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(54) **EVAPORATIVE COOLING SYSTEM FOR SUBSTANTIALLY ENCLOSED STRUCTURES**

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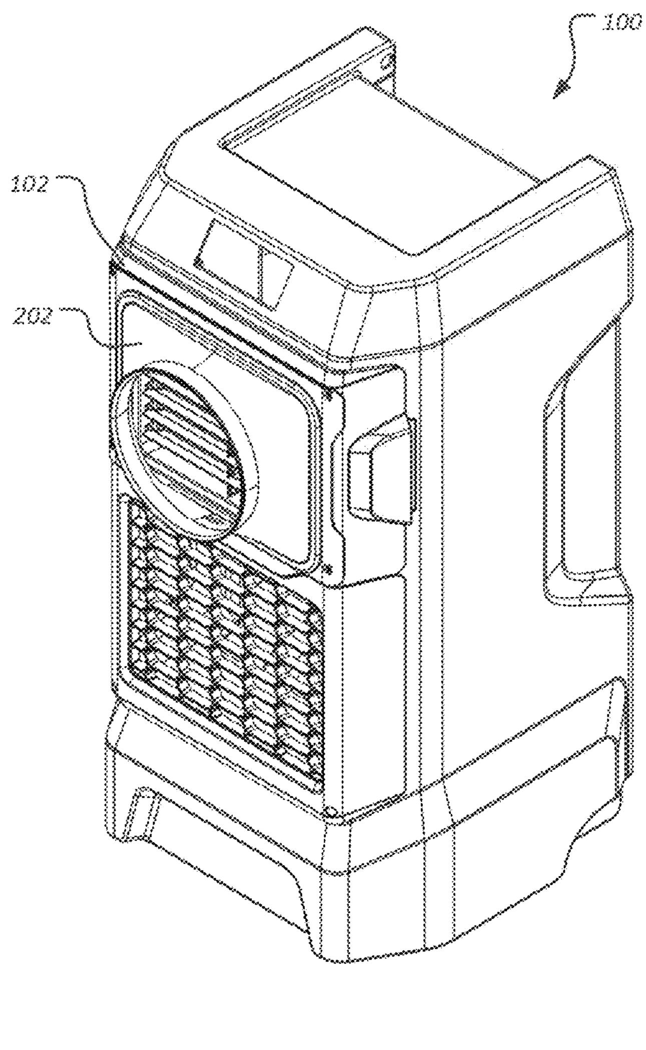
CPC ***F24F 5/0035*** (2013.01); ***F24F 13/0209*** (2013.01); ***F24F 13/0254*** (2013.01); ***F24F 13/06*** (2013.01)

(57) **ABSTRACT**

An evaporative cooling system (ECS) has an output direction system (ODS) having an outer housing, a nozzle configured to receive evaporatively cooled air from the ECS, and a mechanism for selectively moving the nozzle relative to the outer housing. The nozzle is located remote from the outer housing. A method of cooling a substantially enclosed structure includes providing an evaporative cooling system (ECS), operating the ECS to evaporatively cool air and eject the evaporatively cooled air, providing an output direction system (ODS), receiving the evaporatively cooled air from the ECS and into the ODS, transporting the evaporatively cooled air to a location remote from the ECS via the ODS, and outputting the evaporatively cooled air from the ODS through a nozzle.



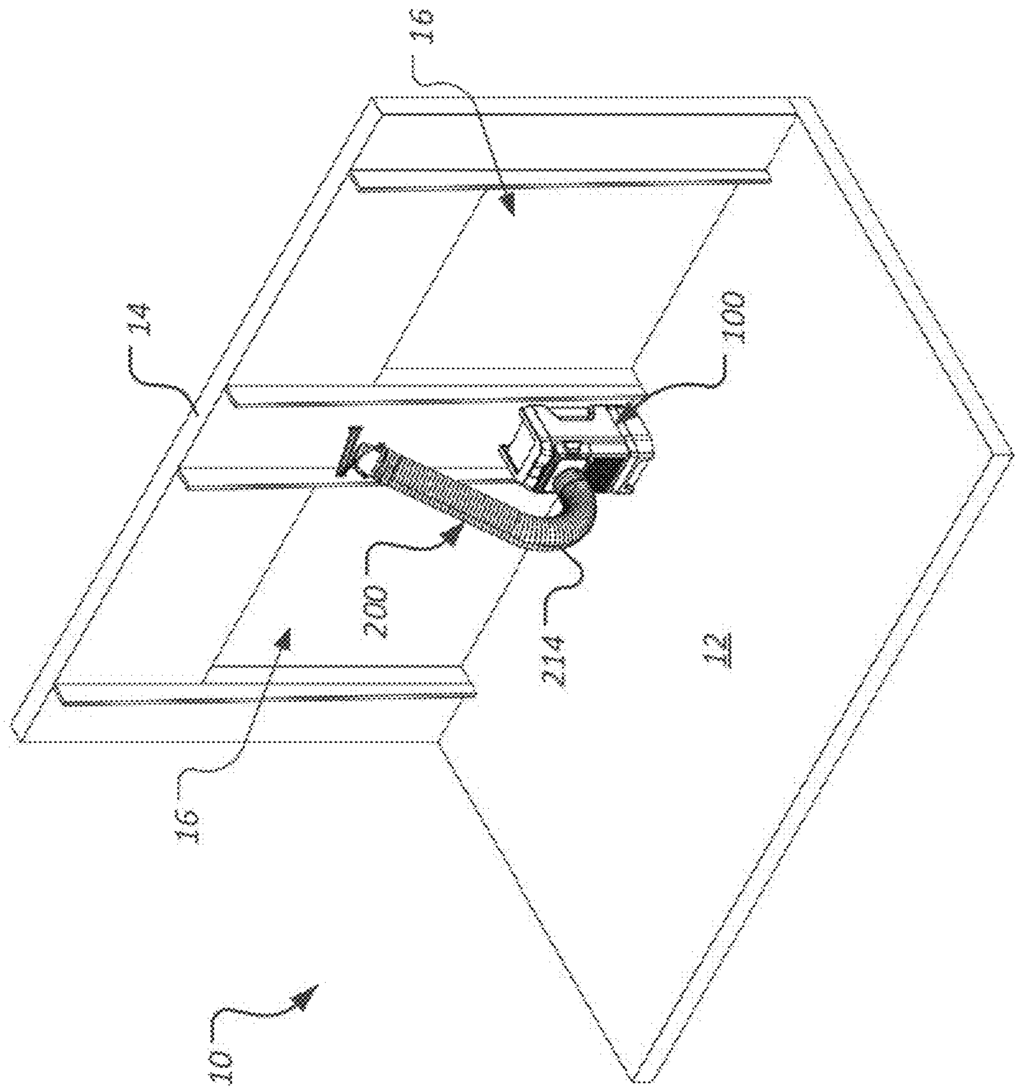


FIG. 1

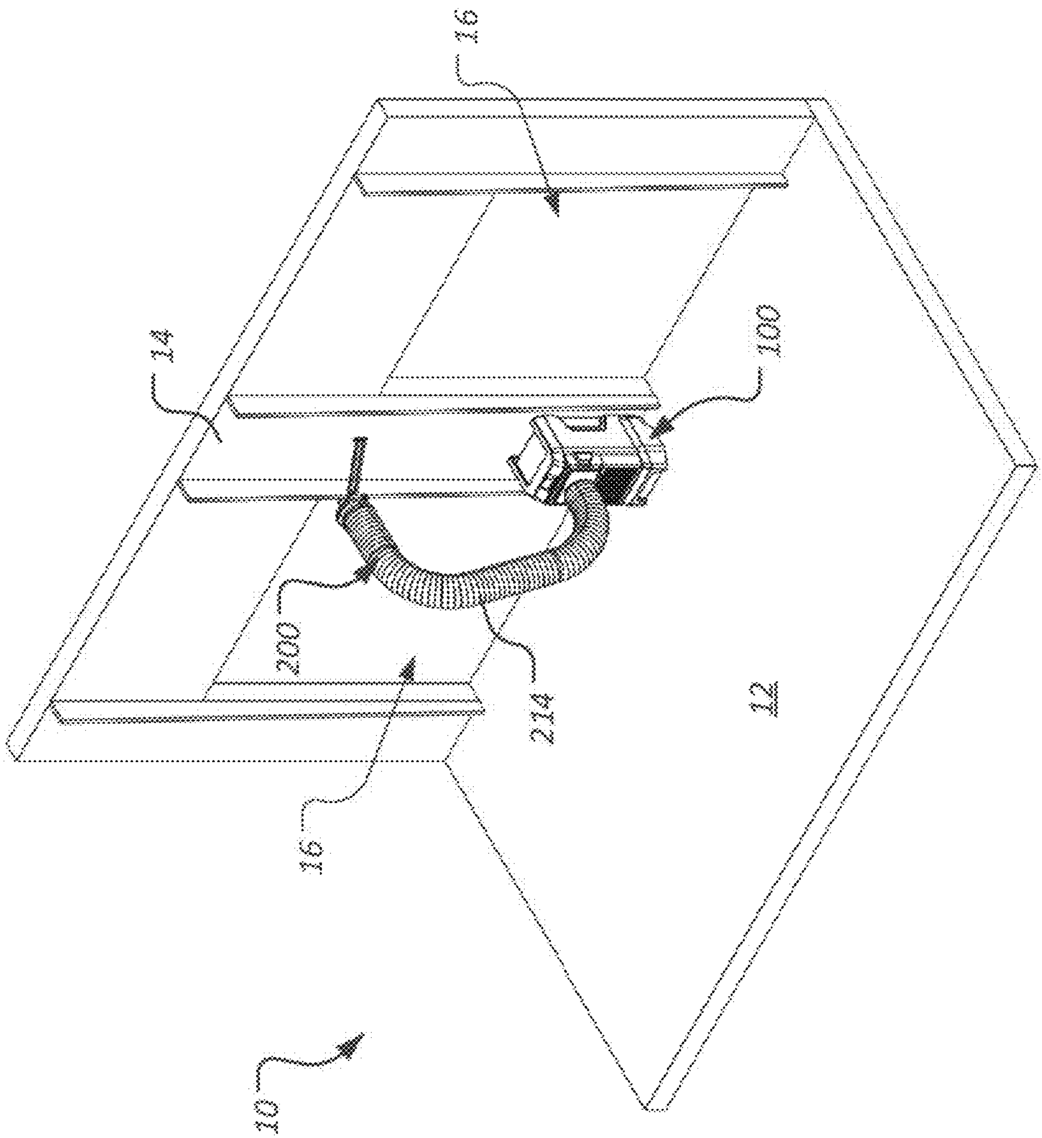


FIG. 2

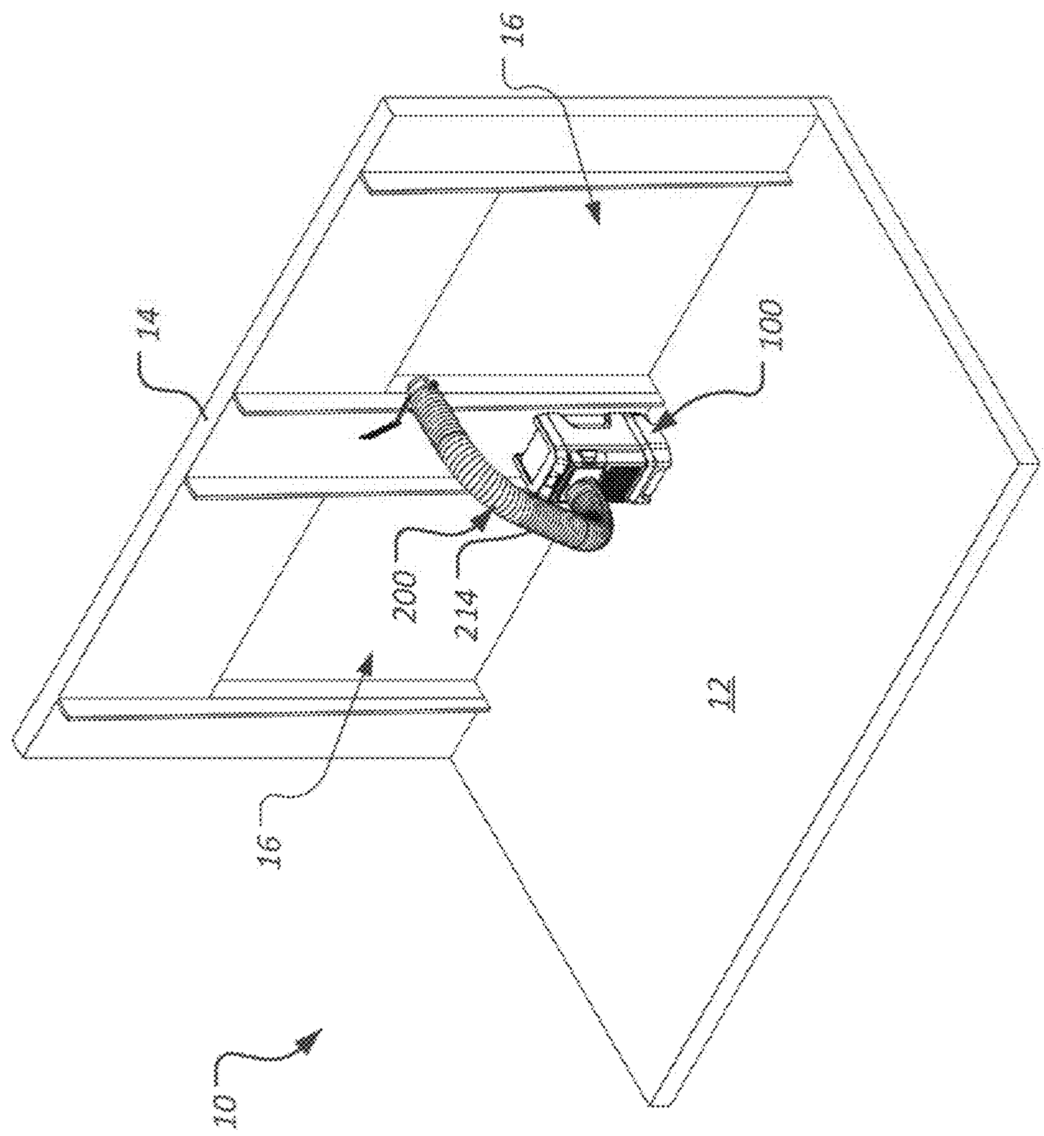


FIG. 3

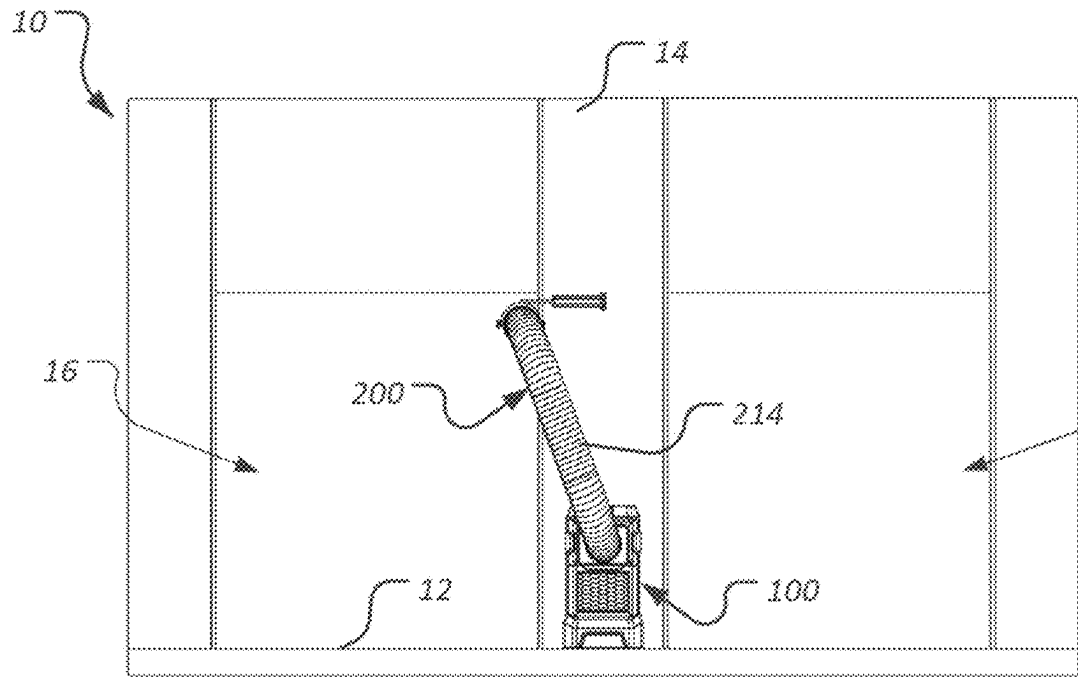


FIG. 4

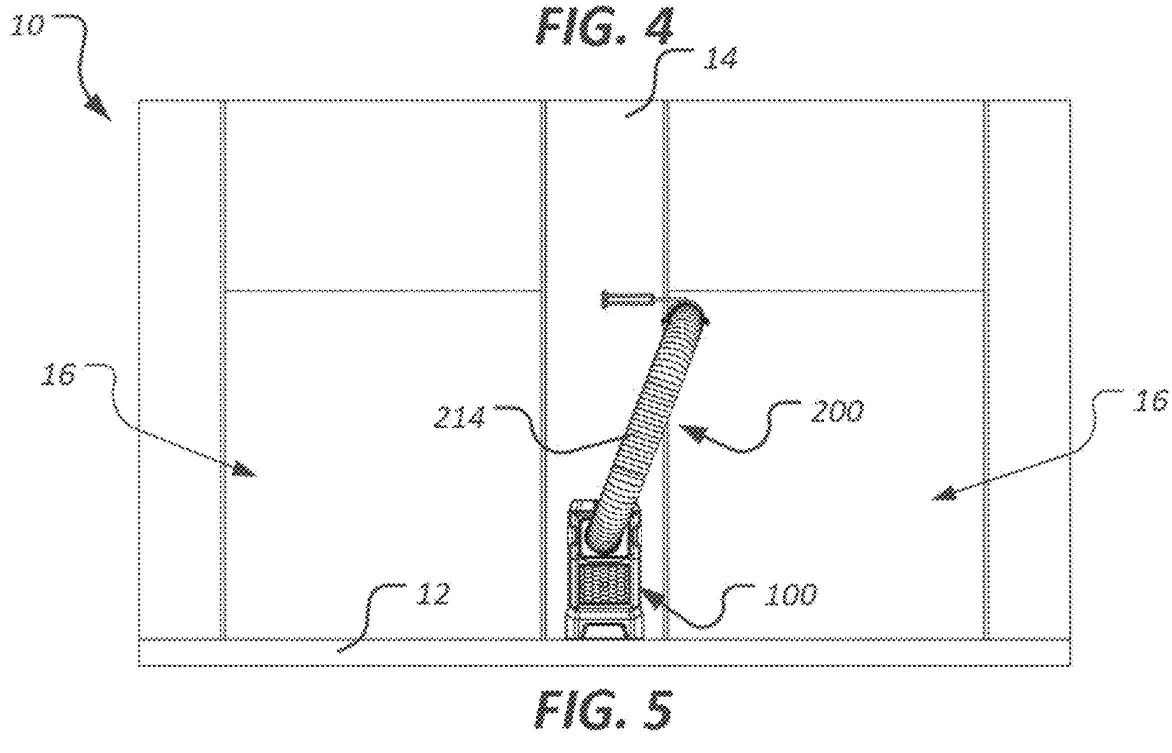


FIG. 5

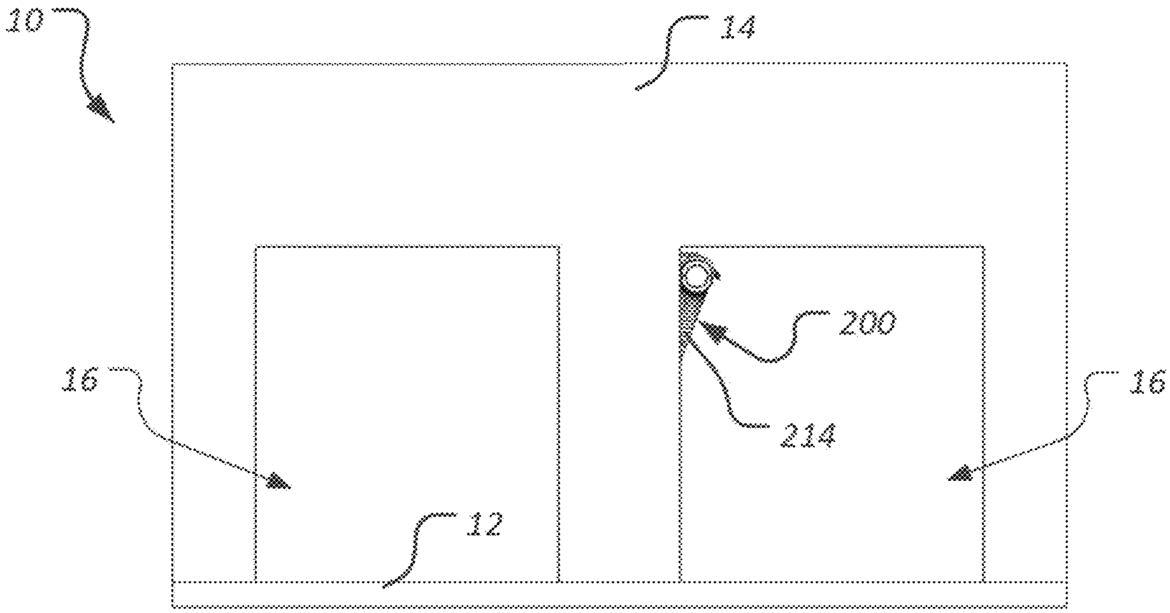


FIG. 6

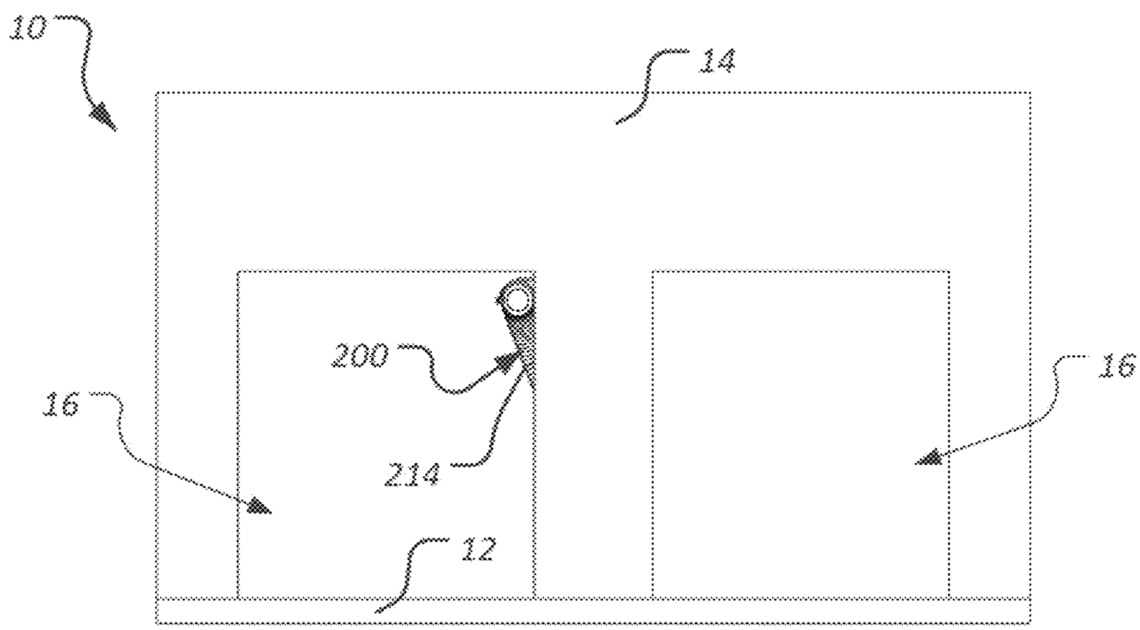


FIG. 7

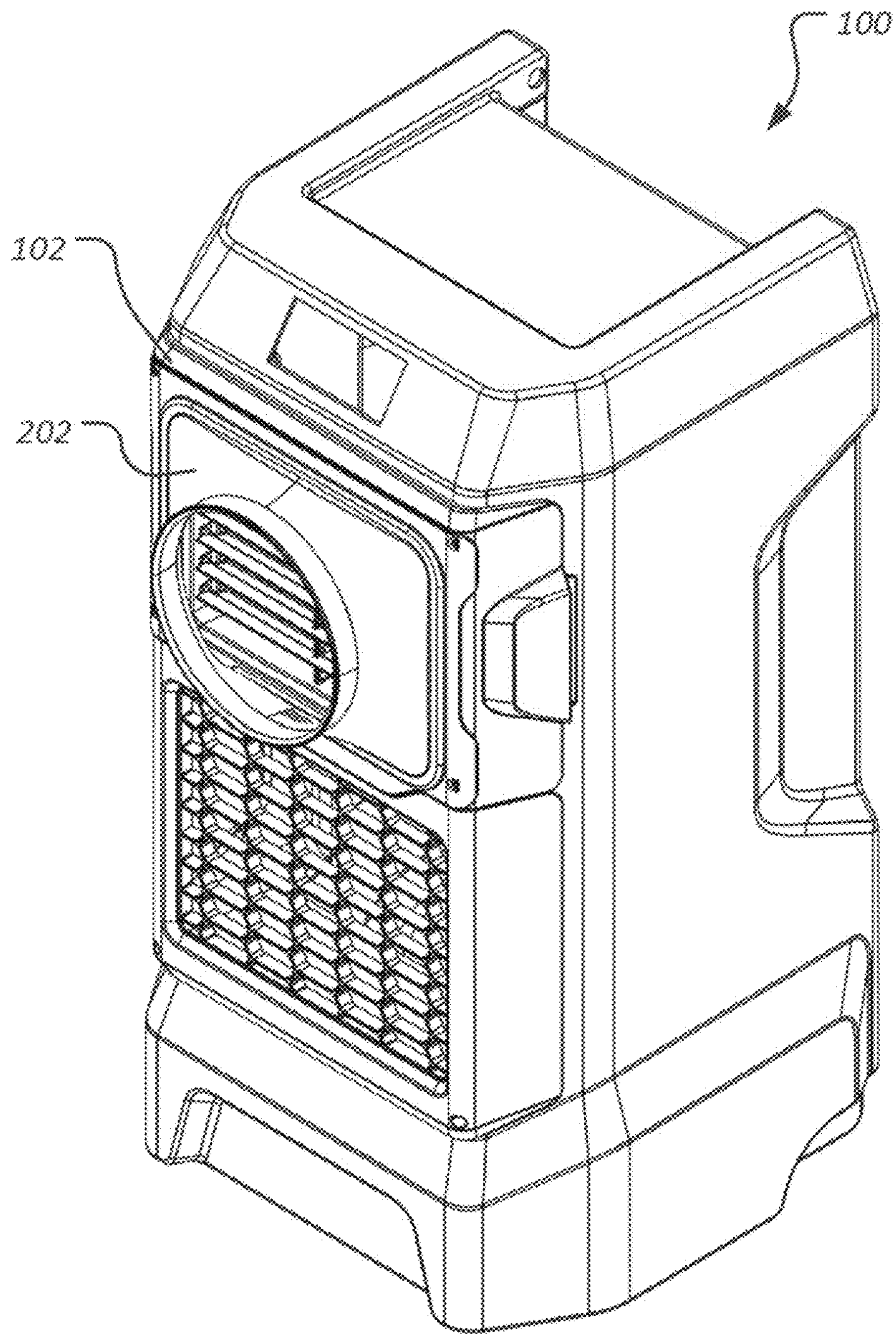


FIG. 8

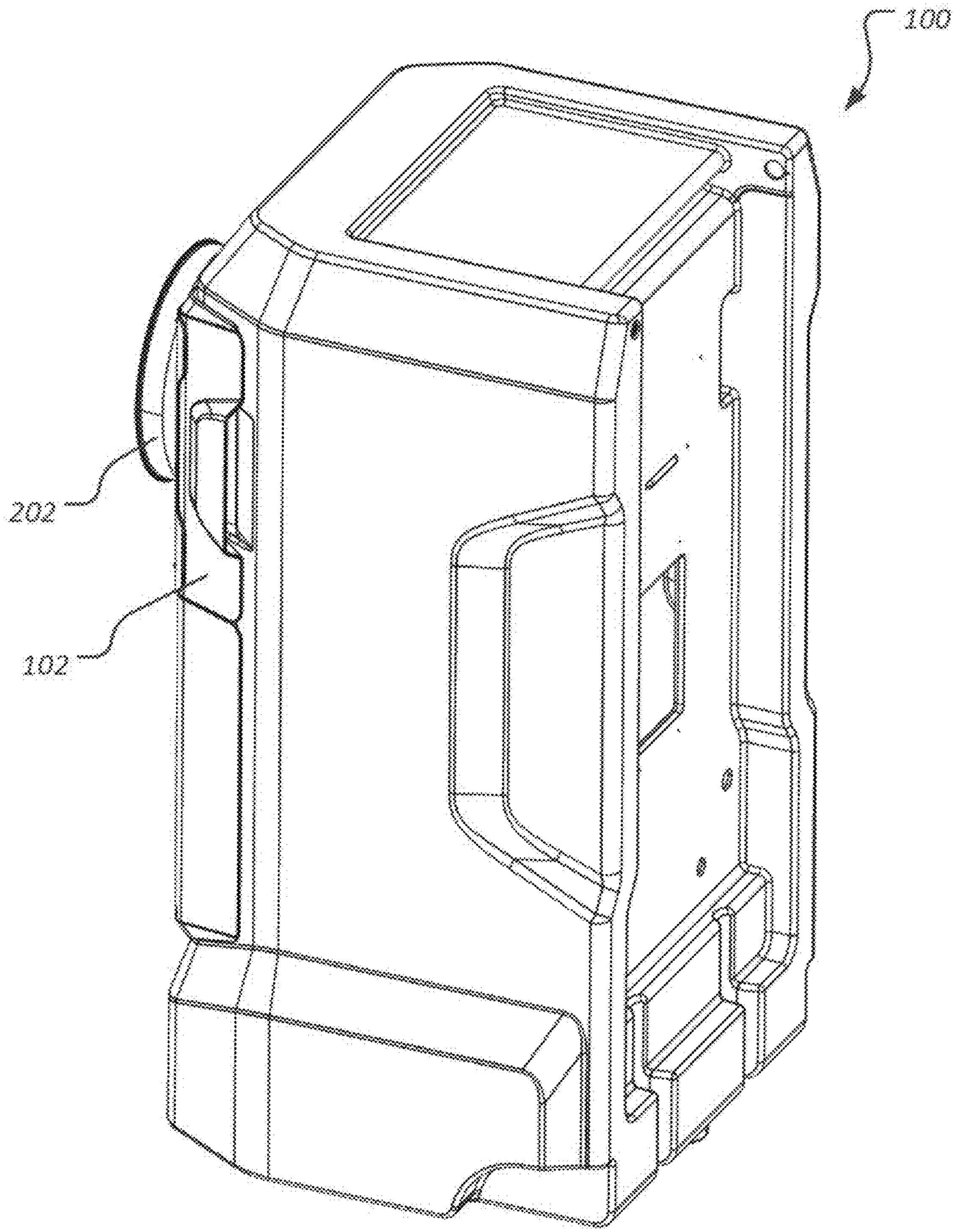


FIG. 9

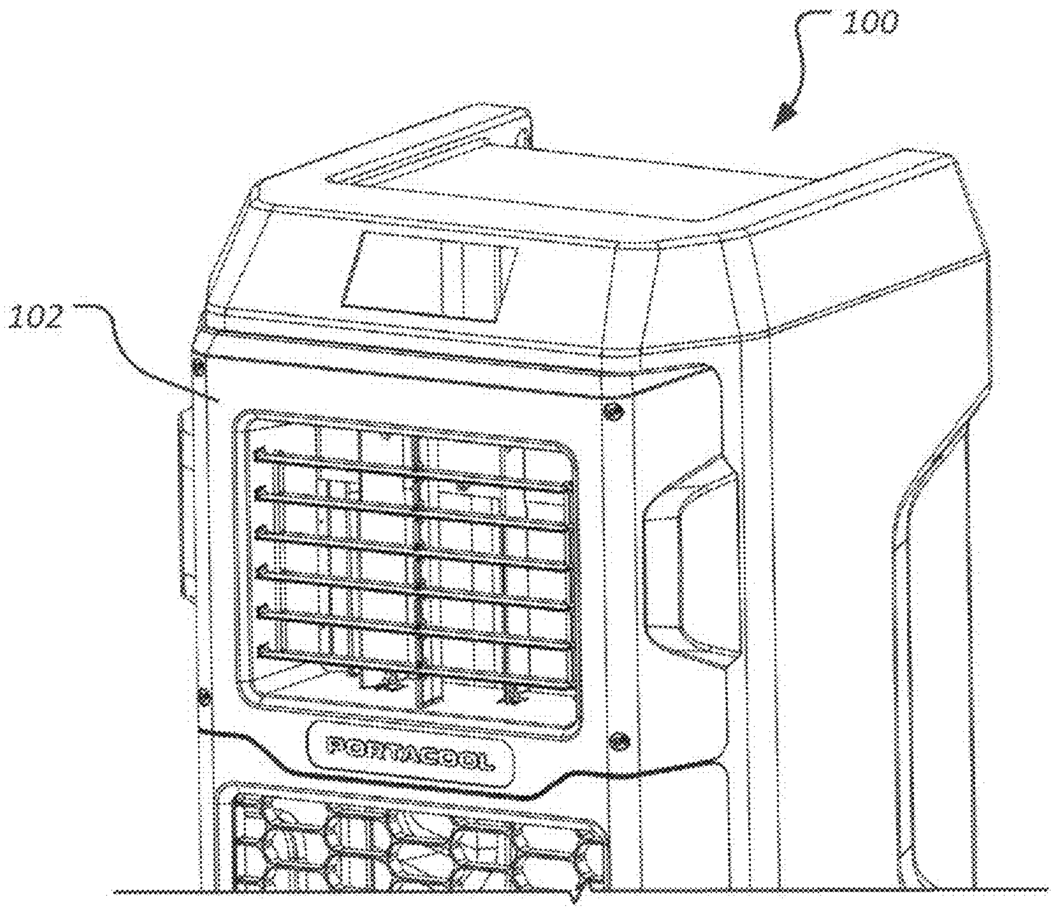


FIG. 10

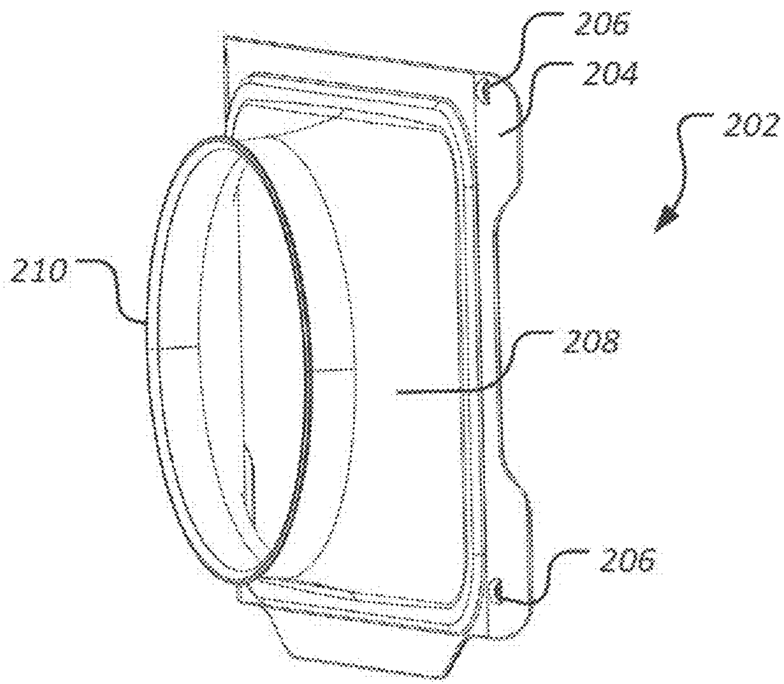


FIG. 11

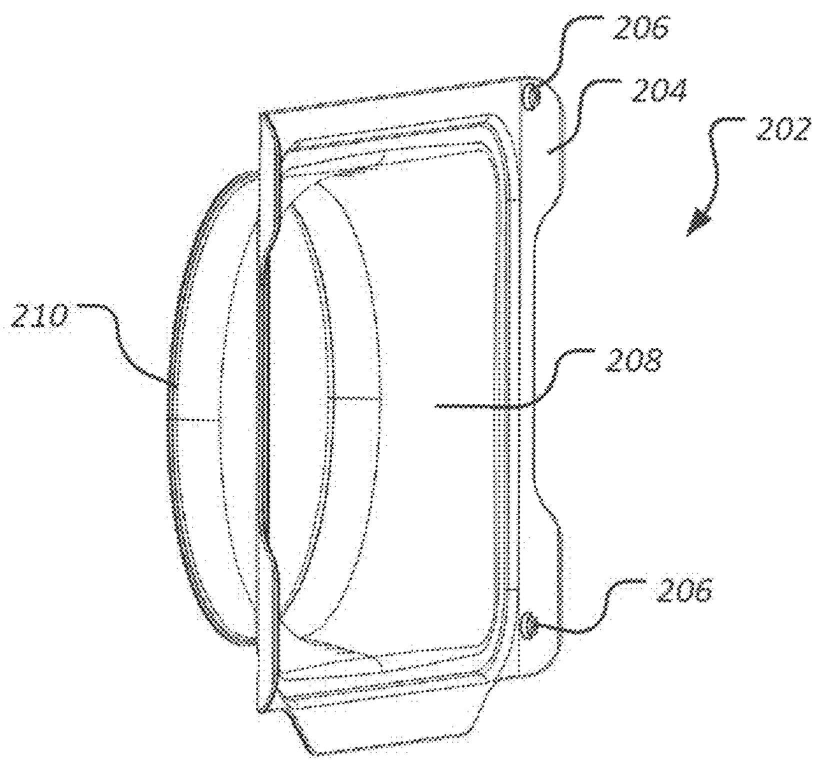


FIG. 12

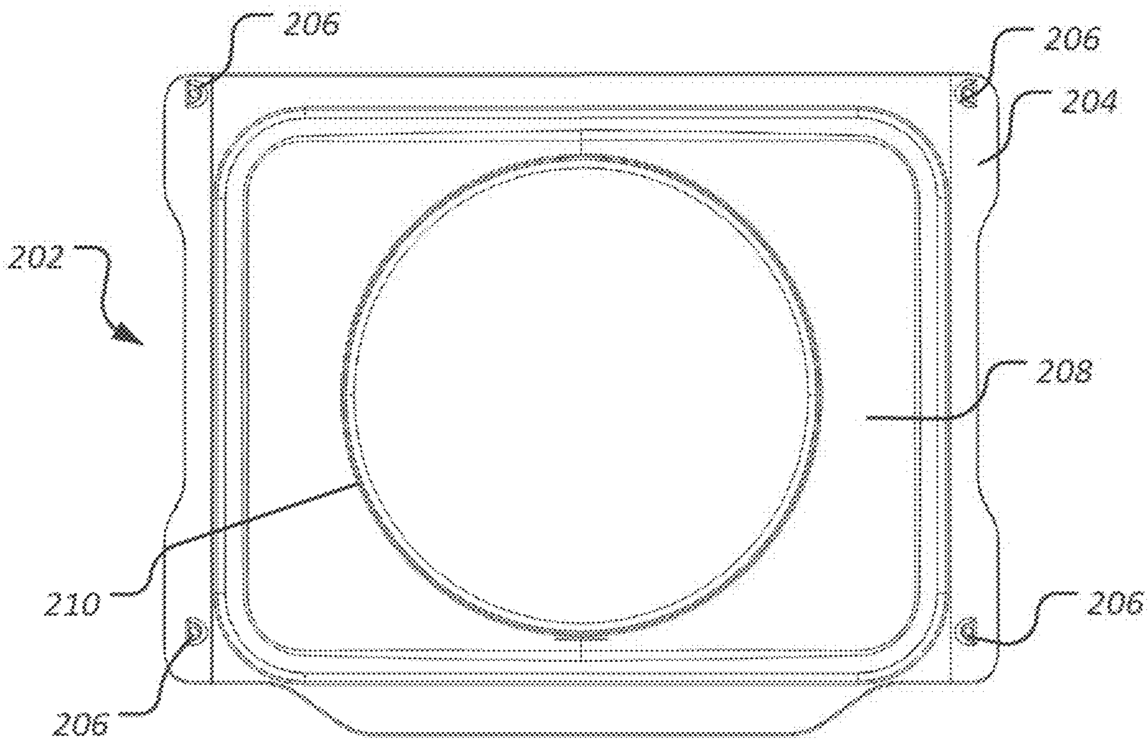


FIG. 13

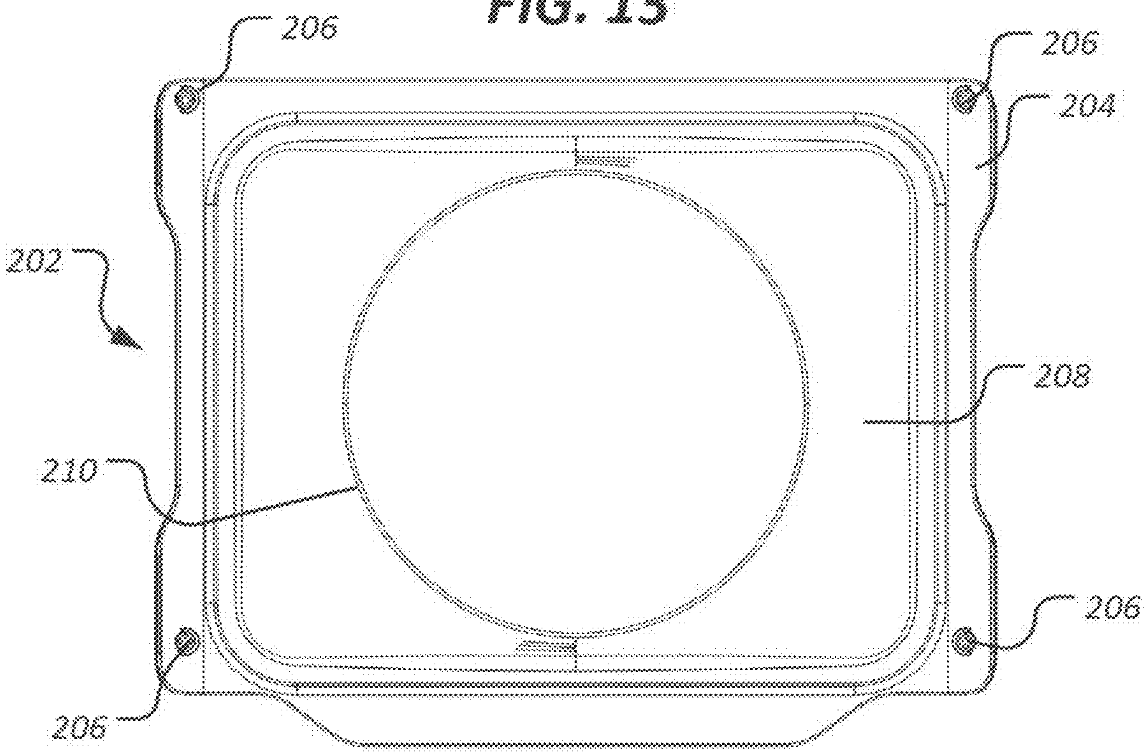


FIG. 14

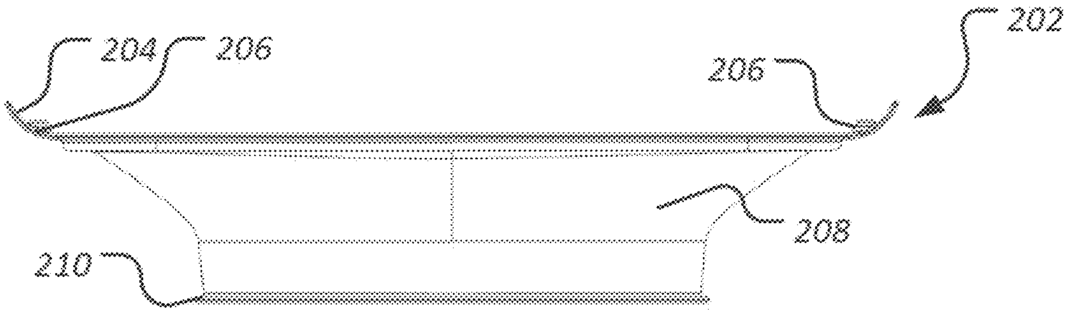


FIG. 15

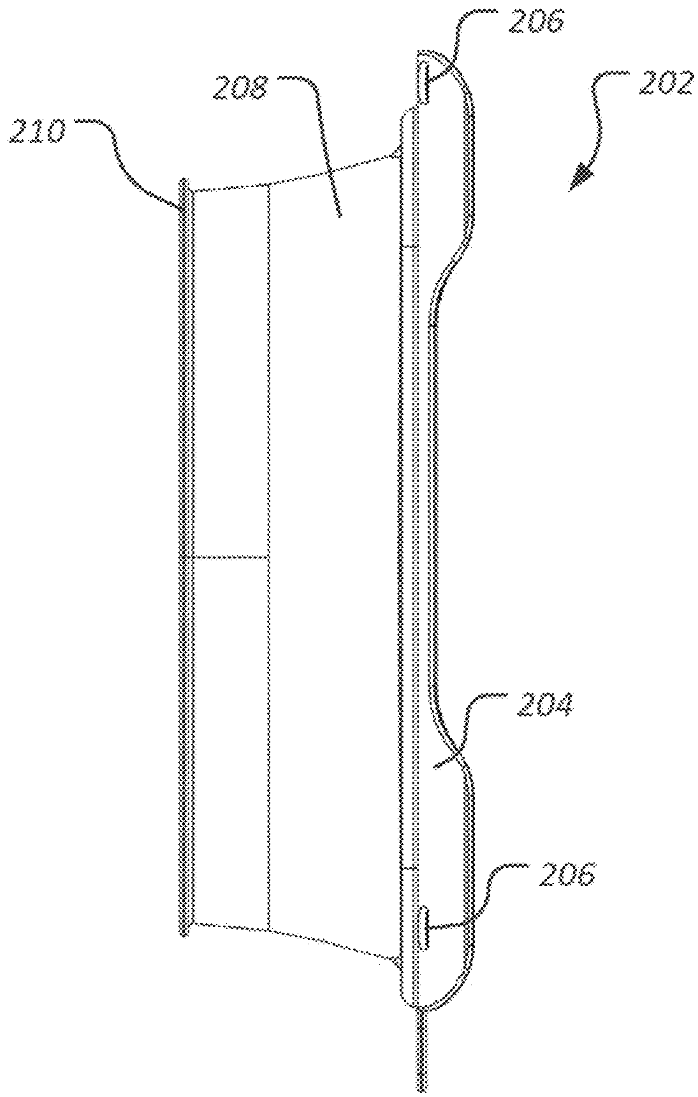
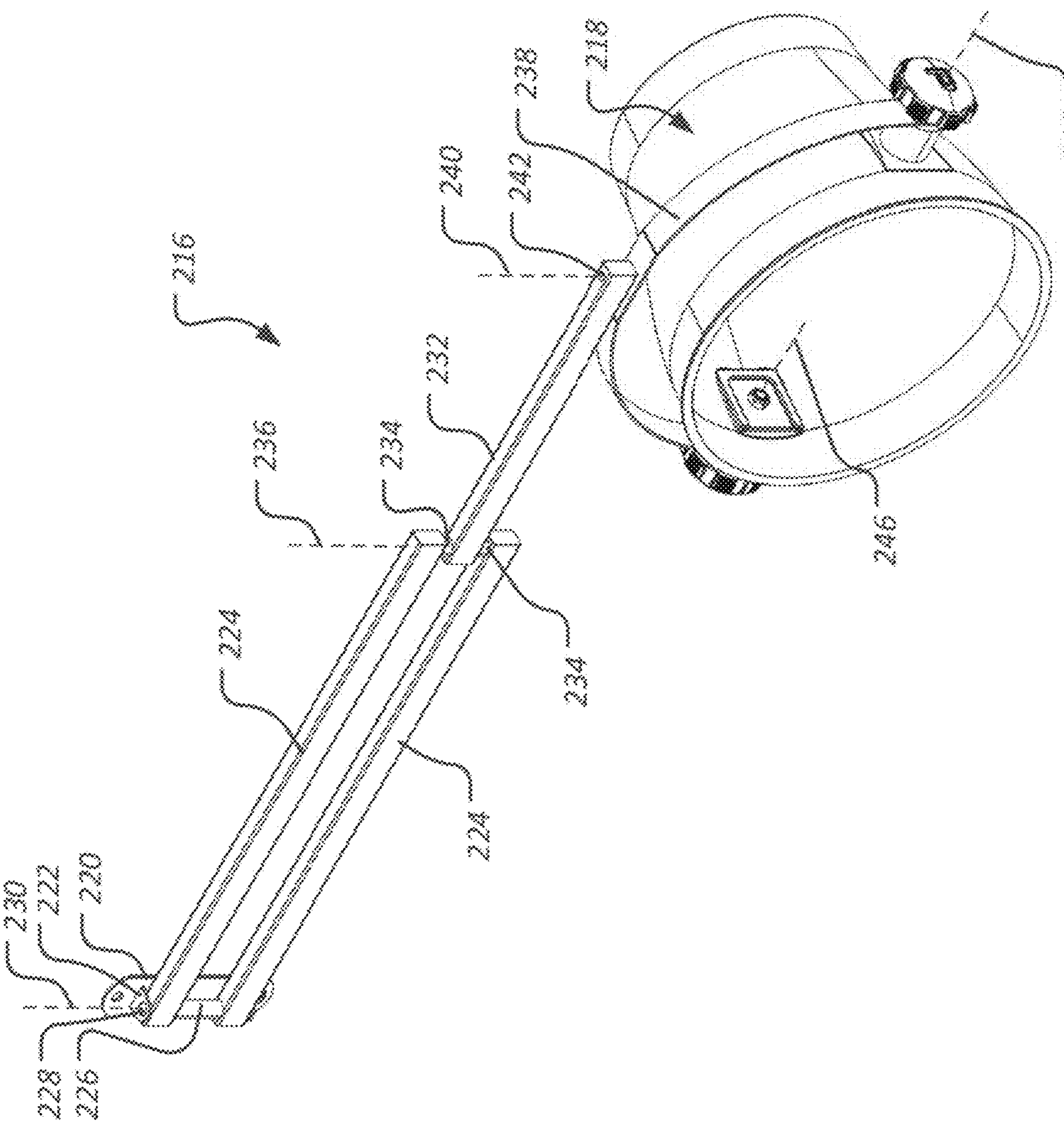


FIG. 16


216
218
238
242
240
246
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232
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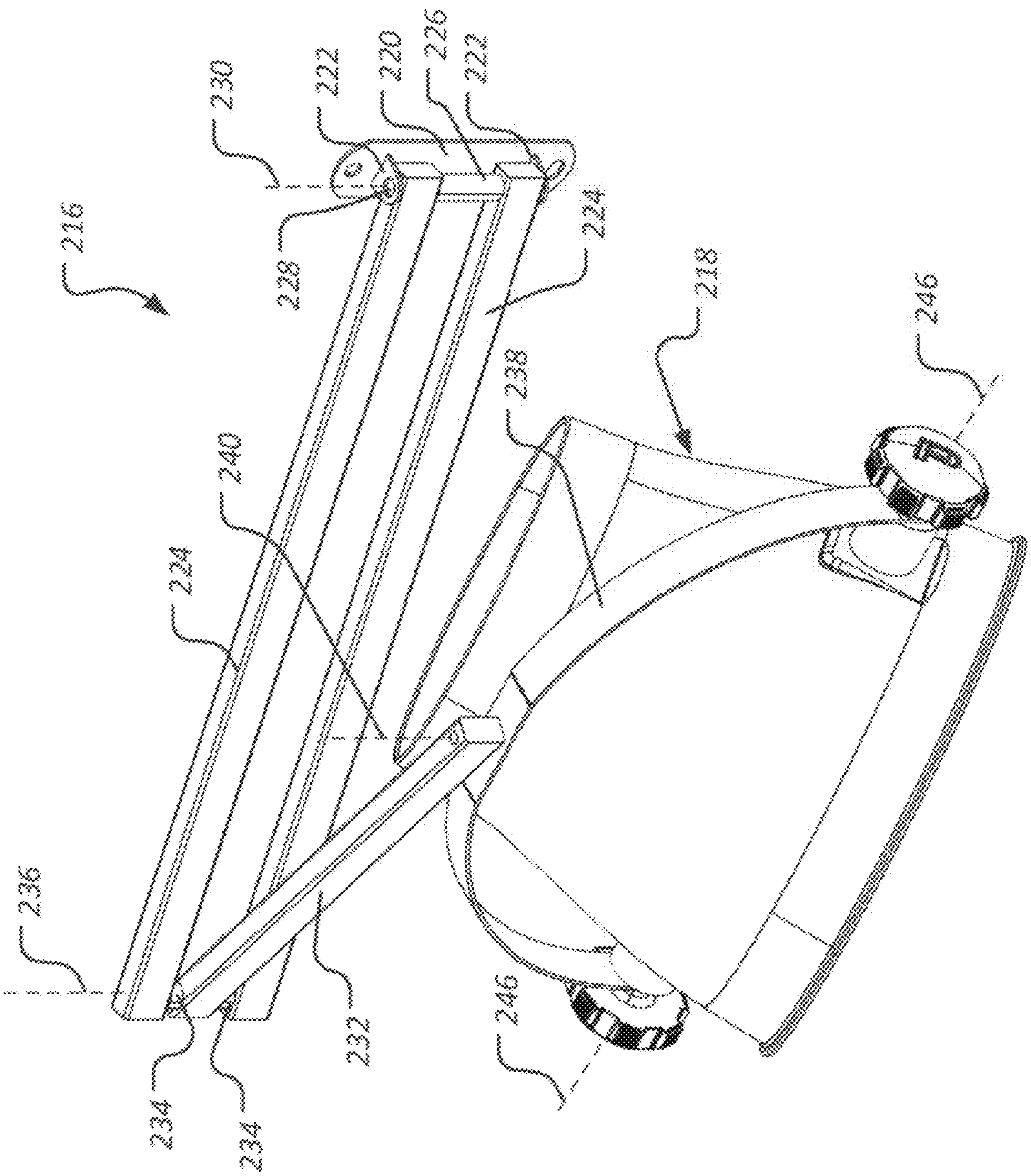
236
234
224
224
230
222
220
228
226

FIG. 17


216
230
222
220
226
222
228
224
218
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238
240
224
236
232
246
234
234

FIG. 18

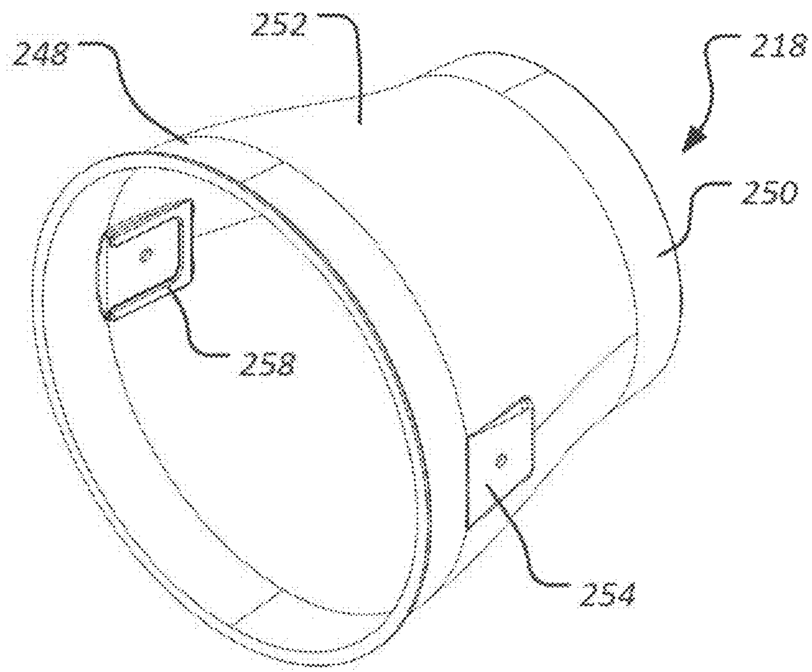

FIG. 19

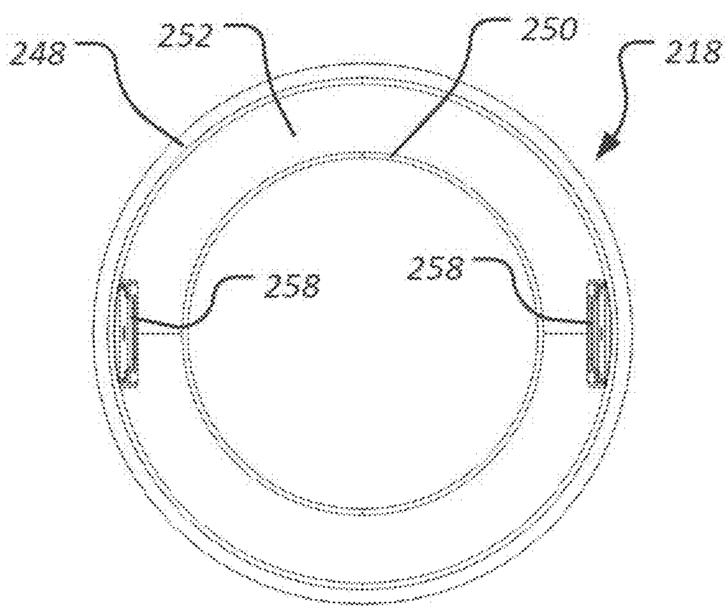

FIG. 20

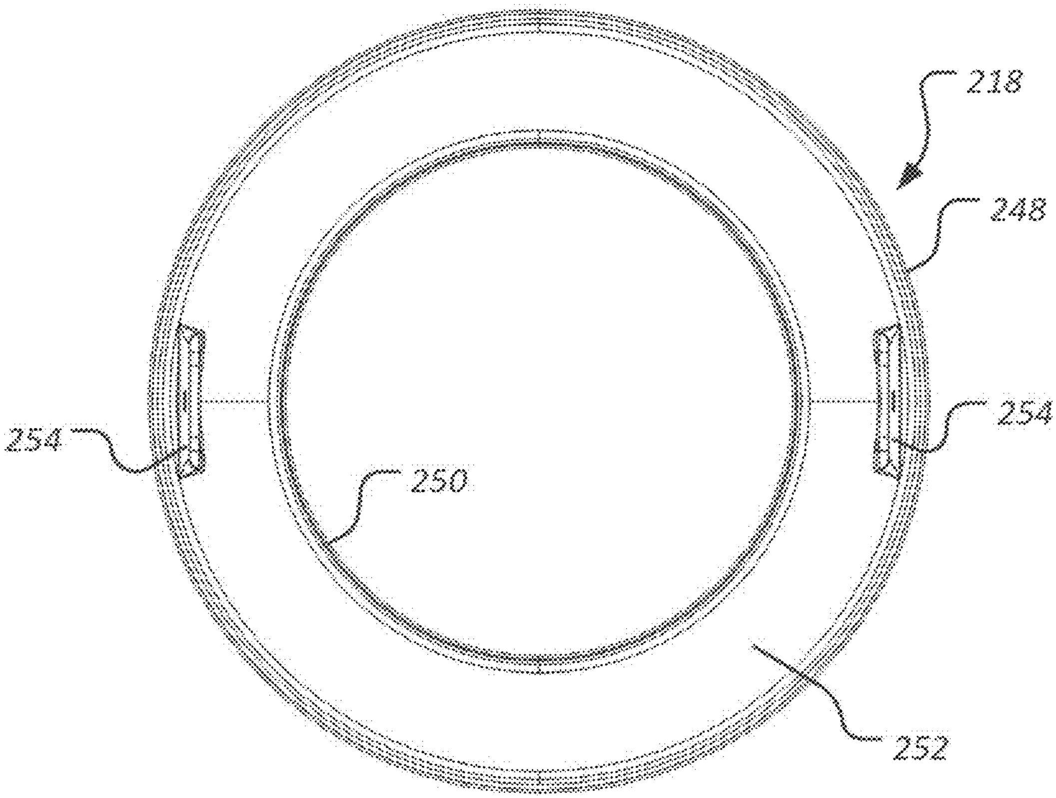

FIG. 21

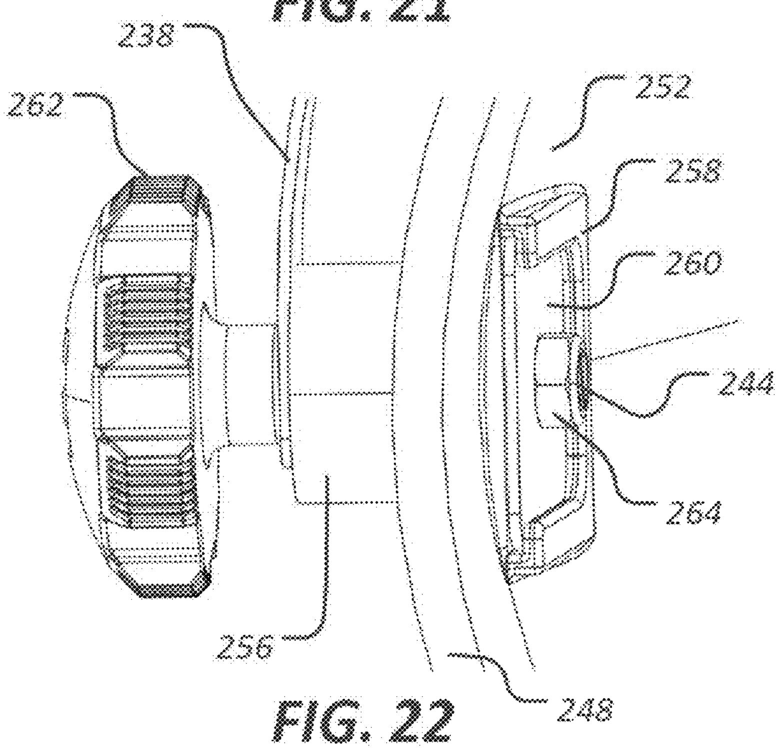

FIG. 22

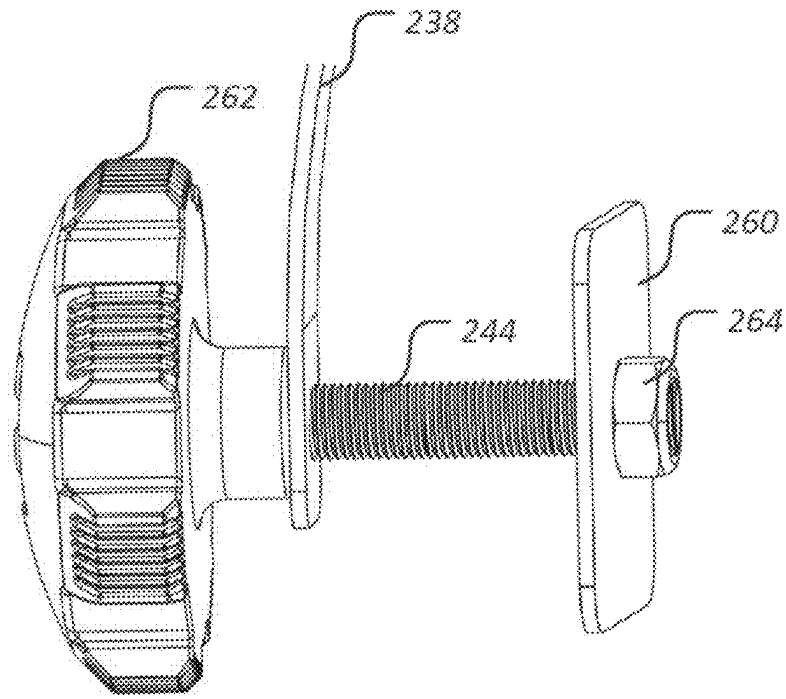
238
262
260
264
244

FIG. 23

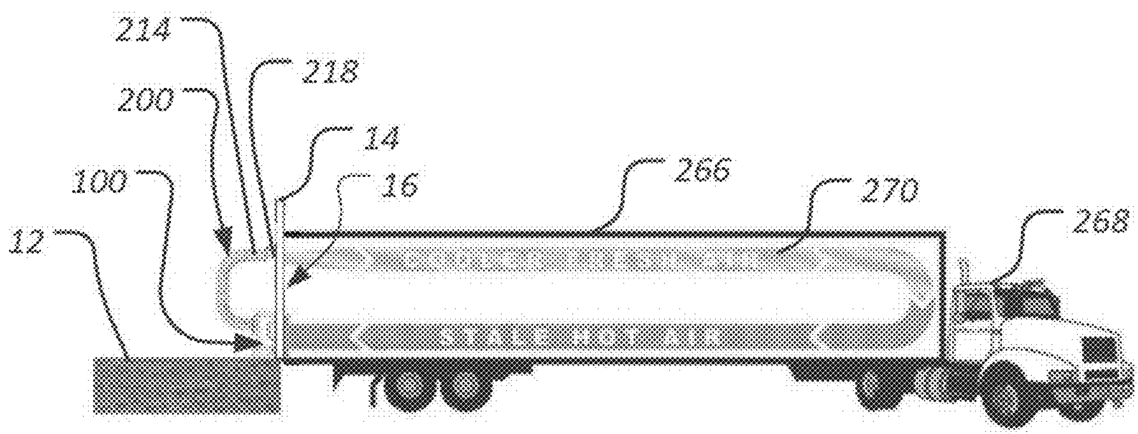
214
218
200
14
100
16
266
270
268
12
STALE HOT AIR

FIG. 24

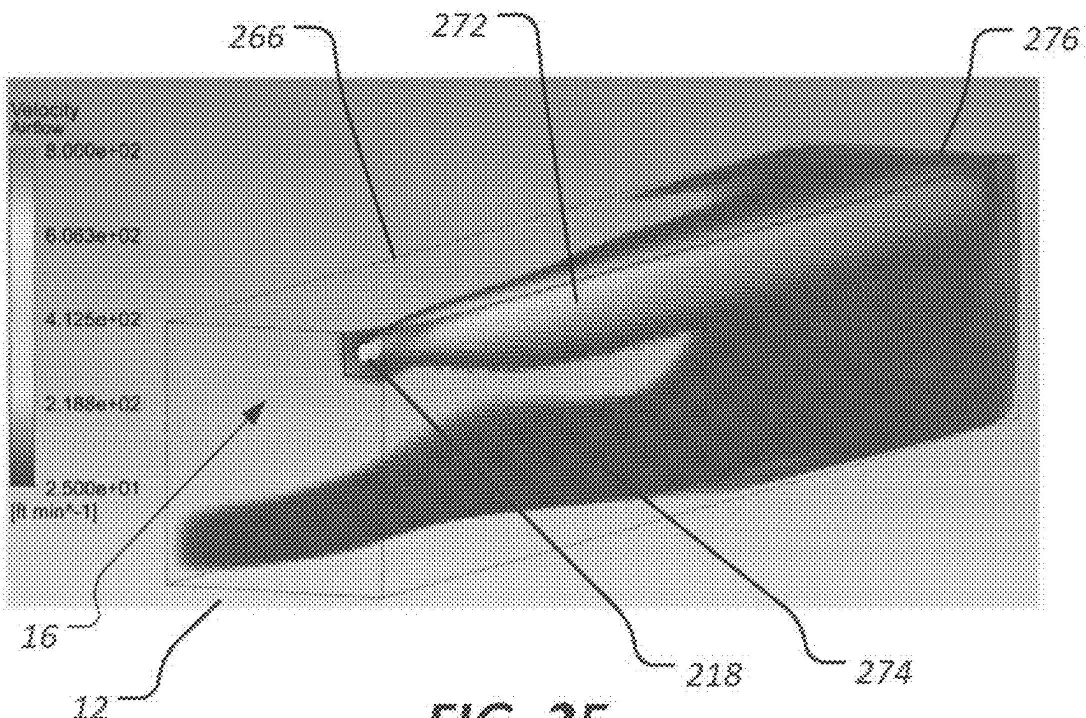

FIG. 25

EVAPORATIVE COOLING SYSTEM FOR SUBSTANTIALLY ENCLOSED STRUCTURES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation-In-Part of and claims the benefit of U.S. patent application Ser. No. 18/236,670 entitled "Stacked Evaporator Air Cooler" and filed 22 Aug. 2023, the entirety of which is hereby incorporated by reference.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND

[0003] In the field of cargo transportation, substantially enclosed structures, namely, trailers, cargo containers, and the like, are utilized for storage and movement of goods. Often, the goods must be removed from the substantially encloses structures by people and machines. However, temperatures within the substantially enclosed structures can be uncomfortably or dangerously extreme for the people and/or machines. Accordingly, there is a need for cooling and heating the interior space of the substantially enclosed structures at least during loading and unloading activities within the substantially enclosed structures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is an oblique view of an evaporative cooling system (ECS) in a dock environment with an output direction system (ODS) in a stowed position according to an embodiment of this disclosure.

[0005] FIG. **2** is an oblique view of the ECS with the ODS configured to output through a left dock.

[0006] FIG. **3** is an oblique view of the ECS with the ODS configured to output through a right dock.

[0007] FIG. **4** is a front view of the ECS with the ODS configured to output through the left dock.

[0008] FIG. **5** is a front view of the ECS with the ODS configured to output through the right dock.

[0009] FIG. **6** is a rear view of the ECS with the ODS configured to output through the left dock.

[0010] FIG. **7** is a rear view of the ECS with the ODS configured to output through the right dock.

[0011] FIG. **8** is an oblique top-front view of a portion of the ECS without showing the ODS.

[0012] FIG. **9** is an oblique top-rear view of a portion of the ECS without showing the ODS.

[0013] FIG. **10** is an oblique top-front close-up view of a portion of the ECS without showing the ODS.

[0014] FIG. **11** is an oblique front-right view of a duct attachment of the ODS.

[0015] FIG. **12** is an oblique rear-right view of the duct attachment of FIG. **11**.

[0016] FIG. **13** is an orthogonal front view of the duct attachment of FIG. **11**.

[0017] FIG. **14** is an orthogonal rear view of the duct attachment of FIG. **11**.

[0018] FIG. **15** is an orthogonal top view of the duct attachment of FIG. **11**.

[0019] FIG. **16** is an orthogonal right view of the duct attachment of FIG. **11**.

[0020] FIG. **17** is an oblique top-right view of a portion of the ODS in a deployed position and without showing a duct and the duct attachment.

[0021] FIG. **18** is an oblique top-right view of the portion of the ODS of FIG. **17** in a stowed position.

[0022] FIG. **19** is an oblique top-right view of a nozzle of the ODS.

[0023] FIG. **20** is an orthogonal front view of the nozzle of FIG. **19**.

[0024] FIG. **21** is an orthogonal rear view of the nozzle of FIG. **19**.

[0025] FIG. **22** is an oblique rear view of a portion of the ODS showing an attachment system of the ODS.

[0026] FIG. **23** is an oblique rear view of the portion of the ODS of FIG. **22** without showing the nozzle and a spacer.

[0027] FIG. **24** is a schematic view of the ECS of FIG. **1** in a shipping dock environment.

[0028] FIG. **25** is a computational airflow velocity analysis of air exiting the nozzle of FIG. **19** into a trailer.

DETAILED DESCRIPTION

[0029] In this disclosure, 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 this disclosure, the devices, members, apparatuses, etc. described herein may be positioned in any desired orientation. Thus, the use of terms such as "above," "below," "upper," "lower," 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, as the device described herein may be oriented in any desired direction.

[0030] FIGS. **1-7** illustrate an evaporative cooling system (ECS) **100** having an output direction system (ODS) **200**, according to an embodiment of this disclosure. In this embodiment, ECS **100** is substantially similar to the portable evaporator air cooler **100** of U.S. patent application Ser. No. 18/236,670 which is hereby incorporated by reference in its entirety. ECS **100** is shown as disposed in a shipping dock environment **10**, such as a conventional shipping dock that is configured to allow cargo trailers to be loaded and unloaded. The shipping dock environment **10** comprises a floor **12**, a wall **14**, and dock doorways **16**. In this embodiment, a portion of ECS **100** is movably disposed on floor **12** in alignment with a portion of wall **14** that is disposed between dock doorways **16**. In this embodiment, output direction system (ODS) **200** is both connected to an outer housing **102** of ECS **100** and supported by wall **14**.

[0031] Referring to FIGS. **8**, **9**, and **11-16**, ODS **200** comprises a duct attachment **202** configured for selective attachment to an outer housing **102** of ECS **100**. A flange **204** of duct attachment **202** can be placed substantially flush against outer housing **102** so that air ejected from ODS **200** is pass through duct attachment **202**. Air that is ejected from ECS **100** can pass through duct attachment **202** through an internal space defined by a converging wall **208** that extends from flange **204** to a duct connection ring **210**. Notably, converging wall **208** comprises a profile that is substantially rectangular at the junction with flange **204** and extends away from ECS **100** in a manner that smoothly transitions to join with the substantially cylindrical tubular shaped duct connection ring **210**. In this embodiment, duct connection ring **210** comprises a lip that can serve as a stop for retention devices used to attach a flexible duct **214** to duct connection ring **210**. FIG. **10** shows ECS **100** with duct attachment **202** removed.

[0032] Referring to FIGS. **17** and **18**, ODS **200** further comprises an adjustable arm mount system **216** and a nozzle **218** carried by arm mount system **216**. Arm mount system **216** comprises a wall plate **220** for attachment to a wall such as wall **14**. Wall plate **220** comprises flanges **222** for accepting base arms **224** and a wall spacer **226** therebetween. Flanges **222**, base arms **224**, and wall spacer **226** comprise holes for accepting wall pin **228** therethrough to allow the base arms **224** to rotate about wall axis **230**. Arm mount system **216** further comprises an extension arm **232** rotatably carried between base arms **224** and spaced by extension spacers **234**. Base arms **224** and extension arm **232** comprise hole for receiving an extension arm pin (not shown) into base arms **224** and through extension arm **232** and extension spacers **234** so that extension arm **232** can rotate about extension axis **236**. Arm mount system **216** further comprises a hanger **238** rotatably mounted to extension arm **232** about hanger axis **240** using a hanger pin **242**. Hanger **238** further comprises holes for accepting mounting bolts **244** therethrough to allow connection of nozzle **218** to hanger **238** in a rotatable manner about nozzle axis **246**.

[0033] Referring now to FIGS. **19-21**, nozzle **218** is shown in isolation. Nozzle **218** is generally tubular and comprises an inlet ring **248** having a first diameter, an outlet ring **250** having a second diameter smaller than the first diameter, and a reducing wall **252** joining the inlet ring **248** to the outlet ring **250**. Nozzle **218** further comprises two mounting pads **254** carried at least partially by the exterior of the reducing wall **252**. The mounting pads **254** provide substantially flat surfaces for abutment with cylindrical spacers **256** shown in FIG. **22**. Mounting pads **254** also comprise holes for receiving mounting bolts **244** therethrough. Nozzle **218** also has two receivers **258** at least partially carried by an inner surface of the reducing wall **252**. The receivers **258** comprise overhanging wall protrusions configured to form a slot for receiving nozzle mount plates **254** therein. In this embodiment, the receivers **258** and nozzle mount plates **260** comprise complementary rectilinear shapes that provide a simplified slide-on mounting feature between the nozzle **218** and the hanger **238**. The nozzle mount plates **260** and related assembly are best shown in FIGS. **22** and **23**. Mounting bolts **244** also carry a tightening knob **262** for screwing the mounting bolt **244** into nut **264** so that the hanger, **238**, spacer **256**, reducing wall **252**, and nozzle mount plates **260** can be sandwiched tightly between the knob **262** and nut **264**.

[0034] Referring now to FIG. **24**, an ECS **100** having an ODS **200** is shown as configured to deliver air cooled by evaporative cooling action of the ECS **100** via ODS **200** to a trailer **266**, positioned by a semi-truck **268**, into a docked position relative to dock doorway **16** of a shipping dock environment **10**. In this embodiment, nozzle **218** is positioned using arm mount system **216** to an upper corner location of dock doorway **16** so that cooled air exits nozzle **218** into an upper side portion of trailer **266**. Airflow path **270** shows a simplified schematic representation of the flow of air ejected from ODS **200**. More specifically, the cool air can enter trailer **266** in an upper portion of trailer **266** and warmer air can flow back out of trailer at a lower portion of trailer **266**.

[0035] Referring now to FIG. **25**, a computational airflow velocity analysis of air ejected from nozzle **218** into trailer **266** is shown. A benefit of using a cross-sectional reducing flowpath of nozzle **218** is that airflow velocity is increased as ejected from nozzle **218**. The higher velocity airflow **272** is generally more tightly formed as compared to conventional fan outputs, and therefore, can reach a far end **276** of trailer **266** without substantial stagnation. In other words, ECS **100** with the aid of ODS **200** can deliver evaporatively cooled air far into trailer **266** whereas conventional delivery methods tend to spread air over greater cross-sectional areas near an entrance of the trailer **266** which leads to stagnation and failure of cooled air reaching far into trailer **266**. In this embodiment, cooler higher velocity airflow **272** enters trailer **266** near an upper side of trailer **266** and reaches far end **276** of trailer before falling, reflecting, and returning back toward an entrance of trailer **266** near dock doorway **16**. In some embodiments, air ejected from nozzle **218** can be substantially laminar as compared to conventional fan outputs, thereby ensuring deep reach of cooled air into trailer **266**. In some cases, ECS **100** is situated between dock doorways so that air taken in by ECS **100** is not primarily air that is immediately leaving trailer **266**. In cases where air temperatures within shipping dock environment **10** are cooler than air exiting trailer **266**, improved cooling can be achieved.

[0036] It will be appreciated that in alternative embodiments, mechanisms other than arm mount system **216** can be used to selectively locate nozzles **218** relative to dock doorways **16**. Further, it will be appreciated that nozzles shaped differently from nozzle **218** can be utilized to provide relatively high velocity air outputs and/or relatively laminar air outputs to similarly reach deep recesses of trailers **266** or other substantially enclosed structures so that evaporatively cooled air can be selectively aimed to produce the airflows demonstrated herein or to selectively target a location within a substantially enclosed structure without prematurely stagnating.

[0037] Still further, it will be appreciated that while the ECS **100** is a system that most generally receives environmental air on a first side and expels air from the same side, alternative embodiments of ESCs are contemplated that receive environmental air or intake air on a first side and expels air from a different side. More specifically, it is contemplated that an alternative ECS can receive air on a first side and expel air on a second generally opposing side. It is further contemplated that an alternative embodiment of an ECS can receive air on a first side and expel air on any other side. Additionally, in some embodiments, a secondary duct can be utilized in association with an ECS air intake so that air exiting a substantially enclosed structure, such as a trailer, can be fed back into the ECS for further evaporative cooling. In some cases, by receiving and expelling air on different sides of an ECS can allow locating the ECS at different locations near the substantially enclosed structures being cooled.

[0038] At least one embodiment is disclosed, and variations, combinations, and/or modifications of the embodiment(s) and/or features of the embodiment(s) made by a person having ordinary skill in the art are within the scope of this disclosure. Alternative embodiments that result from combining, integrating, and/or omitting features of the embodiment(s) are also within the scope of this disclosure. Where numerical ranges or limitations are expressly stated, such express ranges or limitations should be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations (e.g., from about 1 to about 10 includes, 2, 3, 4, etc.; greater than 0.10 includes 0.11, 0.12, 0.13, etc.). For example, whenever a numerical range with a lower limit, R_{EL}, and an upper limit, R_u, is disclosed, any number falling within the range is specifically disclosed. In particular, the following numbers within the range are specifically disclosed: $R=R_s+k^*(R_u-R_l)$, wherein k is a variable ranging from 1 percent to 100 percent with a 1 percent increment, i.e., k is 1 percent, 2 percent, 3 percent, 4 percent, 5 percent, . . . 50 percent, 51 percent, 52 percent, . . . , 95 percent, 96 percent, 95 percent, 98 percent, 99 percent, or 100 percent. Moreover, any numerical range defined by two R numbers as defined in the above is also specifically disclosed.

[0039] Use of the term "optionally" with respect to any element of a claim means that the element is required, or alternatively, the element is not required, both alternatives being within the scope of the claim. Use of broader terms such as comprises, includes, and having should be understood to provide support for narrower terms such as consisting of, consisting essentially of, and comprised substantially of. Accordingly, the scope of protection is not limited by the description set out above but is defined by the claims that follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated as further disclosure into the specification and the claims are embodiment(s) of the present invention. Also, the phrases "at least one of A, B, and C" and "A and/or B and/or C" should each be interpreted to include only A, only B, only C, or any combination of A, B, and C.

What is claimed is:

1. An evaporative cooling system (ECS) having an output direction system (ODS), comprising:
- an outer housing of the ECS;
- a nozzle configured to receive evaporatively cooled air from the ECS; and
- a mechanism for selectively moving the nozzle relative to the outer housing, wherein the nozzle is located remote from the outer housing.

2. The ECS of claim **1**, wherein the mechanism is an arm mount system.

3. The ECS of claim **2**, the arm mount system comprising:
- axes of rotation sufficient for orienting the nozzle in substantially any desired direction.

4. The ECS of claim **1**, wherein the nozzle comprises an inlet ring having a first diameter and an outlet ring comprising a second diameter smaller than the first diameter.

5. The ECS of claim **4**, wherein the inlet ring is connected to the outlet ring by a reducing wall.

6. The ECS of claim **4**, further comprising:
- a duct attachment comprising a flange having a profile that is complementary to a profile of the outer housing.

7. The ECS of claim **6**, wherein the duct attachment comprises a duct connection ring.

8. The ECS of claim **7**, wherein the duct connection ring is connected to the flange by a converging wall.

9. The ECS of claim **8**, wherein the duct attachment is configured to receive air from the ECS with a cross-sectional area greater than a cross-sectional area of an output of the duct connection ring.

10. The ECS of claim **9**, further comprising:
- a flexible duct connected to the duct connection ring and a nozzle of the ODS.

11. The ECS of claim **10**, wherein the ODS comprises an arm mount system.

12. A nozzle for receiving air evaporatively cooled by an evaporative cooling system (ECS), the nozzle comprising:
- an inlet ring comprising a first diameter; and
- an outlet ring comprising a second diameter smaller than the first diameter.

13. The nozzle of claim **12**, further comprising:
- a reducing wall connected between the inlet ring and the outlet ring.

14. The nozzle of claim **13**, wherein the reducing wall carries a mounting pad on an exterior of the reducing wall.

15. The nozzle of claim **14**, wherein the mounting pad is substantially flat and comprises a hole therethrough.

16. The nozzle of claim **13**, wherein the reducing wall carries a receiver on an interior of the reducing wall.

17. The nozzle of claim **16**, wherein the receiver forms a slot for receiving a nozzle mount plate therein.

18. The nozzle of claim **17**, wherein the receiver comprises a hole therethrough.

19. A method of cooling a substantially enclosed structure, comprising:
- providing an evaporative cooling system (ECS);
- operating the ECS to evaporatively cool air and eject the evaporatively cooled air;
- providing an output direction system (ODS);
- receiving the evaporatively cooled air from the ECS and into the ODS;
- transporting the evaporatively cooled air to a location remote from the ECS via the ODS; and
- outputting the evaporatively cooled air from the ODS through a nozzle.

20. The method of claim **19**, further comprising:
- ejecting the evaporatively cooled air from the nozzle into an upper portion of a substantially enclosed structure.

* * * * *