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(54) DUCT SYSTEM FOR HVAC SYSTEM OF AIR-SEALED BUILDING AND METHOD FOR CONDITIONING INTERNAL AIR THEREOF

(57) A duct system (100) for an HVAC system of an air-sealed building (102) and a method (800) for conditioning the internal air of the air-sealed building (102) are disclosed. The method (800) comprises the steps of fluidically connecting an inlet duct (108-1) comprising an inlet damper (112-1), between the central duct (106) and an ambient (110), fluidically connecting an outlet duct (108-2) comprising an outlet damper (112-2), between the central duct (106) and the ambient (110), and configuring a baffle (116) at a predefined location within one or more of the central duct (106), the inlet duct (108-1), and/or the outlet duct (108-2), moving the baffle (116) to a first position, and the inlet damper (112-1) and the outlet damper (112-2) to an opened position to enable outflow of internal air from one or more zones (104) and/or the central duct (106) into the ambient (110) via the outlet duct (108-2), and further enable inflow of ambient air into the central duct (106) and/or the one or more zones (104) via the inlet duct (108-1).

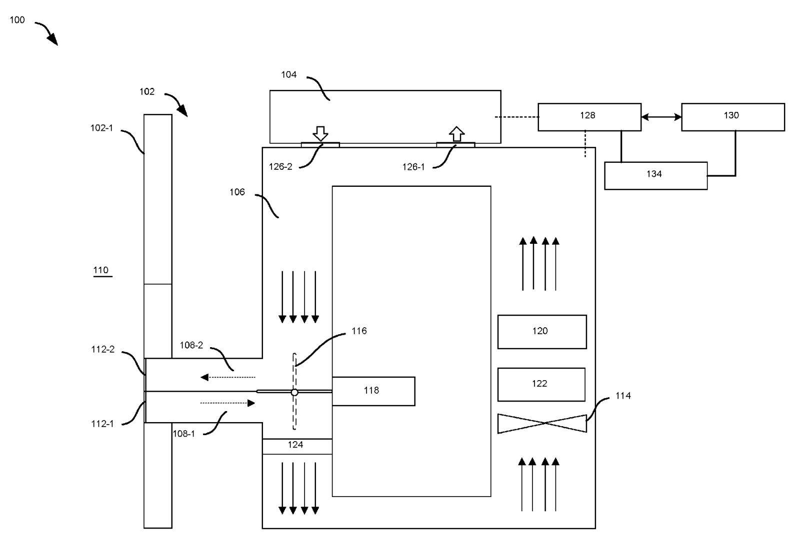

FIG. 1

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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This patent application claims the benefit of US Provisional Patent Application No. 63/508,584, filed on Jun 16, 2023, which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] This invention relates to a duct system for the heating, ventilation, and air conditioning (HVAC) system of an air-sealed building and a method for conditioning the internal air of the air-sealed building.

[0003] Buildings may be air-sealed to prevent leakage of air into and out of the building through cracks and other pathways. Air-sealed buildings may be designed and constructed to minimize the amount of conditioned air leakage from the building in order to improve energy efficiency, indoor air quality, and overall building performance. However, this may result in the buildup of humidity and mold growth, as well as excessive CO_2 levels, inside the building. Moreover, other undesired air contaminants may also build up inside the building. In addition, leaving a window or door open to reduce humidity and contaminant buildup within the building may not always be possible due to security issues. Further, opening the window and door may introduce outside contaminants within the building.

SUMMARY

[0004] According to a first aspect of the invention there is provided a duct system for an HVAC system of an air-sealed building. The duct system comprises a central duct extending between and fluidically connected to one or more zones associated with the building, the central duct configured to facilitate circulation of air therethrough and/or between the one or more zones and the central duct, wherein the one or more zones and the central duct are air-sealed. The duct system further comprises an inlet duct comprising an inlet damper, fluidically connected between the central duct and an ambient, an outlet duct comprising an outlet damper, fluidically connected between the central duct and the ambient, and a variable speed fan associated with the HVAC system, wherein the fan is configured to circulate and control flow of the air through the duct system. Further, the duct system comprises a baffle configured at a predefined location within one or more of the central duct, the inlet duct, and/or the outlet duct, wherein the baffle is configured to move between one or more positions, wherein at a first position among the one or more positions, the baffle and the outlet damper enable outflow of internal air from the one or more zones and/or the central duct into the ambient via the outlet duct, and the baffle and the inlet damper enable inflow of filtered ambient air into the central duct and/or the one or more zones via the inlet duct.

[0005] Optionally, at a second position among the one or more positions, the baffle and the outlet damper restrict the outflow of the internal air from the one or more zones and/or the central duct into the ambient, the baffle and the inlet damper restrict the inflow of the ambient air into the central duct and/or the one or more zones, and the baffle further enables circulation of the internal air within the central duct and/or between the central duct and the one or more zones.

[0006] Optionally, at a third position among the one or more positions, the baffle and the outlet damper enable outflow of the internal air from the one or more zones and/or the central duct into the ambient via the outlet duct, and the inlet damper restricts the inflow of the ambient air into central duct and/or the one or more zones via the inlet duct.

[0007] Optionally, at a fourth position among the one or more positions, the baffle and the inlet damper enable inflow of the ambient air into the central duct and/or the one or more zones via the inlet duct, and the outlet damper restricts the outflow of the internal air from the central duct and/or the one or more zones via the outlet duct.

[0008] Optionally, the baffle is configured at a connecting region between the central duct, the inlet duct, and/or the outlet duct.

[0009] Optionally, the duct system comprises an actuator operatively coupled to the baffle and configured to enable the movement of the baffle between the one or more positions.

[0010] Optionally, the duct system comprises a cooling unit positioned within the central duct and configured to cool one or more of the internal air, and/or the received ambient air while circulating through the central duct and a heating unit positioned within the central duct and configured to heat one or more of the internal air, and/or the received ambient air while circulating through the central duct.

[0011] Optionally, the duct system comprises one or more inlet registers, and one or more outlet registers configured between the one or more zones and the central duct such that one of the inlet registers and one of the outlet registers are provided between each of the zones and the central duct, wherein the inlet registers and the outlet registers facilitate the flow of air between the one or more zones and the central duct.

[0012] Optionally, the duct system comprises one or more zone dampers and one or more booster fans configured with each of the inlet registers and each of the outlet registers, wherein the one or more zone dampers and the one or more booster fans control and/or block the flow of the air between the one or more zones and the central duct.

[0013] Optionally, the air-sealed building comprises a thermostat positioned in the one or more zones, and a controller operatively coupled to the thermostat, the actuator, the inlet damper, the outlet damper, the one or more zone dampers, wherein the controller is configured to receive, from the thermostat, data pertaining to predefined indoor air quality (IAQ) parameters to be maintained at the one or more zones, receive, from the thermostat, real-time IAQ values at the one or more zones, actuate one or more of the actuator, the inlet damper, the outlet damper, the one or more zone dampers, the cooling unit, and the heating unit to facilitate maintaining the predefined IAQ parameters within the one or more zones.

[0014] Optionally, the duct system comprises at least one air filter configured in one or more of the inlet duct, and the central duct, wherein the at least one air filter is configured to clean the ambient air received within the central duct via the inlet duct and/or clean the internal air circulating through the central duct.

[0015] Optionally, the at least one air filter comprises one or more of a HEPA filter, a UV air filter, an electrostatic filter, an activated carbon filter, a pleated filter, and a fiberglass filter.

[0016] Optionally, the duct system comprises an energy recovery system or a heat recovery system configured between the inlet duct and the outlet duct.

[0017] Optionally, the baffle is fixed at a closed position and an inlet damper end of the inlet duct and an outlet damper end of the outlet duct are fluidically connected via a spring-actuated baffle, wherein the spring-actuated baffle is adapted to: remain closed when the inlet damper and the outlet damper are open, and remain open when the inlet damper and the outlet damper are closed to allow flow of the air from the inlet duct to the outlet duct to circulate the air through the duct system.

[0018] According to a second aspect of the invention there is provided a method for conditioning internal air of an air-sealed building comprising a central duct extending between and fluidically connected to one or more zones associated with the building to facilitate circulation of air therethrough and/or between the one or more zones and the central duct. The method comprises the steps of fluidically connecting an inlet duct comprising an inlet damper, between the central duct and an ambient; fluidically connecting an outlet duct comprising an outlet damper, between the central duct and the ambient,; configuring a baffle at a predefined location within one or more of the central duct, the inlet duct, and/or the outlet duct; and moving the baffle to a first position, and the inlet damper and the outlet damper to an opened position to enable outflow of internal air from the one or more zones and/or the central duct into the ambient via the outlet duct, and further enable inflow of filtered ambient air into the central duct and/or the one or more zones via the inlet duct.

[0019] Optionally, the method comprises the steps of moving the baffle to a second position, and the inlet damper and the outlet damper to a closed position to restrict the outflow of the internal air from the one or more zones and/or the central duct into the ambient, restrict the inflow of the ambient air into the central duct and/or the one or more zones, and enable recirculation of the internal air within the central duct and/or between the central duct and the one or more zones.

[0020] Optionally, the method comprises the steps of moving the baffle to a third position, the inlet damper to a closed position, and the outlet damper to the opened position to: enable outflow of the internal air from the one or more zones and/or the central duct into the ambient via the outlet duct; and restrict the inflow of the ambient air into central duct and/or the one or more zones via the inlet duct.

[0021] Optionally, the method comprises the steps of moving the baffle to a fourth position, the inlet damper to the opened position, and the outlet damper to the closed position to enable inflow of the ambient air into the central duct and/or the one or more zones via the inlet duct, and restrict the outflow of the internal air from the central duct and/or the one or more zones via the outlet duct.

[0022] Optionally, the method comprises the steps of actuating a cooling unit that is positioned within the central duct to cool one or more of the internal air, and/or the received ambient air while circulating through the central duct and/or actuating a heating unit that is positioned within the central duct to heat one or more of the internal air, and/or the received ambient air while circulating through the central duct.

[0023] Optionally, the method comprises the steps of providing at least one air filter in one or more of the inlet duct and the central duct to clean the ambient air received within the central duct via the inlet duct and/or clean the internal air circulating through the central duct.

[0024] Optionally, the method comprises the steps of providing one or more inlet registers, and one or more outlet registers between the one or more zones and the central duct such that one of the inlet registers and one of the outlet registers are provided between each of the zones and the central duct, wherein the inlet registers and the outlet registers facilitate the flow of air between the one or more zones and the central duct.

[0025] Optionally, the method comprises the steps of providing one or more zone dampers and one or more booster fans with each of the inlet registers and each of the outlet registers; and controlling the one or more zone dampers and the one or more booster fans to control and/or block the flow of the air between the one or more zones and the central duct.

[0026] Optionally, the method comprises the steps of receiving, by a controller, data pertaining to predefined indoor air quality (IAQ) parameters to be maintained at the one or more zones from a thermostat provided in the one or more zones, receiving, by the controller, real-time IAQ values at the one or more zones being monitored by the thermostat, and actuating, by the controller, one or more of an actuator associated with the baffle, the inlet damper, the outlet damper, the one or more zone dampers, the cooling unit, and the heating unit to facilitate maintaining the predefined IAQ parameters within the one or more zones.

[0027] Optionally, the method comprises the steps of manually operating one or more of the baffle, the inlet damper, the outlet damper, the one or more zone dampers, the cooling unit, and the heating unit to facilitate maintaining predefined IAQ parameters within the one or more zones.

[0028] Optionally, in the method, the air sealed building has a duct system according to the first aspect and optionally including any other features of the duct system as described above.

[0029] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, features, and techniques of the invention will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The accompanying drawings are included to provide a further understanding of the invention by way of example only and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the invention and, together with the description, serve to explain the principles of the invention.

[0031] In the drawings, similar components and/or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label with a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

FIG. 1 shows a duct system implemented in an HVAC system of an air-sealed building, which comprises a movable baffle configured in the central duct system.

FIG. 2 shows the duct system of FIG. 1 where the baffle is in the first position.

FIG. 3 shows the duct system of FIG. 1 where the baffle is in the second position.

FIG. 4 shows a duct system implemented in an HVAC system of an air-sealed building where an inlet damper end of the inlet duct and an outlet damper end of the outlet duct are fluidically connected or shortened, and the inlet damper and the outlet damper are in the open position.

FIG. 5 shows a duct system for an HVAC system of an air-sealed building where the inlet damper end of the inlet duct and the outlet damper end of the outlet duct are fluidically connected or shortened, and the inlet damper and the outlet damper are in the closed position.

FIG. 6 shows a duct system implemented in an HVAC system of an air-sealed building, which comprises a passive spring-actuated baffle configured between the inlet damper end of the inlet duct and the outlet damper end of the outlet duct.

FIG. 7 shows a duct system implemented in an HVAC system of an air-sealed building for creating a negative pressure within the duct system.

FIG. 8 shows a method for conditioning the internal air of an air-sealed building while keeping the building air-sealed.

DETAILED DESCRIPTION

[0032] The following is a detailed description of embodiments of the invention depicted in the accompanying drawings. The embodiments are in such detail as to clearly communicate the invention. However, the amount of detail offered is not intended to limit the anticipated variations of embodiments; on the contrary, the intention is to cover all modifications and alternatives falling within the scope of the invention as set out in the appended claims.

[0033] Various terms are used herein. To the extent a term used in a claim is not defined below, it should be given the broadest definition persons in the pertinent art have given that term as reflected in printed publications and issued patents at the time of filing.

[0034] In the specification, reference may be made to the spatial relationships between various components and to the spatial orientation of various aspects of components as the devices are depicted in the attached drawings. However, as will be recognized by those skilled in the art after a complete reading of the specification, the components of this invention described herein may be positioned in any desired orientation. Thus, the use of terms such as "above," "below," "upper," "lower," "first", "second" or other like terms to describe a spatial relationship between various components or to describe the spatial orientation of aspects of such components should be understood to describe a relative relationship between the components or a spatial orientation of aspects of such components, respectively, described herein may be oriented in any desired direction.

[0035] Air-sealed buildings may be designed and constructed to prevent leakage of air into and out of the building through cracks and other pathways. These air-sealed buildings may help minimize the amount of conditioned air leakage from the building, which may lower the load on the HVAC system of the building, thereby improving energy efficiency and further improving the indoor air quality and overall building performance. However, this may result in the buildup of humidity inside the air-sealed building, which may provide discomfort to the occupants and may also result in mold formation. Moreover, as the building is air-sealed, other undesired air contaminants such as formic acid and radon, and volatile organic compounds (VOCs) given off by material within the building may also build up inside the building. To overcome the contaminant and humidity buildup in the air-sealed building, generally, the window or door of the air-sealed building may be opened to reduce humidity and contaminant buildup within the air-sealed building. However, opening windows or doors may not always be possible due to security issues, especially during nighttime or in urban areas. Further, opening the windows or doors may introduce outside contaminants and pollutants within the building, thereby making it unsafe and uncomfortable for the occupants. Furthermore, opening the windows and doors of the air-sealed building may affect the main objective of keeping the building air-sealed. Thus, there is a need to overcome the above-mentioned drawbacks and shortcomings by providing a simple, efficient, and cost-effective solution to condition the internal air of the building while keeping the building air-sealed.

[0036] This invention provides a simple, efficient, and cost-effective solution in the form of a duct system for the HVAC system of an air-sealed building, which keeps the building air-sealed and conditioned while restricting the buildup of contaminants and humidity within the air-sealed building without the involvement of windows and doors of the air-sealed building. This invention further provides a method for conditioning the internal air of an air-sealed building while keeping the building air-sealed.

[0037] Referring to FIGs. 1 to 7, a duct system 100 for an HVAC system of an air-sealed building 102 is disclosed. The duct system may include a central duct 106 extending between and fluidically connected to one or more zones 104 associated with the building 102. The central duct 106 may be configured to facilitate the circulation of air through the central duct 106 and/or between the zones 104 and the duct 106. Further, the windows, doors, or any other openings including the electrical wiring and plumbing setup of the zones 104 and the central duct 106 may be air-sealed using enclosures, sealing material, and the like to restrict leakage of air into and from the building 102.

[0038] The duct system 100 may further include an inlet duct 108-1 fluidically connected between the central duct 106 and an ambient 110. Further, the duct system 100 may include an outlet duct 108-2 fluidically connected between the central duct 106 and the ambient 110. In one or more embodiments, the opening at the ambient end of the inlet duct 108-1 may be configured with an inlet damper 112-1 (also referred to as inlet louvers, herein) to control the flow of air through the inlet duct 108-1. Further, the opening at the ambient end of the outlet duct 108-2 may be configured with an outlet damper 112-2 (also referred to as outlet louvers, herein) to control the flow of air through the outlet duct 108-2. The inlet damper 112-1 and the outlet damper 112-2 may be configured to move between a closed position and an open position. The inlet damper 112-1 and the outlet damper 112-2 in the closed position may restrict the flow of air (ambient air or return air) through the ambient end opening of the inlet conduit and the outlet conduit, respectively. Further, the inlet damper 112-1 and the outlet damper 112-2 in the open position may allow the flow of air (ambient air or return air) through the ambient end opening of the inlet conduit and the outlet conduit, respectively. Furthermore, the inlet damper 112-1 and outlet damper 112-2 may also be adapted to be moved to a semi-closed or partially open position where they may allow airflow at a reduced rate.

[0039] In one or more embodiments, the duct system 100 may include a variable speed fan or blower 114 (also referred to as a fan 114 or blower 114, hereinafter) configured with the central duct 106 to circulate and control the flow of the air through the duct system 100. However, the fan 114 may also be a single speed fan. The fan 114 may be associated with the HVAC system of the building 102, however, the fan 114 may also be additionally configured with the duct system 100. It is to be appreciated that the use of the existing variable speed fan 114 associated with the HVAC system of the building 102 may allow the duct system 100 to occupy less space, involve fewer components, and be cost-effective. Moreover, the variable speed fan 114 may enable operating the fan 114 at different speeds, thereby controlling the rate at which the air circulates within the duct system 100 as well as controlling the inflow and outflow rates of air into and from the duct system 100 as well as the building 102.

[0040] In one or more embodiments, the duct system 100 may further include a baffle 116 configured at a predefined location within one or more of the central duct 106, the inlet duct 108-1, and/or the outlet duct 108-2. The baffle 116 may be configured at a connecting region between the central duct 106, the inlet duct 108-1, and/or the outlet duct 108-2. The baffle 116 may be configured to move between one or more positions. As illustrated, the inlet duct 108-1 and the outlet duct 108-2 may preferably be in proximity and extending from the central duct 106, with the baffle 116 movably configured within the central duct 106 at the connecting region. Further, the ambient end opening of the inlet duct 108-1 and the outlet duct 108-2 may at least partially extend out through the walls 102-1 or windows of the building 102, however, the rest of the building 102 may remain air-sealed.

[0041] Referring to FIG. 2, in one or more embodiments, when the baffle 116 is at a first position, and the inlet damper 112-1 and the outlet damper 112-2 are at the open position, the outlet damper 112-2 and the baffle 116 may enable the outflow of internal air from the zones 104 and/or from the central duct 106 into the ambient 110 via the outlet duct 108-2 and further the baffle 116 and the inlet damper 112-1 may enable inflow of ambient air into the central duct 106 and/or the zones 104 via the inlet duct 108-1. This may keep the building air-sealed and conditioned while restricting the buildup of contaminants and humidity within the building 102.

[0042] Referring to FIG. 3, in one or more embodiments, when the baffle 116 is at a second position, the inlet damper 112-1 and the outlet damper 112-2 are at the closed position, the baffle 116 and the outlet damper 112-2 may restrict the outflow of the internal air from the zones 104 and/or from the central duct 106 into the ambient 110, the baffle 116 and the inlet damper 112-1 may restrict the inflow of the ambient air into the central duct 106 and/or the one or more zones 104, and the baffle 116 may enable circulation of the internal air within the central duct 106 and/or between the central duct 106 and the one or more zones 104.

[0043] Referring back to FIGs. 1 to 7, in one or more embodiments, the duct system 100 may include an actuator 118 operatively coupled to the baffle 116 and configured to enable automated movement of the baffle 116 between the one or more positions, however, the baffle 116 may also be adapted to be manually moved, by users, between the one or more positions.

[0044] In one or more embodiments, the duct system 100 may include a cooling unit 120 positioned within the central duct 106 and configured to cool and/or dehumidify one or more of the internal air, and/or the received ambient air while circulating through the central duct 106. The cooling unit 120 may mainly comprise an evaporator and a condenser. The evaporator coils of the evaporator may be located inside the duct central duct 106 which may absorb heat from the air flowing through the central duct 106. As warm air passes over the cold evaporator coil, the heat of the air may be transferred to the refrigerant inside the evaporator coil. This may cause the refrigerant to evaporate and turn into a gas. The gas refrigerant may then travel to the condenser which may be located outside the building 102. A compressor may be fluidically connected to the condenser which may compress the refrigerant gas, raising its temperature and pressure. This may cause the refrigerant to condense back into a liquid and release the heat it absorbed from the air (flowing in the central duct 106). The cooled liquid refrigerant may then travel back to the evaporator coil, where the cycle starts again. This process of absorbing heat from the air inside the central duct 106 and releasing it outside may allow the cooling unit 120 to cool and/or dehumidify the internal air or the ambient air entering the duct system 100

[0045] The duct system 100 may further include a heating unit 122 positioned within the central duct 106 and configured to heat one or more of the internal air, and/or the received ambient air while circulating through the central duct 106. The heating unit 122 may be configured to heat the air flowing through the central duct 106. The heating unit 122 may mainly comprise a furnace and an air handler. The furnace may generate heat by burning fuel, such as natural gas, oil, or propane or blends of natural gas and hydrogen, or through the use of an electric heating element. As air is drawn into the furnace, it may pass over a heat exchanger, which may transfer heat from the burning fuel or electric element to the air flowing through the central duct 106, thereby heating the air. In one or more embodiments, the air handler of the heating unit 122 may be the variable speed fan 114 of the HVAC system, however, the air handler may also be a separate blower fan 114. As the variable speed fan 114 or blower fan 114 pulls the heated air through the furnace, it may push the heated air through the duct system 100 and into the various zones 104 of the building 102.

[0046] In one or more embodiments, the duct system 100 may include a heat pump that may be operated as the cooling unit 102 and the heating unit 122 when operated in a cooling mode and heating mode, respectively. The heat pump may replace two separate cooling unit 102 and the heating unit 122, which may be positioned within the central duct 106 and configured to cool and/or heat the internal air, and/or the received ambient air while circulating through the central duct 106.

[0047] In one or more embodiments, the duct system 100 may include at least one air filter 124 positioned within the central duct 106 and/or the inlet duct 108-1. The air filter 124 may be configured to filter one or more of the internal air while circulating through the central duct 106 and/or the received ambient air while entering the duct system 100 via the inlet duct 108-1. In one or more embodiments, the air filter 124 may include but is not limited to a HEPA filter, an UV air filter, an electrostatic filter, an activated carbon filter, a pleated filter, and a fiberglass filter.

[0048] In one or more embodiments, the duct system 100 may include one or more inlet registers 126-1 and one or more outlet registers 126-2 configured between the one or more zones 104 and the central duct 106 such that one of the inlet registers 126-1 and one of the outlet registers 126-2 are provided between each of the zones 104 and the central duct 106. The inlet registers 126-1 and the outlet registers 126-2 may be configured to facilitate the flow of air between the one or more zones 104 and the central duct 106.

[0049] In one or more embodiments, the duct system 100 may include one or more zone dampers (not shown) and one or more booster fans (not shown) configured with each of the inlet registers 126-1 and each of the outlet registers 126-2. The zone dampers and the booster fans may be configured to control and/or block the flow of the air between the zones 104 and the central duct 106. In one or more embodiments, the inlet damper 112-1, the outlet damper 112-2, and the zone dampers may move to an open position to allow air flow therethrough or a closed position to restrict the flow of air therethrough. Further, the dampers may also move to intermediate positions permitting partial/mixed airflows in some embodiments.

[0050] In one or more embodiments, the duct system 100 may include an energy recovery system (ERS) or a heat recovery system (HRS) configured between the inlet duct 108-1 and the outlet duct 108-2. The ERS or HRS may be configured to recover heat and moisture from the air leaving the building 102 through the outlet duct 108-2 and reuse the recovered heat and moisture to condition or preheat or precool the fresh air entering the duct system 100 via the inlet duct 108-1. This may help reduce the load on the duct system 100/HVAC system and save energy. The ERS/HRS may include a heat exchanger and/or a desiccant-based dehumidification system to enable the transfer of heat and moisture between the exhaust air (flowing through the outlet duct 108-2) and the incoming fresh air (flowing through the inlet duct 108-1).

[0051] In one or more embodiments, the building 102 may include a thermostat 128 positioned in the one or more zones 104 and/or within the central duct 106 itself. Further, the duct system 100 may include a controller 130 operatively coupled to or in communication with the thermostat 128, the baffle actuator 118, the inlet damper 112-1, the outlet damper 112-2, the one or more zone dampers through a network via wired or wireless media. However, the thermostat 128 may also be the controller 130 without any limitations. The controller 130 may include one or more processors coupled to a memory executable by the one or more processors to enable the controller 130 to perform one or more designated operations.

[0052] The controller 130, the thermostat 128, the baffle 116 actuator 118, the inlet damper 112-1, the outlet damper 112-2, the one or more zone dampers may include a transceiver or a communication module 134 to communicatively connect the controller 130 to one or more of the thermostat 128, the baffle 116 actuator 118, the inlet damper 112-1, the outlet damper 112-2, the one or more zone dampers, through the network via wired and/or wireless media. The communication module 134 may include one or more of a Bluetooth™ module, a WIFI™ module, a Z-wave module, a Zigbee module, a low-power wide area network (LoRaWAN), and the like. In one or more embodiments, the controller 130 may be a control unit associated with the HVAC system of the building 102. However, in other embodiments, the controller 130 may be a central server that may be in communication with the control unit of the HVAC system.

[0053] The controller 130 may be configured to receive, from the thermostat 128, data pertaining to predefined indoor air quality (IAQ) parameters to be maintained at the one or more zones 104. Occupants/users of the zones 104 may use the thermostat 128 to set the predefined IAQ parameters for their respective zone 104. Further, one or more sensors (not shown) comprising IAQ sensors, temperature sensors, and humidity sensors may be positioned in the zones 104 of the duct system 100 to monitor real-time IAQ values, temperature, and humidity of internal air present in the building 102. In one or more embodiments, the sensors may be associated with the thermostat 128, however, additional sensors may also be positioned within the building 102 or duct system 100. The controller 130 can be in communication with the sensors or thermostat 128. The controller 130 can be configured to receive data pertaining to predefined indoor air quality (IAQ) parameters to be maintained at the zones 104, and the real-time IAQ values, temperature, and humidity of the internal air present in the building 102. The controller 130 may accordingly actuate one or more of the actuator 118, the inlet damper 112-1, the outlet damper 112-2, the one or more zone dampers, the cooling unit 120, and the heating unit 122 to facilitate maintaining the predefined IAQ parameters within the zones 104. In one or more embodiments, the controller 130 may be configured to communicate with a utility company or a curtailment service provider through the network to receive and respond to signals/data pertaining to demand response, time of use power pricing, or carbon intensity. The controller 130 may accordingly control the operation of the duct system 100 based on the data received from the utility company or the curtailment service provider.

[0054] In one implementation, the network can be a wireless network, a wired network or a combination thereof. Network can be implemented as one of the different types of networks, such as intranet, local area network (LAN), wide area network (WAN), a low-power wide area network (LoRaWAN), the internet, and the like. Further, the network may either be a dedicated network or a shared network. The shared network represents an association of the different types of networks that use a variety of protocols, for example, Hypertext Transfer Protocol (HTTP), Transmission Control Protocol/Internet Protocol (TCP/IP), Wireless Application Protocol (WAP), and the like, to communicate with one another. Further, the network can include a variety of network devices, including transceivers, routers, bridges, servers, computing devices, storage devices, and the like. In another implementation the network can be a cellular network or mobile communication network based on various technologies, including but not limited to, Global System for Mobile (GSM), General Packet Radio Service (GPRS), Code Division Multiple Access (CDMA), Long Term Evolution (LTE), WiMAX, 5G or 6G network protocols, and the like.

[0055] Referring to FIG. 4 to 6. in one or more embodiments, the baffle 116 at the connecting region may be fixed at a closed position, and an inlet damper end of the inlet duct 108-1 and an outlet damper end of the outlet duct 108-2 may be shortened. Further, the inlet damper end of the inlet duct 108-1 and the outlet damper end of the outlet duct 108-2 may be shortened or fluidically connected via a spring-actuated baffle 132 or a check-valve 132 as shown in FIG. 6, such that the spring-actuated baffle/check-valve 132 may remain closed when the inlet damper 112-1 and the outlet damper 112-2 are open, and the spring-actuated baffle/check-valve 132 may automatically open when the inlet damper 112-1 and the outlet damper 112-2 are closed to allow the flow of the air from the inlet duct 108-1 to the outlet duct 108-2 to circulate the air through the duct system 100.

[0056] As the movable baffle 116 is fixed, it may act as a fixed barrier in the ductwork. Further, the damper end of the inlet duct 108-1 and outlet duct 108-2 may be shortened, such that when the inlet damper 112-1 and outlet damper 112-2 are closed as shown in FIG. 4 and 5, air may still flow through the duct system 100 and enabling circulation of air within the duct system 100 and building 102, which may be further filtered and/or conditioned before supplying to the zones 104 of the building

102. This may help reduce the involvement and expense of a movable baffle 116, and the baffle 116 actuator 118, however, this may increase friction in the overall duct system 100 and further re-mixing return air with the outside air. This problem may be mitigated by the addition of the passive spring-actuated baffle/check-valve 132 as shown in FIG. 6, which may provide a separation between the air streams when the inlet and outlet dampers 112-1, 112-2 are open, and which may further swing open to allow the return air to flow when the outlet duct 108-2 pressure increases due to closed outlet damper 112-2.

[0057] Referring to FIG. 7, in one or more embodiments, when the baffle 116 is at a third position, the inlet damper 112-1 is at the closed position, and the outlet damper 112-2 is at the open position, the baffle 116 and the outlet damper 112-2 may enable outflow of the internal air from the one or more zones 104 and/or from the central duct 106 into the ambient 110 via the outlet duct 108-2 and the inlet damper 112-1 may restrict the inflow of the ambient air into central duct 106 and/or the one or more zones 104 via the inlet duct 108-1. In such embodiments, the duct system 100 may involve two different sets of the inlet duct 108-1A, 108-1B being configured with an inlet damper 112-1A, 112-1B, and the outlet duct 108-2A, 108-2B being configured with the outlet damper 112-2A, 112-2B. As illustrated, one of the sets of inlet damper 112-1Aand outlet damper 112-2A may be closed and another inlet damper 112-1B may be closed and another outlet damper 112-2B may be open to enable outflow of the internal air from the duct system 100 and restrict the inflow of the ambient air into the duct system 100, thereby creating a negative pressure within the duct system 100.

[0058] In one or more embodiments, (not shown) when the baffle 116 is at a fourth position, the inlet damper 112-1 is at the open position, and the outlet damper 112-2 is at the closed position, the baffle 116 and the inlet damper 112-1 may enable inflow of the ambient air into the central duct 106 and/or the one or more zones 104 via the inlet duct 108-1 and the outlet damper 112-2 may restrict the outflow of the internal air from the central duct 106 and/or the one or more zones 104 via the outlet duct 108-2, thereby creating a positive pressure within the duct system 100.

[0059] In one or more embodiments, the controller 130 may be in communication with a smart electrical panel associated with the building 102. The smart electrical panel may be operatively connected to one or more electrical power outlets associated with the zones 104 of the building 102 and in further communication with the controller130. The smart electrical panel may enable the controller 130 to detect the operation or usage of one or more appliances within the building 102. These appliances may include but are not limited to a cloth dryer, range hood, bathroom ventilator, and fireplace, which may force air out of the building 102, thereby creating a negative pressure within the building 102 and making the duct system 100 less efficient. To overcome this problem, the controller130, upon detection of operation/usage of such appliances, may actuate the duct system 100 to actuate the inlet damper 112-1 to open the inlet duct 108-1 and further enable inflow of the ambient (conditioned) air into the central duct 106 and/or the zones 104 via the inlet duct 108-1, thereby restoring the pressure within the building 102 and the duct system 100.

[0060] Referring to FIG. 8, method 800 for conditioning internal air of an air-sealed building is disclosed. The building may comprise a central duct extending between and fluidically connected to one or more zones associated with the building to facilitate circulation of air therethrough and/or between the and the duct. Method 800 may further involve the inlet duct 108-1, the outlet duct 108-2, the baffle 116, the actuator 118, the inlet damper 112-1, the outlet damper 112-2, and other components associated with the duct system 100 of FIGs. 1 to 7.

[0061] Method 800 may include step 802 of fluidically connecting an inlet duct comprising an inlet damper, between the central duct and an ambient such that an ambient end of the inlet duct remains at least partially outside the walls or doors or windows of the building. Method 800 may further include step 804 of fluidically connecting an outlet duct comprising an outlet damper, between the central duct and the ambient such that the ambient end of the outlet duct remains at least partially outside the walls or doors or windows of the building. Further, method 800 may include step 806 of configuring a baffle at a predefined location within one or more of the central duct, the inlet duct, and/or the outlet duct. In one or more embodiments, the baffle may be configured at the connecting region between the central duct, the inlet duct, and/or the outlet duct.

[0062] Accordingly, in one or more embodiments, method 800 may include step 808 of moving the baffle to a first position, and the inlet damper and the outlet damper to an opened position to enable the outflow of internal air from the one or more zones and/or the central duct into the ambient via the outlet duct, and further enable inflow of ambient air into the central duct and/or the one or more zones via the inlet duct.

[0063] Further, in one or more embodiments, method 800 may include step 810 of moving the baffle to a second position, and the inlet damper and the outlet damper to a closed position to restrict the outflow of the internal air from the one or more zones and/or the central duct into the ambient, restrict the inflow of the ambient air into the central duct and/or the one or more zones, and further enable circulation of the internal air within the central duct and/or between the central duct and the one or more zones.

[0064] In one or more embodiments, method 800 may include steps of moving the baffle to a third position, the inlet damper to a closed position, and the outlet damper to the opened position to enable outflow of the internal air from the one or more zones and/or the central duct into the ambient via the outlet duct and restrict the inflow of the ambient air into central duct and/or the one or more zones via the inlet duct.

[0065] In one or more embodiments, method 800 may include steps of moving the baffle to a fourth position, the inlet damper to the opened position, and the outlet damper to the closed position to enable the inflow of the ambient air into the central duct and/or the one or more zones via the inlet duct and restrict the outflow of the internal air from the central duct and/or the one or more zones via the outlet duct.

[0066] In one or more embodiments, method 800 may include steps of actuating a cooling unit that is positioned within the central duct to cool one or more of the internal air, and/or the received ambient air while circulating through the central duct. Further, in other embodiments, method 800 may include steps of actuating a heating unit that is positioned within the central duct to heat one or more of the internal air, and/or the received ambient air while circulating through the central duct.

[0067] In one or more embodiments, method 800 may include steps of providing at least one air filter in one or more of the inlet duct and the central duct to clean the ambient air received within the central duct via the inlet duct and/or clean the internal air circulating through the central duct.

[0068] In one or more embodiments, method 800 may include steps of providing one or more zone dampers and one or more booster fans with each of the inlet registers and each of the outlet registers. Method may further include controlling the zone dampers and the booster fans to control and/or block the flow of the air between the one or more zones and the central duct.

[0069] In one or more embodiments, method 800 may include steps of receiving, by a controller, data pertaining to predefined indoor air quality (IAQ) parameters to be maintained at the one or more zones from a thermostat provided in the one or more zones. Further, method 800 may include steps of receiving, by the controller, real-time IAQ values at the one or more zones being monitored by the thermostat. Accordingly, method 800 may include steps of actuating, by the controller, one or more of an actuator associated with the baffle, the inlet damper, the outlet damper, the one or more zone dampers, the cooling unit, and the heating unit to facilitate maintaining the predefined IAQ parameters within the one or more zones.

[0070] In other embodiments, the method may include the steps of manually operating one or more of the baffle, the inlet damper, the outlet damper, the one or more zone dampers, the cooling unit, and the heating unit to facilitate maintaining predefined IAQ parameters within the one or more zones.

[0071] Thus, the invention provides a simple, efficient, and cost-effective solution in the form of a duct system for the HVAC system of an air-sealed building, which keeps the building air-sealed and conditioned while restricting the buildup of contaminants and humidity within the air-sealed building without the involvement of windows and doors of the air-sealed building.

[0072] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made without departing from the scope of the invention as set out in the appended claims. Modifications may be made to adopt a particular situation or material to the teachings of the invention without departing from the scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed, but that the invention includes all embodiments falling within the scope of the invention as set out in the appended claims.

[0073] In interpreting the specification, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced. Where the specification claims refer to at least one of something selected from the group consisting of A, B, C .... and N, the text should be interpreted as requiring only one element from the group, not A plus N, or B plus N, etc.

Claims

1. A duct system (100) for an HVAC system of an air-sealed building (102), the duct system comprising:

   a central duct (106) extending between and fluidically connected to one or more zones (104) associated with the building, the central duct configured to facilitate circulation of air therethrough and/or between the one or more zones and the central duct, wherein the one or more zones and the central duct are air-sealed;
   an inlet duct (108-1) comprising an inlet damper (112-1), fluidically connected between the central duct and an ambient (110);
   an outlet duct (108-2) comprising an outlet damper (112-2), fluidically connected between the central duct and the ambient;
   a variable speed fan (114) associated with the HVAC system, wherein the fan is configured to circulate and control flow of the air through the duct system; and
   a baffle (116) configured at a predefined location within one or more of the central duct, the inlet duct, and/or the outlet duct, wherein the baffle is configured to move between one or more positions,
   wherein at a first position among the one or more positions,

      the baffle and the outlet damper enable outflow of internal air from the one or more zones and/or the central duct into the ambient via the outlet duct, and

the baffle and the inlet damper enable inflow of ambient air into the central duct and/or the one or more zones via the inlet duct.

2. The duct system (100) of claim 1, wherein at a second position among the one or more positions,

the baffle (116) and the outlet damper (112-2) restrict the outflow of the internal air from the one or more zones (104) and/or the central duct (106) into the ambient (110),

the baffle and the inlet damper (112-1) restrict the inflow of the ambient air into the central duct and/or the one or more zones, and

the baffle further enables circulation of the internal air within the central duct and/or between the central duct and the one or more zones.

3. The duct system (100) of claim 1 or 2, wherein at a third position among the one or more positions,

the baffle (116) and the outlet damper (112-2) enable outflow of the internal air from the one or more zones (104) and/or the central duct (106) into the ambient (110) via the outlet duct (108-2), and

the inlet damper (112-1) restricts the inflow of the ambient air into the central duct and/or the one or more zones via the inlet duct (108-1); and/or

wherein at a fourth position among the one or more positions,

the baffle (116) and the inlet damper (112-1) enable inflow of the ambient air into the central duct (106) and/or the one or more zones (104) via the inlet duct (108-1), and

the outlet damper (112-2) restricts the outflow of the internal air from the central duct and/or the one or more zones via the outlet duct (108-2).

4. The duct system (100) of any preceding claim, wherein the baffle (116) is configured at a connecting region between the central duct (106), the inlet duct (108-1), and/or the outlet duct (108-2); and/or wherein the duct system comprises an actuator (118) operatively coupled to the baffle (116) and configured to enable the movement of the baffle between the one or more positions.

5. The duct system (100) of any preceding claim, wherein the duct system comprises:

a cooling unit (120) positioned within the central duct (106) and configured to cool one or more of the internal air, and/or the received ambient air while circulating through the central duct; and

a heating unit (122) positioned within the central duct and configured to heat one or more of the internal air, and/or the received ambient air while circulating through the central duct.

6. The duct system (100) of any preceding claim, wherein the duct system comprises one or more inlet registers (126-1), and one or more outlet registers (126-2) configured between the one or more zones (104) and the central duct (106) such that one of the inlet registers and one of the outlet registers are provided between each of the zones and the central duct, wherein the inlet registers and the outlet registers facilitate the flow of air between the one or more zones and the central duct; optionally

wherein the duct system comprises one or more zone dampers and one or more booster fans configured with each of the inlet registers and each of the outlet registers, wherein the one or more zone dampers and the one or more booster fans control and/or block the flow of the air between the one or more zones and the central duct.

7. The duct system (100) of claim 6, wherein the air-sealed building (102) comprises:

a thermostat (128) positioned in the one or more zones (104);

a controller (130) operatively coupled to the thermostat, the actuator (118), the inlet damper (112-1), the outlet damper (112-2), the one or more zone dampers, wherein the controller is configured to:

receive, from the thermostat, data pertaining to predefined indoor air quality "IAQ" parameters to be maintained at the one or more zones;

receive, from the thermostat, real-time IAQ values at the one or more zones; and

actuate one or more of the actuators, the inlet damper, the outlet damper, the one or more zone dampers, the cooling unit (120), and the heating unit (122) to facilitate maintaining the predefined IAQ parameters within the one or more zones.

8. The duct system (100) of any preceding claim, wherein the duct system comprises at least one air filter (124) configured in one or more of the inlet duct (108-1), and the central duct (106), wherein the at least one air filter is configured to clean the ambient air received within the central duct via the inlet duct and/or clean the internal air circulating through the central duct,

optionally wherein the at least one air filter (124) comprises one or more of a HEP A filter, a UV air filter, an electrostatic filter, an activated carbon filter, a pleated filter, and a fiberglass filter.

9. The duct system (100) of any preceding claim, wherein the duct system comprises an energy recovery system or a heat recovery system configured between the inlet duct (108-1) and the outlet duct (108-2); and/or

wherein the baffle (116) is fixed at a closed position and an inlet damper end of the inlet duct and an outlet damper end of the outlet duct are fluidically connected via a spring-actuated baffle (132),
wherein the spring-actuated baffle is adapted to:

remain closed when the inlet damper (112-1) and the outlet damper (112-2) are open, and
remain open when the inlet damper and the outlet damper are closed to allow flow of the air from the inlet duct to the outlet duct to circulate the air through the duct system.

10. A method (800) for conditioning internal air of an air-sealed building (102) comprising a central duct (106) extending between and fluidically connected to one or more zones (104) associated with the building to facilitate circulation of air therethrough and/or between the one or more zones and the central duct, the method comprising the steps of:

fluidically connecting (802) an inlet duct (108-1) comprising an inlet damper (112-1), between the central duct and an ambient (110);
fluidically connecting an outlet duct (108-2) comprising an outlet damper (112-2), between the central duct and the ambient;
configuring (806) a baffle (116) at a predefined location within one or more of the central ducts, the inlet duct, and/or the outlet duct; and
moving (808) the baffle to a first position, and the inlet damper and the outlet damper to an opened position to enable outflow of internal air from the one or more zones and/or the central duct into the ambient via the outlet duct, and further enable inflow of ambient air into the central duct and/or the one or more zones via the inlet duct.

11. The method (800) of claim 10, wherein the method comprises the steps of moving (810) the baffle (116) to a second position, and the inlet damper (112-1) and the outlet damper (112-2) to a closed position to:

restrict the outflow of the internal air from the one or more zones (104) and/or the central duct (106) into the ambient (110);
restrict the inflow of the ambient air into the central duct and/or the one or more zones; and
enable circulation of the internal air within the central duct and/or between the central duct and the one or more zones.

12. The method (800) of any of claims 10 and 11, wherein the method comprises the steps of moving the baffle (116) to a third position, the inlet damper (112-1) to a closed position, and the outlet damper (112-2) to the opened position to:

enable outflow of the internal air from the one or more zones (104) and/or the central duct (106) into the ambient (110) via the outlet duct (108-2); and
restrict the inflow of the ambient air into the central duct and/or the one or more zones via the inlet duct (108-1); and/or

moving the baffle to a fourth position, the inlet damper to the opened position, and the outlet damper to the closed position to:

enable inflow of the ambient air into the central duct and/or the one or more zones via the inlet duct; and
restrict the outflow of the internal air from the central duct and/or the one or more zones via the outlet duct.

13. The method (800) of any of claims 10 to 12, wherein the method comprises the steps of:

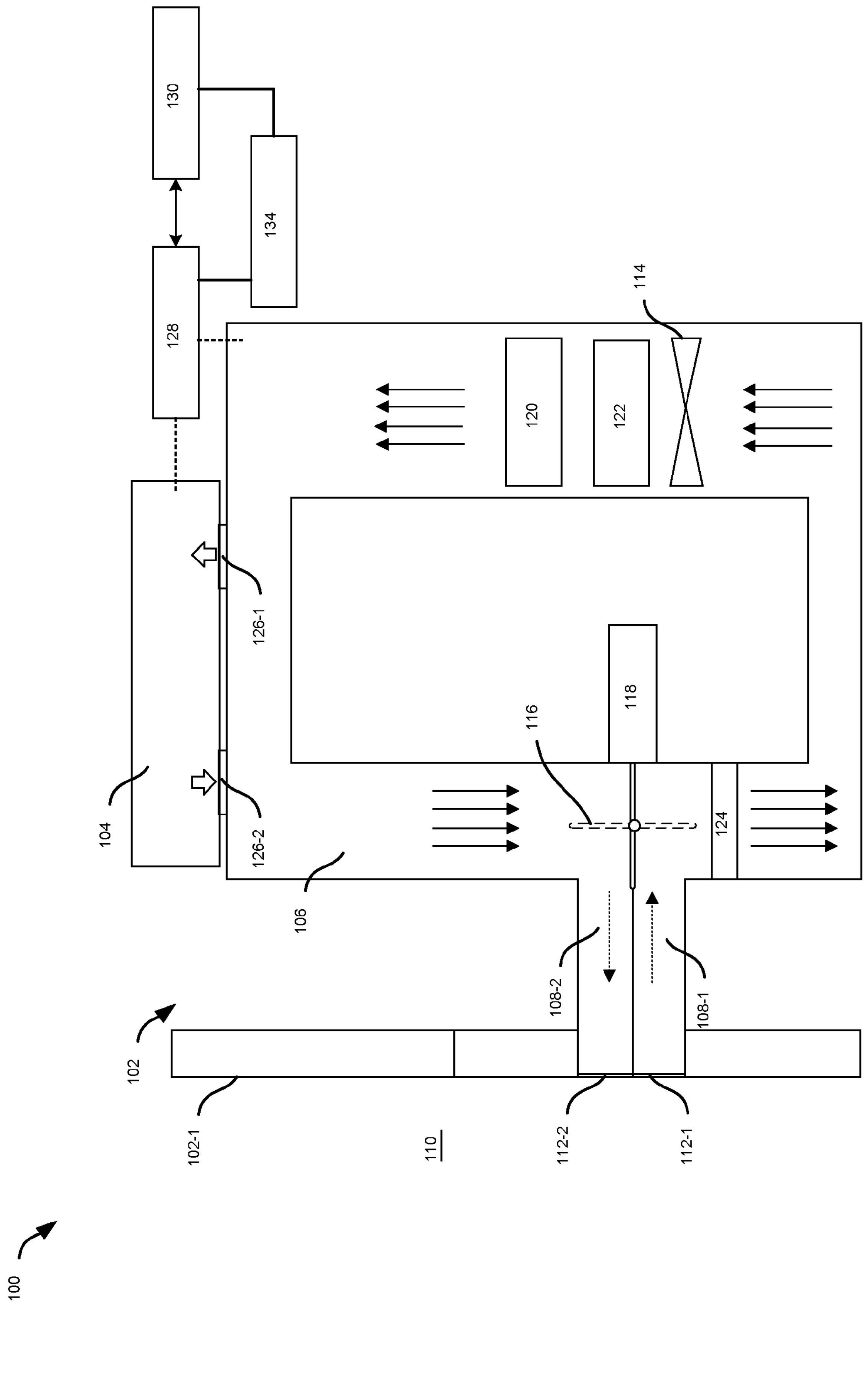
actuating a cooling unit (120) that is positioned within the central duct (106) to cool one or more of the internal air, and/or the received ambient air while circulating through the central duct; and/or
actuating a heating unit (122) that is positioned within the central duct to heat one or more of the internal air, and/or the received ambient air while circulating through the central duct; and/or
wherein the method comprises the steps of providing at least one air filter (124) in one or more of the inlet duct (108-1) and the central duct (106) to clean the ambient air received within the central duct via the inlet duct and/or clean the internal air circulating through the central duct.

14. The method (800) of any of claims 10 to 13, wherein the method comprises the steps of providing one or more inlet registers (126-1), and one or more outlet registers (126-2) between the one or more zones (104) and the central duct (106) such that one of the inlet registers and one of the outlet registers are provided between each of the zones and the central duct, wherein the inlet registers and the outlet registers facilitate the flow of air between the one or more zones and the central duct; optionally

wherein the method comprises the steps of providing one or more zone dampers and one or more booster fans with each of the inlet registers and each of the outlet registers; and
controlling the one or more zone dampers and the one or more booster fans to control and/or block the flow of the air between the one or more zones and the central duct (106).

15. The method (800) of claim 14, wherein the method comprises the steps of:

receiving, by a controller (130), data pertaining to predefined indoor air quality "IAQ" parameters to be maintained at the one or more zones (104) from a thermostat (128) provided in the one or more zones;
receiving, by the controller, real-time IAQ values at the one or more zones being monitored by the thermostat; and
actuating, by the controller, one or more of an actuator associated with the baffle (116), the inlet damper (108-1), the outlet damper (108-2), the one or more zone dampers, the cooling unit (120), and the heating unit (122) to facilitate maintaining the predefined IAQ parameters within the one or more zones (104); and/or
wherein the method comprises the steps of manually operating one or more of the baffle, the inlet damper, the outlet damper, the one or more zone dampers, the cooling unit, and the heating unit to facilitate maintaining predefined IAQ parameters within the one or more zones.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112-1
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FIG. 1

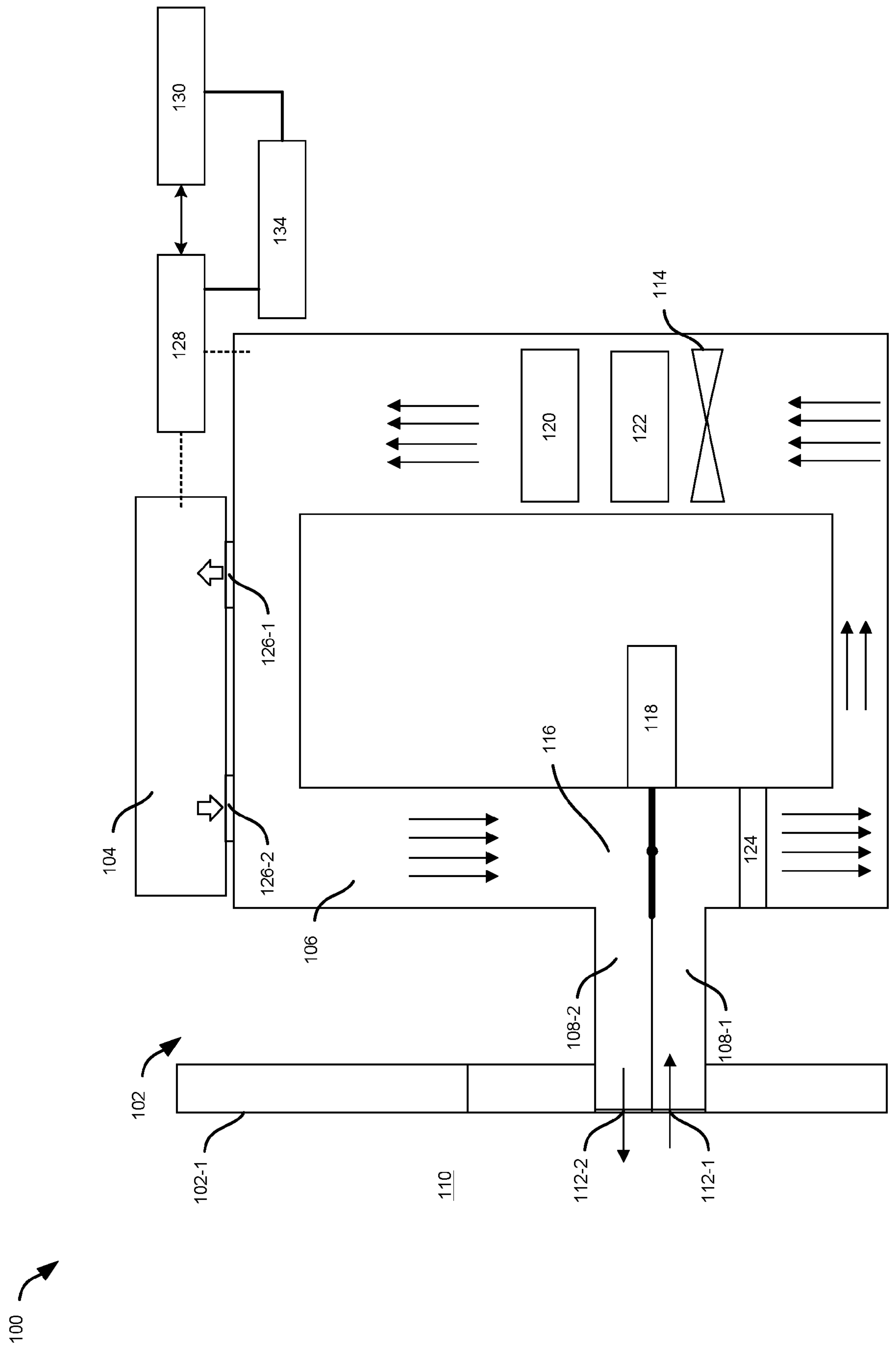
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FIG. 2

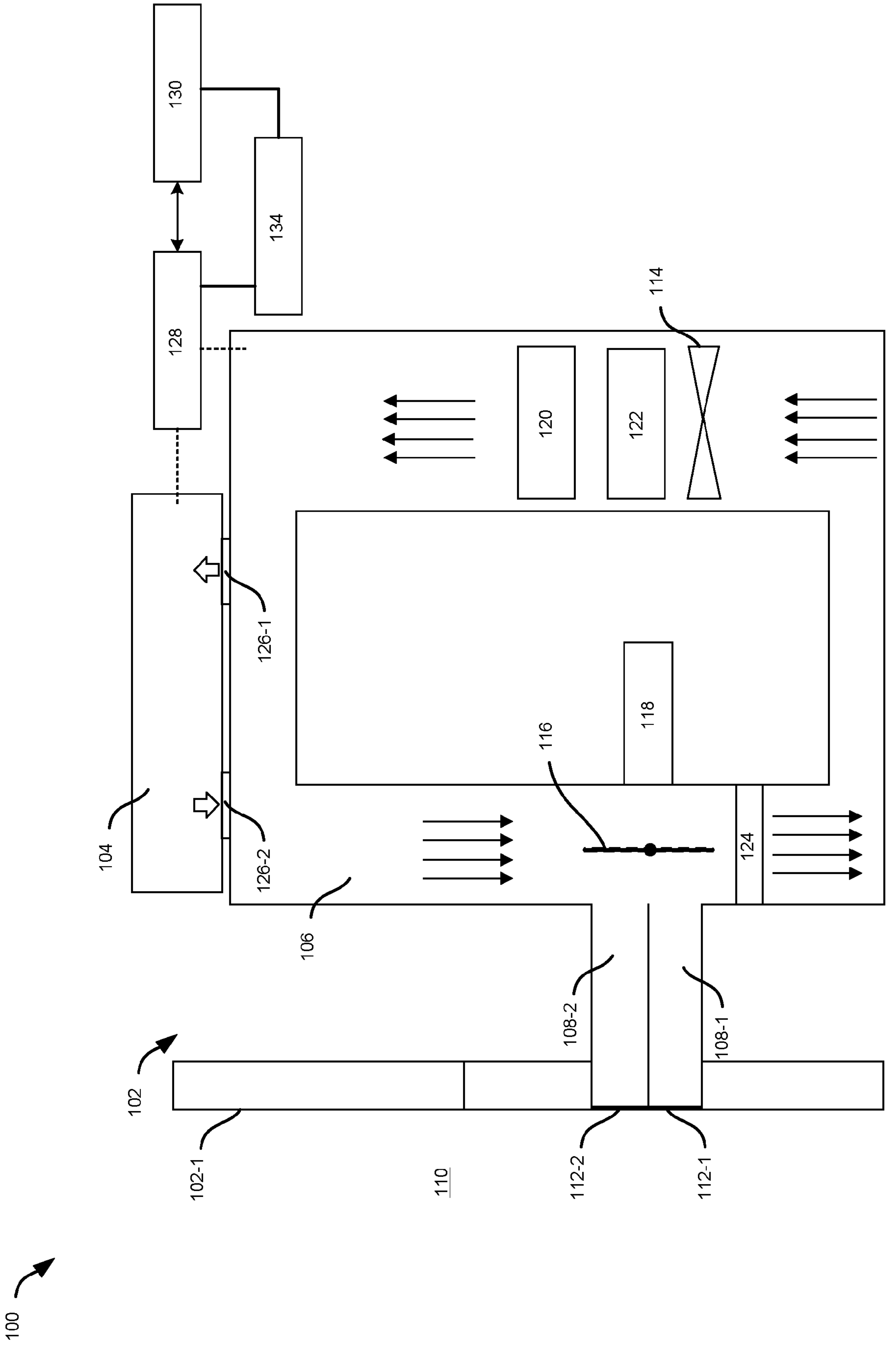
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FIG. 3

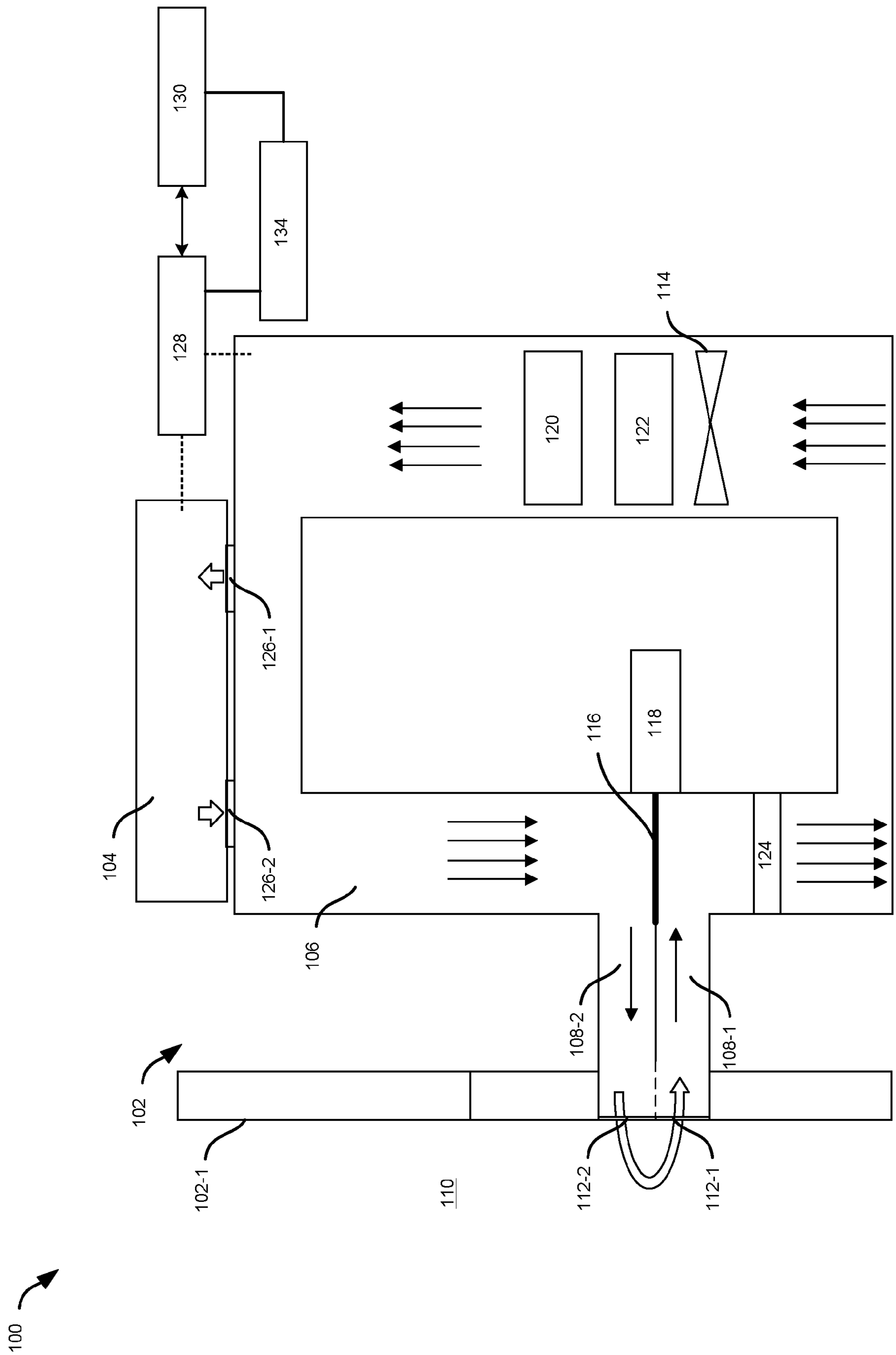

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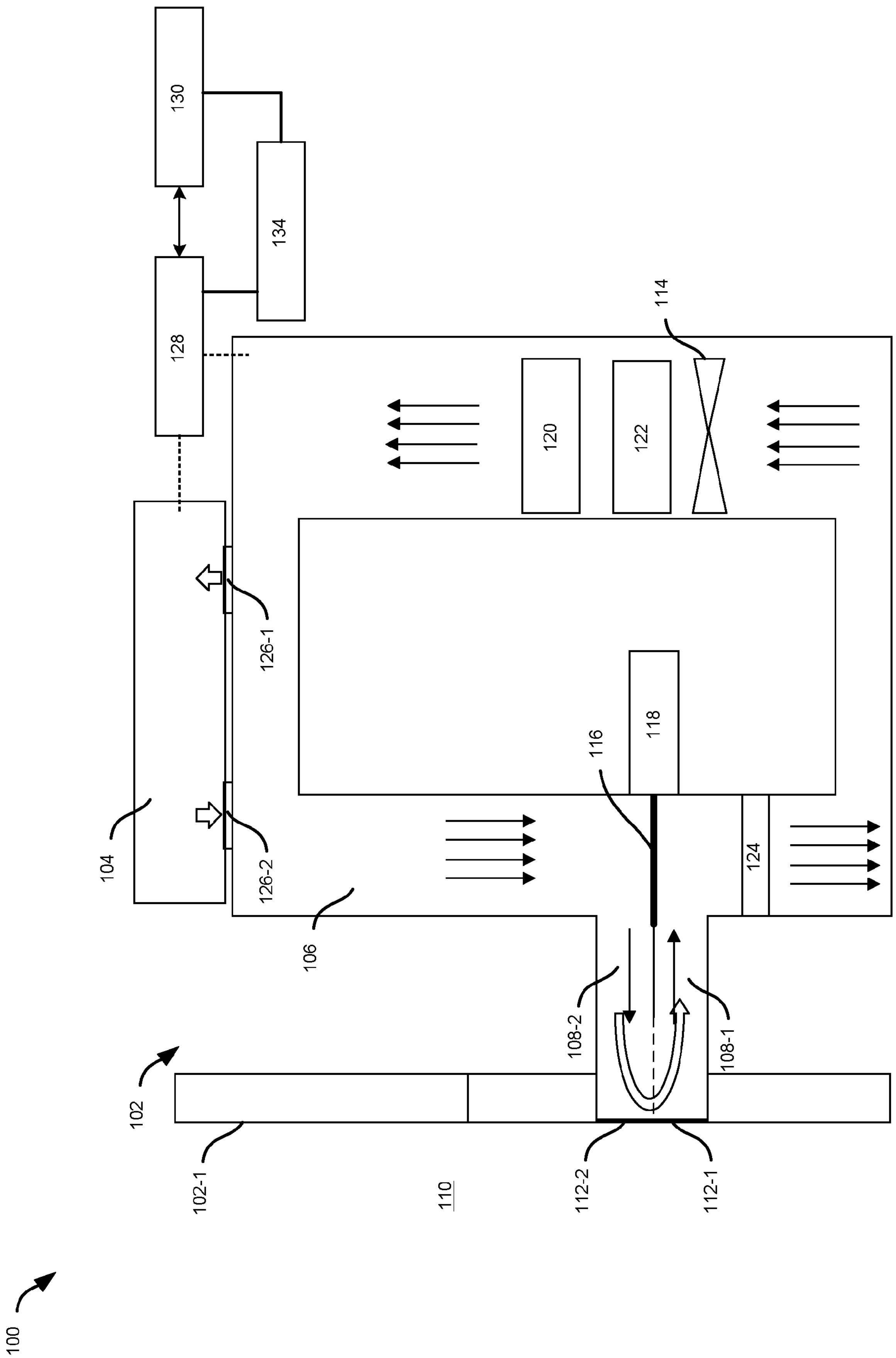
FIG. 4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112-1
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FIG. 5

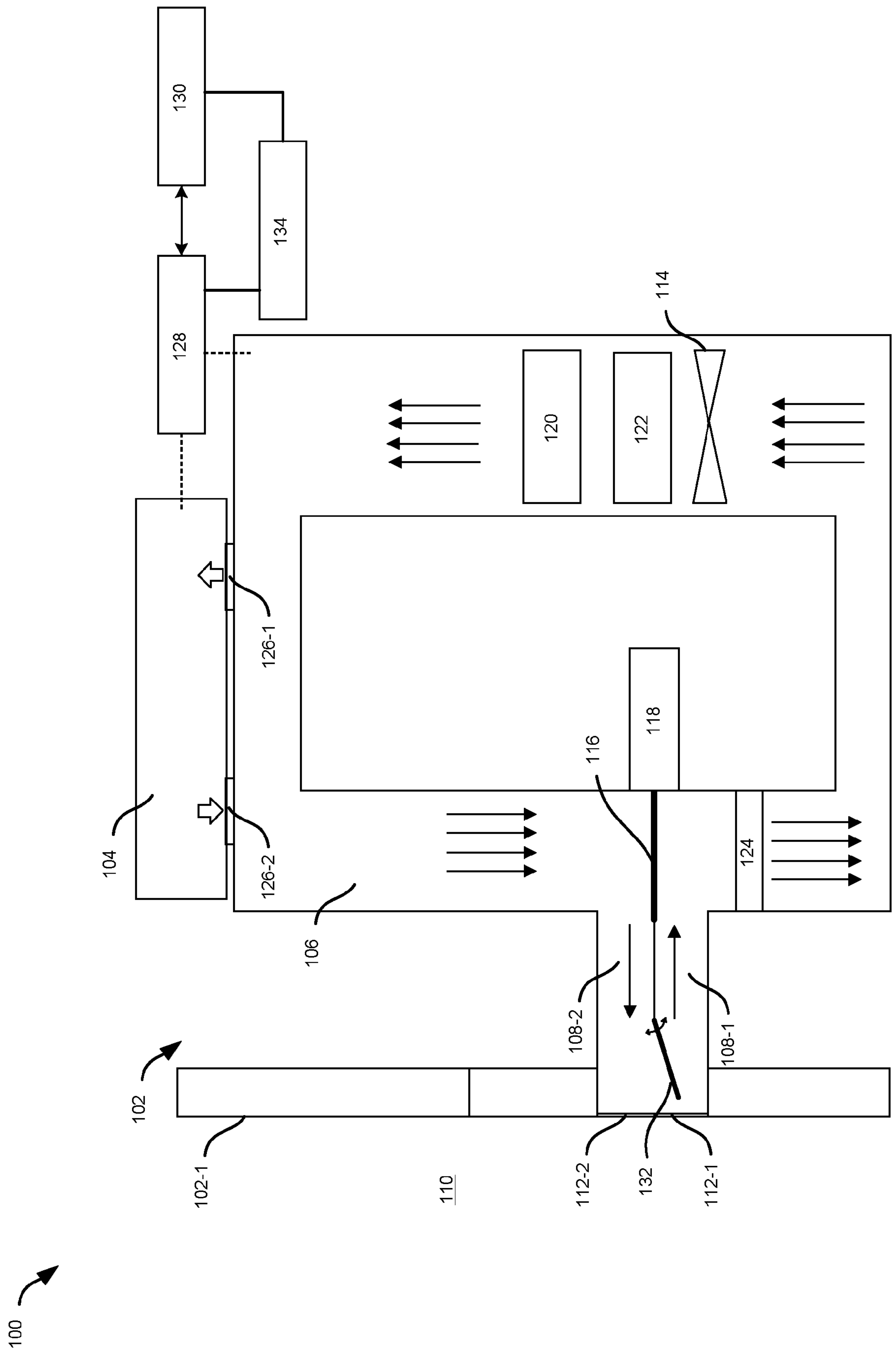
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FIG. 6

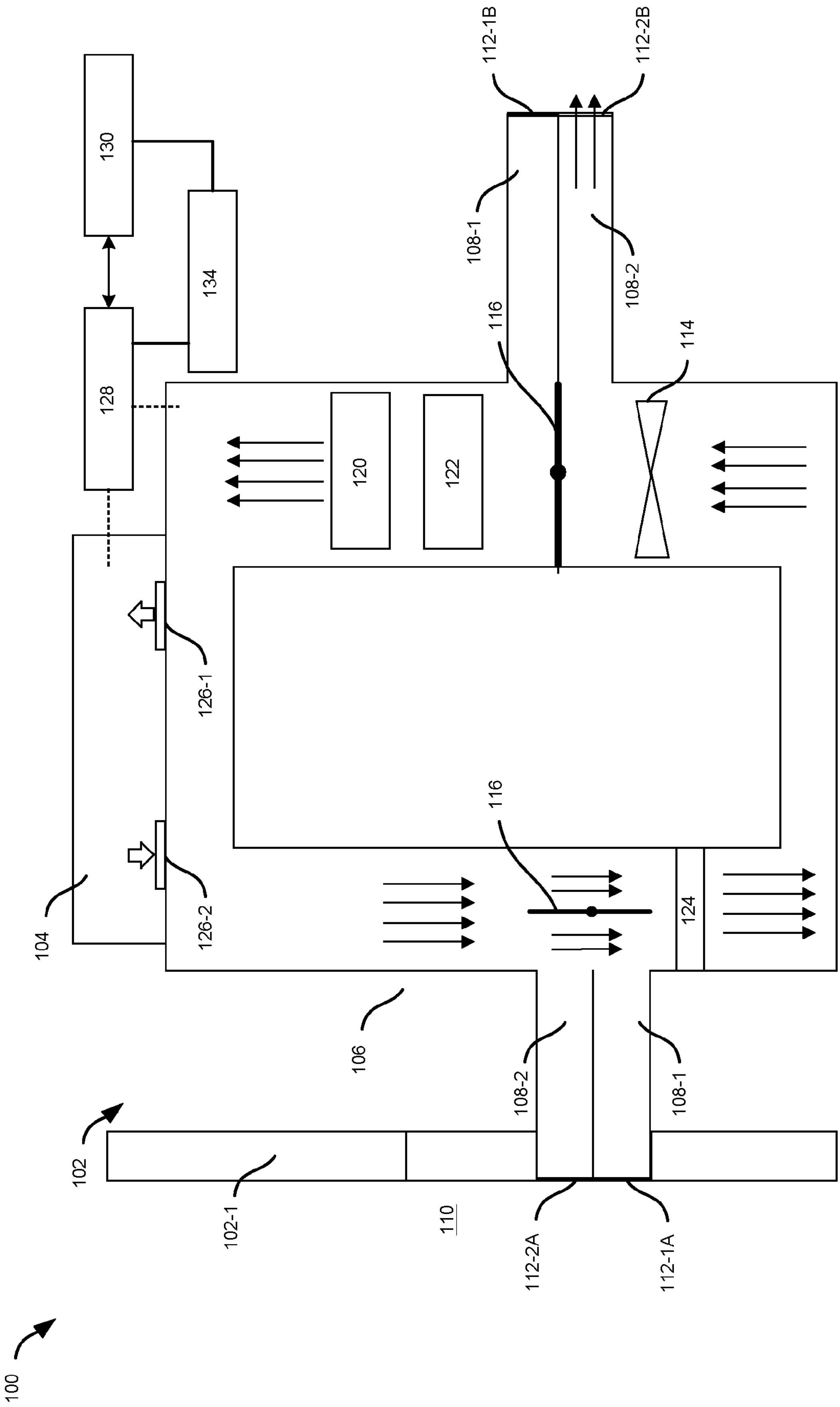
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FIG. 7

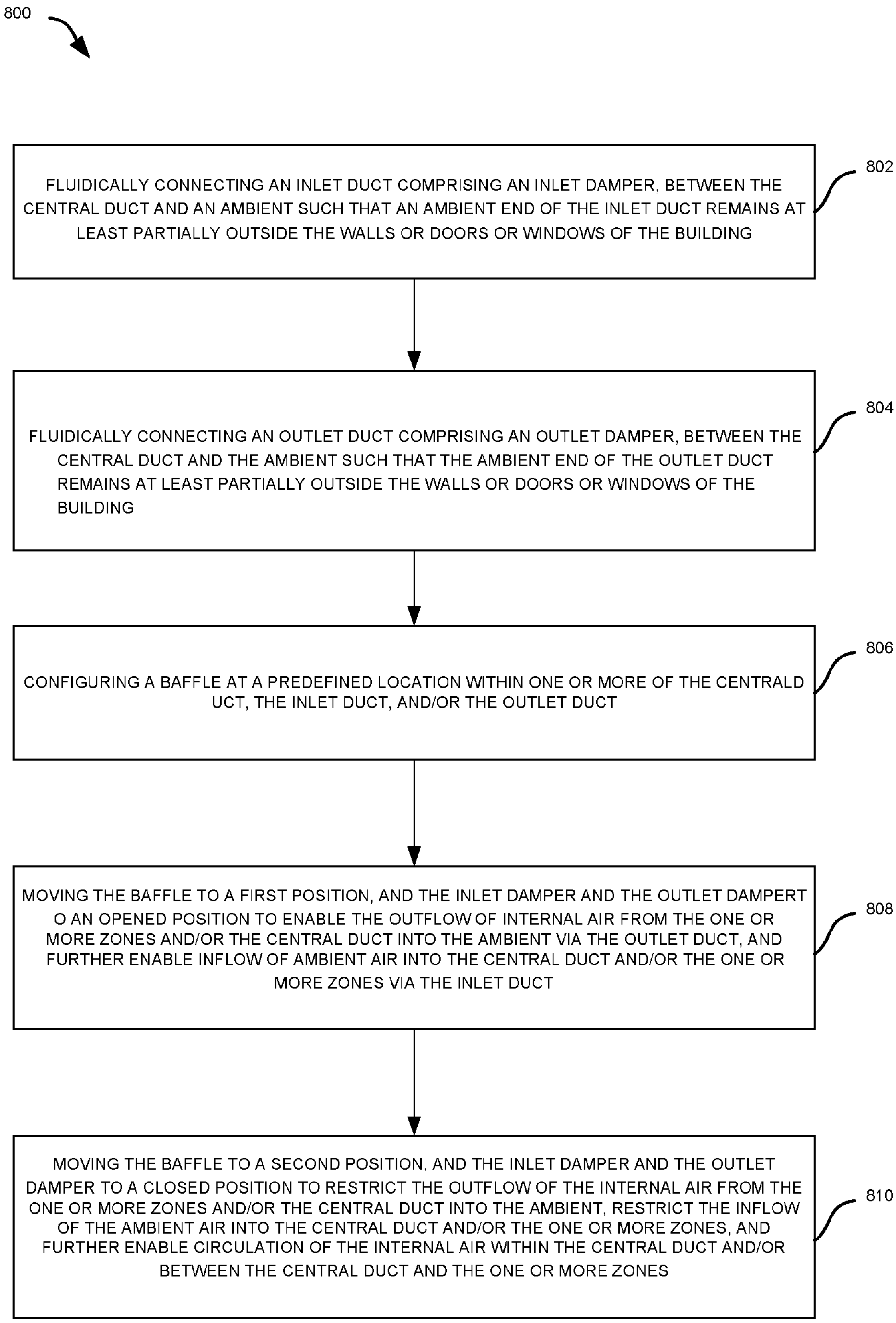
800
FLUIDICALLY CONNECTING AN INLET DUCT COMPRISING AN INLET DAMPER, BETWEEN THE CENTRAL DUCT AND AN AMBIENT SUCH THAT AN AMBIENT END OF THE INLET DUCT REMAINS AT LEAST PARTIALLY OUTSIDE THE WALLS OR DOORS OR WINDOWS OF THE BUILDING
802
FLUIDICALLY CONNECTING AN OUTLET DUCT COMPRISING AN OUTLET DAMPER, BETWEEN THE CENTRAL DUCT AND THE AMBIENT SUCH THAT THE AMBIENT END OF THE OUTLET DUCT REMAINS AT LEAST PARTIALLY OUTSIDE THE WALLS OR DOORS OR WINDOWS OF THE BUILDING
804
CONFIGURING A BAFFLE AT A PREDEFINED LOCATION WITHIN ONE OR MORE OF THE CENTRALD UCT, THE INLET DUCT, AND/OR THE OUTLET DUCT
806
MOVING THE BAFFLE TO A FIRST POSITION, AND THE INLET DAMPER AND THE OUTLET DAMPERT O AN OPENED POSITION TO ENABLE THE OUTFLOW OF INTERNAL AIR FROM THE ONE OR MORE ZONES AND/OR THE CENTRAL DUCT INTO THE AMBIENT VIA THE OUTLET DUCT, AND FURTHER ENABLE INFLOW OF AMBIENT AIR INTO THE CENTRAL DUCT AND/OR THE ONE OR MORE ZONES VIA THE INLET DUCT
808
MOVING THE BAFFLE TO A SECOND POSITION, AND THE INLET DAMPER AND THE OUTLET DAMPER TO A CLOSED POSITION TO RESTRICT THE OUTFLOW OF THE INTERNAL AIR FROM THE ONE OR MORE ZONES AND/OR THE CENTRAL DUCT INTO THE AMBIENT, RESTRICT THE INFLOW OF THE AMBIENT AIR INTO THE CENTRAL DUCT AND/OR THE ONE OR MORE ZONES, AND FURTHER ENABLE CIRCULATION OF THE INTERNAL AIR WITHIN THE CENTRAL DUCT AND/OR BETWEEN THE CENTRAL DUCT AND THE ONE OR MORE ZONES
810

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 24 18 2418

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

F24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	11 November 2024	Decking, Oliver

CATEGORY OF CITED DOCUMENTS

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