card port **154** of the host (primary) HVAC air measurement device **112**, or any other suitable data transmission method to one or more external computing devices, as described in greater detail herein. In certain embodiments, an operator may select a particular data transmission method from the second level menu options by manipulating the "Enter" button of the inputs **126** of the host (primary) HVAC air measurement device **112** when the particular data transmission method is presented via the display **122** of the host (primary) HVAC air measurement device **112**, at which point the host (primary) HVAC air measurement device **112** may begin transmitting the data log using the selected data transmission method.

[0076] It will be appreciated that the menu options described with reference to FIGS. **14** through **19** are merely exemplary, and are not intended to be limiting. In particular, in other embodiments, additional or fewer menu options relating to data logging and/or data transmission may be presented to operators, and used by the host (primary) HVAC air measurement device **112** to determine how to collect and/or transmit data relating to parameters of air flow through air flow paths of HVAC systems, as described in greater detail herein.

[0077] FIG. **20** is a flow diagram of a method **158** for operating the host (primary) HVAC air measurement device **112** described in greater detail herein. As illustrated in FIG. **20**, in certain embodiments, the method **158** includes displaying, via control circuitry **148** of the host (primary) HVAC air measurement device **112**, a parameter selection menu via the display **122** of the host (primary) HVAC air measurement device **112**, wherein the parameter selection menu presents one or more parameters of air flow through an air flow path of an HVAC system as one or more selectable parameter options, wherein the one or more parameters are detected by one or more sensors **106**, **132** disposed within the air flow path of the HVAC system (block **160**). In addition, in certain embodiments, the method **158** includes receiving, via the control circuitry **148** of the HVAC air measurement device **112**, one or more parameter selection commands from one or more inputs **126** of the HVAC air measurement device **112**, wherein the one or more parameter selection commands relate to one or more selected parameters of the one or more parameters (block **162**). In addition, in certain embodiments, the method **158** includes receiving, via the control circuitry **148** of the HVAC air measurement device **112**, data relating to the one or more parameters from the one or more sensors **106**, **132** (block **164**). In addition, in certain embodiments, the method **158** includes transmitting, via the control circuitry **148** of the HVAC air measurement device **112**, data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device **112** based at least in part on the one or more parameter selection commands (block **166**).

[0078] In addition, in certain embodiments, transmitting, via the control circuitry **148** of the HVAC air measurement device **112**, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device **112** includes transmitting the data to a building management system. In addition, in certain embodiments, transmitting, via the control circuitry **148** of the HVAC air measurement device **112**, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device **112** includes transmitting the data to a cloud storage service. In addition, in certain embodiments, transmitting, via the control circuitry **148** of the HVAC air measurement device **112**, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device **112** includes storing the data on a memory card received by a memory card port **154** of the HVAC air measurement device **112**. In certain embodiments, historical data may be stored in the memory media **150** of the HVAC air measurement device **112**, which may include both data logged and transmitted, as described in greater detail herein, as well as data collected over time by the HVAC air measurement device **112**.

[0079] In addition, in certain embodiments, the parameter selection menu presents one or more data logging frequencies as one or more selectable data logging frequency options, and the method **158** includes receiving, via the control circuitry **148** of the HVAC air measurement device **112**, a data logging frequency selection command from the one or more inputs **126**, wherein the data logging frequency selection command relates to a selected data logging frequency; logging, via the control circuitry **148** of the HVAC air measurement device **112**, the data relating to the one or more parameters in a log file at the selected data logging frequency; and transmitting, via the control circuitry **148** of the HVAC air measurement device **112**, the log file directly from the HVAC air measurement device **112**.

[0080] In addition, in certain embodiments, the parameter selection menu presents the one or more sensors **106**, **132** as one or more selectable sensor options, and the method **158** includes receiving, via the control circuitry **148** of the HVAC air measurement device **112**, one or more sensor selection commands from the one or more inputs **126**, wherein the one or more sensor selection commands relate to one or more selected sensors **106**, **132** of the one or more sensors **106**, **132**; and transmitting, via the control circuitry **148** of the HVAC air measurement device **112**, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device **112** based at least in part on the one or more sensor selection commands.

[0081] In addition, in certain embodiments, the method **158** includes receiving, via the control circuitry **148** of the host (primary) HVAC air measurement device **112**, a subset of the data relating to the one or more parameters from one or more client (ancillary) HVAC air measurement devices **128**.

[0082] FIG. **21** is a flow diagram of a data logging process **168** that may be utilized using the HVAC air measurement devices **112**, **128** described herein. As illustrated in FIG. **21**, the data logging process **168** may begin with booting the host (primary) HVAC air measurement device **112** (block **170**), after which the host (primary) HVAC air measurement device **112** may load data logging settings, for example, from the memory media **150** of the host (primary) HVAC air measurement device **112** (block **172**) and, in certain embodiments, a command to reset a data logging device (e.g., a client (ancillary) HVAC air measurement device **128**, in certain situations) (block **174**). At this point, a decision may be made whether data logging is enabled for the particular HVAC air measurement device **112**, **128** (decision branch **176**). If data logging is not enabled for the HVAC air measurement device **112**, **128**, then the data logging process **168** ends (block **178**). However, if data logging is enabled for the HVAC air measurement device **112**, **128**, then the data logging process **168** starts a data logging loop (block **180**).

[0083] At this point, a decision may be made whether it is time for a new data logging event (decision branch **182**). If it is not time for a new data logging event, the data logging process **168** begins the data logging loop again (block **180**). However, if it is time for a new data logging event, a decision may be made whether a new log file needs to be started (decision branch **184**). In certain embodiments, a new log file may be started for the first log file since boot or when a full **24** hours have passed starting a new log file for the next day. If a new log file does not need to be started, the data logging process **168** may proceed to sending data to the log file (block **186**). However, if a new log file does need to be started, the data logging process **168** may continue by setting a new log file name (block **188**). In certain embodiments, the log file name may follow a predefined naming convention, such as MBBBBDDD.csv, where M=type of the HVAC air measurement device **112**, **128** (e.g., H=host, P=primary, C=client, and A=ancillary), BBBB=a number of boots since data logging was enabled for the HVAC air measurement device **112**, **128**, and DDD=a number of days of data logging on the current boot number.

[0084] After the new log file has been named, a command may be sent for the data logging device to start a new log file using the new log file name (e.g., a command being sent from a host (primary) HVAC air measurement device **112** to a client (ancillary) HVAC air measurement device **128**) (block **190**). Then, header text for the new log file may be sent (e.g., from a host (primary) HVAC air measurement device **112** to a client (ancillary) HVAC air measurement device **128**) (block **192**). In certain embodiments, the header text and the data logged may be dependent on the particular device settings that are loaded in block **172**). For example, as described in greater detail herein, the log file may log data from sensor(s) **106**, **132** associated with the particular HVAC air measurement device **112**, **128**, may log data that are averages from several sensors **106**, **132** associated with the particular HVAC air measurement device **112**, **128**, may log data that are averages for a particular HVAC component (e.g., a particular fan, a particular duct, etc.), and so forth.

[0085] Then, data may be sent to the log file (block **186**), and the next data logging event time may be set (block **194**), at which point the data logging loop ends (block **196**), and the data logging process **168** proceeds back to the start of a new data logging loop (block **180**). In certain embodiments, the data logging event timing may be at set intervals, as described in greater detail herein. The steps of the data logging process **168** are merely exemplary, and are not intended to be limiting. Indeed, additional steps may be included in the data logging process **168** or some of the illustrated steps may be omitted from the data logging process **168**.

[0086] While only certain features and embodiments of the disclosure have been illustrated and described, many modifications and changes may occur to those skilled in the art, such as variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, including temperatures and pressures, mounting arrangements, use of materials, colors, orientations, and so forth without materially departing from the novel teachings and advantages of the subject matter recited in the claims. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the disclosure. Furthermore, in an effort to provide a concise description of the exemplary embodiments, all features of an actual implementation may not have been described, such as those unrelated to the presently contemplated best mode of carrying out the disclosure, or those unrelated to enabling the claimed disclosure. It should be noted that in the development of any such actual implementation, as in any engineering or design project, numerous implementation specific decisions may be made. Such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure, without undue experimentation.

1. A heating, ventilation, and/or air conditioning (HVAC) air measurement device, comprising:

a housing;

a display disposed on an outer surface of the housing;

one or more inputs disposed on the outer surface of the housing; and

control circuitry configured to be electrically connected to one or more sensors disposed within an air flow path of an HVAC system, wherein the one or more sensors are configured to detect one or more parameters of air flow through the air flow path, wherein the control circuitry is configured to:

display a parameter selection menu via the display, wherein the parameter selection menu presents the one or more parameters as one or more selectable parameter options;

receive one or more parameter selection commands from the one or more inputs, wherein the one or more parameter selection commands relate to one or more selected parameters of the one or more parameters;

receive data relating to the one or more parameters from the one or more sensors; and transmit data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more parameter selection commands.

2. The HVAC air measurement device of claim **1**, wherein transmitting the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device comprises transmitting the data to a building management system.

3. The HVAC air measurement device of claim **1**, wherein transmitting the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device comprises transmitting the data to a cloud storage service.

4. The HVAC air measurement device of claim **1**, comprising a memory card port configured to receive a memory card, wherein transmitting the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device comprises storing the data on the memory card.

5. The HVAC air measurement device of claim **1**, wherein the parameter selection menu presents one or more data logging frequencies as one or more selectable data logging frequency options, and wherein the control circuitry is configured to:

receive a data logging frequency selection command from the one or more inputs, wherein the data logging frequency selection command relates to a selected data logging frequency;

log the data relating to the one or more parameters in a log file at the selected data logging frequency; and

transmit the log file directly from the HVAC air measurement device.

6. The HVAC air measurement device of claim **1**, wherein the parameter selection menu presents the one or more sensors as one or more selectable sensor options, and wherein the control circuitry is configured to:

receive one or more sensor selection commands from the one or more inputs, wherein the one or more sensor selection commands relate to one or more selected sensors of the one or more sensors; and

transmit the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more sensor selection commands.

7. The HVAC air measurement device of claim **1**, wherein the control circuitry is configured to receive a subset of the data relating to the one or more parameters from one or more other HVAC air measurement devices.

8. The HVAC air measurement device of claim **1**, wherein the one or more parameters comprise a temperature of the air flow through the air flow path.

9. The HVAC air measurement device of claim **1**, wherein the one or more parameters comprise a flow rate of the air flow through the air flow path.

10. The HVAC air measurement device of claim **1**, wherein the one or more parameters comprise a relative humidity of the air flow through the air flow path.

11. The HVAC air measurement device of claim **1**, wherein the one or more parameters comprise a barometric pressure of the air flow through the air flow path.

12. The HVAC air measurement device of claim **1**, wherein the one or more parameters comprise a refrigerant detection of refrigerant within the air flow through the air flow path.

13. A method, comprising:

displaying, via control circuitry of a heating, ventilation, and/or air conditioning (HVAC) air measurement device, a parameter selection menu via a display of the HVAC air measurement device, wherein the parameter selection menu presents one or more parameters of air flow through an air flow path of an HVAC system as one or more selectable parameter options, wherein the one or more parameters are detected by one or more sensors disposed within the air flow path of the HVAC system;

receiving, via the control circuitry of the HVAC air measurement device, one or more parameter selection commands from one or more inputs of the HVAC air measurement device, wherein the one or more parameter selection commands relate to one or more selected parameters of the one or more parameters;

receiving, via the control circuitry of the HVAC air measurement device, data relating to the one or more parameters from the one or more sensors; and

transmitting, via the control circuitry of the HVAC air measurement device, data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more parameter selection commands.

14. The method of claim **13**, wherein transmitting, via the control circuitry of the HVAC air measurement device, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device comprises transmitting the data to a building management system.

15. The method of claim **13**, wherein transmitting, via the control circuitry of the HVAC air measurement device, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device comprises transmitting the data to a cloud storage service.

16. The method of claim **13**, wherein transmitting, via the control circuitry of the HVAC air measurement device, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device comprises storing the data on a memory card received by a memory card port of the HVAC air measurement device.

17. The method of claim **13**, wherein the parameter selection menu presents one or more data logging frequencies as one or more selectable data logging frequency options, and wherein the method comprises:

receiving, via the control circuitry of the HVAC air measurement device, a data logging frequency selection command from the one or more inputs, wherein the data logging frequency selection command relates to a selected data logging frequency;

logging, via the control circuitry of the HVAC air measurement device, the data relating to the one or more parameters in a log file at the selected data logging frequency; and transmitting, via the control circuitry of the HVAC air measurement device, the log file directly from the HVAC air measurement device.

18. The method of claim **13**, wherein the parameter selection menu presents the one or more sensors as one or more selectable sensor options, and wherein the method comprises:

receiving, via the control circuitry of the HVAC air measurement device, one or more sensor selection commands from the one or more inputs, wherein the one or more sensor selection commands relate to one or more selected sensors of the one or more sensors; and

transmitting, via the control circuitry of the HVAC air measurement device, the data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more sensor selection commands.

19. The method of claim **13**, wherein the method comprises receiving, via the control circuitry of the HVAC air measurement device, a subset of the data relating to the one or more parameters from one or more other HVAC air measurement devices.

20. A heating, ventilation, and/or air conditioning (HVAC) air measurement system, comprising:

one or more sensors configured to be disposed within an air flow path of an HVAC system, wherein the one or more sensors are configured to detect one or more parameters of air flow through the air flow path; and

an HVAC air measurement device, comprising:

a housing;

a display disposed on an outer surface of the housing;

one or more inputs disposed on the outer surface of the housing; and

control circuitry configured to be electrically connected to the one or more sensors, wherein the control circuitry is configured to:

display a parameter selection menu via the display, wherein the parameter selection menu presents the one or more parameters as one or more selectable parameter options;

receive one or more parameter selection commands from the one or more inputs, wherein the one or more parameter selection commands relate to one or more selected parameters of the one or more parameters;

receive data relating to the one or more parameters from the one or more sensors; and

transmit data relating to the one or more selected parameters of the one or more parameters directly from the HVAC air measurement device based at least in part on the one or more parameter selection commands.

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