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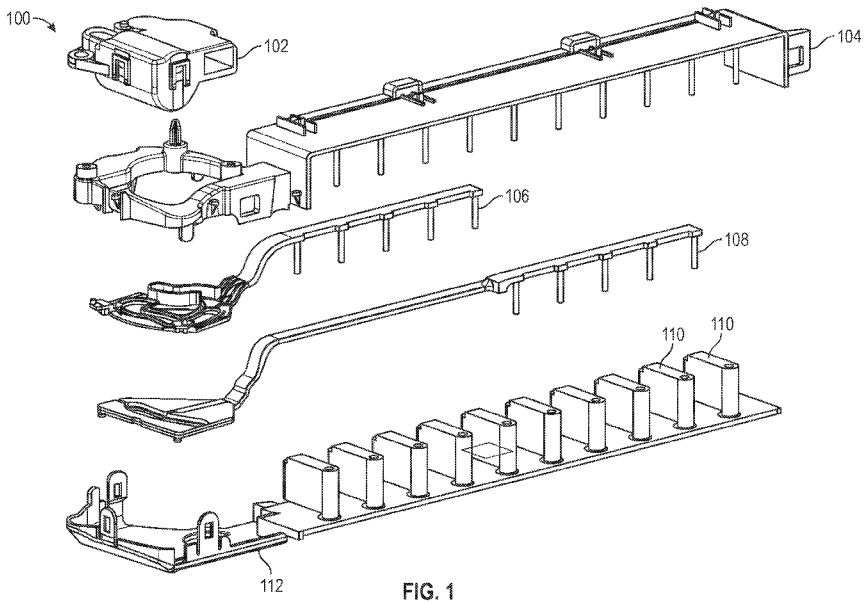

FIG. 1

(57) Abstract: Air steering assembly (100) for steering air into a space, including a housing (104), a first linkage component (106, 108) and a plurality of deformable steering vanes (110), wherein the housing (104) is configured to house the plurality of deformable steering vanes (110), the first linkage component (106, 108) is in contact with at least a first subset of the plurality of deformable steering vanes (110), the plurality of deformable steering vanes (110) is made of elastomeric material so that responsive to a movement of the first linkage component (106, 108), the first subset of the plurality of deformable steering vanes (110) deform toward a first direction to steer air into the space.

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AIR STEERING ASSEMBLY COMPRISING ELASTOMERIC STEERING VANES

CLAIM FOR PRIORITY

[0001] This international application claims the benefit of priority of U.S. Provisional Application No. 63/510,833, filed June 28, 2023, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to systems and methods for steering air into a space. More particularly, some embodiments of the present disclosure relate to assemblies and mechanisms that employ deformable materials to steer the air in a desired direction into the space.

BACKGROUND

[0003] An air vent is usually disposed downstream from an air circulation device in a vehicle. For example, many vehicles include a heating, ventilation, and air conditioning (HVAC) system that allows a vehicle occupant to control the temperature or adjust other settings of a vehicle interior. The HVAC system can include a fan or blower to circulate conditioned air into the vehicle interior through one or more vents. To improve a user experience, it may be desirable to steer or direct the air flow as the air passes through the one or more vents.

SUMMARY

[0004] The systems, methods and devices of this disclosure each have several innovative embodiments, no single one of which is solely responsible for all of the desirable attributes disclosed herein. Details of one or more implementations of the subject matter described in this specification are set forth in the accompanying drawings and the description below.

[0005] In some aspects, the techniques described herein relate to an air steering assembly for steering air into a space, the air steering assembly including: a plurality of steering vanes made of elastomeric material; a housing configured to house the plurality of steering vanes; and a first linkage component in contact with at least a first subset of the plurality of steering vanes, wherein, responsive to a

movement of the first linkage component, the first subset of the plurality of steering vanes deform toward a first direction.

[0006] In some aspects, the techniques described herein relate to an air steering assembly, wherein air is steered toward the first direction into the space.

[0007] In some aspects, the techniques described herein relate to an air steering assembly, further including a first motor, wherein the first motor is configured to drive the first linkage component.

[0008] In some aspects, the techniques described herein relate to an air steering assembly, further including a second linkage component that is in contact with at least a second subset of the plurality of steering vanes, wherein the second subset of the plurality of steering vanes deform toward a second direction responsive to a movement of the second linkage component, and wherein the second direction is different from the first direction.

[0009] In some aspects, the techniques described herein relate to an air steering assembly, wherein the first motor is configured to drive the second linkage component.

[0010] In some aspects, the techniques described herein relate to an air steering assembly, wherein the first direction is one of a left direction, a right direction, a top direction, and a bottom direction in relation to the housing.

[0011] In some aspects, the techniques described herein relate to an air steering assembly, wherein the elastomeric material includes one or more of Thermoplastic Vulcanizates (TPV), Thermoplastic Elastomers (TPE), ThermoPlastic Copolyester (TPC), Liquid Silicone Rubber (LSR), Thermoplastic Silicone Vulcanizates (TPSiV) and Ethylene Propylene Diene Monomer (EPDM).

[0012] In some aspects, the techniques described herein relate to an air steering assembly including: a plurality of vanes made of an elastomeric material; and a housing supporting the plurality of vanes; wherein the plurality of vanes are configured to elastically deform relative to the housing.

[0013] In some aspects, the techniques described herein relate to an air steering assembly, wherein the housing is rigid.

[0014] In some aspects, the techniques described herein relate to an air steering assembly, further including a motor configured to elastically deform the plurality of vanes.

[0015] In some aspects, the techniques described herein relate to all embodiments described and discussed above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Throughout the drawings, reference numbers may be re-used to indicate correspondence between referenced elements. The drawings are provided to illustrate examples of the subject matter described herein and not to limit the scope thereof.:

[0017] **FIG. 1** illustrates an exploded view of an example air steering assembly having elastomeric vanes according to some embodiments of the present disclosure.

[0018] **FIG. 2** depicts a perspective view of an example air steering assembly according to some embodiments of the present disclosure.

[0019] **FIG. 3** illustrates contrasting movement of steering vanes 310A and deformation of elastomeric vanes 310B of the present disclosure in accordance with some embodiments of the present disclosure.

[0020] **FIGS. 4A-4C** illustrate a pair of the elastomeric vanes 310B from FIG. 3 in three different user selectable modes for steering the air passing through the air steering assembly in accordance with some embodiments of the present disclosure.

[0021] **FIG. 5A** depicts a perspective view of partial housings and the elastomeric vanes of FIG. 1 to illustrate manufacturing and assembling techniques in accordance with some embodiments of the present disclosure.

[0022] **FIG. 5B** depicts another perspective view of a housing and elastomeric vanes to illustrate manufacturing and assembling techniques in accordance with some embodiments of the present disclosure.

[0023] **FIG. 6** illustrates a perspective view showing an example air steering assembly in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0024] Generally described, one or more aspects of the present disclosure correspond to systems and methods that use elastomers for flexibly steering air into a space. More specifically, some embodiments of the present disclosure disclose mechanisms and assemblies that deform elastomers for steering air

toward desired directions of an enclosed space, such as an interior of a vehicle. In some embodiments, instead of using more rigid vanes that rotate along bearings, steering vanes made of elastomers are deformed smoothly in one or more directions and/or degrees for steering air responsive to movements of linkage components driven by one or more motors.

[0025] Advantageously, utilizing elastomeric vanes for steering air can achieve smoother air flow compared with utilizing more rigid vanes (e.g., vanes made of rigid plastic material) for steering air, which may result in more abrupt air flow. As such, through disclosed mechanisms and air steering assemblies, air flow into an enclosed space may be less noisy and less turbulent, thereby achieving better occupant experience.

[0026] Additionally, steering air toward desired directions through deforming elastomeric vanes can increase the durability and sustainability of the disclosed air steering systems compared with steering air by rotating an air vane along a rotational axis. In the latter, material fatigue and wear resulting from friction between vanes and associated mechanical components (e.g., bearings) may limit or constrain the durability of an air steering system. In accordance with some embodiments of the present disclosure, the disclosed air steering system may be operable to steer air toward different directions for over fifty thousand cycles by deforming its elastomeric vanes based on movements of linkage components driven by one or more motors.

[0027] The disclosed systems and methods further implement techniques to reduce the number of discrete components needed for assembling the air steering systems, thereby resulting in a reduction of manufacturing cost and increase of system integration. Rather than assembling individual pieces of the steering vanes to a housing through rotational bearings, some disclosed techniques mold elastomeric vanes into the housing as one integral unit or piece. In some embodiments, over-molding techniques are adopted to deploy elastomeric vanes as one piece within the housing through two-shot molding, where a plastic housing is molded in the first shot and the elastomeric vanes are molded in the second shot. As such, fewer mechanical components (e.g., fasteners, bearings, or the like) are needed for assembling the disclosed air steering system or device, which not only reduces manufacturing costs and increases system integration but streamlines the manufacturing process through saving assembly time.

[0028] Typically, an enclosed space (e.g., an interior of a vehicle) includes air steering devices or air vents to steer air into the enclosed space. Some air steering systems use plastic vanes to steer air toward desired directions. Specifically, a plastic vane may move (e.g., rotate) along an axis against a bearing to steer air toward different directions. When the vane moves, the entire surface of the vane may rotate along the axis by the same angle to cause a change of direction of an air flow into the enclosed space. As the entire surface of the vane is relatively rigid to the air flow, there may be situations where direction of the air flow may be abruptly affected by the change of angle of the surface of the vane. The abrupt change of air flow may result in noise or more air turbulence, which may deteriorate user experience.

[0029] Further, to facilitate movements or rotation of the steering vanes, mechanical components (e.g., rotational bearings or fasteners or the like) are generally utilized. As the vanes rotate against the bearings, friction may gradually wear associated parts, limiting the durability of the air steering device. Additionally, manufacturing the air steering device usually requires assembling a considerable number (e.g., over twenty) of individual components which may adversely impact cost and time for production.

[0030] To address at least a portion of the above problems, air steering assemblies and mechanisms are disclosed in accordance with some embodiments of the present disclosure. In some embodiments, a steering device can allow air flow into a space be directed toward various directions by deforming steering vanes that are made of elastomeric materials. Specifically, elastomeric vanes may be deformed in response to movements of one or more linkage components that are in contact with the elastomeric vanes.

[0031] In some embodiments, one or more motors may be utilized to drive the one or more linkage components to move in a particular manner to deform the elastomeric vanes accordingly, thereby allowing air flow be directed toward a particular direction. In some embodiments, some elastomeric vanes are deformed by movements of a first linkage component while other elastomeric vanes are deformed by movements of a second linkage component. In some embodiments, the first linkage component and the second linkage component can be driven by a single motor.

[0032] In some embodiments, elastomeric vanes associated with the first linkage component and elastomeric vanes associated with the second linkage component may be deformed toward the same direction (e.g., all deformed toward left or all deformed toward right) or different direction (e.g., some deformed toward left and some deformed toward right). In some embodiments, in addition to deforming horizontally (e.g., deform toward left or right), elastomeric vanes may be deformed vertically (e.g., deform upward or downward) through deploying additional linkage components and an additional motor for driving the additional linkage components to cause vertical deformation.

[0033] In some embodiments, elastomeric vanes of the disclosed air steering system may deform smoothly (e.g., with a certain curvature) rather than abruptly (e.g., with segmented straight lines). In some embodiments, elastomeric vanes are deformed such that consistent cross-sections between elastomeric vanes for air flow are maintained. Advantageously, by steering air through deforming elastomeric vanes, less noise and air turbulence may be generated. In other embodiments, flexible hinges (e.g., living hinges) may be utilized to facilitate movements of steering vanes.

[0034] In some embodiments, at least some portions of the disclosed air steering system may be manufactured through injection molding. For example, two-shot molding may be utilized to integrate a housing and elastomeric vanes, where the housing may be made during the first shot and the elastomeric vanes may be integrated with the housing during the second shot. Advantageously, rather than having to assemble individual vanes into the housing, elastomeric vanes formed as one piece may be integrated with the housing.

[0035] In some embodiments, to leverage injection molding, steering vanes may be made by various elastomeric thermoplastic including but not limited to one or more of Thermoplastic Vulcanizates (TPV), Thermoplastic Elastomers (TPE), ThermoPlastic Copolyester (TPC), Liquid Silicone Rubber (LSR), Thermoplastic Silicone Vulcanizates (TPSiV) and Ethylene Propylene Diene Monomer (EPDM). In some embodiments, thickness of the disclosed elastomeric vanes may be uniform between each elastomeric vanes and may be between 1.0 to 10.0 millimeters. In other embodiments, the thickness of the disclosed elastomeric vanes may be non-uniform between each elastomeric vanes and may have different ranges other than between 1.0 to 10.0 millimeters.

[0036] Although the various aspects will be described in accordance with illustrative embodiments and combination of features, one skilled in the relevant art will appreciate that the examples and combination of features are illustrative in nature and should not be construed as limiting. More specifically, aspects of the present application may be applicable with various types of air vent, steering vent, air steering device under different contexts, such as when associated with a building room, an interior of a vehicle, or any other spaces where air steering may be desired. Still further, although specific architectures of air steering assemblies for steering air toward desired directions will be described, such illustrative air steering mechanisms or assemblies should not be construed as limiting. Accordingly, one skilled in the relevant art will appreciate that the aspects of the present application are not necessarily limited to application to any particular types of air steering assembly, air steering assemblies infrastructure or illustrative interactions between components of disclosed air steering assemblies.

[0037] **FIG. 1** illustrates an exploded view of an example air steering assembly 100 according to some embodiments of the present disclosure. As shown in **FIG. 1**, the example air steering assembly 100 includes a motor 102, a partial housing 104, a linkage component 106, a linkage component 108, elastomeric vanes 110, and a partial housing 112. **FIG. 1** depicts the elastomeric vanes 110 be integrated with the partial housing 112. In some embodiments, the elastomeric vanes 110 may be integrated with the partial housing 112 and/or the partial housing 104 through injection molding (e.g., two-shot molding).

[0038] When assembled, the linkage component 106 and the linkage component 108 may be in contact with the elastomeric vanes 110. In operation, the linkage component 106 and the linkage component 108 may be driven by the motor 102 to move in predefined directions (e.g., along the direction the linkage component 106 and the linkage component 108 extend). Responsive to the movements of the linkage component 106 and the linkage component 108, the elastomeric vanes 110 may be deformed accordingly to steer air from an air source (not shown in **FIG. 1**) toward different directions.

[0039] Although not shown in **FIG. 1**, the air steering assembly 100 may be deployed or installed within various types of spaces, such as an enclosed space. The enclosed space may be an interior of a fixed structure (e.g., a building room) or an internal space of different types of transportation tools, including but not

limited to aircrafts, spacecrafts, trucks, vessels, maritime, ferries and vans. By deploying the air steering assembly 100 into a space, air flow from an air source may be directed toward desired directions within the space through the operation of various components of the air steering assembly 100.

[0040] **FIG. 2** depicts a perspective view of an example air steering assembly 200 according to some embodiments of the present disclosure. As shown in **FIG. 2**, the air steering assembly 200 includes a motor 202, a housing 204, a linkage component 206, a linkage component 208 and elastomeric vanes 210-1 and 210-2. As discussed above, the elastomeric vanes 210-1 and 210-2 may include elastomers or deformable materials, including but not limited to, Thermoplastic Vulcanizates (TPV), Thermoplastic Elastomers (TPE), ThermoPlastic Copolyester (TPC), Liquid Silicone Rubber (LSR), Thermoplastic Silicone Vulcanizates (TPSiV) and Ethylene Propylene Diene Monomer (EPDM).

[0041] As assembled in **FIG. 2**, the linkage component 206 may be in contact with the elastomeric vanes 210-2 and the linkage component 208 may be in contact with the elastomeric vanes 210-1. In other words, the linkage component 206 and the linkage component 208 may mechanically connect the elastomeric vanes 210-2 and 210-1 to the motor 202, respectively. Hence, when the linkage component 206 moves, the elastomeric vanes 210-2 may deform because of the contact between the linkage component 206 and the elastomeric vanes 210-2; and when the linkage component 208 moves, the elastomeric vanes 210-1 may deform because of the contact between the linkage component 208 and the elastomeric vanes 210-1. Although not illustrated in **FIG. 2**, the linkage component 206 may cause the elastomeric vanes 210-2 to deform in one direction (e.g., toward left) and the linkage component 208 may cause the elastomeric vanes 210-1 to deform in the same direction or a different direction (e.g., toward right).

[0042] As illustrated in **FIG. 2**, the linkage component 206 and the linkage component 208 may be mechanically connected to the motor 202 such that the linkage component 206 and the linkage component 208 may be driven to move by the motor 202. In other embodiments, more linkage components and more motors may be utilized by the air steering assembly 200 to cause the elastomeric vanes 210-1 and 210-2 to deform in more directions (e.g., deform horizontally toward left or right and deform vertically upward or downward).

[0043] In some embodiments, the housing 204 may be made of plastic or other materials that are rigid or stiff enough to support the elastomeric vanes 210-1 and 210-2 as well as the linkage component 206 and the linkage component 208. In some embodiments, the motor 202 may be controlled by a motion control microcontroller (MCU), a microprocessor and/or associated firmware to rotate in different speeds or directions such that the elastomeric vanes 210-1 and 210-2 may deform with different speeds and toward different directions.

[0044] **FIG. 3** illustrates contrasting movement of steering vanes 310A and deformation of elastomeric vanes 310B of the present disclosure in accordance with some embodiments of the present disclosure. The elastomeric vanes 310B may be integrated as the elastomeric vanes 110 with the example air steering assembly 100 of **FIG. 1** and/or the elastomeric vanes 210-1/210-2 with the example air steering assembly 200 of **FIG. 2**. As illustrated in **FIG. 3**, the steering vanes 310A may move by rotating around an axis 314A. Although not shown **in FIG. 3**, the steering vanes 310A may be assembled to a rotational bearing to be driven by a motor to rotate around the axis 314A. As shown in **FIG. 3**, the shape of the steering vanes 310A may not change while rotating around the axis 314A. Notably, while rotating around the axis 314A against the rotational bearing, friction resulted from contact between the steering vanes 310A and the rotational bearing (not shown in **FIG. 3**) may cause wear of associated components.

[0045] As illustrated in **FIG. 3**, the elastomeric vanes 310B may deform in response to movement of an associated linkage component driven by a motor. In some embodiments, the elastomeric vanes 310B may include a first edge (e.g., a leading edge) 318B and a second edge (e.g., a trailing edge) 316B. During the deformation of the elastomeric vanes 310B, the first edge 318B may stay relatively fixed while the second edge 316B may move because of the deformation of the elastomeric vanes 310B. In some embodiments, the deformation of the elastomeric vanes 310B may be caused by movements of a linkage component that is in contact with the first edge 318B of the elastomeric vanes 310B. Advantageously, without the wear of components resulted from friction associated with rotational movements, the air steering assembly 100 or the air steering assembly 200 may be more durable.

[0046] **FIGS. 4A-4C** illustrate various representations of deformations of one of the elastomeric vanes 210-1 and one of the elastomeric vanes 210-2 of **FIG. 2** in

accordance with some embodiments of the present disclosure. As shown in **FIG. 4A**, the elastomeric vane 210-1 and the elastomeric vane 210-2 may both deform toward the right. In some embodiments, the deformation illustrated in **FIG. 4A** may be caused by the linkage component 208 connected with the elastomeric vane 210-1 and the linkage component 206 connected with the elastomeric vane 210-2 to both move in the same direction (e.g., toward right side of **FIG. 2**). Although not explicitly shown in **FIG. 4A**, in some embodiments, the extent or degree of deformations between the elastomeric vane 210-1 and the elastomeric vane 210-2 may be the same or may be different based on different movements associated with the linkage component 206 and the linkage component 208.

[0047] As shown in **FIG. 4B**, the elastomeric vane 210-1 and the elastomeric vane 210-2 may deform toward different directions. More specifically, the elastomeric vane 210-1 may deform toward the left and the elastomeric vane 210-2 may deform toward the right, or vice versa. In some embodiments, the deformation illustrated in **FIG. 4B** may be caused by the linkage component 208 connected with the elastomeric vane 210-1 and the linkage component 206 connected with the elastomeric vane 210-2 to move in different directions (e.g., the linkage component 208 may move toward the left side of **FIG. 2** and the linkage component 206 may move toward the right side of **FIG. 2**).

[0048] As shown in **FIG. 4C**, the elastomeric vane 210-1 and the elastomeric vane 210-2 may both deform toward the left. In some embodiments, the deformation illustrated in **FIG. 4C** may be caused by the linkage component 208 connected with the elastomeric vane 210-1 and the linkage component 206 connected with the elastomeric vane 210-2 to both move in the same direction (e.g., toward left side of **FIG. 2**).

[0049] As illustrated in **FIGS. 4A-4C**, the elastomeric vanes 210-1 and 210-2 may deform more smoothly (e.g., with a certain curvature) rather than abruptly (e.g., with segmented straight lines). Advantageously, the smooth deformation as well as the less rigid property of the elastomeric vanes 210-1 and 210-2 may allow the air steering assembly 100 or the air steering assembly 200 to steer air with less noise and less air turbulence.

[0050] **FIG. 5A** depicts a perspective view of the partial housing 104, the partial housing 112 and the elastomeric vanes 110 of **FIG. 1** to illustrate manufacturing and assembling techniques in accordance with some embodiments of the present

disclosure. In some embodiments, a two-shot molding may be utilized to integrate the partial housing 104, the partial housing 112 and the elastomeric vanes 110. For example, during the first shot, material (e.g., plastic) for the partial housing 104 and/or the partial housing 112 may be injected through molding. During the second shot, elastomers for the elastomeric vanes 110 may be injected to be integrated with the partial housing 104 and the partial housing 112.

[0051] **FIG. 5B** depicts a perspective view of a housing 504 and elastomeric vanes 110 to illustrate manufacturing and assembling techniques in accordance with some embodiments of the present disclosure. In some embodiments, the housing 504 may function the same or similarly to the partial housing 104 and partial housing 112 of **FIG. 1**. In some embodiments, a two-shot molding may be utilized to integrate the housing 504 and the elastomeric vanes 110. For example, during the first shot, material (e.g., plastic) for the housing 504 may be injected through molding. During the second shot, elastomers for the elastomeric vanes 110 may be injected to be integrated with the housing 504.

[0052] As such, instead of assembling individual elastomeric vanes separately through the use of other mechanical parts (e.g., bearings), the elastomeric vanes 110 can be structured and formed as an integral piece to be integrated with the partial housing 104 and the partial housing 112 or as an integral piece to be integrated with the housing 504. Advantageously, the assembly time associated with assembling the air steering assembly 100 or the air steering assembly 200 can be reduced. Additionally, without mechanical components for attaching the elastomeric vanes 110 to the partial housing 104, the partial housing 112 or the housing 504, fewer mechanical components (e.g., fasteners, bearings, or the like) are needed for assembling the air steering assembly 100 or the air steering assembly 200, which further reduces costs associated with manufacturing or assembling the air steering assembly 100 or the air steering assembly 200.

[0053] **FIG. 6** illustrates a perspective view showing an example air steering assembly 600 in accordance with some embodiments of the present disclosure. As shown in **FIG. 6**, the air steering assembly 600 includes the motor 602, the housing 604, the linkage component 606, the linkage component 608, the elastomeric vanes 610, the elastomeric vane 616 and the motor 614. As illustrated in **FIG. 6**, the linkage component 606 may be mechanically connected with the motor 602 and the linkage component 606 may be driven to move when the motor

602 is actuated. Further, the linkage component 608 may be mechanically connected with the motor 614 such that the linkage component 608 may be driven to move as the motor 614 moves. In some embodiments, some or all of the elastomeric vanes 610 may be in contact with the linkage component 606. In some embodiments, the elastomeric vane 616 may be in contact with the linkage component 608.

[0054] In some embodiments, the elastomeric vanes 610 may steer air toward left or right depending on the movements associated with the linkage component 606. For example, when the motor 602 moves, the linkage component 606 may move. In response to the movements of the linkage component 606, the elastomeric vanes 610 may deform toward left or right of **FIG. 6** so as to steer air toward left or right. Additionally, when the motor 614 moves, the linkage component 608 may move. Responsive to the movements of the linkage component 608, the elastomeric vane 616 may deform upward or downward to steer air upward or downward. As such, the air steering assembly 600 may steer air not only horizontally (e.g., toward left or right) but vertically (e.g., upward or downward).

[0055] As illustrated in **FIG. 6**, the number of the elastomeric vanes 610 equals ten and the number of the elastomeric vane 616 equals one. It should be noted that, in some embodiments, the number of elastomeric vanes 610 and/or the elastomeric vane 616 can be more or fewer than what is shown in **FIG. 6**. Further, it should be noted that, in some embodiments, the number of linkage components as well as the motors can be more or fewer than what is illustrated in **FIG. 6**.

[0056] The foregoing disclosure is not intended to limit the present disclosure to the precise forms or particular fields of use disclosed. As such, it is contemplated that various alternate embodiments and/or modifications to the present disclosure, whether explicitly described or implied herein, are possible in light of the disclosure. Having thus described embodiments of the present disclosure, a person of ordinary skill in the art will recognize that changes may be made in form and detail without departing from the scope of the present disclosure. Thus, the present disclosure is limited only by the claims.

[0057] In the foregoing specification, the disclosure has been described with reference to specific embodiments. However, as one skilled in the art will appreciate, various embodiments disclosed herein can be modified or otherwise implemented in various other ways without departing from the spirit and scope of

the disclosure. Accordingly, this description is to be considered as illustrative and is for the purpose of teaching those skilled in the art the manner of making and using various embodiments of the disclosed display assemblies.

[0058] It is to be understood that the forms of disclosure herein shown and described are to be taken as representative embodiments. Equivalent elements, materials, processes or steps may be substituted for those representatively illustrated and described herein. Moreover, certain features of the disclosure may be utilized independently of the use of other features, all as would be apparent to one skilled in the art after having the benefit of this description of the disclosure. Expressions such as "including", "comprising", "incorporating", "consisting of", "have", "is" used to describe and claim the present disclosure are intended to be construed in a non-exclusive manner, namely allowing for items, components or elements not explicitly described also to be present. Reference to the singular is also to be construed to relate to the plural. Further, various embodiments disclosed herein are to be taken in the illustrative and explanatory sense, and should in no way be construed as limiting of the present disclosure.

[0059] All joinder references (e.g., attached, affixed, coupled, connected, and the like) are only used to aid the reader's understanding of the present disclosure, and may not create limitations, particularly as to the position, orientation, or use of the systems and/or methods disclosed herein. Therefore, joinder references, if any, are to be construed broadly. Moreover, such joinder references do not necessarily infer that two elements are directly connected to each other. Additionally, all numerical terms, such as, but not limited to, “first,” “second,” “third,” “primary,” “secondary,” “main” or any other ordinary and/or numerical terms, should also be taken only as identifiers, to assist the reader's understanding of the various elements, embodiments, variations and/or modifications of the present disclosure, and may not create any limitations, particularly as to the order, or preference, of any element, embodiment, variation and/or modification relative to, or over, another element, embodiment, variation and/or modification.

[0060] The illustrative algorithms described in connection with the embodiments disclosed herein can be implemented as electronic hardware (e.g., ASICs or FPGA devices), computer software that runs on computer hardware, or combinations of both. Moreover, the various illustrative logical blocks and modules described in connection with the embodiments disclosed herein can be implemented or

performed by a machine, such as a processor device, a digital signal processor ("DSP"), an application specific integrated circuit ("ASIC"), a field programmable gate array ("FPGA") or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein.

[0061] A processor device can be a microprocessor, but in the alternative, the processor device can be a controller, microcontroller, or state machine, combinations of the same, or the like. A processor device can include electrical circuitry configured to process computer-executable instructions. In another embodiment, a processor device includes an FPGA or other programmable device that performs logic operations without processing computer-executable instructions. A processor device can also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration. Although described herein primarily with respect to digital technology, a processor device may also include primarily analog components. For example, some or all of the rendering techniques described herein may be implemented in analog circuitry or mixed analog and digital circuitry. A computing environment can include any type of computer system, including, but not limited to, a computer system based on a microprocessor, a mainframe computer, a digital signal processor, a portable computing device, a device controller, or a computational engine within an appliance, to name a few.

[0062] It will also be appreciated that one or more of the elements depicted in the drawings/figures can also be implemented in a more separated or integrated manner, or even removed or rendered as inoperable in certain cases, as is useful in accordance with a particular application.

EXAMPLES

[0063] Some embodiments may include one or more of the following examples:

[0064] Example 1 includes an air steering assembly for steering air into a space, the air steering assembly comprising: a plurality of steering vanes formed of an elastomeric material; a housing configured to house the plurality of steering vanes; and a first linkage component in contact with at least a first subset of the plurality of steering vanes, wherein, responsive to a movement of the first

linkage component, the first subset of the plurality of steering vanes deform toward a first direction.

[0065] Example 2 includes the subject matter of Example 1, wherein air is steered toward the first direction into the space.

[0066] Example 3 includes the subject matter of Example 1 or Example 2, further comprising a first motor to drive the first linkage component in contact with the first subset of the plurality of steering vanes.

[0067] Example 4 includes the subject matter of any one of Examples 1-3, further comprising a second motor and a second linkage component that is in contact with at least a second subset of the plurality of steering vanes.

[0068] Example 5 includes the subject matter of any one of Examples 1-4, wherein the second motor drives the second linkage component in contact with the second subset of the plurality of steering vanes toward a second direction.

[0069] Example 6 includes the subject matter of any one of Examples 1-5, wherein the first direction is one of a left direction, a right direction, a top direction, and a bottom direction in relation to the housing.

[0070] Example 7 includes the subject matter of any one of Examples 1-6, wherein the elastomeric material includes one or more of Thermoplastic Vulcanizates (TPV), Thermoplastic Elastomers (TPE), ThermoPlastic Copolyester (TPC), Liquid Silicone Rubber (LSR), Thermoplastic Silicone Vulcanizates (TPSiV) and Ethylene Propylene Diene Monomer (EPDM).

[0071] Example 8 includes an air steering assembly comprising: a plurality of deformable vanes made of an elastomeric material; a housing supporting the plurality of deformable vanes; and a motor to induce a deformation of the plurality of deformable vanes.

[0072] Example 9 includes the subject matter of Example 8, wherein the housing is a more rigid housing relative to the plurality of deformable vanes.

[0073] Example 10 includes the subject matter of any one of Example 9 or Example 9, wherein the motor is operatively connected to at least one linkage component that contacts the plurality of deformable vanes to induce the deformation.

[0074] Example 11 includes the subject matter of any one of Examples 8-10, wherein the deformation is along a horizontal axis relative to the housing.

[0075] Example 12 includes the subject matter of any one of Examples 8-11, wherein the elastomeric material includes one or more of Thermoplastic Vulcanizates (TPV), Thermoplastic Elastomers (TPE), ThermoPlastic Copolyester (TPC), Liquid Silicone Rubber (LSR), Thermoplastic Silicone Vulcanizates (TPSiV) and Ethylene Propylene Diene Monomer (EPDM).

[0076] Example 13 includes the subject matter of any one of Examples 8-12, wherein the motor is a first motor, and the air steering assembly further comprises a second motor.

[0077] Example 14 includes the subject matter of any one of Examples 8-13, wherein the first motor induces a first deformation of the plurality of deformable vanes along a first axis, and wherein the second motor induces a second deformation of the plurality of deformable vanes along a second axis.

[0078] Example 15 includes the subject matter of any one of Examples 8-14, wherein the plurality of deformable vanes comprises a first subset of deformable vanes and a second subset of deformable vanes, and wherein the first motor induces the deformation of the first subset of deformable vanes and the second motor induces the deformation of the second subset of deformable vanes.

[0079] Example 16 includes the subject matter of any one of Examples 8-15, wherein the plurality of deformable vanes of the elastomeric material are molded into the housing to form a single integral unit.

[0080] Example 17 includes the subject matter of any one of Examples 8-16, wherein each deformable vane among the plurality of deformable vanes comprises a uniform thickness between 1.0 and 10.0 millimeters.

[0081] Example 18 includes the subject matter of any one of Examples 8-17, wherein the housing comprises a first partial housing and a second partial housing, and wherein the plurality of deformable vanes are secured between the first partial housing and the second partial housing.

[0082] Example 19 includes the subject matter of any one of Examples 8-18, wherein the plurality of deformable vanes are molded on the second partial housing.

[0083] Example 20 includes the subject matter of any one of Examples 8-19, further comprising a motion control microcontroller (MCU) to control the motor.

[0084] Although the present disclosure has been described with reference to specific example embodiments, it will be evident that various modifications and

changes may be made to these embodiments without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

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CLAIMS

1. An air steering assembly for steering air into a space, the air steering assembly comprising:

a plurality of steering vanes formed of an elastomeric material;

a housing configured to house the plurality of steering vanes; and

a first linkage component in contact with at least a first subset of the plurality of steering vanes,

wherein, responsive to a movement of the first linkage component, the first subset of the plurality of steering vanes deform toward a first direction.

2. The air steering assembly of claim 1, wherein air is steered toward the first direction into the space.

3. The air steering assembly of claim 1, further comprising a first motor to drive the first linkage component in contact with the first subset of the plurality of steering vanes.

4. The air steering assembly of claim 1, further comprising a second motor and a second linkage component that is in contact with at least a second subset of the plurality of steering vanes.

5. The air steering assembly of claim 4, wherein the second motor drives the second linkage component in contact with the second subset of the plurality of steering vanes toward a second direction.

6. The air steering assembly of claim 1, wherein the first direction is one of a left direction, a right direction, a top direction, and a bottom direction in relation to the housing.

7. The air steering assembly of claim 1, wherein the elastomeric material includes one of Thermoplastic Vulcanizates (TPV), Thermoplastic Elastomers (TPE), ThermoPlastic Copolyester (TPC), Liquid Silicone Rubber (LSR), Thermoplastic Silicone Vulcanizates (TPSiV) and Ethylene Propylene Diene Monomer (EPDM).

8. An air steering assembly comprising:

a plurality of deformable vanes made of an elastomeric material;

a housing supporting the plurality of deformable vanes; and

a motor to induce a deformation of the plurality of deformable vanes.

9. The air steering assembly of claim 8, wherein the housing is a more rigid housing relative to the plurality of deformable vanes.

10. The air steering assembly of claim 8, wherein the motor is operatively connected to at least one linkage component that contacts the plurality of deformable vanes to induce the deformation.

11. The air steering assembly of claim 8, wherein the deformation is along a horizontal axis relative to the housing.

12. The air steering assembly of claim 8, wherein the elastomeric material includes one of Thermoplastic Vulcanizates (TPV), Thermoplastic Elastomers (TPE), ThermoPlastic Copolyester (TPC), Liquid Silicone Rubber (LSR), Thermoplastic Silicone Vulcanizates (TPSiV) and Ethylene Propylene Diene Monomer (EPDM).

13. The air steering assembly of claim 8, wherein the motor is a first motor, and the air steering assembly further comprises a second motor.

14. The air steering assembly of claim 13, wherein the first motor induces a first deformation of the plurality of deformable vanes along a first axis, and wherein the second motor induces a second deformation of the plurality of deformable vanes along a second axis.

15. The air steering assembly of claim 13, wherein the plurality of deformable vanes comprises a first subset of deformable vanes and a second subset of deformable vanes, and wherein the first motor induces the deformation of the first subset of deformable vanes and the second motor induces the deformation of the second subset of deformable vanes.

16. The air steering assembly of claim 8, wherein the plurality of deformable vanes of the elastomeric material are molded into the housing to form a single integral unit.

17. The air steering assembly of claim 8, wherein each deformable vane among the plurality of deformable vanes comprises a uniform thickness between 1.0 and 10.0 millimeters.

18. The air steering assembly of claim 8, wherein the housing comprises a first partial housing and a second partial housing, and wherein the plurality of deformable vanes are secured between the first partial housing and the second partial housing.

19. The air steering assembly of claim 18, wherein the plurality of deformable vanes are molded on the second partial housing.

20. The air steering assembly of claim 8, further comprising a motion control microcontroller (MCU) to control the motor.

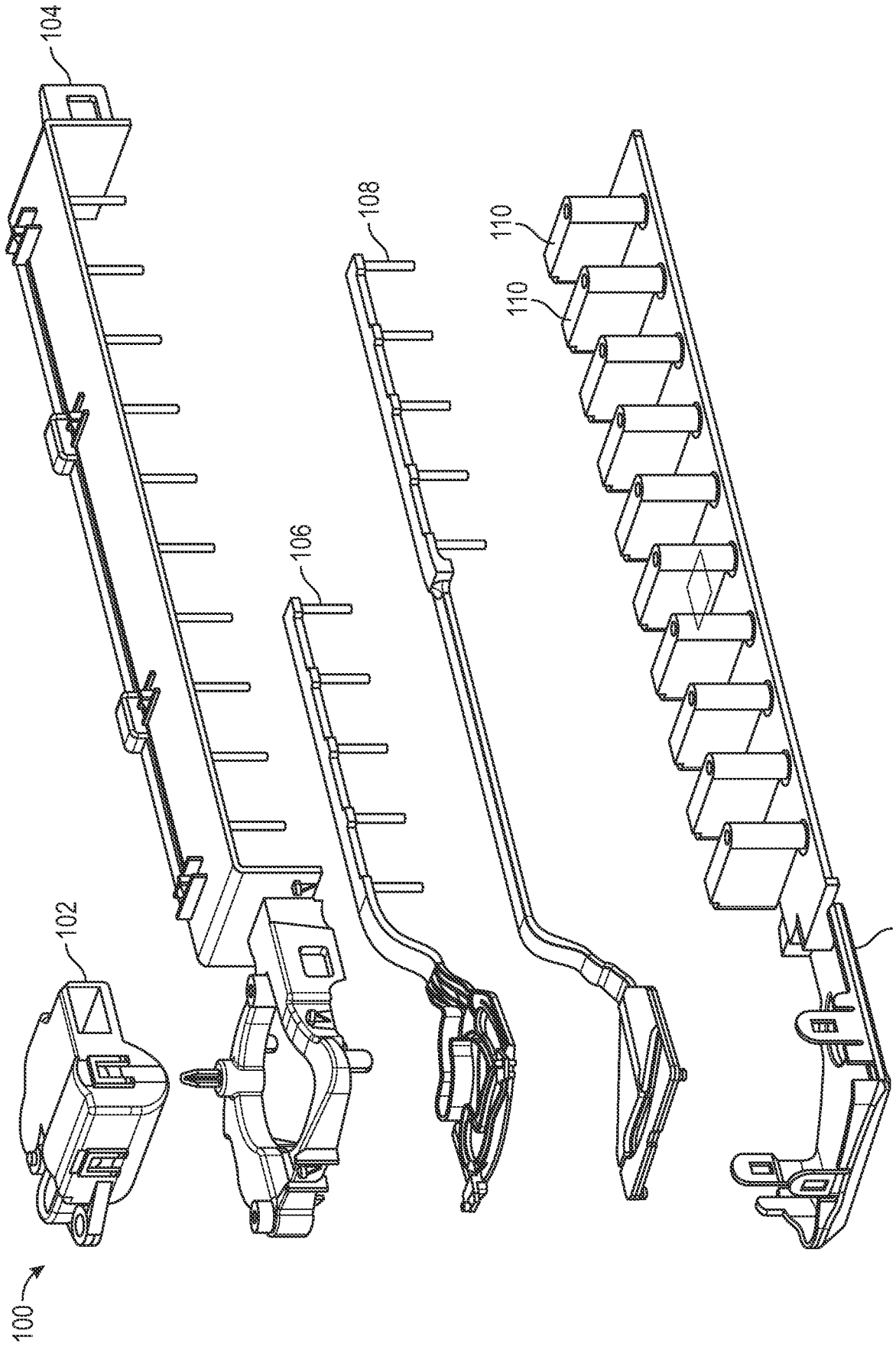

FIG. 1

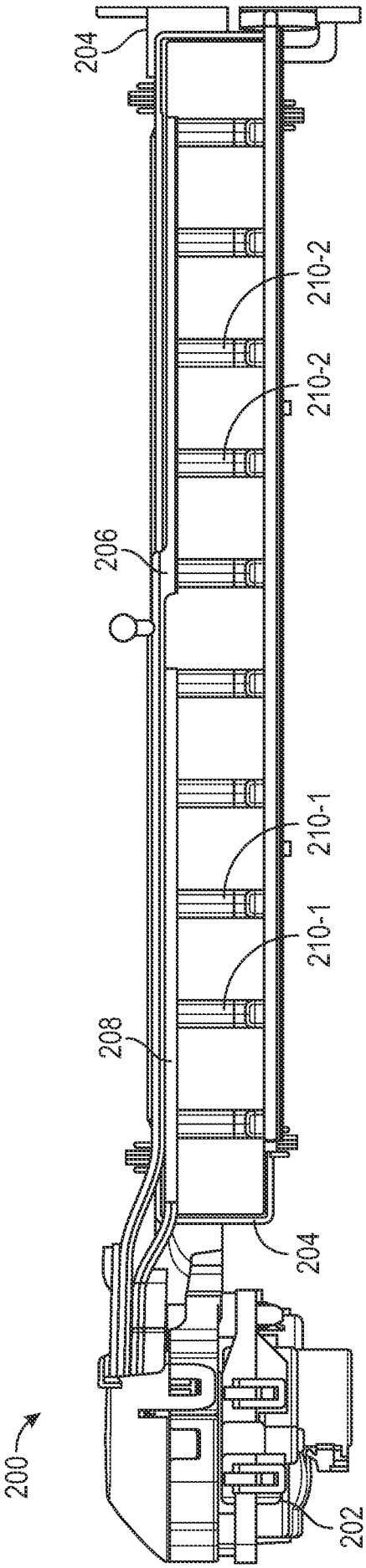

FIG. 2

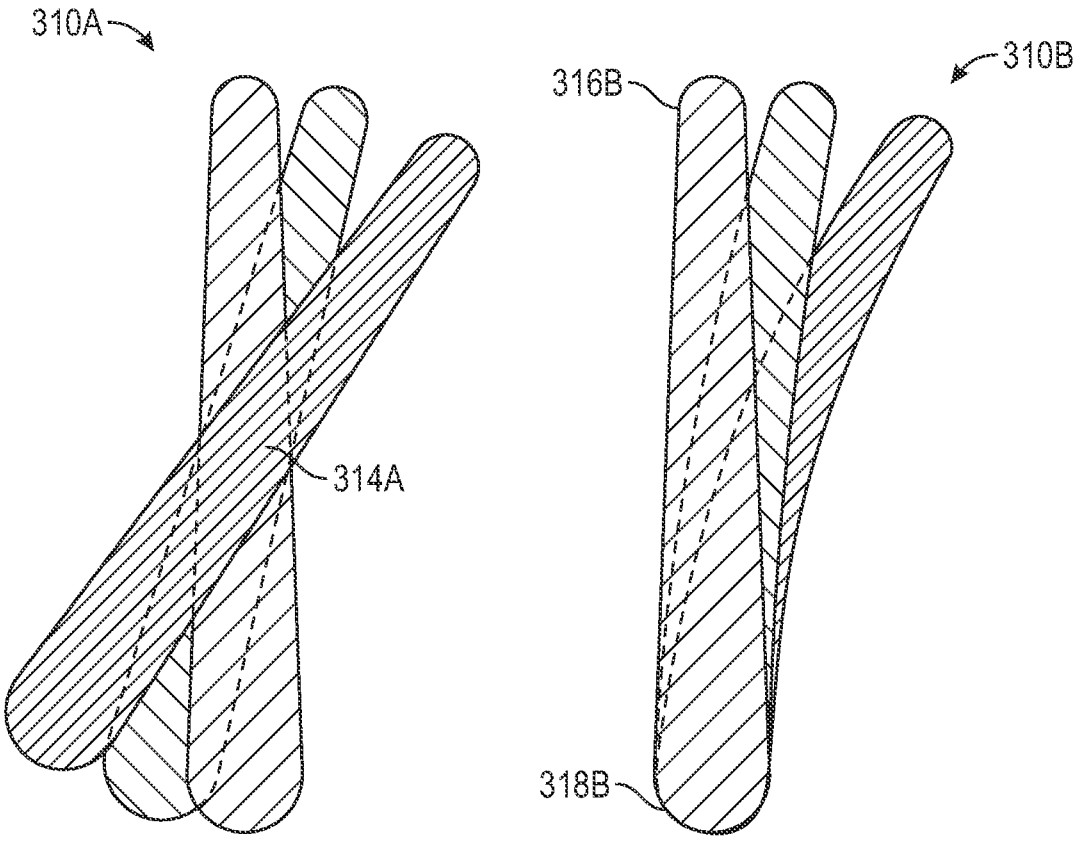

FIG. 3

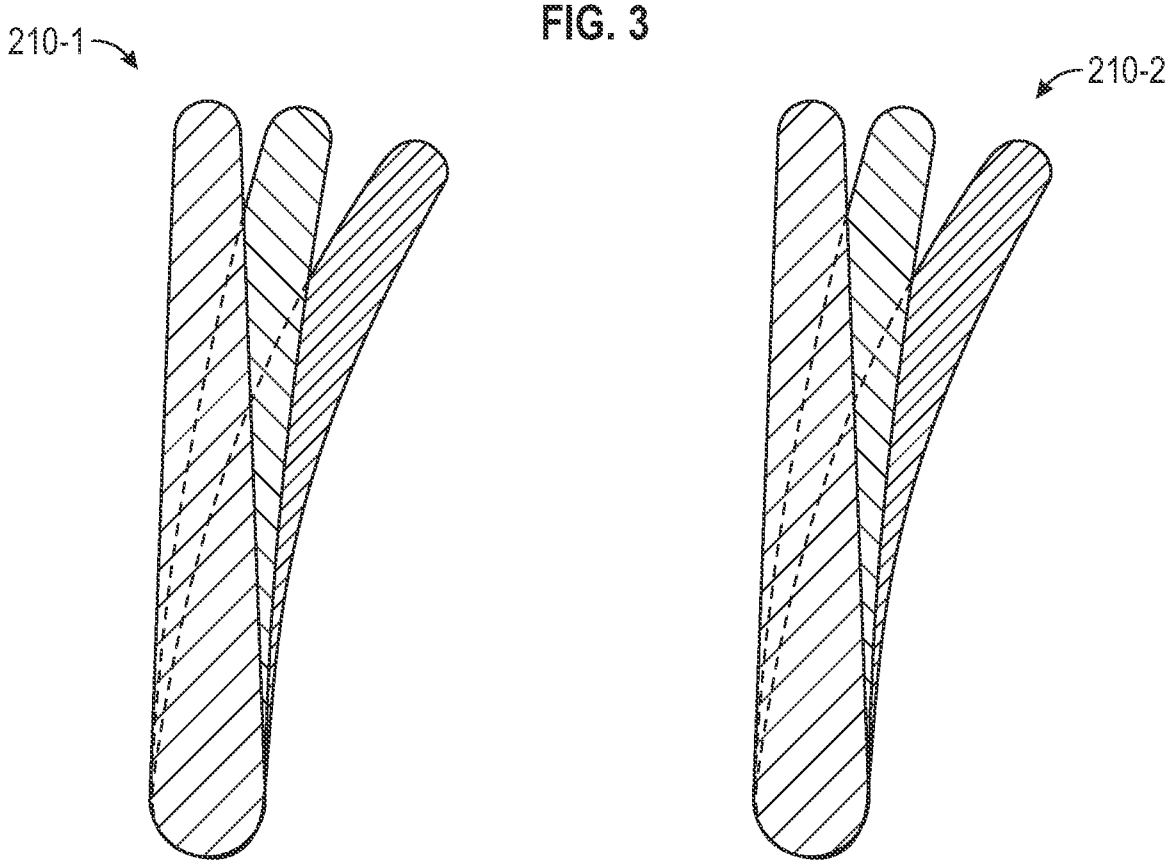

FIG. 4A

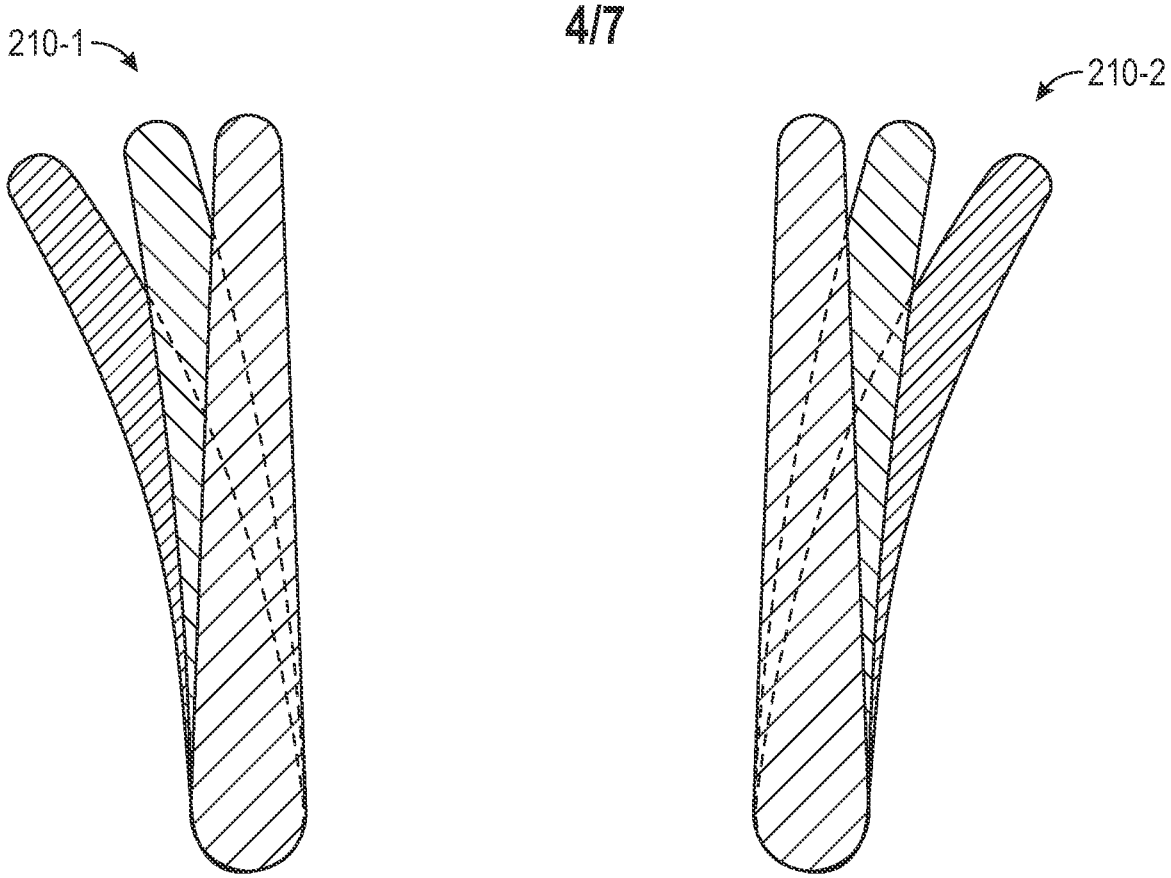

FIG. 4B

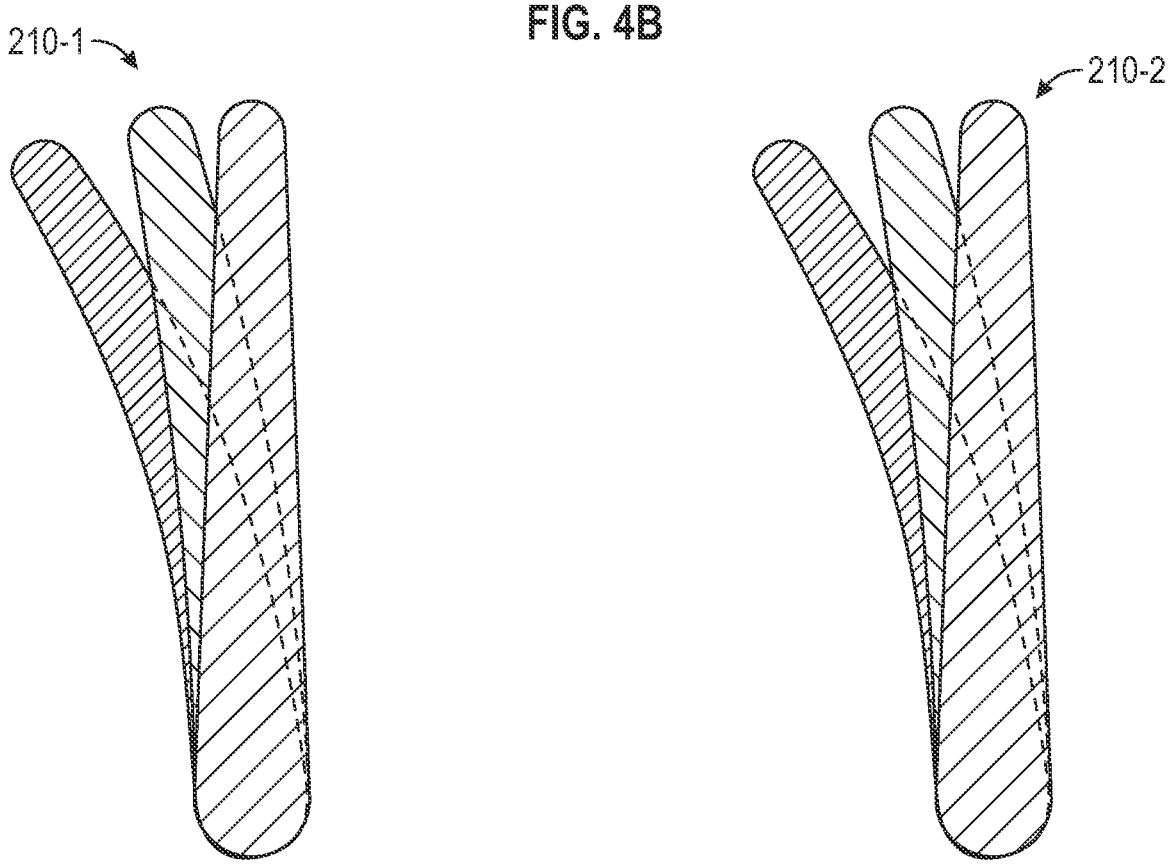

FIG. 4C

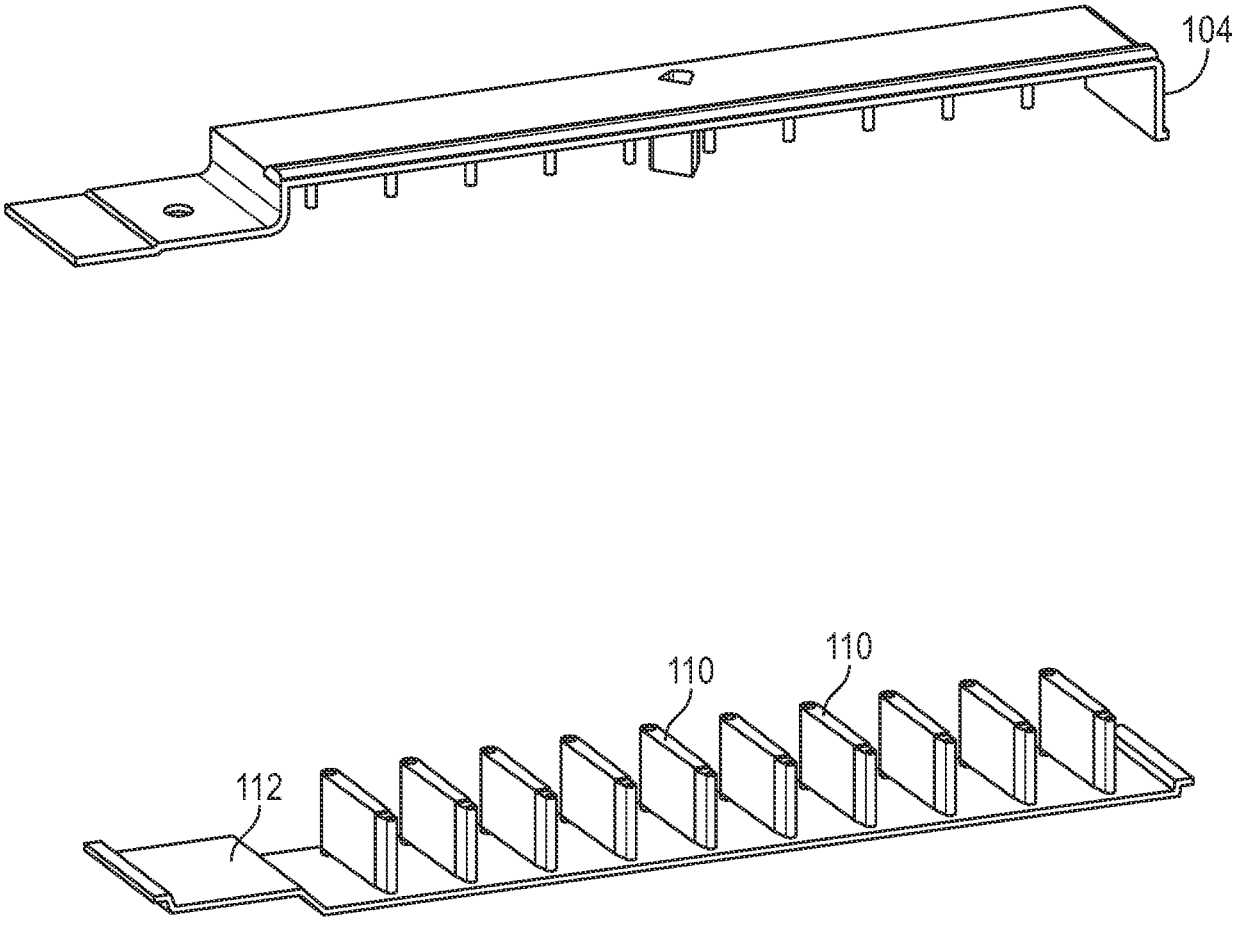

FIG. 5A

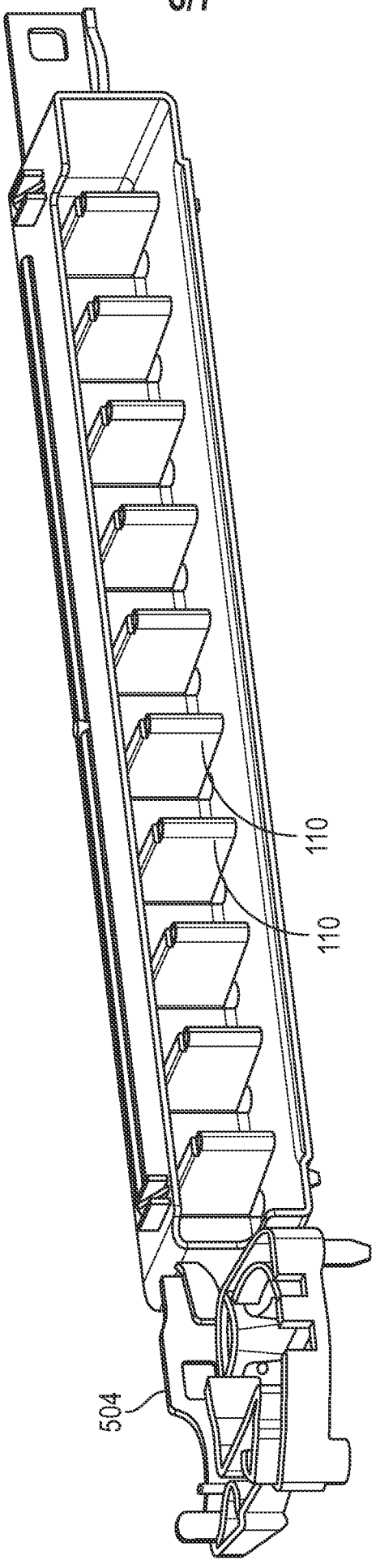

FIG. 5B

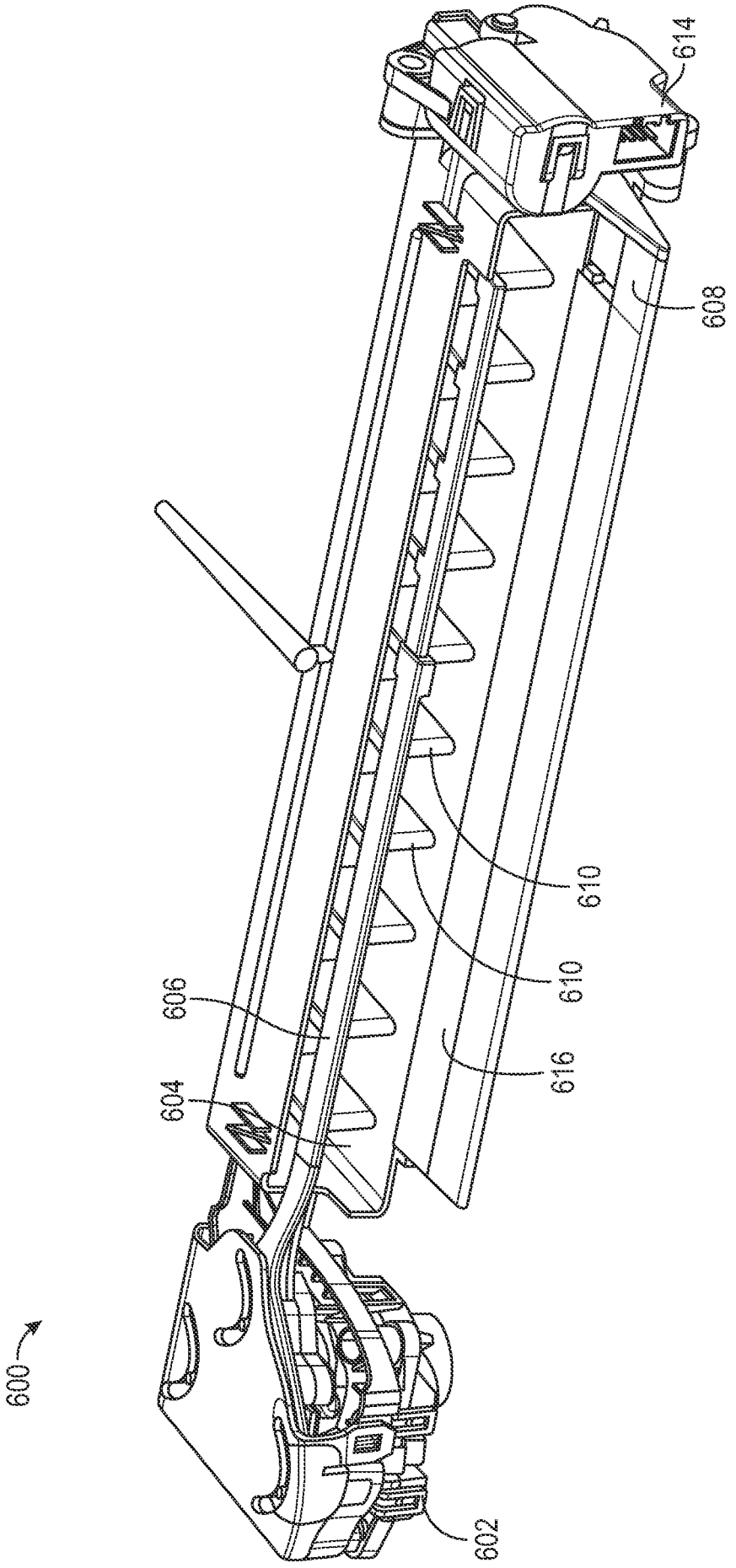

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/035602

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60H1/34 F24F13/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60H F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2022/281292 A1 (GOMEZ BRAVO MANZO ENRIQUE [US] ET AL) 8 September 2022 (2022-09-08) paragraphs [0051] - [0101]; figures 1-23	1-20
X	JP H04 136657 A (TOYODA GOSEI KK) 11 May 1992 (1992-05-11) paragraph [0001]; figures 1-8	1-20
X	EP 3 736 149 A1 (NIO ANHUI HOLDING CO LTD [CN]) 11 November 2020 (2020-11-11) paragraphs [0043] - [0072]; figures 1-5	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 September 2024	16/10/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Flori, Massimiliano

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2024/035602

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 3736149 A1	11-11-2020