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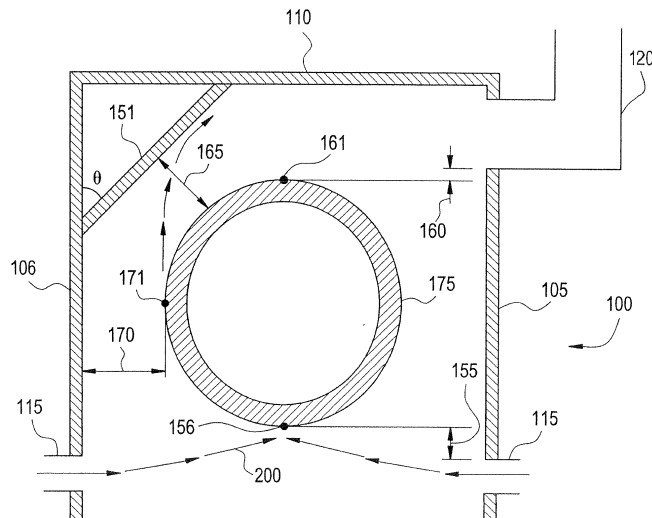
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(54) **System and apparatus for enclosing equipment**

(57) An enclosure (100) having a top (110) and at least one side (105) to surround equipment (175) is disclosed. The enclosure (100) includes a first set of ventilation ports (115) disposed toward the bottom (156) of the enclosure (100), a second set of ventilation ports (120) disposed toward the top (110) of the enclosure (100), and a baffle (150, 151) disposed proximate the top

(110) at the interior of the enclosure (100). The top of the opening of the first set of ventilation ports (115) is disposed to be lower than the bottom (156) of the equipment (175), the bottom of the opening of the second set of ventilation ports (120) is disposed to be higher than the top (161) of the equipment (175), and the baffle (150, 151) is configured to direct a cooling medium toward the second set of ventilation ports (120).

FIG. 6



Description

BACKGROUND OF THE INVENTION

[0001] The present disclosure relates generally to equipment enclosures, and particularly to enclosures surrounding power plant equipment.

[0002] Power generating equipment, such as gas turbines for example, may create significant amounts of acoustic energy (noise) during operation. Therefore it is common practice, as may be required by national agencies or the power station operators, to enclose such equipment within sound enclosures to dampen, or prevent transmission of, this acoustic energy into the surrounding environment. In addition to acoustic energy, many types of power generating equipment also generate large quantities of heat. When this equipment is sited indoors, a means to dissipate the heat to the exterior of the building and maintain specific thermal operating conditions may be required. Presently, enclosures utilize blowers to force cooling air through the enclosures to remove the heat generated by the equipment contained therein. Often, these are large blowers that may utilize motors from twenty to forty horsepower in size. These blowers may consume significant energy and require regular repair and maintenance, which may have a negative impact on the uptime of the generating equipment. Accordingly, there is a need in the art for an equipment enclosure arrangement that overcomes these drawbacks.

BRIEF DESCRIPTION OF THE INVENTION

[0003] An embodiment of the invention includes an enclosure having a top and at least one side to surround equipment. A first set of ventilation ports is disposed toward the bottom of the enclosure, a second set of ventilation ports is disposed toward the top of the enclosure, and a baffle is disposed proximate the top at the interior of the enclosure. The top of the opening of the first set of ventilation ports is disposed to be lower than the bottom of the equipment, the bottom of the opening of the second set of ventilation ports is disposed to be higher than the top of the equipment, and the baffle is configured to direct a cooling medium toward the second set of ventilation ports.

[0004] Another embodiment of the invention includes a power plant system comprising generating equipment. The generating equipment includes a generator, which is mechanically driven by a gas turbine or a steam turbine. The gas turbine comprises an inlet plenum, and an exhaust diffuser. The power plant system includes an enclosure enclosing at least one of the generator, the gas turbine, the steam turbine, the inlet plenum, and the exhaust diffuser, or any combination of the foregoing. The enclosure includes a top and at least one side to surround the equipment. A first set of ventilation ports is disposed toward the bottom of the enclosure, a second set of ven-

tilation ports is disposed toward the top of the enclosure, and a baffle is disposed toward the top at the interior of the enclosure. The top of the opening of the first set of ventilation ports is disposed to be lower than the bottom of the equipment, the bottom of the opening of the second set of ventilation ports is disposed to be higher than the top of the equipment, and the baffle is configured to direct a cooling medium toward the second set of ventilation ports.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Embodiments of the present invention will now be described, by way of example, only, referring to the exemplary drawings wherein like elements are numbered alike in the accompanying Figures:

Figure 1 depicts a top perspective view of an exemplary power plant in accordance with embodiments of the invention;

Figure 2 depicts a front perspective view of an exemplary enclosure in accordance with an embodiment of the invention;

Figure 3 depicts a front perspective view of an exemplary enclosure in accordance with an embodiment of the invention;

Figure 4 depicts a cross section view of an exemplary enclosure as depicted in Figure 3 in accordance with an embodiment of the invention;

Figure 5 depicts a front perspective view of an exemplary enclosure in accordance with an embodiment of the invention; and

Figure 6 depicts a cross section view of an exemplary enclosure as depicted in Figure 5 in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0006] An embodiment of the invention provides a naturally ventilated power plant equipment enclosure, employing natural convection as opposed to forced convection. The enclosure is designed to limit the transmission of acoustic energy generated by the equipment, while maintaining appropriate thermal conditions for operation of the equipment. In an embodiment, the enclosure includes ventilation inlets near the enclosure bottom and ventilation outlets near the enclosure top. The inlets may be located on or near the floor or at or near the bottom of the enclosure sidewalls. The outlets may be positioned on the enclosure roof or near the top of the enclosure sidewalls. In an embodiment, outlets may be located on the top of a pitched roof to drive maximum buoyancy flow through the enclosure. If outlets are not disposed on the

enclosure top, due to an obstruction for example, or for reasons relating to the desire to use the enclosure top as a storage area, for example, ventilation outlets may be positioned on the enclosure sidewalls.

[0007] Baffles, or any airflow management member suitable for directing a cooling medium, such as air, may be used to increase buoyancy flow, divert the ventilation airflow, and improve natural ventilation through the enclosure to uniformly cool the equipment. Baffle quantity and arrangement will depend on the number and location of outlets.

[0008] Referring now to Figure 1, an exemplary embodiment of a power plant 50 is depicted. The exemplary power plant 50 may include an exhaust enclosure 55 to enclose a gas turbine exhaust diffuser, a gas turbine enclosure 60 to enclose a gas turbine and associated piping, an inlet plenum barrier 65 to enclose a gas turbine inlet and load compartment, a generator barrier 70 to enclose a generator, and a steam turbine enclosure 75 to enclose a steam turbine and associated piping. As used herein, reference numeral 75 may also be used to represent additional enclosures not depicted in Figure 1, to enclose equipment such as high pressure valves, fuel gas supply systems, and compressors, for example.

[0009] Referring now to Figure 2, an embodiment of an exemplary equipment enclosure 100 is depicted. As used herein, reference numeral 100 will refer to an equipment enclosure in general, and it will be appreciated that the enclosure 100 may be any of the enclosures 55, 60, 65, 70, 75 utilized within the power plant 50. A plurality of surfaces (also herein referred to as sides) 105 and a top 110 surround power plant equipment (not visible in Figure 2) to reduce the transmission of acoustic energy (noise) that is created by operation of the equipment. An exemplary gas turbine exhaust diffuser 140 disposed within the enclosure 100 is depicted. An access port 142 allows connection of the equipment to adjoining power generation equipment as necessary. A first set of ventilation ports (also referred to herein as inlets) 115 and a second set of ventilation ports (also referred to herein as outlets) 120 allow for the flow of a cooling medium, such as air, within the enclosure 100 to carry away heat that is generated by operation of the equipment. In an embodiment, the inlets 115 are disposed on sides 105 (both the visible side and the opposing hidden side) proximate to the bottom of the enclosure 100. The outlets 120 are disposed on the top 110 of the enclosure, proximate to the center of the top 110. Locating the outlets 120 on a pitched top 110 provides maximum natural convective cooling through the enclosure 100 via maximum buoyancy of the airflow by utilizing the top 110 as a baffle to direct the air toward the outlets 120.

[0010] The sides 105 and top 110 are constructed of suitable materials configured to minimize, or at least reduce, the transmission of acoustic energy (noise) generated by operation of the equipment. In an exemplary embodiment, the sides 105 and top 110 may be configured to limit the transmission of acoustic energy to a maximum

sound pressure level of 74 dbA (decibel A-weighted). Sound pressure level limits may vary, and may be set by equipment operators, local, and national authorities. Alternate embodiments may be configured to meet the variation of sound pressure level limits required.

[0011] While an embodiment has been described depicting three inlets 115 on side walls 105, it will be appreciated that scope of the invention is not so limited, and that the invention will also apply to enclosures 100 with different numbers of inlets 115, such as one, two, three, four, or more, that may be disposed on one or more sides 105 of the enclosure. Further, an embodiment of the invention may allow the inlets 115 to be disposed on the bottom of the enclosure 100. While an embodiment has been described depicting three outlets 120 along the center of the top 110, it will be appreciated that the scope of the invention is not so limited, and that it will also apply to enclosures 100 having different numbers of outlets 120 arranged along the top 110, such as one, two, three, four, or more. While the exemplary embodiment has been described depicting one access port 142 through a side 105, it will be appreciated that the scope of the invention is not so limited, and that it will apply to enclosures 100 having various numbers and configurations of access ports 142 as may be required, for example, through the sides 105, top 110, or bottom to provide mechanical, fuel, electrical, exhaust, and thermal connections between the equipment and the surrounding environment.

[0012] Referring now to Figure 3, an exemplary embodiment employing outlets 120 on two opposing sides 105 proximate to the top 110 of the enclosure 100 is depicted. Location of the outlets 120 on two opposing sides 105 may be the result of overhead restrictions preventing the use of outlets 120 located on the top 110 as depicted in Figure 2. The outlets 120 may also be placed on two opposing sides 105 to allow for configuration of a flat top 110 surface, which may be used for the location of additional equipment, or for general storage.

[0013] Referring now to Figure 4, a cross sectional view of the enclosure 100 shown in Figure 3 is depicted. A representation of the equipment is indicated with reference numeral 175. Note that reference numeral 175 may represent either the equipment, or features of the equipment, such as an exhaust plenum / diffuser associated with a turbine for example. As used herein, reference numeral 175 will be used to represent the equipment located within the enclosure 100.

[0014] In addition to restricting the acoustic energy transmitted by the equipment 175 to the external environment, an embodiment of the enclosure 100 is also configured to maintain appropriate thermal conditions, which may be necessary for proper equipment operation, or may be health-based requirements, set by the appropriate authorities. In an exemplary embodiment, where the enclosure 100 is used to enclose an exemplary turbine exhaust plenum / diffuser 175, the gasses flowing through the exhaust plenum / diffuser 175 may reach temperatures of 1100 degrees Fahrenheit (593 degrees

Celsius). In an exemplary embodiment, proper thermal management may require a maximum internal enclosure 100 temperature of 140 degrees Fahrenheit (60 degrees Celsius). Further, an exemplary exhaust plenum / diffuser may require a temperature differential less than or equal to 25 degrees Fahrenheit (14 degrees Celsius) between a top 161 center and a bottom 156 center location of the equipment 175.

[0015] As a cooling medium, such as air currents depicted by wavy lines 200, enters the enclosure 100 via the inlets 115, heat generated by the equipment 175 is transferred to the surrounding internal ambient air 200, causing it to expand, become less dense, and rise, until it exits via the outlets 120. In an embodiment of the enclosure 100, the number and size of inlets 115 and outlets 120 will be determined by the thermal and acoustic properties of the equipment 175. Increased heat generation typically results in requiring an increase in total inlet 115 and outlet 120 area. However, if the size of inlets 115 and outlets 120 become too large, the ability of the enclosure 100 to restrict transmission of acoustic energy may be reduced.

[0016] As a result of the expansion of the air 200, the volume flow rate of air 200 leaving the enclosure 100 from the outlets 120 is greater than the volume flow rate of air 200 entering via the inlets 115. A ventilation area shall be defined by the size of the ventilation ports 115, 120. Accordingly, to prevent a possible flow restriction, an embodiment of the invention has a first ventilation area of the inlets 115 equal to or less than a second ventilation area of the outlets 120. In an embodiment, the ratio of the second ventilation area to the first ventilation area may range from 1.1 to 1.5 depending upon the specific thermal characteristics of the embodiment. It is contemplated that a ratio of 1.1 to 1.5 will provide sufficient heat transfer while limiting the outlet opening for noise control.

[0017] In an embodiment, the inlets 115 are sized and disposed so as to direct incoming air 200 to the bottom 156 center location of the equipment 175. In an embodiment, the top of the opening of the inlet 115 is located lower than the bottom 156 of the equipment 175, as indicated by dimension 155. The actual distance represented by dimension 155 may vary depending upon such factors as inlet 115 and outlet 120 size, and enclosure 100 thermal properties, for example. Similarly, in order to best utilize a "chimney" effect created by the buoyancy of the heated air 200, an embodiment has the bottom of the opening of the outlets 120 located higher than the top 161 of the equipment 175, as indicated by dimension 160. The actual distance represented by dimension 160 may vary depending upon such factors as inlet 110 and outlet 120 size, and enclosure 100 thermal properties, for example.

[0018] As may be validated by Computational Fluid Dynamics (CFD) Software, a baffle 150 may be used to direct a cooling medium such as air, maximize air stream velocity, and prevent localized areas of increased tem-

perature. In an embodiment, as depicted in Figure 4 with outlets 120 disposed on two sides 105, the baffle 150 may be disposed toward the top 110 at the interior of the enclosure 100, configured to be upward sloping from a region proximate the top 161 center of the equipment 175 toward the sides 105 in which the outlets 120 are disposed. It may be appreciated from the depiction of air currents 200 in Figure 4, that in the absence of the baffle 150, heated air rising from the top 161 of the equipment 175 would rise straight up to the top 110 of the enclosure, and would not be directed toward the sides 105 upon which the outlets 120 are disposed. Accordingly, the baffle 150 is configured and disposed so as to direct the air toward the outlets 120, creating the appropriate uniform airflow over the top 161 of the equipment 175 to prevent the formation of a localized high temperature area, thereby providing uniform equipment 175 temperature.

[0019] Referring now to Figure 5, an exemplary embodiment employing outlets 120 on one side 105 proximate to the top 110 of the enclosure 100 is depicted. Location of the outlets 120 on one side 105 may be the result of overhead restrictions preventing the use of outlets 120 located on the top as depicted in Figure 2, or adjacent equipment preventing the use of outlets 120 on two sides 105 as depicted in Figure 3. Further, a flat top 110 surface may allow for the location of additional equipment, or for general storage.

[0020] Referring now to Figure 6, an embodiment of a cross sectional view of the enclosure 100 shown in Figure 5 is depicted. It will be appreciated that in response to the set of outlets 120 being located on only one side 105, a baffle 151 with an alternate configuration is utilized. In an embodiment, the baffle 151 is disposed between one side 106 and the top 110 of the enclosure 100, opposite the side 105 on which the outlets 120 are disposed. The baffle 151 will be upward sloping from the side 106 of the enclosure opposite the side 105 at which the outlets 120 are disposed toward the interior top 110 of the enclosure 100. It may be appreciated from the depiction of air currents 200 in Figure 6 that in the absence of the baffle 151, heated air rising from the side 171 of the equipment 175 would rise straight up to the corner between the side 106 and the top 110 of the enclosure 100, and would not be directed to the outlets 120.

[0021] The baffle 151 will accelerate heated air 200 towards the outlets 120 on the opposite side 105. This will increase airflow over the top 161 of the equipment 175, the equipment 175 will be uniformly cooled, and hotspots or dead/recirculation zones inside the enclosure 100 will be eliminated or substantially reduced. In an exemplary embodiment, the baffle 151 is disposed such that an angle θ formed between the baffle and the side 106 is about 45 degrees. As used herein, the term "about" represents deviation that may result from optimizing the particular enclosure 100 to the thermal or geometric characteristics that may be required for operation of the particular equipment 175 contained therein. Further, to properly direct airflow, maximize air stream velocity, and pre-

vent localized areas of increased temperature, it is contemplated that the smallest distance (represented by reference numeral 165) from the baffle 151 to the equipment 175 will be equal to or less than the smallest distance (represented by reference numeral 170) from the equipment to the interior of the side 106.

[0022] As described above in reference to Figure 4, the location of the equipment 175 in relation to the inlets 115 and outlets 120 of an embodiment is such that the top of the opening of the inlets 115 is located lower than the bottom 156 of the equipment 175 as indicated by dimension 155. The configuration of inlet 115 size and location of an embodiment is such that the air currents 200 from the inlets 115 is directed toward the bottom 156 center of the equipment 175, as illustrated in Figures 4 and 6. Likewise, an embodiment has the bottom of the opening of the outlets 120 located higher than the top 161 of the equipment 175 as indicated by dimension 160.

[0023] As disclosed, some embodiments of the invention may include some of the following advantages: ability to eliminate blower use for heat removal; ability to eliminate, or at least reduce, blower noise, which can contribute to overall power plant noise levels, thereby reducing overall system noise; increased equipment uptime by eliminating blower maintenance; reduced energy consumption via elimination of blower use; and, reduction in space consumed by blower motors and fans.

[0024] 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 and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best or only mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

Claims

1. An enclosure (100), comprising:

a plurality of surfaces (105, 110) configured to surround equipment (175), the plurality of surfaces (105, 110) comprising a top (110) and at least one side (105);

the plurality of surfaces (105, 110) comprising a first set of ventilation ports (115) disposed toward the bottom of the enclosure (100), and a second set of ventilation ports (120) disposed toward the top (110) of the enclosure (100); and a baffle (150, 151) disposed proximate the top (110) at the interior of the enclosure (100);

wherein the baffle (150, 151) is configured to direct a cooling medium (200) toward the second set of ventilation ports (120);

wherein the top of the opening of the first set of ventilation ports (115) is disposed to be lower than the bottom (156) of the equipment (175); and

wherein the bottom of the opening of the second set of ventilation ports (120) is disposed to be higher than the top (110) of the equipment (175).

2. The enclosure (100) of Claim 1, wherein:

the first set of ventilation ports (115) are disposed on at least one side (105) of the enclosure (100) proximate to the bottom ; and the first set of ventilation ports (115) are configured to direct the incoming cooling medium toward the bottom (156) center of the equipment (175).

3. The enclosure (100) of Claim 1, wherein:

the first set of ventilation ports (115) have a first ventilation area, and the second set of ventilation ports (120) have a second ventilation area, which is equal to or larger than the first ventilation area.

4. The enclosure (100) of Claim 1, wherein:

the second set of ventilation ports (120) are disposed on the at least one side (105) of the enclosure (100) proximate the top (110) of the enclosure (100);

the at least one side (105) comprises two opposing sides (105);

the second set of ventilation ports (120) are disposed on the two opposing sides (105) proximate the top (110) of the enclosure (100); and the baffle (150) is configured to be upward sloping from a region proximate the top (110) center of the equipment (175) toward the sides (105) in which the second set of ventilation ports (120) are disposed.

5. The enclosure (100) of Claim 1, wherein:

the second set of ventilation ports (120) are disposed on the at least one side (105) of the enclosure (100) proximate the top (110) of the enclosure (100);

the second set of ventilation ports (120) are disposed on only one side (105) of the enclosure (100) proximate the top (110) of the enclosure (100);

the baffle (151) is configured to be upward sloping from the side (106) of the enclosure (100) opposite the side (105) at which the second set of ventilation ports (120) are disposed toward the interior top (110) of the enclosure (100); the baffle (151) is disposed at an angle of about forty-five degrees relative to the enclosure side (106); and

the baffle (151) is disposed such that the smallest distance (165) from the equipment (175) to the baffle (151) will be equal to or less than the smallest distance (171) from the equipment (175) to the interior of the enclosure side (106) from which the baffle (150) slopes.

6. The enclosure (55) of Claim 1, wherein:

the enclosure top (110) comprises a pitch disposed to align with the center of the equipment (175), the pitch being elevated toward the equipment (175) center; and

the second set of ventilation ports (120) are disposed on the enclosure (100) top (110), proximate to the peak of the pitch.

7. A power plant system (50), comprising generating equipment (175), the generating equipment (175) comprising a generator, the generator mechanically driven by a gas turbine or a steam turbine, the gas turbine comprising an inlet plenum, an exhaust diffuser (140), the power plant system (50) further comprising:

an enclosure (100) enclosing at least one of the generator, the gas turbine, the steam turbine, the inlet plenum, and the exhaust diffuser (140), or any combination of the foregoing, the enclosure (100) comprising:

a plurality of surfaces (105, 110) configured to surround the equipment (175), the plurality of surfaces (105) comprising a top (110) and at least one side (105);

the plurality of surfaces (105) comprising a first set of ventilation ports (115) disposed toward the bottom of the enclosure (100), and a second set of ventilation ports (120) disposed toward the top (110) of the enclosure; and

a baffle (150, 151) disposed proximate the

top (110) at the interior of the enclosure (100);

wherein the baffle (150, 151) is configured to direct a cooling medium toward the second set of ventilation ports (120);

wherein the top of the opening of the first set of ventilation ports (115) is disposed to be lower than the bottom of the equipment (175); and

wherein the bottom (156) of the opening of the second set of ventilation ports (120) is disposed to be higher than the top (161) of the equipment (175).

8. The power plant system (50) of Claim 7, wherein:

the ventilation ports (115, 120), in conjunction with the baffle (150, 151), are configured to maintain an ambient temperature within the enclosure (100) less than or equal to 140 degrees Fahrenheit, and to maintain a temperature difference between the top (161) center and the bottom (156) center of the equipment (175) of less than or equal to 25 degrees Fahrenheit.

9. The power plant system (50) of Claim 7, wherein:

the second set of ventilation ports (120) are disposed on the at least one side (105) of the enclosure (100) proximate the top (110) of the enclosure (100);

the at least one side (105) comprises two opposing sides (105);

the second set of ventilation ports (120) are disposed on the two opposing sides (105) proximate the top (110) of the enclosure (100); and the baffle (150) is configured to be upward sloping from a region proximate the top (161) center of the equipment (175) toward the sides (105) in which the second set of ventilation ports (120) are disposed.

10. The power plant system (50) of Claim 7, wherein:

the second set of ventilation ports (120) are disposed on the at least one side (105) of the enclosure (100) proximate the top (110) of the enclosure (100).

the second set of ventilation ports (120) are disposed on only one side (105) of the enclosure (100) proximate the top (110) of the enclosure (100);

the baffle (151) is configured to be upward sloping from the side (106) of the enclosure (100) opposite the side (105) at which the second set of ventilation ports (120) are disposed toward the interior top (110) of the enclosure (100); the baffle (151) is disposed at an angle of about forty-five degrees relative to the enclosure (100)

side (106); and
the baffle (151) is disposed such that the smallest distance (165) from the equipment (175) to the baffle (151) will be equal to or less than the smallest distance (170) from the equipment (175) to the interior of the enclosure (100) side (106) from which the baffle (151) slopes.

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FIG. 1

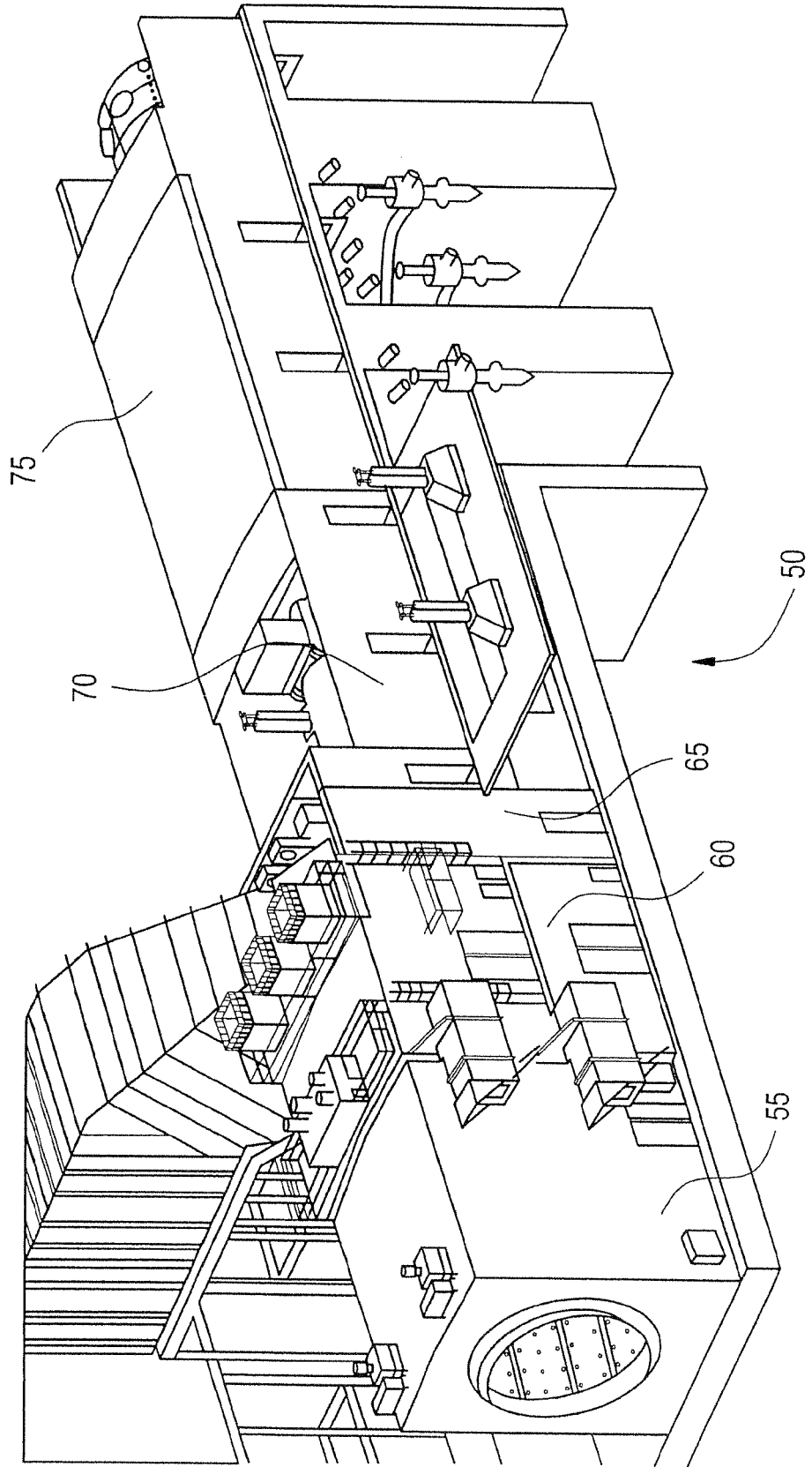


FIG. 2

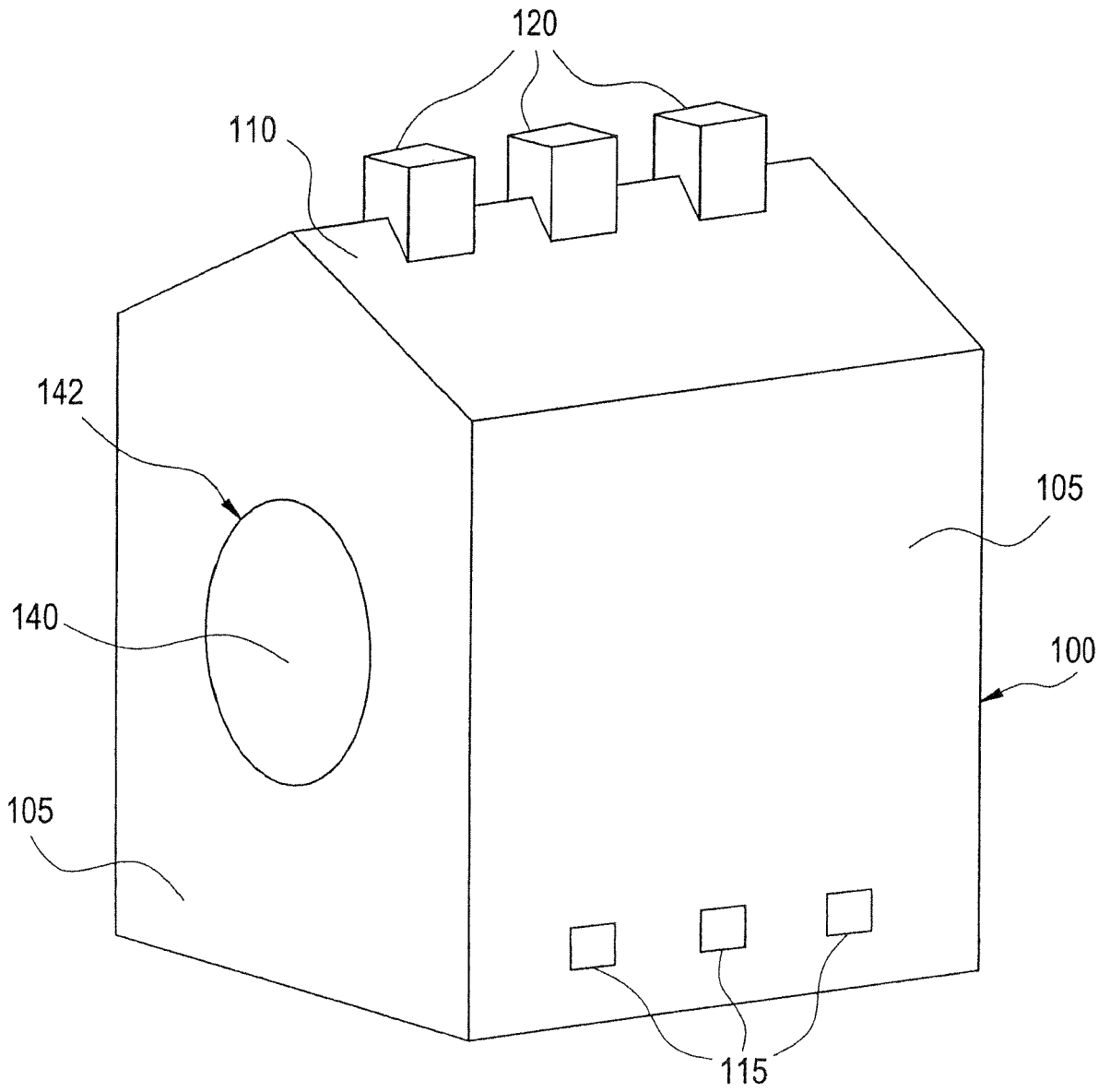


FIG. 3

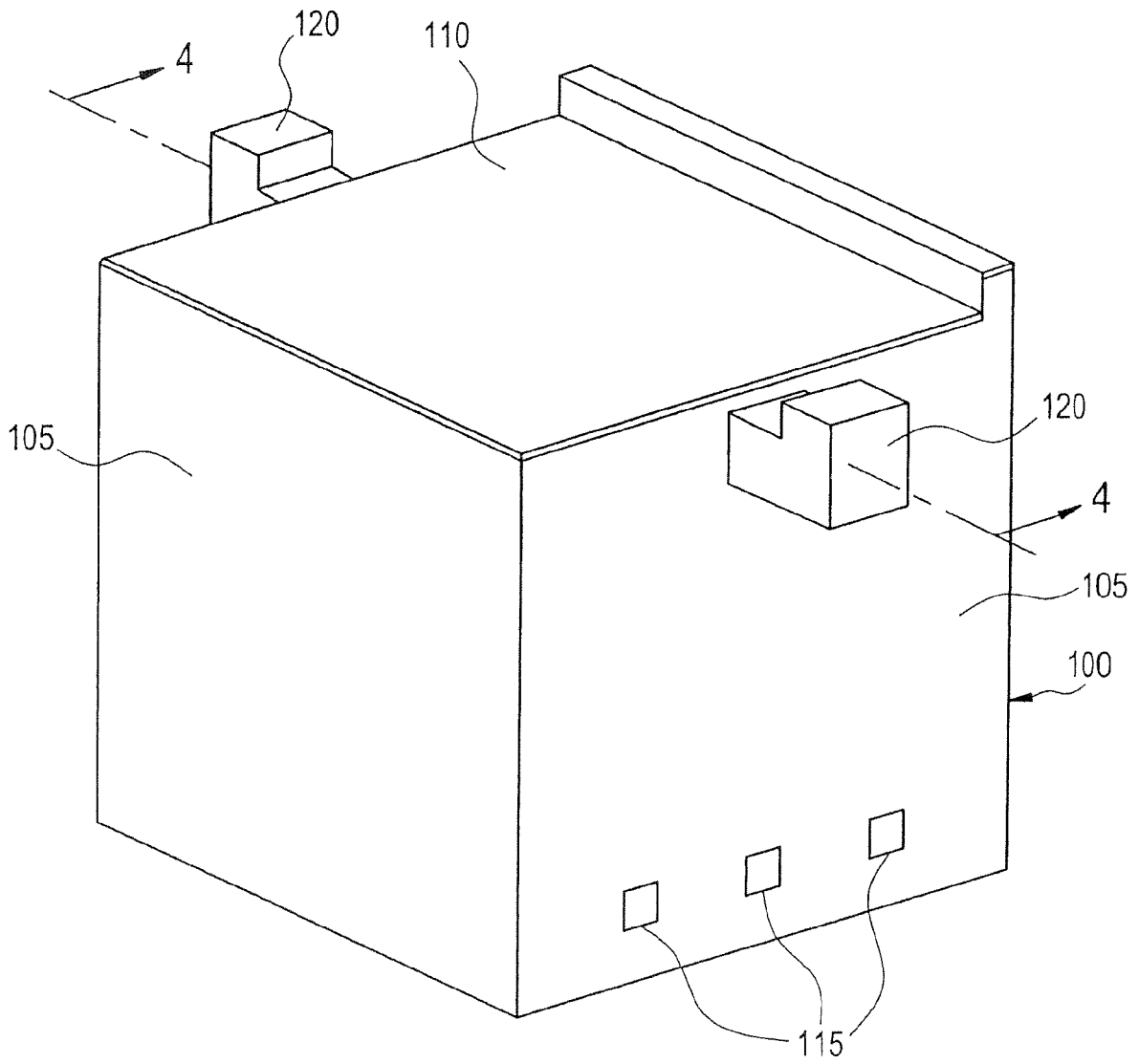


FIG. 4

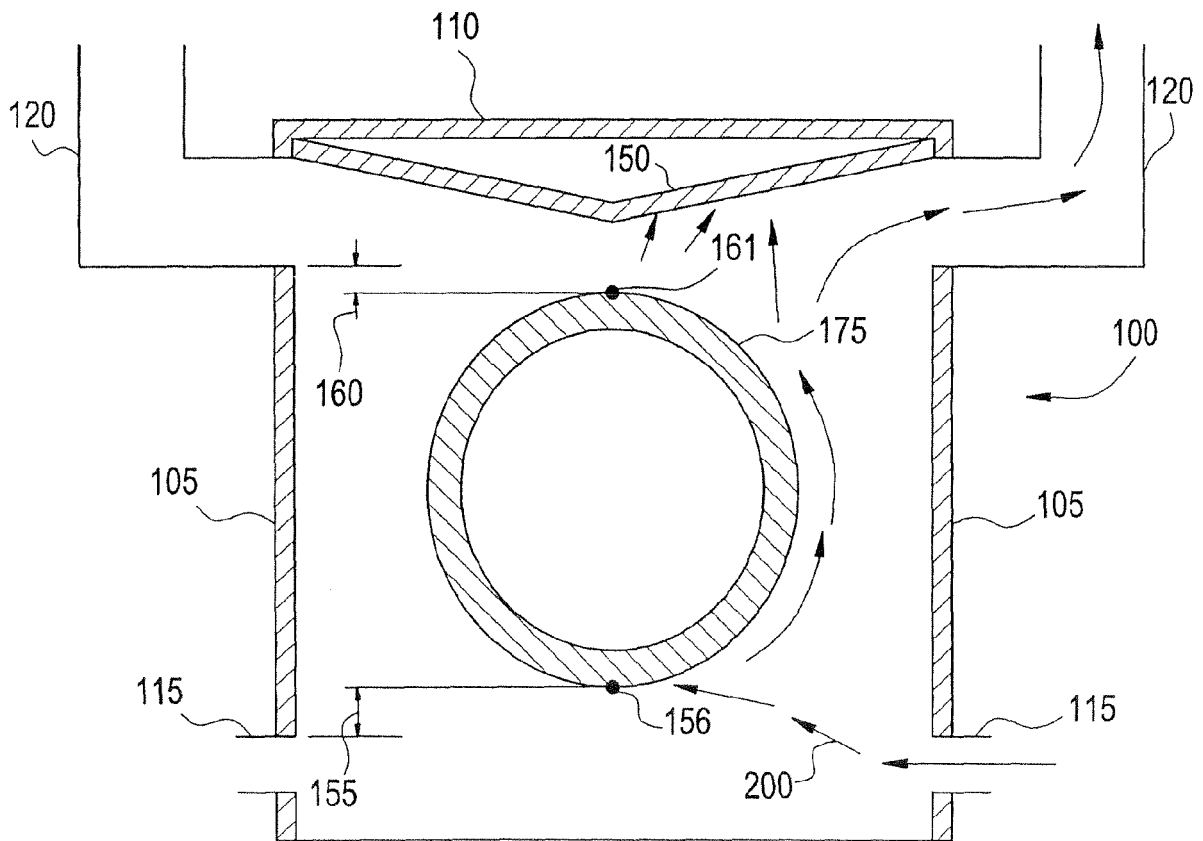


FIG. 5

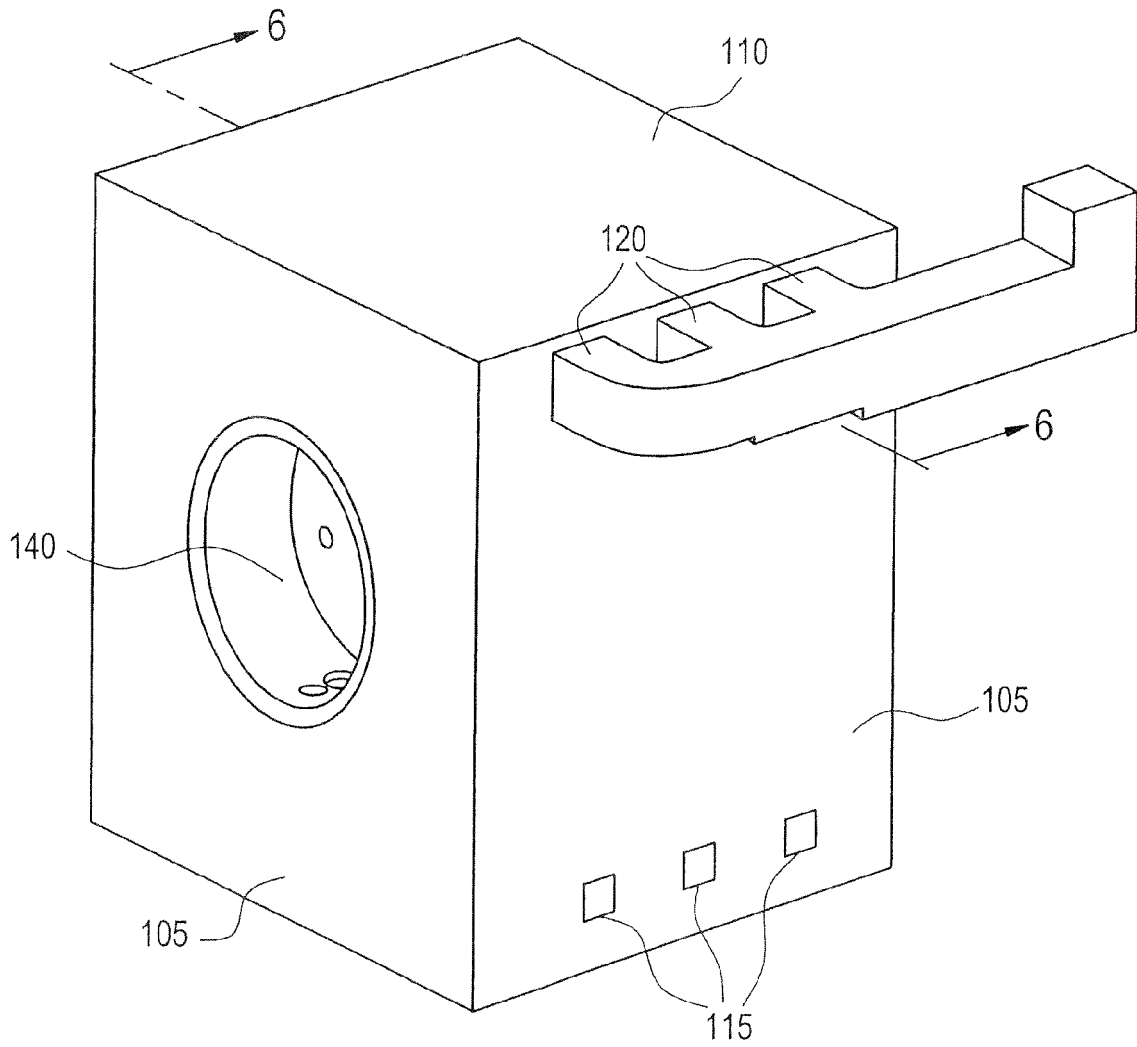


FIG. 6

