(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 August 2017 (03.08.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/132460 A1

(51) International Patent Classification:
H05K 7/20 (2006.01)

(21) International Application Number:
PCT/US2017/015259

(22) International Filing Date:
27 January 2017 (27.01.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
15/011,413 29 January 2016 (29.01.2016) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

[Continued on next page]

(54) Title: BACKFLOW STOPPER WITH ACOUSTIC BARRIER

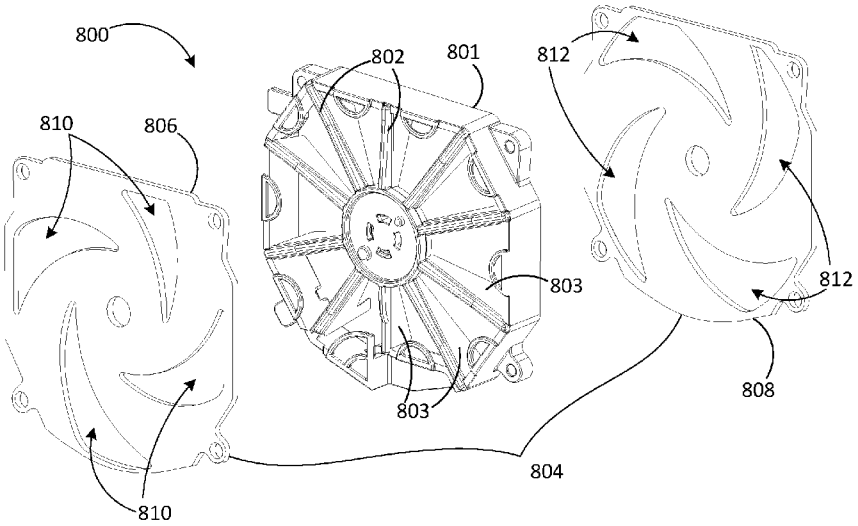


FIGURE 8

(57) Abstract: To provide enhanced operation of data storage devices and systems, various systems, apparatuses, and methods are provided herein. In a first example, a backflow assembly includes a backflow stopper comprising a frame configured to structurally support a fin array when coupled to a fan, the fin array comprising a plurality of flexural deformation elements and associated fin elements arrayed in a radial arrangement to establish a pathway for airflow, each of the flexural deformation elements configured to move an attached fin element responsive to airflow impacting the attached fin element. An acoustic barrier assembly is positioned adjacently to the backflow stopper and configured to attenuate acoustic waves emanating from the fan.

WO 2017/132460 A1

Published:

— *with international search report (Art. 21(3))*

BACKFLOW STOPPER WITH ACOUSTIC BARRIER

TECHNICAL FIELD

[0001] Aspects of the disclosure are related to the field of data storage and attenuation of acoustics in data storage enclosures.

TECHNICAL BACKGROUND

[0002] Computer and network systems such as data storage systems, server systems, cloud storage systems, personal computers, and workstations, typically include data storage devices for storing and retrieving data. These data storage devices can include hard disk drives (HDDs), solid state storage drives (SSDs), tape storage devices, optical storage drives, hybrid storage devices that include both rotating and solid state data storage elements, and other mass storage devices.

[0003] As computer systems and networks grow in numbers and capability, there is a need for ever increasing storage capacity. Data centers, cloud computing facilities, and other at-scale data processing systems have further increased the need for digital data storage systems capable of transferring and holding immense amounts of data. Data centers can house this large quantity of data storage devices in various rack-mounted and high-density storage configurations.

[0004] One approach to providing sufficient data storage in data centers is the use of arrays of independent data storage devices. Many data storage devices can be held in an electronics enclosure. An electronics enclosure is a modular unit that can hold and operate independent data storage devices in an array, computer processors, routers and other electronic equipment. The data storage devices are held and operated in close proximity within the electronics enclosure, so that many data storage devices can be fit into a defined volume.

[0005] While densities and workloads for the data storage devices increase, individual data enclosures can experience increased failure rates due to the increased densities and higher operating temperatures. Therefore, electronics enclosures typically include strong cooling fans or other cooling devices. If a fan fails in an electronics enclosure having two or more fans, the failed fan becomes the pathway of least resistance for airflow and diverts cooling airflow away from the data storage devices. Some electronics enclosures include

assemblies with hinged louvers that attach to the exhaust-side of the fan. When a fan fails, the louvers close under the force gravity or an active servo mechanism and prevent backflow through the failing fan. These louver assemblies are typically mounted external to the data storage assemblies or electronics enclosures to maximize usage of interior space for electronics components. Externally mounted backflow louvers add bulk to the enclosure and can interfere with cables, power cords, and walls near to the enclosure. Furthermore, louvered designs include many moving parts which can lead to reduced reliability of electronics enclosures.

[0006] Moreover, tight packing of data storage devices within enclosures, such as within rack-mount modular units, can lead to harsher vibrational and thermal environments for data storage devices. These harsh environments, such as due to fan vibrations or other acoustic disturbances, can affect reliability and readability of data storage devices that incorporate rotating magnetic media.

[0007] Strong cooling fans used in these systems may result in large acoustic disturbances on top of the disturbances due to neighboring drives seeking. Such acoustic disturbance on the data storage devices positioned close to cooling fans in an enclosure can be great enough to significantly degrade the performance of those drives positioned close to the cooling fans.

OVERVIEW

[0008] To provide enhanced operation of data storage devices and systems, various systems, apparatuses, and methods are provided herein. In a first example, a backflow assembly includes a backflow stopper comprising a frame configured to structurally support a fin array when coupled to a fan, the fin array comprising a plurality of flexural deformation elements and associated fin elements arrayed in a radial arrangement to establish a pathway for airflow, each of the flexural deformation elements configured to move an attached fin element responsive to airflow impacting the attached fin element. An acoustic barrier assembly is positioned adjacently to the backflow stopper and configured to attenuate acoustic waves emanating from the fan.

[0009] In another example, a data storage assembly includes an enclosure configured to house at least one data storage device and a fan assembly configured to provide airflow within the enclosure to ventilate the at least one data storage device, wherein a plurality of

acoustic waves emanate toward an interior of the enclosure from one or more fans of the fan assembly during operation. A backflow assembly is coupled to the fan assembly and includes a fin array comprising a plurality of fin elements arrayed to establish a pathway for airflow and a frame configured to structurally support the fin array. Each of the fin elements is configured to move in response to airflow impacting thereon. The backflow assembly is configured to deflect and attenuate at least a portion of the plurality of acoustic waves away from the at least one data storage device.

[0010] In another example, a data storage system includes an enclosure housing at least one data storage device and having a first opening on a first side and a second opening on a second side of the enclosure opposite the first side. A fan assembly is coupled to the enclosure and configured to draw an airflow through the first opening toward the second opening, the fan assembly generating a plurality of acoustic waves toward the at least one data storage device during operation. A backflow stopper assembly is coupled to the fan assembly and configured to deflect and attenuate at least a portion of the plurality of acoustic waves away from the at least one data storage device. The backflow stopper assembly also includes a fin array comprising a plurality of fin elements arrayed to establish a pathway for the airflow through the backflow stopper assembly, each of the fin elements configured to move responsive to the airflow impacting thereon. The at least one data storage device impedes the airflow through the housing by a first flow impedance value, and the backflow stopper assembly impedes the airflow through the housing by a second flow impedance value. The second flow impedance value is less than the first flow impedance value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Many aspects of the disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views. While several embodiments are described in connection with these drawings, the disclosure is not limited to the embodiments disclosed herein. On the contrary, the intent is to cover all alternatives, modifications, and equivalents.

[0012] Figure 1 illustrates an assembled view and an exploded view of backflow stopper assembly for preventing backflow through a cooling fan.

[0013] Figure 2 illustrates an assembled view and an exploded view of fan assembly with a backflow stopper for preventing backflow through a cooling fan.

[0014] Figure 3 illustrates an electronics enclosure with backflow prevention for preventing backflow through a cooling fan.

[0015] Figure 4A illustrates airflow within an electronics enclosure when a cooling fan fails without backflow stopper assemblies installed.

[0016] Figure 4B illustrates airflow within an electronics enclosure when a cooling fan fails with backflow stopper assemblies installed.

[0017] Figure 5 illustrates an assembled view and an exploded view of backflow preventer assembly for preventing backflow through a cooling fan.

[0018] Figure 6A illustrates a backflow preventer assembly in a closed state for blocking backflow through a cooling fan.

[0019] Figure 6B illustrates a backflow preventer assembly in an open state allowing airflow through a fan.

[0020] Figure 7 illustrates a bulkhead assembly with fans and backflow preventers for preventing backflow through the cooling fans.

[0021] Figure 8 illustrates a backflow assembly with acoustic vibration disturbance reduction.

[0022] Figure 9 illustrates a schematic diagram of a data storage system incorporating a backflow assembly with acoustic vibration disturbance reduction.

[0023] Figure 10 illustrates a bulkhead assembly with a plurality of the backflow assemblies of Figure 8 mounted thereon.

[0024] Figure 11 illustrates a backflow assembly with acoustic vibration disturbance reduction.

[0025] Figure 12 illustrates a bulkhead assembly with a plurality of the backflow assemblies of Figure 11 mounted thereon.

DETAILED DESCRIPTION

[0026] Figure 1 illustrates an assembled view and an exploded view of backflow stopper assembly 100 for preventing backflow through a cooling fan. Backflow stopper assembly 100 comprises frame 104, fin array 106 and flex limiter elements 112. Frame 104 is configured to structurally support fin array 106 when coupled to a fan. Fin array 106 comprises a plurality of flexural deformation elements 108 and associated fin elements 110 arrayed in a radial arrangement to establish a pathway for airflow. Each of flexural deformation elements 108 is configured to move an attached fin element 110 responsive to airflow impacting attached fin element 110. Flex limiter elements 112 couple to frame 104 and are configured to limit flexure of fin elements 110 beyond a predetermined flexure in relation to frame 104 to stop backflow of air through fin array 106.

[0027] Frame 104 is configured to structurally support fin array 106 when coupled to a fan. Frame 104 comprises coupling holes 116 matching coupling holes 116 of fin array 106 and coupling holes 116 of flex limiter elements 112. Frame 104 structurally supports fin array 106 by coupling fin array 106 to frame 104 using mechanical fasteners configured to engage coupling holes 116. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fastener compatible with coupling holes 116. Adhesives, tapes and welds can also be used to couple fin array 106 to frame 104. Alternatively, frame 104 can comprise a plate with holes for fasteners. In this example, frame 104 couples to fin array 106 by the compressive force of fasteners used to secure backflow stopper assembly 100 to a fan-mount bulkhead.

[0028] The configuration of frame 104 is selected, in part, by the fan coupled to frame 104. Suitable fan types include axial-flow, centrifugal and cross-flow, or other type fans, including combinations and variations thereof. Frame 104 geometry allows a maximum amount of airflow through frame 104 while coupled to a fan and occupies a minimal depth so that it can be installed inside of an electronics enclosure having limited space constraints. However, backflow stopper assembly can also be mounted on the exterior of an electronics enclosure. The depth of frame 104 is determined by the depth of fin array

106 when fin elements 110 are fully open. Frame 104 permits fin elements 110 to fully open without interfering with the fan.

[0029] Frame 104 is configurable to couple fin array 106 to a fan. Figure 1 illustrates frame 104 and fin array 106 having coupling holes 116 so that mechanical fasteners can be used to couple fin array 106 to a fan. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fastener compatible with coupling holes 116. Alternatively, fin array 106 can couple to frame 104 using snap-lock features. Adhesives, tapes and welds can also be used to couple fin array 106 to frame 104.

[0030] One or more flex limiter elements 112 couple to frame 104. Figure 1 illustrates frame 104 and flex limiter elements 112 having coupling holes 116 so that mechanical fasteners can be used to couple frame 104 to flex limiter elements 112. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fastener compatible with coupling holes 116. Alternatively, flex limiter elements 112 can couple to frame 104 using snap-lock features. Adhesives, tapes and welds can also be used to couple flex limiter elements 112 to frame 104.

[0031] Figure 1 illustrates frame 104 having a void interior for airflow to pass through. Other examples of frame 104 can have a different configuration including interior structural members as will be shown below. Frame 104 as illustrated in Figure 1 is comprised of only perimeter structure. Frame 104 is configurable to adapt to different fin array 106 and fan configurations.

[0032] Frame 104 can be manufactured from various materials comprising metals, alloys, polymers, ceramics, composites or some other material having desirable properties. The method of manufacturing frame 104 is dependent on the material used for construction. For example, metals or alloys can be machined or punched, while polymers can be injection molded or vacuum formed.

[0033] Fin array 106 comprises a plurality of flexural deformation elements 108 and associated fin elements 110 arrayed in a radial arrangement to establish a pathway for airflow, each flexural deformation element 108 is configured to move an attached fin element 110 responsive to airflow impacting attached fin element 110. Fin array 106 allows airflow to pass through in only one direction. Airflow passes through fin array 106 when fin elements 110 are in an open position and airflow is blocked when fin elements

110 are in a closed position. One or more flex limiter elements 112 can be used to limit flexure of fin elements 110 beyond a predetermined flexure in relation to frame 104 to stop backflow of air through the fin array.

[0034] Fin array 106 is configured to have a thin depth when fin elements 110 are in an open position permitting backflow stopper assembly 100 to be installed on the interior of an electronics enclosure having limited space constraints. Fin array 106 can be configured to open fin elements 110 to a pre-determined angle in relation to a plane parallel to fin array 106 to meet limited space constraints. For example, fin array 106 can be configured to open fin elements 110 to 40°, 45° or 90° in relation to a plane parallel to fin array 106. Opening fin elements 110 to 90° will consume a greater depth than opening fin elements 110 only 40° using the same fin array 106. Similarly, the size of fin elements 110 impacts the depth of fin array 106. Smaller and more numerous fin elements 110 will consume less depth than larger and less numerous fin elements 110 while permitting the same volume of airflow. Additionally, fin array 106 is configurable to default to either an open or closed state depending upon the intended application.

[0035] Fin array 106 is configurable to selectively open or close individual fin elements 110 via flexural deformation elements 108 responsive to airflow impacting individual fin elements 110. One way to configure fin array 106 to have selectively opening and closing fin elements 110 is to use different materials for flexural deformation elements 108. However, flexural deformation elements 108 can be made in several ways. Flexural deformation elements 108 can comprise a long beam. In the case of a long beam, flexural deformation elements 108 can utilize bending or torsional properties of the beam. Figure 1 provides an example of flexural deformation elements 108 comprising a long beam that deforms in a torsional manner. Flexural deformation elements 108 can be made from a thin section by selecting a thin sheet or by scoring (removing thickness locally). Additionally, flexural deformation elements can be made by narrowing a section of material to achieve desirable flexural deformation properties. For example, provided the thickness and material of flexural deformation elements 108 are generally equal, a wider flexural deformation element 108 will be less impacted than a narrower flexural deformation element 108 by the same airflow. Figure 1 provides an example of flexural deformation elements 108 made by narrowing a section of material. Finally, a

combination of all the above methods can be used to make flexural deformation elements 108.

[0036] Some considerations when selecting materials for flexural deformation elements 108 include cost, stiffness, and environmental factors. Flexural deformation elements 108 flex to open and close fin elements 110, therefore the stiffness, or the modulus of elasticity, affects how flexural deformation elements 108 react to changes in airflow. Stiffness of flexural deformation elements 108 can be adjusted when using the same piece of material for fin elements 110 and flexural deformation elements 108 by selectively removing material to form flexural deformation elements 108. Figure 1 illustrates an example of flexural deformation elements 108 cut from the same piece of material as fin elements 110. Alternatively, flexural deformation elements 108 can comprise different materials than fin elements 110. In this case, both material selection and geometry of flexural deformation elements 108 will determine the stiffness of flexural deformation elements 108.

[0037] Environmental factors are considered when selecting material for flexural deformation elements 108 because backflow stopper assembly 100 can be used inside of electrical enclosures and must meet certain industry standards. In some examples, flexural deformation elements 108 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent flexural deformation elements 108 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. For example, flexural deformation elements 108 might have a U.L. approved fire rating of 94 V-0 or better. Metals, alloys, and flame retardant materials are good examples of materials that can be used for flexural deformation elements 108. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for flexural deformation elements 108 and meet U.L. approved fire rating of 94 V-0 or better.

[0038] Various methods of manufacturing flexural deformation elements 108 can be employed depending upon the material selected. For example, some materials that can be used to make flexural deformation elements 108 are easily manufactured using stamping, die cutting or laser cutting operations. While other materials may be better suited to injection molding, vacuum forming, scoring or some other operations. In some examples, fin array 106 can be constructed from flexural deformation elements 108 made of one

material and fin elements 110 from another. Dissimilar materials can be assembled into fin array 106 by using lamination techniques, adhesives, heat bonds or other mechanical joining processes.

[0039] Fin elements 110 close in the event of fan failure thereby preventing backflow that would compromise the efficiency of the cooling system. Flexural deformation elements 108 coupled to fin elements 110 flex to open and close fin elements 110. Flexural deformation elements 108 elements are configurable to react to changes in airflow and open and close fin elements 110 in response. The flexure of flexural deformation elements 108 can be configured by material selection and geometry. Fin elements 110 bear a minimal structural load by airflow in the open position. Fin elements 110 are structurally loaded by airflow in the closed position. Flex limiter elements 112 provide additional support to fin elements 110 when fin elements 110 experience load. Therefore, material strength is not a critical factor when selecting materials for fin elements 110.

[0040] Some considerations when selecting materials for fin elements 110 include cost, stiffness, and environmental factors. Environmental factors are considered when selecting material for fin elements 110 because backflow stopper assembly 100 can be used inside of electrical enclosures and must meet certain industry standards. For example, fin elements 110 might have a U.L. approved fire rating of 94 V-0 or better. In some examples, fin elements 110 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent fin elements 110 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. Metals, alloys, and flame retardant materials are good examples of materials that can be used for fin elements 110. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for fin elements 110 and meet U.L. approved fire rating of 94 V-0 or better.

[0041] Various methods of manufacturing fin elements 110 can be employed depending upon the material selected. For example, some materials that can be used to make fin elements 110 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to injection molding, vacuum forming, scoring or some other operations. In some examples, fin array 106 can be constructed from fin elements 110 made of one material and flexural deformation

elements 108 from another. Dissimilar materials can be assembled into fin array 106 by using lamination techniques, adhesives, heat bonds or other mechanical joining processes.

[0042] One or more flex limiter elements 112 couple to frame 104 and are configured to limit flexure of fin elements 110 beyond a predetermined flexure in relation to frame 104 to stop backflow of air through fin array 106. Figure 1 illustrates frame 104 and flex limiter elements 112 having coupling holes 116 so that mechanical fasteners can be used to couple frame 104 to flex limiter elements 112. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fastener compatible with coupling holes 116. Alternatively, flex limiter elements 112 can couple to frame 104 using snap-lock features. Adhesives, tapes and welds can also be used to couple flex limiter elements 112 to frame 104.

[0043] Flex limiter elements 112 limit flexure of fin elements 110 beyond a predetermined flexure in relation to frame 104 to stop backflow of air through fin array 106 by providing mechanical interference with fin elements 110, thereby inhibiting further movement. Figure illustrates flex limiter elements 112 as a plate with material removed to permit airflow through flex limiter elements 112. Flex limiter elements 112 can be a mesh in some examples. Flex limiter elements 112 allow fin elements 110 to be constructed of lighter and more flexible materials by providing additional support to fin elements 110 during load. It is desirable for flex limiter elements to be as thin as possible while still providing the necessary support to fin elements 110 to allow backflow stopper assembly 100 to be installed into electronic enclosures having limited space constraints. It is also desirable that flex limiter elements 112 have minimal structure to avoid negatively impacting airflow though backflow stopper assembly 100.

[0044] Flex limiter elements 112 can be constructed from a variety of materials. Some considerations when selecting materials for flex limiter elements 112 include cost, stiffness, and environmental factors. Environmental factors are considered when selecting material for flex limiter elements 112 because backflow stopper assembly 100 can be used inside of electrical enclosures and must meet certain industry standards. For example, flex limiter elements 112 might have a U.L. approved fire rating of 94 V-0 or better. Metals, alloys, polymers, ceramics, composites or other materials having desirable properties can be used to manufacture flex limiter elements 112.

[0045] Methods of manufacturing flex limiter elements 112 depend on the material used for construction. For example, some materials that can be used to make flex limiter elements 112 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to injection molding, vacuum forming, scoring or some other operations.

[0046] Figure 2 illustrates an assembled view and an exploded view of fan assembly with a backflow stopper 200. Fan assembly with a backflow stopper 200 blocks airflow from passing through a fan 214 in the event fan 214 fails. Allowing airflow to pass through fan 214 when fan 214 has failed can compromise the efficiency of the cooling system in an electronic enclosure because fan 214 provides a path of lesser resistance for airflow than moving over electronic components. Fan assembly with a backflow stopper 200 is designed to be compact so that it can fit in the interior of an electronics enclosure having limited space constraints. Fan assembly with a backflow stopper 200 can be installed into existing electronics enclosures by mounting to the bulkhead that supports the cooling system.

[0047] Fan assembly with a backflow stopper 200 comprises fan 214 and backflow stopper assembly 202. Fan 214 can be any type or configuration of fan. Backflow stopper assembly 202 is configurable to work with any fan. Typically, fan 214 will comprise an electronic fan used for cooling electronics enclosures.

[0048] Fan 214 comprises a mechanical fan with rotating blades to create airflow. Fan 214 can comprise an axial-flow, centrifugal or cross-flow, or some other type of fan, including combinations or variations. Axial-flow fans have blades that force air to move parallel to the shaft about which the blades rotate and are commonly used for cooling electronic equipment and typically comprise case mount frames for mounting the fan within an electronics enclosure. Fan 214 further comprises a motor. Some suitable motors for use with Fan 214 include AC, DC brushed or DC brushless motors.

[0049] Backflow stopper assembly 202 comprises frame 204, fin array 206 and flex limiter elements 212. Backflow stopper assembly 202 is an example of backflow stopper assembly 100; however, backflow stopper assembly 202 can have alternative configurations and operations than backflow stopper assembly 100.

[0050] Backflow stopper assembly 202 comprises frame 204 configured to structurally support fin array 206 and couple fin array 206 to fan 214. Fin array 206 comprises a plurality of flexural deformation elements 208 and associated fin elements 210 arrayed in a radial arrangement to establish a pathway for airflow, each of flexural deformation elements 208 is configured to move an attached fin element 210 responsive to airflow impacting the attached fin element 210. Backflow stopper assembly 202 also comprises one or more flex limiter elements 212 coupled to frame 204 and configured to limit flexure of fin elements 210 beyond a predetermined flexure in relation to frame 204 to stop backflow of air through fin array 206.

[0051] Frame 204 is configured to structurally support fin array 206 when coupled to fan 214. Frame 204 is configurable to structurally support fin array 206 by coupling to fin array 206. The depth of frame 204 is determined by the depth of fin array 206. Frame 204 permits fin elements 210 to fully open without interfering with fan 214. Figure 2 illustrates frame 204 and fin array 206 having coupling holes 216 so that mechanical fasteners can be used to couple frame 204 to fin array 206. Mechanical fasteners that can be used comprise screws, bolts, push-in rivets and other fasteners for use with coupling holes 216. Adhesives or tapes can also be used to couple frame 204 to fin array 206. Frame 204 can mechanically couple to fin array 206 using snap-fit geometry.

[0052] Frame 204 couples fin array 206 to fan 214. Figure 2 illustrates frame 204 with coupling holes 216 so that mechanical fasteners can be used to couple frame 204 to fan 214. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fastener compatible with coupling holes 116. Frame 204 can also couple to fin array 206 to fan 214 using snap-lock features.

[0053] One or more flex limiter elements 212 couple to frame 204. Figure 2 illustrates frame 204 and flex limiter elements 212 having coupling holes 216 so that mechanical fasteners can be used to couple frame 204 to fin array 206. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fastener compatible with coupling holes 216. Alternatively, one or more flex limiter elements 212 can couple to frame 204 using snap-lock features.

[0054] Figure 2 illustrates frame 204 having a void interior for airflow to pass through. Other examples of frame 204 can have entirely different configurations as will be shown.

For example, frame 204 can comprise interior structural members. Frame 204 as illustrated in Figure 2 is comprised of only perimeter structure. Frame 204 is configurable to adapt to different fin array 206 and fan 214 configurations.

[0055] Frame 204 can be manufactured from various materials comprising metals, alloys, polymers, ceramics, composites or some other materials having desirable properties. The method of manufacturing frame 204 is dependent on the material used for construction. For example, metals or alloys can be machined or punched, while polymers can be injection molded or vacuum formed.

[0056] Fin array 206 comprises a plurality of flexural deformation elements 208 and associated fin elements 210 arrayed in a radial arrangement to establish a pathway for airflow, each flexural deformation element 208 is configured to move an attached fin element 210 responsive to airflow impacting attached fin element 210. Fin array 206 allows airflow to pass through in only one direction. Airflow passes through fin array 206 when fin elements 210 are in an open position and airflow is blocked when fin elements 210 are in a closed position. One or more flex limiter elements 212 limits flexure of fin elements 210 beyond a predetermined flexure in relation to frame 204 to stop backflow of air through fin array 206.

[0057] Fin array 206 is configured to have a thin depth when fin elements 210 are in an open position permitting fan assembly with a backflow stopper 200 to be installed on the interior of an electronics enclosure having limited space constraints. In some examples, backflow stopper 200 has a depth of less than 20 millimeters. Fin array 206 can be configured to open fin elements 210 to pre-determined angles in relation to a plane parallel to fin array 206 to meet limited space constraints. For example, fin array 206 can be configured to open fin elements 210 to 40°, 45° or 90° in relation to a plane parallel to fin array 206. Opening fin elements 210 to 90° will consume a greater depth than opening the same fin elements 210 only 40°. Similarly, the size of fin elements 210 impacts the depth of fin array 206. Smaller and more numerous fin elements 210 consume less depth than larger and less numerous fin elements 210 while permitting the same volume of airflow. Additionally, fin array 206 is configurable to default to either an open or closed state depending upon the intended application. In this example, fin array 206 defaults to an open state.

[0058] Fin array 206 is configurable to selectively open or close individual fin elements 210 via flexural deformation elements 208 responsive to airflow impacting the individual fin elements 210. Flexural deformation elements 208 are configured to move an attached fin element 210 responsive to airflow impacting fin element 210. Flexural deformation elements 208 can be configured to move an attached fin element 210 differing amounts responsive to the same airflow simply by changing the geometry of flexural deformation elements 208. For example, provided the thickness and material of the flexural deformation elements 208 are equal, a wider flexural deformation element 208 will be less impacted than a narrower flexural deformation element 208 by the same airflow. Another way to configure fin array 206 to have selectively opening and closing fin elements 210 is to use different materials for flexural deformation elements 208.

[0059] Fin array 206 can be formed from a single piece of a flexible material of a predetermined thickness that establishes an open state of fin array 206 when the airflow is provided by fan 214 and a closed state of fin array 206 when the airflow is in a direction opposite to that provided by fan 214. Alternatively, fin array 206 can be formed from a laminated assembly of one or more flexible materials with a first layer of the laminated assembly of a first thickness that establishes an open state of fin array 206 when the airflow is provided by fan 214 and a closed state of fin array 206 when the airflow is in a direction opposite to that provided by fan 214, and the second layer of the laminated assembly of a second thickness to form fin elements 210 and provide rigidity to fin elements 210.

[0060] Flexural deformation elements 208 can be made in several ways. Flexural deformation elements 208 can be configured to move an attached fin element 210 differing amounts responsive to the same airflow simply by changing the geometry of flexural deformation elements 208. Another way to configure fin array 206 to have selectively opening and closing fin elements 210 is to use different materials for flexural deformation elements 208. Flexural deformation elements 208 can comprise a long beam. In the case of a long beam, flexural deformation elements 208 can utilize bending or torsional properties of the beam. Flexural deformation elements 208 can be made from a thin section by selecting a thin sheet or by scoring (removing thickness locally). Additionally, flexural deformation elements can be made by narrowing a section of material to achieve desirable flexural deformation properties. For example, provided the thickness and

material of the flexural deformation elements 208 are generally equal, a wider flexural deformation element 208 will be less impacted than a narrower flexural deformation element 208 by the same airflow. Finally, a combination of all the above methods can be used to make flexural deformation elements 208.

[0061] Some considerations when selecting materials for flexural deformation elements 208 include cost, stiffness, and environmental factors. Flexural deformation elements 208 flex to open and close fin elements 210, therefore the stiffness, or the modulus of elasticity, affects how flexural deformation elements 208 react to changes in airflow. Stiffness of flexural deformation elements 208 can be adjusted when using the same piece of material for fin elements 210 and flexural deformation elements 208 by selectively removing material to form flexural deformation elements 208. Figure 2 illustrates an example of flexural deformation elements 208 cut from the same piece of material as fin elements 210. Alternatively, flexural deformation elements 208 can comprise different materials than fin elements 210. In this case, both material selection and geometry of flexural deformation elements 208 will determine the stiffness of flexural deformation elements 208.

[0062] Environmental factors are considered when selecting material for flexural deformation elements 208 because fan assembly with a backflow stopper 200 can be used inside of electronics enclosures and must meet certain industry standards. For example, flexural deformation elements 208 might have a U.L. approved fire rating of 94 V-0 or better. In some examples, flexural deformation elements 208 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent flexural deformation elements 208 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. Metals, alloys, and flame retardant materials are good examples of materials that can be used for flexural deformation elements 208. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for flexural deformation elements 208 and meet U.L. approved fire rating of 94 V-0 or better.

[0063] Various methods of manufacturing flexural deformation elements 208 can be employed depending upon the material selected. For example, some materials that can be used to make flexural deformation elements 208 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to

injection molding, vacuum forming, scoring of some other operations. In some examples, fin array 206 can be constructed from flexural deformation elements 208 made of one material and fin elements 210 from another. Dissimilar materials can be assembled into fin array 206 by using lamination techniques, adhesives, heat bonds or other mechanical joining processes.

[0064] Fin elements 210 close in the event of fan 214 failures thereby preventing backflow that would compromise the efficiency of the cooling system. Flexural deformation elements 208 coupled to fin elements 210 flex to open and close fin elements 210. Flexural deformation elements 208 elements are configurable to react to changes in airflow and open and close fin elements 210 in response. The flexure of flexural deformation elements 208 can be configured by material selection and geometry. Fin elements 210 bear a minimal structural load by airflow in the open position. Fin elements 210 are structurally loaded by airflow in the closed position. Flex limiter elements 212 provide additional support to fin elements 210 when fin elements 210 experience load in the closed position. Therefore, material strength is not a critical factor when selecting materials for fin elements 210.

[0065] Some considerations when selecting materials for fin elements 210 include cost, stiffness, and environmental factors. Environmental factors are considered when selecting material for fin elements 210 because fan assembly with a backflow stopper 202 can be used inside of electrical enclosures and must meet certain industry standards. For example, fin elements 210 might have a U.L. approved fire rating of 94 V-0 or better. In some examples, fin elements 210 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent fin elements 210 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. Metals, alloys, and flame retardant materials are good examples of materials that can be used for fin elements 210. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for fin elements 210 and meet U.L. approved fire rating of 94 V-0 or better.

[0066] Various methods of manufacturing fin elements 210 can be employed depending upon the material selected. For example, some materials that can be used to make fin elements 210 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to injection molding,

vacuum forming, scoring of some other operations. In some examples, fin array 206 can be constructed from fin elements 210 made of one material and flexural deformation elements 208 from another. Dissimilar materials can be assembled to make fin array 206 by using lamination techniques, adhesives, heat bonds or other mechanical joining processes.

[0067] One or more flex limiter elements 212 couple to frame 204 and are configured to limit flexure of fin elements 210 beyond a predetermined flexure in relation to frame 204 to stop backflow of air through fin array 206. Flex limiter elements 212 limit flexure of fin elements 210 beyond a predetermined flexure in relation to frame 204 to stop backflow of air through fin array 206 by providing mechanical interference with fin elements 210 thereby inhibiting further movement. Flex limiter elements 212 allow fin elements 210 to be constructed of lighter and more flexible materials by providing additional support to fin elements 210 during load. It is desirable for flex limiter elements 212 to be as thin as possible while still providing the necessary support to fin elements 210 to allow fan assembly with a backflow stopper 200 to be installed into electronics enclosures having limited space constraints. It is also desirable that flex limiter elements 212 have minimal structure to avoid negatively impacting airflow though fan assembly with a backflow stopper 200.

[0068] Various methods can be used to couple flex limiter elements 212 to frame 204. Figure 2 illustrates frame 204 having coupling holes 216 so that mechanical fasteners can be used to couple one or more flex limiter elements 212 to frame 204. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fastener compatible with coupling holes 216. Alternatively, flex limiter elements 212 can couple to frame 204 using snap-lock features. Adhesives, tapes and welds can also be used to couple flex limiter elements 212 to frame 204.

[0069] Flex limiter elements 212 can be constructed from a variety of materials. Some considerations when selecting materials for flex limiter elements 212 include cost, stiffness and environmental factors. Environmental factors are considered when selecting material for flex limiter elements 212 because fan assembly with a backflow stopper 200 can be used inside of electronics enclosures and must meet certain industry standards. For example, flex limiter elements 212 might have a U.L. approved fire rating of 94 V-0 or

better. Metals, alloys, polymers, ceramics, composites or other materials having desirable properties can be used to manufacture flex limiter elements 212.

[0070] Methods of manufacturing flex limiter elements 212 depend on the material used for construction. For example, stamping operations or laser cutting are appropriate manufacturing methods if metals or alloys are used for flex limiter elements 212.

[0071] Figure 3 illustrates electronics enclosure with backflow prevention 300 for housing sleds 320 for supporting electronic devices. Figure 3 illustrates enclosure 318 having excess interior room for the sake of illustration. Electronics enclosure with backflow prevention 300 includes one or more fan assemblies with backflow preventers 302. Fan assembly with a backflow preventer 302 provides an example of fan assembly with a backflow stopper 200; however, fan assembly with a backflow preventer 302 can have alternative configurations and operations than fan assembly with a backflow stopper 200. Fan assembly with a backflow preventer 302 comprises fan 314 and backflow preventer 316. Backflow preventer 316 is an example of backflow stopper assembly 100 and backflow stopper assembly 202; however, backflow preventer 316 can have alternative configurations and operations than backflow stopper assembly 100 or backflow stopper assembly 202.

[0072] Electronics enclosure with backflow prevention 300 comprises enclosure 318 configured to encase and support sleds 320 containing electronic devices and one or more fans 314 each with a corresponding backflow preventer 316. Backflow preventers 316 comprise frame 304, fin array 306 and flex limiter elements 312. Frame 304 is configured to structurally support fin array 306 and couple fin array 306 to fan 314. Fin array 306 comprises a plurality of flexural deformation elements 308 and associated fin elements 310 arrayed in a radial arrangement to establish a pathway for airflow, each of flexural deformation elements 308 is configured to move an attached fin element 310 responsive to airflow impacting attached fin element 310. Backflow preventer 316 further comprises one or more flex limiter elements 312 coupled to frame 304 and configured to limit flexure of fin elements 310 beyond a predetermined flexure in relation to frame 304 to stop backflow of air through fin array 306.

[0073] Enclosure 318 is configured to encase and support sleds 320 containing electronic devices. In some examples, enclosure 318 does not include sleds 320 or support

structure for sleds 320. Sleds 320 provide structural and electrical support for a plurality of electronic devices arranges in an array. Electronic devices comprise data storage devices, computer processing units, routers and network elements, for example. Data storage devices comprise hard disk drives, solid state drives, and hybrid drives. Hybrid drives are data storage devices that couple a rotating magnetic media to a solid state memory for enhanced performance. Sleds 320 communicatively couple to electrical connectors within enclosure 318 to communicate with external devices.

[0074] Enclosure 318 includes bulkhead 322 for mounting cooling fans 314. Bulkhead 322 comprises structural elements for mounting cooling equipment, power and electrical connectors. Bulkhead 322 is typical of what would be found in an electronics enclosure, such as enclosure 318, for example. Fans 314 can be mounted on either on the interior or exterior of bulkhead 322. Likewise, backflow preventer 302 can be installed on either the interior or exterior of bulkhead 322. Figure 3 illustrates fans 314 and backflow preventers 302 mounted on the interior of bulkhead 322. However, in some examples fans 314 can be mounted to the exterior of bulkhead 322 and backflow preventers 302 mounted to the interior of bulkhead 604 and vice-versa. Enclosure 318 can be manufactured from various materials comprising metals, alloys, polymers, ceramics, composites or other materials having desirable properties.

[0075] Electronics enclosure with backflow prevention 300 comprises one or more fans 314. Fans 314 can mount to bulkhead 322 either on the interior or exterior of enclosure 318. Likewise, backflow preventer 316 can be installed on either the interior or exterior of enclosure 318. Figure 3 illustrates fan assembly with backflow preventer 302 mounted on the interior back-side of enclosure 318. However, fan assembly with backflow preventer 302 can be mounted to the front, top and bottom and interior and exterior of electronics enclosure 318. In some examples fans 314 can be mounted to the interior of enclosure 318 and backflow preventers 316 mounted to the exterior of enclosure 318 and vice-versa.

[0076] Fan 314 comprises a mechanical fan with rotating blades to create airflow. Fan 314 can comprise an axial-flow, centrifugal or cross-flow type fan, for example. Axial-flow fans have blades that force air to move parallel to the shaft about which the blades rotate and are commonly used for cooling electronic equipment and typically comprise case mount frames for mounting the fan within an electronics enclosure. Fan 314 further

comprises a motor. Some suitable motors for use with Fan 214 include AC, DC brushed or DC brushless motors.

[0077] Frame 304 is configured to structurally support fin array 306 and couple fin array 306 to fan 314. Frame 304 is configurable to structurally support fin array 306 by coupling to fin array 306. The depth of frame 304 is determined by the depth of fin array 306. Frame 304 permits fin elements 310 to fully open without interfering with fan 314. Mechanical fasteners can be used to couple frame 304 to fin array 305. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fasteners. Alternatively, frame 304 can couple fin array 306 to fan 314 using snap-lock features. Adhesives, tapes and welds can also be used to couple fin array 306 to frame 304. Alternatively, in some examples, frame 304 comprises an intermediate plate, compressed between fin array 306 and bulkhead 322 by fasteners secured into bulkhead 322.

[0078] One or more flex limiter elements 312 couple to frame 304. Mechanical fasteners can be used to couple flex limiter elements 312 to frame 304. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fasteners. Alternatively, one or more flex limiter elements 312 can couple to frame 304 using snap-lock features. Adhesives, tapes and welds can also be used to couple one or more flex limiter elements 312 to frame 304.

[0079] Frame 304 can be manufactured from various materials comprising metals, alloys, polymers, ceramics, composites or some other materials having desirable properties. The method of manufacturing frame 304 is dependent on the material used for construction. For example, metals or alloys can be machined or punched, while polymers can be injection molded or vacuum formed.

[0080] Fin array 306 comprises a plurality of flexural deformation elements 308 and associated fin elements 310 arrayed in a radial arrangement to establish a pathway for airflow, each flexural deformation element 308 is configured to move an attached fin element 310 responsive to airflow impacting attached fin element 310. Fin array 306 allows airflow to pass through in only one direction. Airflow passes through fin array 306 when fin elements 310 are in an open position and airflow is blocked when fin elements 310 are in a closed position. One or more flex limiter elements 312 can be used to limit

flexure of fin elements 310 beyond a predetermined flexure in relation to frame 304 to stop backflow of air through fin array 306.

[0081] Fin array 306 is configured to have a thin depth when fin elements 310 are in an open position permitting backflow preventer 316 to be installed on the interior of enclosure 318 having limited space constraints. Fin array 306 can be configured to open fin elements 310 to pre-determined angles in relation to a plane parallel to fin array 306 to meet limited space constraints. For example, fin array 306 can be configured to open fin elements 310 to 40°, 45° or 90° in relation to a plane parallel to fin array 306. Opening fin elements 310 to 90° will consume a greater depth than opening the same fin elements 310 only 40°. Similarly, the size of fin elements 310 impacts the depth of fin array 306. Smaller and more numerous fin elements 310 consume less depth than larger and less numerous fin elements 310 while permitting the same volume of airflow. Additionally, fin array 306 is configurable to default to either an open or closed state depending upon the intended application. In this example, fin array 306 defaults to an open state, thereby reducing load on fans 314 when operating.

[0082] Fin array 306 is configurable to selectively open or close individual fin elements 310 via flexural deformation elements 308 depending upon airflow impacting the individual fin elements 310. Flexural deformation elements 308 are configured to move an attached fin element 310 responsive to airflow impacting fin element 310. Flexural deformation elements 308 can be configured to move an attached fin element 310 differing amounts responsive to the same airflow simply by changing the geometry of flexural deformation elements 308. For example, provided the thickness and material of the flexural deformation elements 308 are equal, a wider flexural deformation element 308 will be less impacted than a narrower flexural deformation element 308 by the same airflow. Another way to configure fin array 306 to have selectively opening and closing fin elements 310 is to use different materials for flexural deformation elements 308.

[0083] Fin array 306 can be formed from a single piece of a flexible material of a predetermined thickness that establishes an open state of fin array 306 when the airflow is provided by fan 314 and a closed state of fin array 306 when the airflow is in a direction opposite to that provided by fan 314. Alternatively, fin array 306 can be formed from a laminated assembly of one or more flexible materials with a first layer of the laminated assembly of a first thickness that establishes an open state of fin array 306 when the

airflow is provided by fan 314 and a closed state of fin array 306 when the airflow is in a direction opposite to that provided by fan 314, and the second layer of the laminated assembly of a second thickness to form fin elements 310 and provide rigidity to fin elements 310. Some considerations when selecting materials for flexural deformation elements 308 include cost, stiffness, and environmental factors. Flexural deformation elements 308 flex to open and close fin elements 310, therefore the stiffness, or the modulus of elasticity, affects how flexural deformation elements 308 react to changes in airflow. Stiffness of flexural deformation elements 308 can be adjusted when using the same piece of material for fin elements 310 and flexural deformation elements 308 by selectively removing material to form flexural deformation elements 308. Flexural deformation elements 308 can be cut from the same piece of material as fin elements 310. Alternatively, flexural deformation elements 308 can comprise different materials than fin elements 310. In this case, both material selection and geometry of flexural deformation elements 308 will determine the stiffness of flexural deformation elements 308.

[0084] Environmental factors are considered when selecting material for flexural deformation elements 308 because backflow preventer 316 can be used inside of enclosure 318 and must meet certain industry standards. For example, flexural deformation elements 308 might have a U.L. approved fire rating of 94 V-0 or better. In some examples, flexural deformation elements 308 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent flexural deformation elements 308 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. Metals, alloys, and flame retardant materials are good examples of materials that can be used for flexural deformation elements 308. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for flexural deformation elements 308 and meet U.L. approved fire rating of 94 V-0 or better.

[0085] Various methods of manufacturing flexural deformation elements 308 can be employed depending upon the material selected. For example, some materials that can be used to make flexural deformation elements 308 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to injection molding, vacuum forming, scoring or some other operations. In some examples, fin array 306 can be constructed from flexural deformation elements 308 made of one

material and fin elements 310 from another. Dissimilar materials can be assembled to form fin array 306 by using lamination techniques, adhesives, heat bonds or other mechanical joining processes.

[0086] Fin elements 310 close in the event of fan 314 failures thereby preventing backflow that would compromise the efficiency of the cooling system. Flexural deformation elements 308 coupled to fin elements 310 flex to open and close fin elements 310. Flexural deformation elements 308 elements are configurable to react to changes in airflow and open and close fin elements 310 in response. The flexure of flexural deformation elements 308 can be configured by material selection and geometry. Fin elements 310 bear a minimal structural load by airflow in the open position. Fin elements 310 are structurally loaded by airflow in the closed position. Flex limiter elements 312 provide additional support to fin elements 310 when fin elements 310 experience load in the closed position. Therefore, material strength is not a critical factor when selecting materials for fin elements 310.

[0087] Some considerations when selecting materials for fin elements 310 include cost, stiffness, and environmental factors. Environmental factors are considered when selecting material for fin elements 310 because fan assembly with a backflow preventer 302 can be used inside of enclosure 318 and must meet certain industry standards. For example, fin elements 310might have a U.L. approved fire rating of 94 V-0 or better. In some examples, fin elements 310 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent fin elements 310 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. Metals, alloys, and flame retardant materials are good examples of materials that can be used for fin elements 310. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for fin elements 310 and meet U.L. approved fire rating of 94 V-0 or better.

[0088] Various methods of manufacturing fin elements 310 can be employed depending upon the material selected. For example, some materials that can be used to make fin elements 310 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to injection molding, vacuum forming, scoring or some other operations. In some examples, fin array 306 can be constructed from fin elements 310 made of one material and flexural deformation

elements 308 from another. Dissimilar materials can be assembled to make fin array 306 by using lamination techniques, adhesives, heat bonds or other mechanical joining processes.

[0089] One or more flex limiter elements 312 couple to frame 304 and are configured to limit flexure of fin elements 310 beyond a predetermined flexure in relation to frame 304 to stop backflow of air through fin array 306. Flex limiter elements 312 limit flexure of fin elements 310 beyond a predetermined flexure in relation to frame 304 to stop backflow of air through fin array 306 by providing mechanical interference with fin elements 310 thereby inhibiting further movement. Flex limiter elements 312 allow fin elements 310 to be constructed of lighter and more flexible materials by providing additional support to fin elements 310 during load. It is desirable for flex limiter elements 312 to be as thin as possible while still providing the necessary support to fin elements 310 to allow fan assembly with a backflow preventer 302 to be installed into electrical enclosures having limited space constraints. It is also desirable that flex limiter elements 312 have minimal structure to avoid negatively impacting airflow though fan assembly with a backflow preventer 302.

[0090] Various methods can be used to couple flex limiter elements 312 to frame 304. Mechanical fasteners can be used to couple flex limiter elements 312 to frame 304. Suitable mechanical fasteners comprise screws, bolts, push-in rivets, snap-lock fasteners or other fasteners. Alternatively, flex limiter elements 312 can couple to frame 304 using snap-lock features. Adhesives, tapes and welds can also be used to couple flex limiter elements 312 to frame 304.

[0091] Flex limiter elements 312 can be constructed from a variety of materials. Some considerations when selecting materials for flex limiter elements 312 include cost, stiffness, and environmental factors. Environmental factors are considered when selecting material for flex limiter elements 312 because backflow preventer 316 can be used inside of enclosure 318 and must meet certain industry standards. For example, flex limiter elements 312 might have a U.L. approved fire rating of 94 V-0 or better. Metals, alloys, polymers, ceramics, composites or some other materials having desirable properties can be used to manufacture flex limiter elements 312.

[0092] Methods of manufacturing flex limiter elements 312 depend on the material used for construction. For example, some materials that can be used to make fin elements 312 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to injection molding, vacuum forming, or scoring operations. Alternatively, flex limiter elements can be manufactured using polymers and injection molding techniques.

[0093] Figures 4A and 4B illustrate the operation of backflow stoppers 402 within enclosure 418. Backflow stopper 402 is an example of backflow stopper assembly 100, backflow stopper assembly 202 and backflow preventer 316; however, backflow stopper 402 may have alternative configurations and methods of operation than backflow stopper assembly 100, backflow stopper assembly 202 and backflow preventer 316.

[0094] During normal operation airflow is drawn from the front of enclosure (illustrated as the right side of enclosure 418 in Figures 4A and 4B) evenly past electronic devices 420, absorbing heat from electronic devices 420, and exhausted out the back of enclosure 418 (illustrated as the left side of enclosure 418 in Figures 4A and 4B). Some examples of enclosure 418 allow airflow to be drawn in from the top, bottom, and sides of enclosure 418. Fan 424 failure will result in similar inefficient airflow modes when fan 424 fails in either example. Therefore, for the sake of simplicity in explanation, it is assumed that during normal operation airflow is drawn evenly from the front to the back of enclosure 418 to cool electronic devices 420.

[0095] Figure 4A illustrates airflow within enclosure 418 when fan 424 fails and does not have backflow stopper 402 installed. When fan 424 fails without a backflow stopper 402, failing fan 424 becomes the path of least resistance for airflow. In this example fan 414 is still operational after fan 424 fails. Fan 414 draws some airflow past electronic devices 420; however, failing fan 424 provides a pathway for airflow with lesser resistance than airflow drawn from the front of enclosure 418 and past electronic devices 420 thereby circumventing cooling airflow past electronic devices 420.

[0096] Figure 4B illustrates airflow within enclosure 418 when fan 424 fails and backflow stoppers 402 are installed. Enclosure 418 comprises backflow stoppers 402, fan 416, electronic devices 420, and failing fan 424. Backflow stopper 402 closes fin elements thereby blocking backflow through fan 424 when fan 424 fails. Fan 424 is no

longer the pathway for least resistance as in Figure 4A. Fan 414 continues to draw air from the front of enclosure 418, past electronic devices 420 and exhausts the air out of the back of enclosure 418.

[0097] Figure 5 illustrates an assembled view and an exploded view of backflow preventer assembly 500. Backflow preventer assembly 500 is an example of backflow stopper assembly 100, backflow stopper assembly 202, backflow preventer 316 and backflow stopper 402; however, backflow preventer assembly 500 may have alternative configurations and methods of operation than backflow stopper assembly 100, backflow stopper assembly 202, backflow preventer 316 and backflow stopper 402.

[0098] Backflow preventer assembly 500 comprises frame 504, fin array 506 and fin array retainer 524. Frame 504 is configured to structurally support fin array 506 and couple fin array 506 to a fan. Fin array 506 comprises a plurality of flexural deformation elements 508 and associated fin elements 510 arrayed in a radial arrangement to establish a pathway for airflow, each of flexural deformation elements 508 is configured to move an attached fin element 510 responsive to airflow impacting attached fin element 510. One or more flex limiter elements 512 integral to frame 504 are configured to limit flexure of fin elements 510 beyond a predetermined flexure in relation to frame 504 to stop backflow of air through fin array 506.

[0099] Backflow preventer assembly 500 comprises frame 504, fin array 506 and fin array retainer 524 coupled together by snap-locking elements 526 to create a complete backflow preventer assembly 500. Frame 504 comprises large reference stud 540 and small reference stud 542 to position fin array 506 and fin array retainer 524 in relation to frame 504 and each other. Fin array 506 comprises pairs of fin elements 510 that open and close fin elements 510 in opposing pairs responsive to airflow allowing fin array 506 to have less depth than using a single fin element 510 to cover the same surface area. In this example, backflow preventer assembly 500 has a depth of less than 20 millimeters. Fin limiter elements 512 are integral to frame 504 in this example.

[00100] Frame 504 is configured to structurally support fin array 506 and couple fin array 506 to a fan. Frame 504 comprises large reference stud 540 and small reference stud 542 configured to engage large reference hole 534 and small reference hole 538 of fin array 506 to position fin array 506 in relation to frame 504. Large reference stud 540 and

small reference stud 542 also engage large reference hole 528 and small reference hole 530 of fin array retainer 524 to position fin array retainer 524 in relation to frame 504 an fin array 506. Frame 504 includes interior spoke-like structural members radiating outward from a central hub to structurally support fin array 506 between flexural deformation elements 508 and fin elements 510. Fin array retainer 524 structurally supports fin array 506 by applying pressure to fin array 506 against the spoke-like structural members of frame 504 by engaging snap-locking elements 526 of fin array retainer 524 with coupling hole 536 of fin array 506 and snap-lock coupling hole 544 of frame 504. Frame 504 includes fan coupling holes 546 for coupling fin array 506 to a fan. Frame 504 is comprised of an injection moldable polymer. Frame 504 is manufactured using injection molding methods.

[00101] Fin array 506 comprises a plurality of flexural deformation elements 508 and associated fin elements 510 arrayed in a radial arrangement to establish a pathway for airflow, each of flexural deformation elements 508 is configured to move an attached fin element 510 responsive to airflow impacting attached fin element 510. Fin array 506 allows airflow to pass through in only one direction. Airflow passes through fin array 506 when fin elements 510 are in an open position and airflow is blocked when fin elements 510 are in a closed position. Figure 5 illustrates fin array 506 with fin elements 510 fully open. While not illustrated in Figure 5, fin array 506 further comprises one or more flexural deformation elements 508 each individually configurable to flex and move an attached fin element 510 a pre-determined amount in relation to other flexural limiting elements 508 and fin elements responsive 510 to airflow. This allows backflow preventer assembly 500 to mitigate detrimental impact caused to airflow within an electronics enclosure in the event that the fan is failing, but has not completely failed. Backflow preventer assembly 500 can close a portion of fin elements 510 responsive to airflow. For example, if the fan is only operating at one-half capacity, flexural limiting elements 508 can close one-half of fin elements 510. Fin array 506 defaults to an open state in this example.

[00102] Flexural deformation elements 508 couple to fin elements 510 and open and close fin elements 510 by flexing. Flexural deformation elements 508 can be configured to respond differently to particular airflows. For example, flexural deformation elements 508 having a high degree of stiffness, or a high modulus of elasticity, will not flex as much

as flexural deformation elements 508 having a lower degree of stiffness, or modulus of elasticity, given the same airflow. Thus, flexural deformation elements 508 can be configured to flex in response to varying airflows.

[00103] Flexural deformation elements 508 can be made in several ways. Flexural deformation elements 508 can be configured to move an attached fin element 510 differing amounts responsive to the same airflow simply by changing the geometry of flexural deformation elements 508. Another way to configure fin array 506 to have selectively opening and closing fin elements 510 is to use different materials for flexural deformation elements 508. Flexural deformation elements 508 can comprise a long beam. In the case of a long beam, flexural deformation elements 508 can utilize bending or torsional properties of the beam. Flexural deformation elements 508 can be made from a thin section by selecting a thin sheet or by scoring (removing thickness locally). Figure 5 provides an example of flexural deformation elements 508 by selecting a thin sheet. Additionally, flexural deformation elements can be made by narrowing a section of material to achieve desirable flexural deformation properties. For example, provided the thickness and material of the flexural deformation elements 508 are generally equal, a wider flexural deformation element 508 will be less impacted than a narrower flexural deformation element 508 by the same airflow. Finally, a combination of all the above methods can be used to make flexural deformation elements 508.

[00104] In this example, fin array 506 comprises flexural deformation elements 508 and fin elements 510 comprised of a laminated assembly of one or more flexible materials with a first layer of the laminated assembly of a first thickness that establishes an open state of fin array 506 when the airflow is provided by the fan and a closed state of fin array 506 when the airflow is in a direction opposite to that provided by the fan, and the second layer of the laminated assembly of a second thickness to form fin elements 510 and provide rigidity to fin elements 510.

[00105] Fin array 506 includes large reference hole 534 and small reference hole 538 for positioning fin array 506 in relation to frame 504. Snap-locking elements 526 of fin array retainer 524 engage fan coupling hole 546 of fin array 506 and snap-lock coupling hole 544 of frame 504 to hold backflow preventer assembly 500 together.

[00106] Some considerations when selecting materials for flexural deformation elements 508 include cost, stiffness, and environmental factors. Flexural deformation elements 508 flex to open and close fin elements 510, therefore the stiffness, or the modulus of elasticity, affects how flexural deformation elements 508 react to changes in airflow. Stiffness of flexural deformation elements 508 can be configured to flex in response to differing airflows by selecting, material, thickness and by selectively removing material to form flexural deformation elements 508.

[00107] Environmental factors are considered when selecting material for flexural deformation elements 508 because backflow preventer assembly 500 can be used inside of an electronics enclosure and must meet certain industry standards. For example, flexural deformation elements 508 might have a U.L. approved fire rating of 94 V-0 or better. In some examples, flexural deformation elements 508 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent flexural deformation elements 508 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. Metals, alloys, and flame retardant materials are good examples of materials that can be used for flexural deformation elements 508. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for flexural deformation elements 508 and meet U.L. approved fire rating of 94 V-0 or better.

[00108] Fin elements 510 close in the event of cooling fan failure thereby preventing backflow that would compromise the efficiency of the cooling system. Flexural deformation elements 508 coupled to fin elements 510 flex to open and close fin elements 510. Flexural deformation elements 508 elements are configurable to react to changes in airflow and open and close fin elements 510 in response. The flexure of flexural deformation elements 508 can be configured by material selection and geometry. Fin elements 510 bear a minimal structural load by airflow in the open position. Fin elements 510 are structurally loaded by airflow in the closed position. Flex limiter elements 512 provide additional support to fin elements 510 when fin elements 510 experience load in the closed position. Therefore, material strength is not a critical factor when selecting materials for fin elements 510.

[00109] Some considerations when selecting materials for fin elements 510 include cost, stiffness, and environmental factors. Environmental factors are important to consider

when selecting material for fin elements 510 because backflow preventer assembly 500 can be used inside of electronics enclosures and must meet certain industry standards. For example, fin elements 510 might have a U.L. approved fire rating of 94 V-0 or better. In some examples, fin elements 510 can experience temperatures ranging from 40°C to 60°C in operation. Therefore, structural integrity of a material at temperature and pressure might be considered to prevent fin elements 510 from experiencing creep or otherwise losing shape at elevated operating temperatures and pressures. Metals, alloys, and flame retardant materials are good examples of materials that can be used for fin elements 510. High-density polyethylene or ITWFormex® provide two examples of materials that can be used for fin elements 510 and meet U.L. approved fire rating of 94 V-0 or better.

[00110] Various methods of manufacturing fin elements 510 can be employed depending upon the material selected. For example, some materials that can be used to make fin elements 510 are easily manufactured using stamping, die cutting and laser cutting operations. While other materials may be better suited to injection molding, vacuum forming, scoring or some other operations.

[00111] Figure 5 illustrates backflow preventer assembly 500 having multiple flex limiter elements 512 integral to frame 504 configured to limit flexure of fin elements 510 beyond a predetermined flexure in relation to frame 504 to stop backflow of air through fin array 506. Flex limiter elements 512 limit flexure of fin elements 510 beyond a predetermined flexure in relation to frame 504 to stop backflow of air through fin array 506 by providing mechanical interference with fin elements 510 thereby inhibiting further movement. Flex limiter elements 512 allow fin elements 510 to be constructed of lighter and more flexible materials by providing additional support to fin elements 510 during load. It is desirable that flex limiter elements 512 have minimal structure to avoid negatively impacting airflow though backflow preventer assembly 500.

[00112] Fin array retainer 524 comprises snap-locking elements 526, large reference hole 528, small reference hole 530, and retainer spokes 532. Snap-locking elements 526 engage coupling hole 536 of fin array 506 and snap-lock coupling hole 544 of frame 504 to hold backflow preventer assembly 500 together. Large reference hole 528 and small reference hole 530 position fin array retainer 524 in relation to frame 504 and fin array 506. Retainer spokes 532 provide structural support for fin array 506 by securing fin array

506 to frame 504. Fin array retainer is manufactured from injection moldable polymer by an injection molding process.

[00113] Figures 6A and 6B illustrate the operation of backflow preventer assembly 500. Figure 6A illustrates backflow preventer assembly 500 in a closed state to prevent backflow of air through fin elements 510. Fin elements 510 are in contact with flex limiter elements 512 in the closed position providing fin elements 510 with additional structural support. Figure 6B illustrates backflow preventer assembly 500 in an open state allowing airflow through fin elements 510.

[00114] Figure 6A illustrates an example of backflow preventer assembly 500 in a closed state to prevent backflow of air through a fan. While the fan is not illustrated in Figure 6A it is assumed for the sake of explanation that the fan has failed and flexural deformation elements 508 have closed fin elements 510 to prevent backflow of air through the fan. A plurality of flex limiter elements 510 integral to frame 504 provide additional structural support to fin elements 510 when fin elements 510 experience load. Figure 6A illustrates fin elements 510 blocking airflow.

[00115] Figure 6B illustrate an example of backflow preventer assembly 500 in an open state allowing airflow through a fan. While the fan is not illustrated in Figure 6B it is assumed for the sake of illustration that the fan is operational and flexural deformation elements 508 are in a default open state. Figure 6B illustrates airflow through the pathway for airflow of fin array 506.

[00116] Figure 7 illustrates a bulkhead assembly with fans and backflow preventers 700 similar to what is typically found in electronic enclosures such as enclosure 318 or enclosure 418, for example. Backflow preventer 702 is an example of backflow stopper assembly 100, backflow stopper assembly 202, backflow preventer 316, backflow stopper 402 and backflow preventer assembly 500; however, backflow preventer 702 may have alternative configurations and methods of operation than backflow stopper assembly 100, backflow stopper assembly 202, backflow preventer 316, backflow stopper 402 and backflow preventer assembly 500.

[00117] Bulkhead assembly with fans and backflow preventers 700 comprises a plurality of backflow preventers 702, bulkhead 704, screws 706, a plurality of electrical connectors 708, and a plurality of fans 714. Backflow preventers 702 are coupled to fans 714. Fans

714 mount to bulkhead 704 using screws 706. Electrical connectors 708 communicatively couple to electronic devices, such as data storage devices held inside an electronics enclosure.

[00118] Backflow preventers 702 block airflow through fans 714 in the event one or more fans 714 fails, thereby blocking the path of least resistance for airflow and forcing airflow to continue passing over electronic components within the electronics enclosure. Figure 7 illustrates fans 714 in working order and backflow preventers 702 in an open state allowing airflow to pass through backflow preventers 702.

[00119] Bulkhead 704 comprises structural elements for mounting cooling equipment, power and electrical connectors. Bulkhead 704 is typical of what would be found in an electronics enclosure, such as enclosure 318, for example. Fans 714 can be mounted on either on the interior or exterior of bulkhead 704. Likewise, backflow preventer 702 can be installed on either the interior or exterior of bulkhead 704. Figure 7 illustrates fans 714 and backflow preventers 702 mounted on the interior of bulkhead 704. However, in some examples fans 714 can be mounted to the exterior of bulkhead 704 and backflow preventers 702 mounted to the interior of bulkhead 704 and vice-versa.

[00120] Backflow preventers 702 comprise a frame configured to structurally support a fin array when coupled to fans 714. The fin array comprising a plurality of flexural deformation elements and associated fin elements arrayed in a radial arrangement to establish a pathway for airflow, each of the flexural deformation elements configured to move an attached fin element responsive to airflow impacting the attached fin element; and one or more flex limiter elements coupled to the frame and configured to limit flexure of the fin elements beyond a predetermined flexure in relation to the frame to stop backflow of air through the fin array.

[00121] Backflow preventers 702 block airflow through fans 714 when the fin array is in a closed state. Flexural deformation elements couple to fin elements and open and close fin elements by flexing. The flexibility of flexural deformation elements determines how fin array will react to differing airflows. Flexural deformation elements having a high degree of stiffness, or modulus of elasticity, will flex less than flexural deformation elements having a lesser degree of stiffness, or modulus of elasticity, given the same airflow.

[00122] The fin array can be formed from a single piece of a flexible material of a predetermined thickness that establishes an open state of the fin array when the airflow is provided by the fan and a closed state of the fin array when the airflow is in a direction opposite to that provided by the fan. Alternatively, the fin array can be a laminated assembly of one or more flexible materials with a first layer of the laminated assembly of a first thickness that establishes an open state of the fin array when the airflow is provided by the fan and a closed state of the fin array when the airflow is in a direction opposite to that provided by the fan, and the second layer of the laminated assembly of a second thickness to form the fins and provide rigidity to the fins.

[00123] While not illustrated in Figure 7, the one or more flex limiter elements are integral to the frame in this example. The plurality of flex limiter elements are configured to limit flexure of the fin elements beyond a predetermined flexure in relation to the frame to stop backflow of air through the fin array. The flex limiter elements also provide structural support to the fin elements when the fin array is under load in a closed state.

[00124] Fans 714 comprise axial-flow fans with case mount frames for mounting to bulkhead assembly with fans and backflow preventers 700. Fans 714 further comprise motors. Some suitable motors for use with fans 714 include AC, DC brushed or DC brushless motors.

[00125] Drives which incorporate rotating media, such as rotating magnetic media of hard disk drives or hybrid disk drives, among others, also include various electromechanical elements to position read/write heads over the spinning media. These electromechanical elements include armatures, motors, actuators, voice coils, servos, or other elements which can be affected by vibration of the drive elements themselves or by vibrational environment in which the drives are included. This vibrational environment can include vibrations or acoustic disturbances introduced by the ventilation fans, as well as the drives themselves. For example, a drive which performs many random read/write operations can induce more vibration into the surrounding environment of that drive due to rapid movements of the associated electromechanical elements within the drive. Other components within a storage enclosure, such as fans, can also affect the vibration levels within an associated enclosure.

[00126] Figure 8 illustrates a backflow assembly 800 configured to reduce vibrations or acoustic disturbances on the drives that are introduced by the ventilation fans. Backflow assembly 800 includes a backflow preventer 801 that is an example of backflow stopper assembly 100, backflow stopper assembly 202, backflow preventer 316, backflow stopper 402, backflow preventer assembly 500, and backflow preventer 702. However, backflow preventer 801 may have alternative configurations and methods of operation than the backflow preventers and assemblies presented above.

[00127] To reduce vibrations or acoustic disturbances within an enclosure, an acoustic barrier assembly 804 having first and second acoustic barrier plates 806, 808. Thus, backflow assembly 800 forms a backflow stopper with integrated acoustic barrier assembly. First and second acoustic barrier plates 806, 808 include respective pluralities of airflow passages 810, 812 formed therethrough. While backflow assembly 800 is shown with first and second acoustic barrier plates 806, 808, additional acoustic barrier plate layers may be incorporated therein. Additionally, while first and second acoustic barrier plates 806, 808 are shown as plates independently added to the front and back sides of backflow preventer 801, acoustic dampening layers 806, 808 may instead be added onto the flaps, inside, front, and back of the backflow preventer 801.

[00128] Figure 9 illustrates a schematic diagram of a data storage system 900 incorporating backflow assembly 800. Data storage system 900 includes an electronics chassis or enclosure 902 housing a data storage array 904 of one or more data storage devices 906. A fan assembly 908 having one or more fans 910 or other cooling and ventilation elements for providing airflow 912 to the elements of data storage system 900. Airflow 912 is drawn through openings 914 on a first side of enclosure 902 and expelled through openings 916 on a second side of enclosure 902.

[00129] To reduce negative effects to the rate of airflow 912 through the electronics enclosure 902 and the cooling performance of the fan assembly 908, acoustic barrier assembly 804 is constructed such that its impedance to airflow 912 is lower than the impedance of the other components within the electronics enclosure 902 to airflow 912 without the acoustic barrier assembly 804 in the system 900. In this manner, the flow of airflow 912 through the system 900 is not significantly affected through the addition of the acoustic barrier assembly 804.

[00130] Attenuation via the acoustic barrier assembly 804 occurs as acoustic waves get absorbed by or reflect off of the surfaces of the first and second acoustic barrier plates 806, 808 prior to reaching the data storage array 904 and other electronic devices within the electronics enclosure 902. Maximizing effectiveness of acoustic attenuation by the acoustic barrier assembly 804 includes offsetting passages 810, 812 formed in a non-overlapping or offset arrangement such that a direct line-of-sight is blocked between the fans 910 of the fan assembly 908 and the electronic storage devices 906 within the electronics enclosure 902. In this manner, acoustic waves emanating from the fan assembly 908 do not impinge on the data storage array 904 without being at least reflected or redirected multiple times through the acoustic barrier assembly 804. The acoustic waves may be reflected or redirected entirely away from the interior of the enclosure 902 (as illustrated by acoustic waves 918, 920) and may be reflected multiple times through the acoustic barrier assembly 804 (as illustrated by acoustic waves 922, 924) before penetrating into the interior of enclosure 902, which decreases their intensity.

[00131] In addition, at least a portion of the energy of acoustic waves emanating from the fan assembly 908 may be absorbed by the material of the first and second acoustic barrier plates 806, 808 such that they are blocked from penetrating into the interior of enclosure 902. A portion of the energy of the acoustic waves may also be absorbed by the material of the plurality of flexural deformation elements 801 or the fin elements 802 of backflow preventer 801. For example, Figure 9 illustrates an acoustic wave 926 reflecting multiple times through the acoustic barrier assembly 804 and getting absorbed by first acoustic barrier plate 806. The more times an acoustic wave is forced to come into contact with the first and second acoustic barrier plates 806, 808 through reflection, the greater the ability the acoustic barrier assembly 804 has of significantly reducing or entirely absorbing its intensity. The material of first and second acoustic barrier plates 806, 808 can comprise foams, polymers, metal foams, glass fibers, cellulose, baffles, resonant chambers, or other materials and elements that absorb or trap acoustic waves at disturbance frequencies.

[00132] Figure 10 shows three assembled backflow assemblies 1000, 1002, 1004 modeled after backflow assembly 800 and mounted into bulkhead 704 of Figure 7. As can be seen, the design of assemblies 1000-1004 is space-saving and uses the space already

existing in the bulkhead 704. Thus, cross-flow of the airflow within the enclosure is not obstructed.

[00133] Figure 11 illustrates an assembled view of a backflow assembly 1100 configured to reduce vibrations or acoustic disturbances on the drives that are introduced by the ventilation fans. Backflow assembly 1100 blocks airflow from passing through a fan in the event the fan fails. In addition, backflow assembly 1100 is configured to reduce vibrations or acoustic disturbances within an enclosure caused by the ventilation fans. Backflow assembly 1100 is an example of backflow stopper assembly 100, backflow stopper assembly 202, backflow preventer 316, backflow stopper 402, backflow preventer assembly 500, backflow preventer 702, and backflow preventer 801. However, backflow preventer 1100 may have alternative configurations and methods of operation than the backflow preventers and assemblies presented above.

[00134] Backflow assembly 1100 includes a frame 1102, fin array 1104, and flex limiter elements 1106. Fin array 1104 comprises a plurality of fins 1108-1114 arrayed in an arrangement about frame 1102 to establish a pathway for airflow, each fin 1108-1114 responsive to airflow impacting thereon. Fins 1108, 1112 are configured to pivot about an axis parallel to a first axis 1116 passing through frame 1102, and fins 1110, 1114 are configured to pivot about an axis parallel to a second axis 1118 passing through frame 1102. Flex limiter element 1106 coupled to frame 1102 is configured to limit flexure or pivoting of fins 1108-1114 beyond the boundaries of frame 1102 to stop backflow of air therethrough. Fin array 1104 allows airflow to pass through in only one direction. Airflow passes through fin array 1104 when fins 1108-1114 are in an open position and airflow is blocked when fins 1108-1114 are in a closed position.

[00135] Fins 1108-1114 can be formed from a single layer or from a laminated assembly of one or more layers. Fins 1108-1114 comprises one or more acoustically active materials that can alter acoustic properties associated with fan assemblies to reduce negative acoustic effects on the storage devices within an electronics enclosure. Fins 1108-1114 accomplish acoustic effect reduction at least through a dampening or absorption of acoustic frequencies as well as through a redirection or reflection of the acoustic frequencies or waves.

[00136] The material or material composition of fins 1108-1114 is designed to dampen or absorb at least a portion of acoustic wave energy within the material of the attenuator. Fins 1108-1114 can comprise foams, polymers, metal foams, glass fibers, cellulose, baffles, resonant chambers, or other materials and elements that absorb or trap acoustic waves at disturbance frequencies.

[00137] The material of fins 1108-1114 typically has one or more attenuation frequencies or frequency ranges over which acoustic waves are attenuated or reduced. In a further example, fins 1108-1114 can include metamaterials that can be selectively tuned though microstructures to dampen certain selected acoustic frequencies.

[00138] In addition to dampening acoustic waves within the material itself, the outer surface 1120 of the fins 1108-1114 may include contours or other texturing 1122 designed to reflect and scatter the acoustic waves in directions away from storage devices within the electronics enclosure. In this manner, the waves may be reflected before they can reach the storage devices; thus, reducing their intensity within the electronics enclosure. In a preferable embodiment, the texturing 1122 of the outer surface 1120 maximizes acoustic wave scattering to minimize the amount of acoustic waves that have a direct line of propagation toward the storage devices.

[00139] As illustrated in Figure 11, texture 1122 of surface 1120 includes surface undulations designed to reflect acoustic waves away from surface 1120 in many different directions. In one example, fins 1108-1114 are made of corrugated cardboard. The corrugated cardboard may provide surface undulations on both sides of the fin 1108-1114. That is, while a first side of fins 1108-1114 is shown in Figure 11, the second, reverse side of fins 1108-1114 may present the other side of the undulations toward the source of the acoustic disturbance. In this manner, both undulating sides of dual-sided fins 1108-1114 may be used to help scatter acoustic waves impinging thereon. The surface texturing can also help with impedance matching of the interface to the airborne acoustic waves.

[00140] Figure 12 shows three assembled backflow assemblies 1200, 1202, 1204 modeled after backflow assembly 1100 and mounted into bulkhead 704 of Figure 7. As can be seen, the design of assemblies 1200-1204 is space-saving and uses the space already existing in the bulkhead 704. Thus, cross-flow of the airflow within the enclosure is not obstructed.

[00141] The included descriptions and figures depict specific embodiments to teach those skilled in the art how to make and use the best mode. For the purpose of teaching inventive principles, some conventional aspects have been simplified or omitted. Those skilled in the art will appreciate variations from these embodiments that fall within the scope of the invention. Those skilled in the art will also appreciate that the features described above can be combined in various ways to form multiple embodiments. As a result, the invention is not limited to the specific embodiments described above, but only by the claims and their equivalents.

CLAIMS

What is claimed is:

1. A data storage assembly comprising:

an enclosure configured to house at least one data storage device;

a fan assembly configured to provide airflow within the enclosure to ventilate the at least one data storage device, wherein a plurality of acoustic waves emanate toward an interior of the enclosure from one or more fans of the fan assembly during operation;

a backflow assembly coupled to the fan assembly and comprising:

a fin array comprising a plurality of fin elements arrayed to establish a pathway for airflow, each of the fin elements configured to move in response to airflow impacting thereon; and

a frame configured to structurally support the fin array; and

wherein the backflow assembly is configured to deflect and attenuate at least a portion of the plurality of acoustic waves away from the at least one data storage device.

2. The data storage assembly of claim 1 wherein the backflow assembly comprises:

a first acoustic barrier plate coupled to a first side of the frame; and

a second acoustic barrier plate coupled to a second side of the frame opposite the first side.

3. The data storage assembly of claim 2 wherein the first acoustic barrier plate has a first plurality of apertures formed therein;

wherein the second acoustic barrier plate has a second plurality of apertures formed therein; and

wherein first and second pluralities of apertures are formed in an offset arrangement.

4. The data storage assembly of claim 3 wherein the first and second pluralities of apertures are configured to allow the airflow to pass through the backflow assembly; and

wherein a flow resistance of the backflow assembly to the airflow passing therethrough is less than a flow resistance of the airflow passing through the electronic storage device.

5. The data storage assembly of claim 3 wherein the non-overlapping arrangement of the first and second pluralities of apertures prevents impingement of an acoustic wave of the plurality of acoustic waves on the at least one data storage device from the fan assembly directly without coming into contact with the backflow assembly.

6. The data storage assembly of claim 2 wherein the first and second acoustic barrier plates are constructed of a material configured to absorb at least a portion of the plurality of acoustic waves impinging thereon.

7. The data storage assembly of claim 1 wherein the fin elements comprise a material configured to absorb at least a portion of an energy of the plurality of acoustic waves.

8. The data storage assembly of claim 1 wherein each of the fin elements comprises a contoured surface configured to deflect the at least a portion of the plurality of acoustic waves away from the at least one data storage device.

9. The data storage assembly of claim 8 wherein the contoured surface comprises corrugated cardboard.

10. The data storage assembly of claim 1 wherein the plurality of fin elements comprises a first pair of fins configured to pivot about a first axis and a second pair of fins configured to pivot about a second axis orthogonal to the first axis.

11. A data storage system comprising:

an enclosure housing at least one data storage device and having a first opening on a first side and a second opening on a second side of the enclosure opposite the first side;

a fan assembly coupled to the enclosure and configured to draw an airflow through the first opening toward the second opening, the fan assembly generating a plurality of acoustic waves toward the at least one data storage device during operation;

a backflow stopper assembly coupled to the fan assembly and configured to deflect and attenuate at least a portion of the plurality of acoustic waves away from the at least one data storage device, the backflow stopper assembly comprising a fin array comprising a plurality of fin elements arrayed to establish a pathway for the airflow through the backflow stopper assembly, each of the fin elements configured to move responsive to the airflow impacting thereon;

wherein the at least one data storage device impedes the airflow through the housing by a first flow impedance value;

wherein the backflow stopper assembly impedes the airflow through the housing by a second flow impedance value; and

wherein the second flow impedance value is less than the first flow impedance value.

12. The data storage system of claim 11 wherein the backflow stopper assembly comprises a backflow stopper and a pair of acoustic barrier plates, wherein the backflow stopper assembly is positioned between the pair of acoustic barrier plates.

13. The data storage system of claim 12 wherein the pair of acoustic barrier plates comprises a first plate and a second plate;

wherein the first plate has a first plurality of apertures formed therein;

wherein the second plate has a second plurality of apertures formed therein; and

wherein first and second pluralities of apertures are formed in an offset arrangement.

14. The data storage system of claim 13 wherein the non-overlapping arrangement of the first and second pluralities of apertures prevents impingement of an acoustic wave of the plurality of acoustic waves on the at least one data storage device without coming into contact with the backflow assembly.

15. The data storage system of claim 11 wherein each of the fin elements comprises a material configured to absorb at least a portion of an energy of the plurality of acoustic waves; and

wherein each of the fin elements comprises a contoured surface configured to deflect the at least a portion of the plurality of acoustic waves away from the at least one data storage device.

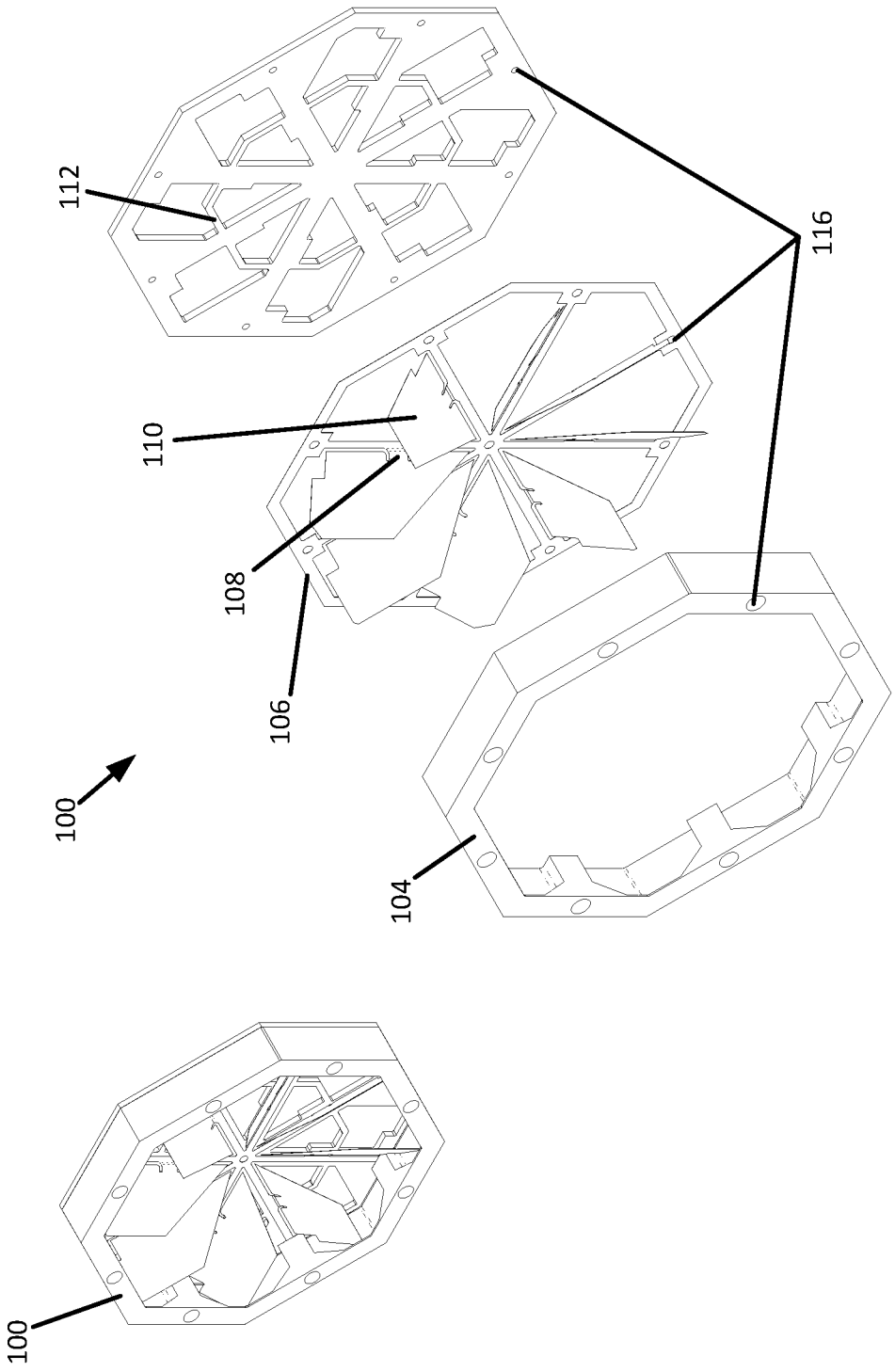


FIGURE 1

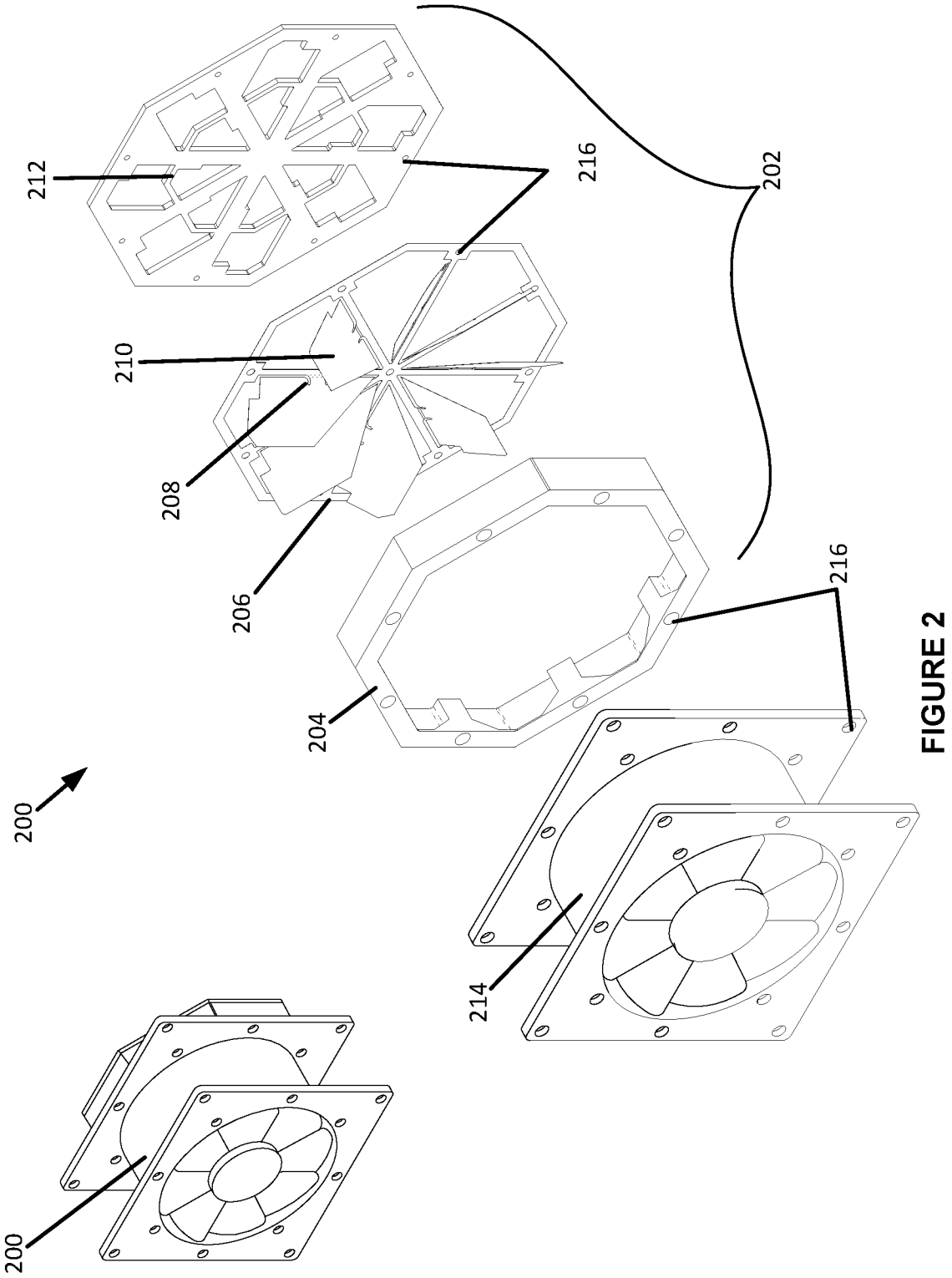


FIGURE 2

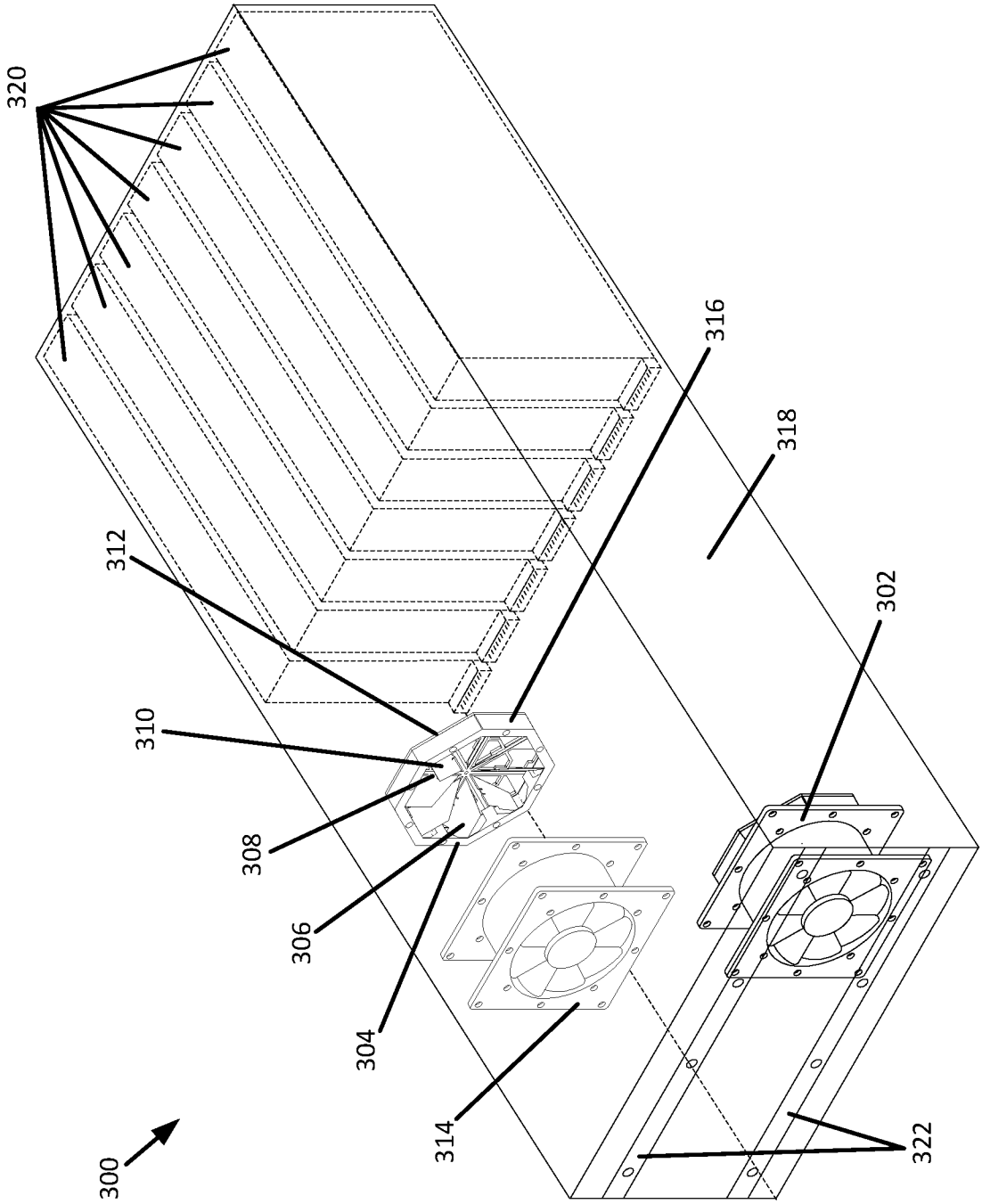


FIGURE 3

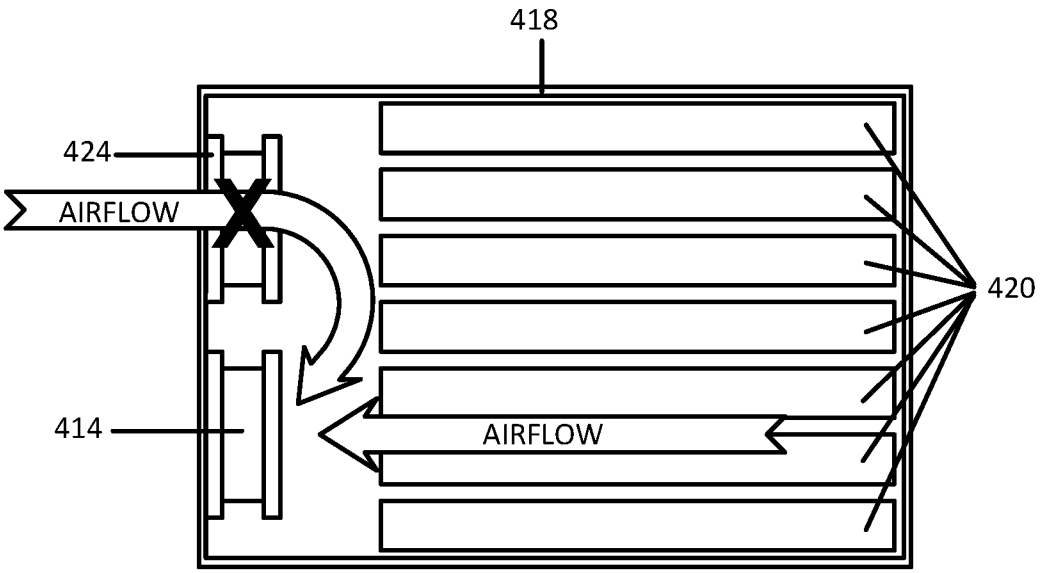


FIGURE 4A

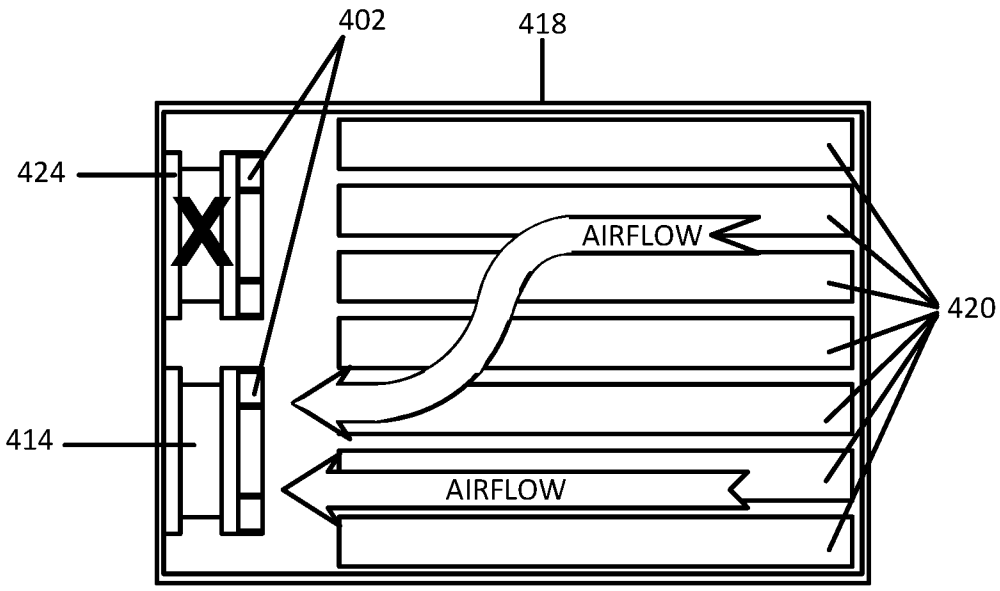


FIGURE 4B

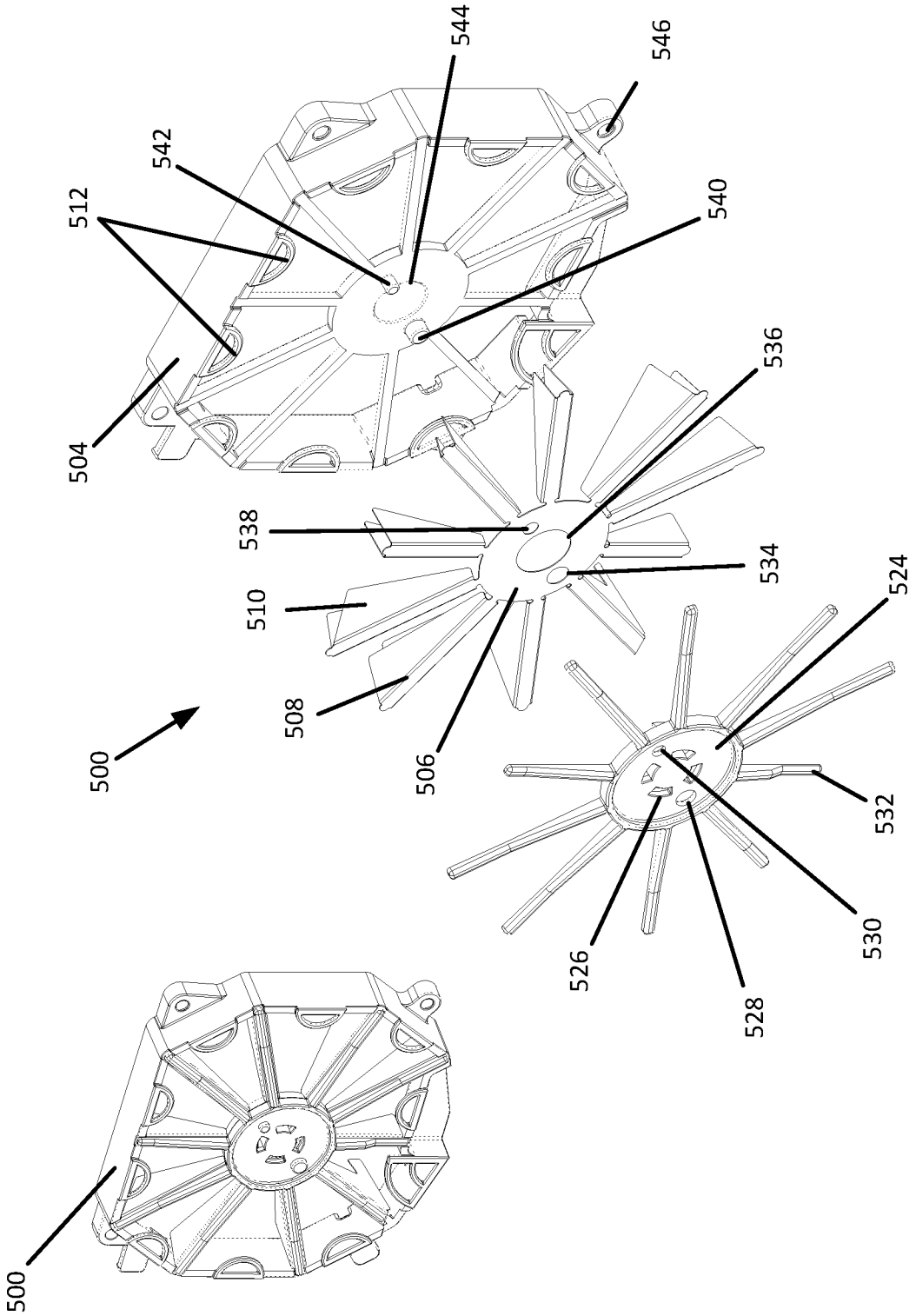

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FIGURE 5

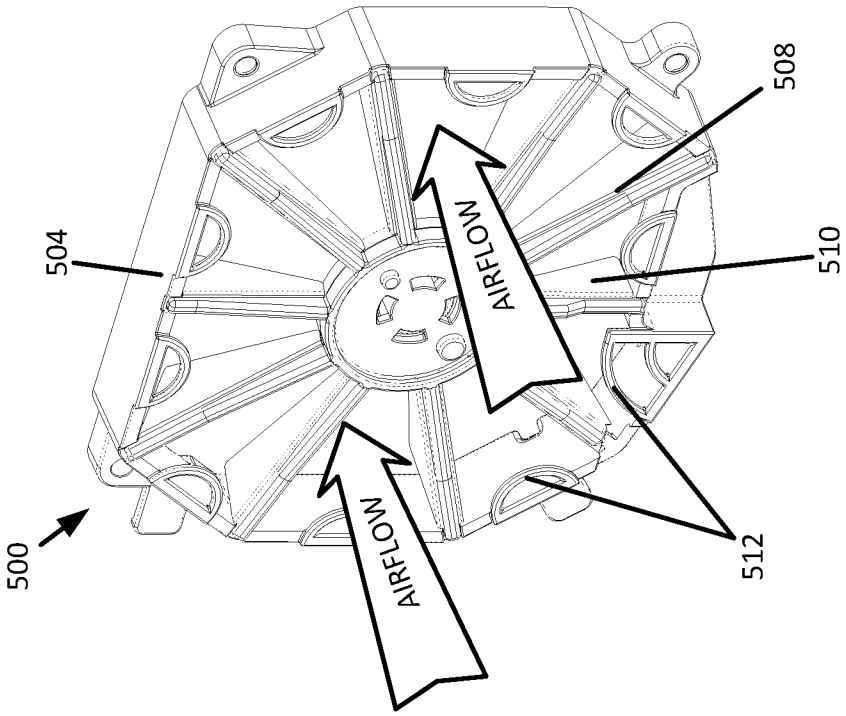


FIGURE 6B

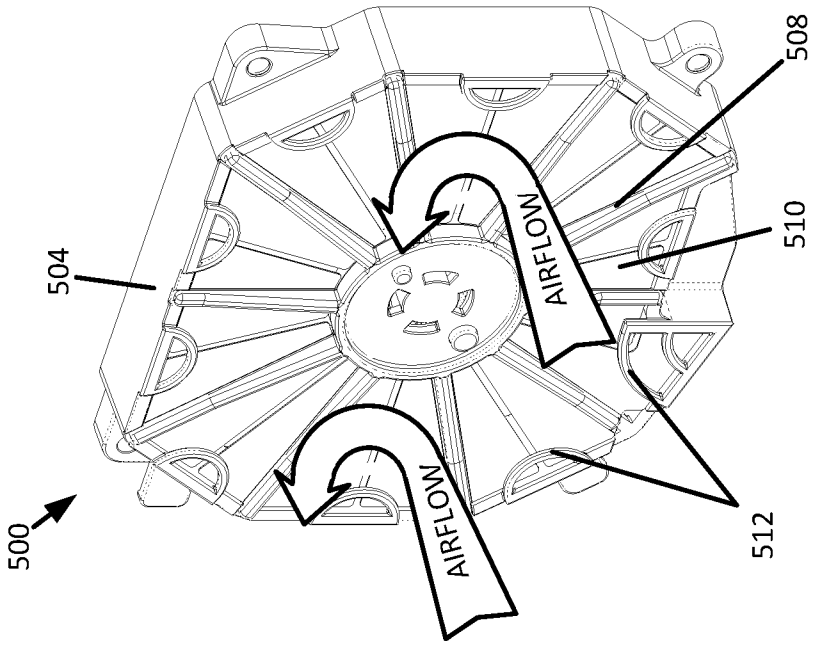


FIGURE 6A

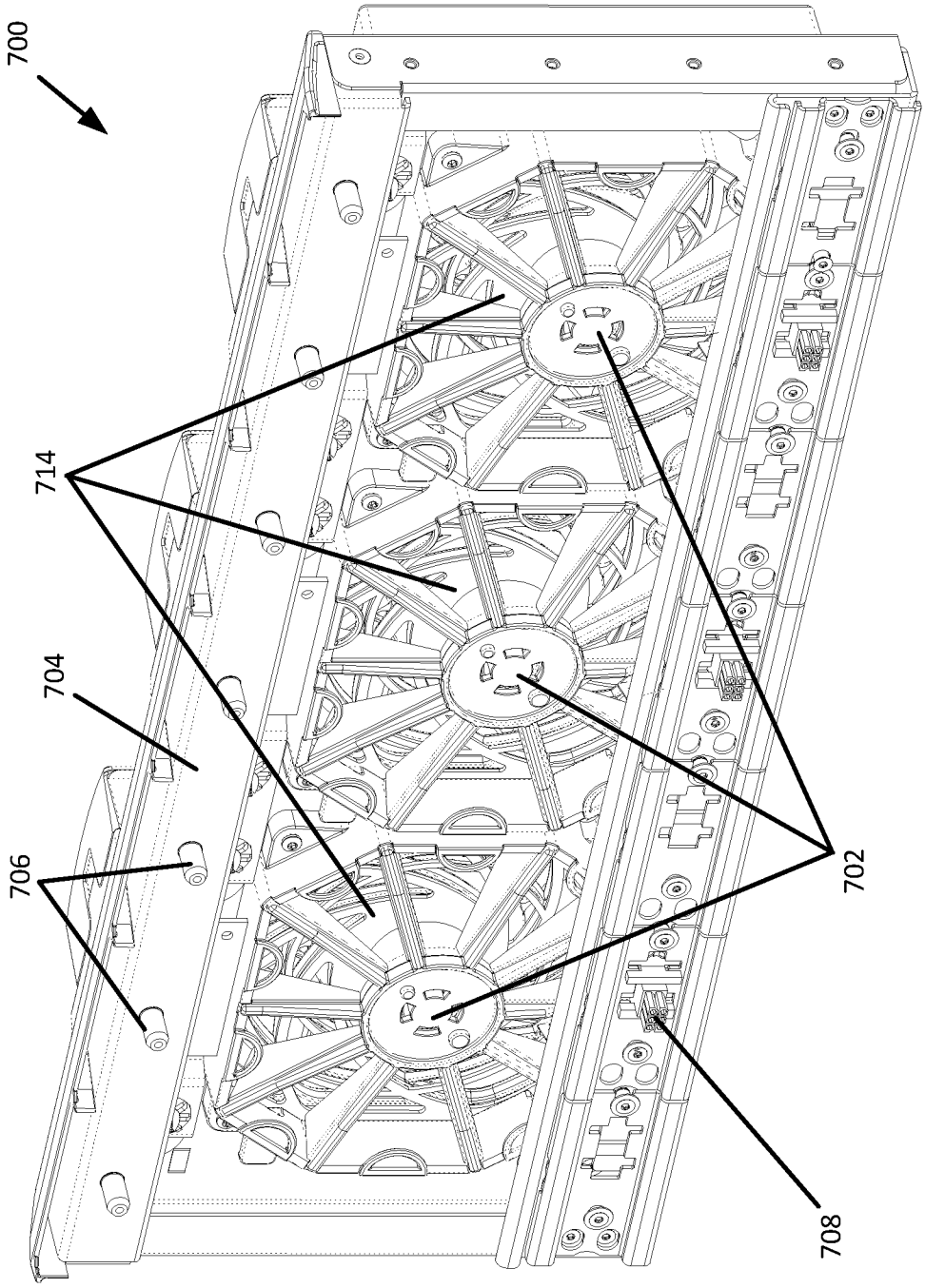


FIGURE 7

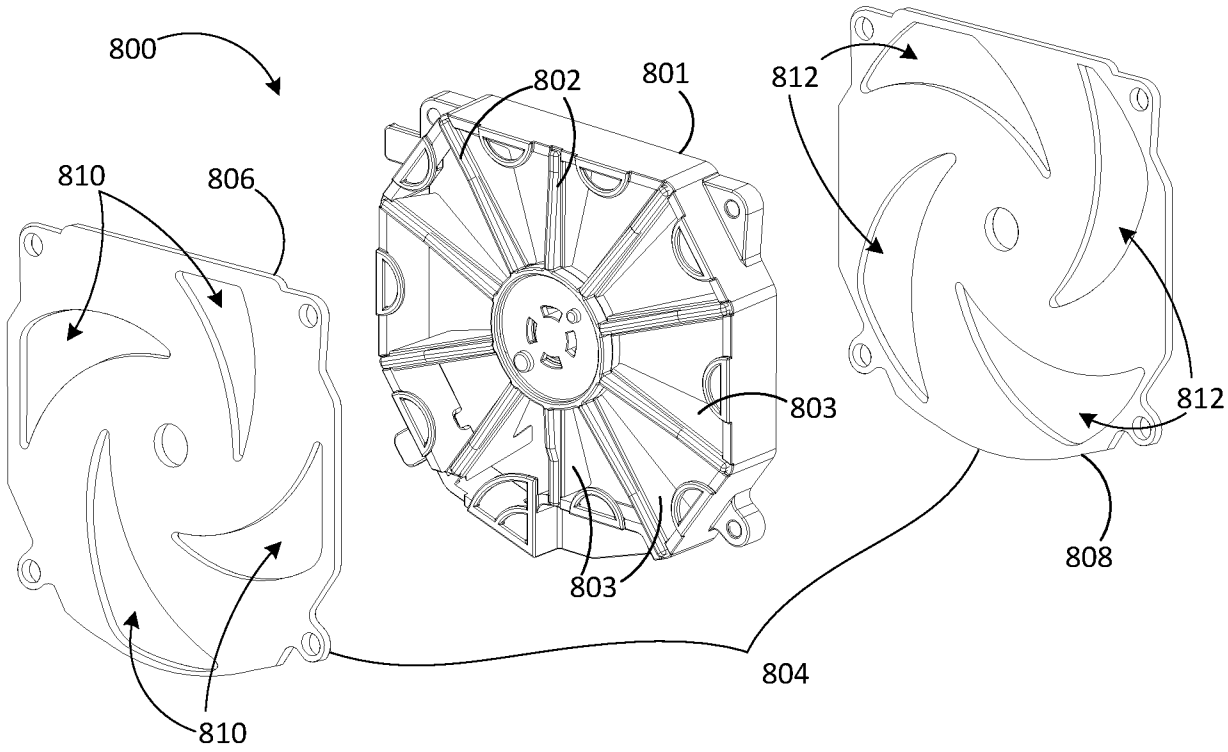


FIGURE 8

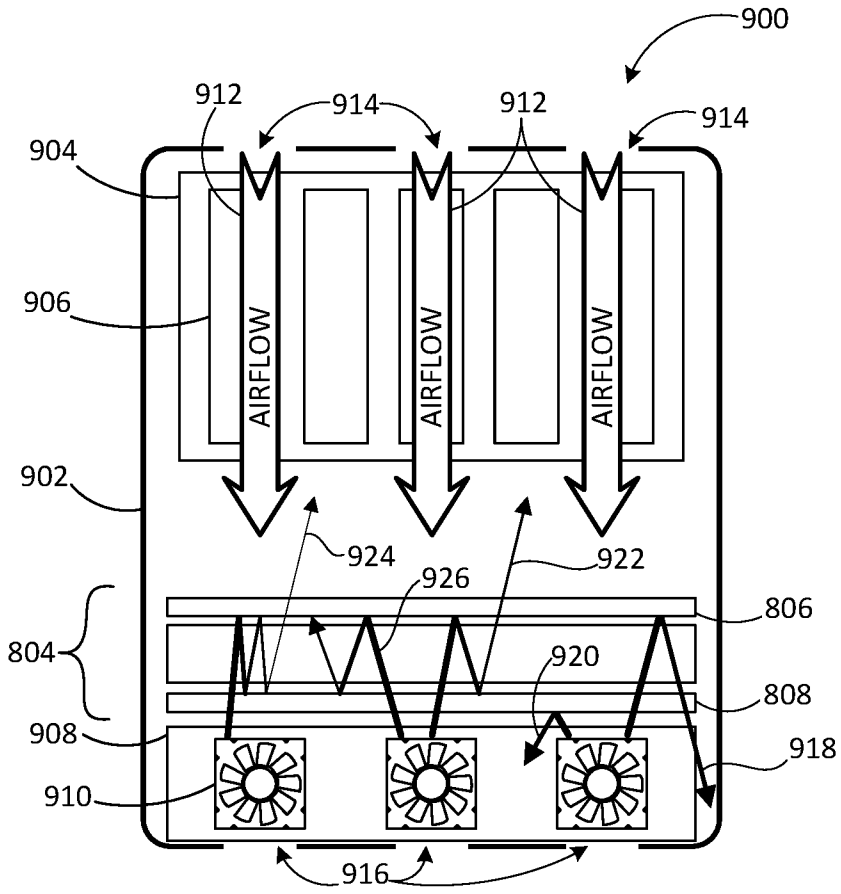


FIGURE 9

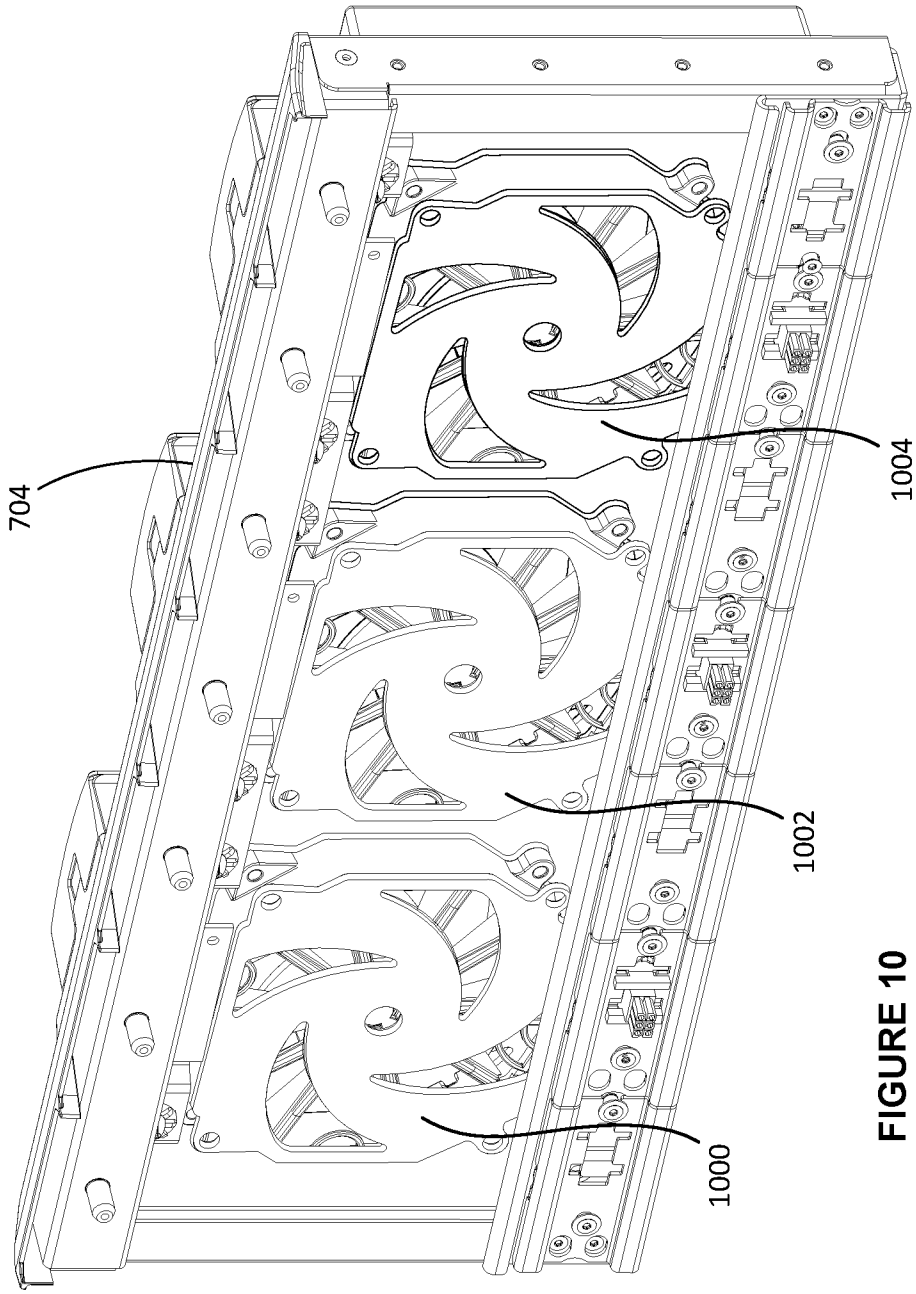


FIGURE 10

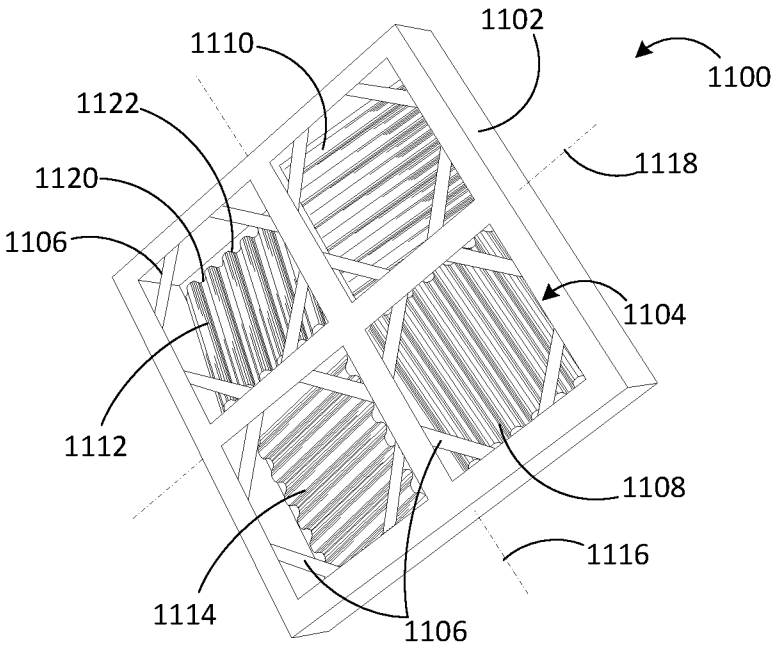


FIGURE 11

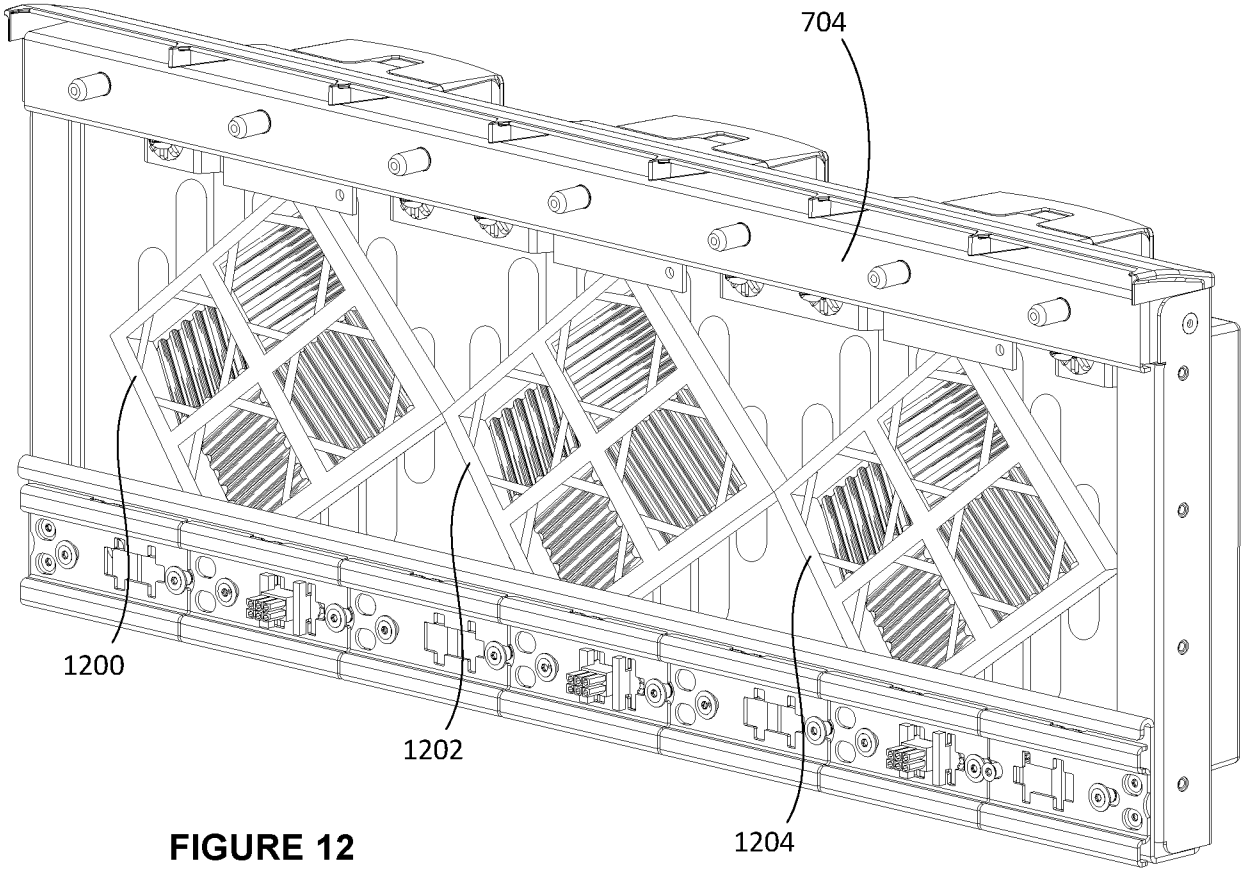


FIGURE 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/015259

A. CLASSIFICATION OF SUBJECT MATTER

H05K 7/20(2006.01)i

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)
H05K 7/20; F24F 7/007; F24F 7/013; H05K 5/02; H05K 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: data storage system, fan, acoustic wave, backflow stopper, acoustic barrier plate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0324025 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 05 December 2013 See paragraphs [0028]-[0040], claim 10 and figures 3-5.	1-15
A	US 2006-0073783 A1 (I-HSUAN TSAI et al.) 06 April 2006 See paragraphs [0044]-[0046] and figures 2A-2B.	1-15
A	US 2014-0342652 A1 (HUAWEI TECHNOLOGIES CO., LTD.) 20 November 2014 See paragraphs [0074]-[0075] and figure 6.	1-15
A	US 2004-0023614 A1 (EDWARD C. KOPLIN) 05 February 2004 See paragraphs [0039]-[0040] and figures 4A-4E.	1-15
A	JP 06-331191 A (OCHIAI YASUYOSHI) 29 November 1994 See paragraphs [0010]-[0014] and figures 1-3.	1-15

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

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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
20 April 2017 (20.04.2017)	**20 April 2017 (20.04.2017)**

Name and mailing address of the ISA/KR
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Korean Intellectual Property Office
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KIM, Sung Gon
Telephone No. +82-42-481-8746

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2017/015259

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