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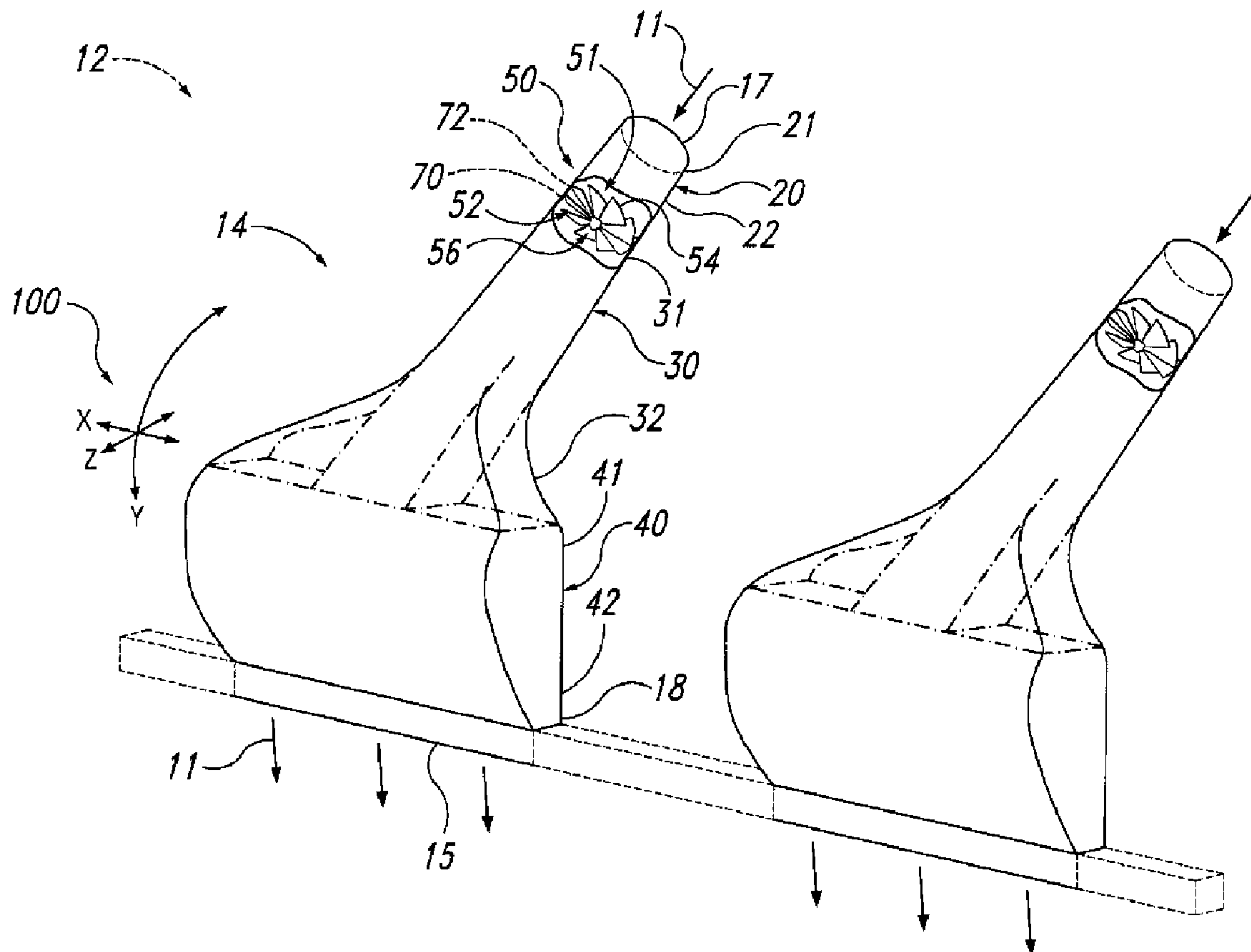
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(54) Title: AIR DIFFUSER SYSTEMS, METHODS, AND APPARATUSES



(57) Abrégé/Abstract:

Aircraft, air conditioning systems, and air diffusers that may be used to create a quiet, comfortable environment within an aircraft cabin are disclosed. For example, an aircraft cabin air diffuser, which may be used in an air conditioning system and/or an aircraft,

(57) **Abrégé(suite)/Abstract(continued):**

may include an inlet section, a neck section downstream of the inlet section, an outlet section downstream of the neck section, and a flow controller within the neck section. The flow controller may be a passive pressure controller (configured to affect air flow through the passive pressure controller in response to an air pressure differential across the passive pressure controller) and/or a vortex inducer (configured to create a vortex of air downstream of the vortex inducer).

ABSTRACT

Aircraft, air conditioning systems, and air diffusers that may be used to create a quiet, comfortable environment within an aircraft cabin are disclosed. For example, an aircraft cabin air diffuser, which may be used in an air conditioning system and/or an aircraft, may include an inlet section, a neck section downstream of the inlet section, an outlet section downstream of the neck section, and a flow controller within the neck section. The flow controller may be a passive pressure controller (configured to affect air flow through the passive pressure controller in response to an air pressure differential across the passive pressure controller) and/or a vortex inducer (configured to create a vortex of air downstream of the vortex inducer).

AIR DIFFUSER SYSTEMS, METHODS, AND APPARATUSES

FIELD

The present disclosure relates to air diffuser systems, methods, and apparatuses.

5 BACKGROUND

Many aircraft are designed to fly at high altitudes, e.g., from **10,000** feet (ft) (about **3,000** meters (m)) to upwards of **41,000** ft (about **12,500** m), while providing a safe, comfortable cabin environment. To maintain this cabin environment, a typical aircraft includes an air conditioning system, with appropriate pressure, temperature, and
10 moisture regulation, to circulate fresh air within the passenger cabin. An aircraft air conditioning system is sometimes referred to as an air conditioning pack, an air handling system, and/or an air circulation system. An air conditioning system may circulate outside air mixed with an approximately equal amount of highly filtered air from the passenger cabin. The combined outside and filtered air is ducted to the cabin and
15 distributed to cabin outlets throughout the cabin, typically louvers, air distribution rails, vents, and personal air outlets (e.g., eyeball gaspers above passenger seating). Air diffusers direct the ducted air into the cabin outlets.

Inside the cabin, air diffusers and outlets are generally arranged along the side walls of the cabin and sometimes along the overhead. The air flows in generally circular
20 patterns and exits through grilles, often on either side of the cabin floor, and, on airplanes with overhead recirculation, the air may exit through overhead grilles. For commercial aircraft, the FAA (Federal Aviation Administration) requires a minimum air flow and cabin pressure. For new aircraft, the minimum air flow is **0.55** pounds per minute (lbs/min) per occupant (about **250** grams per minute (g/min) per occupant) and
25 the minimum cabin pressure is **0.75** bar (**75** kilopascal (kPa)).

The cabin air flow is continuous and is used for maintaining a comfortable cabin temperature, pressurization, and/or overall air quality. About half of the air exiting the

cabin is exhausted from the airplane through one or more outflow valves in the fuselage, which also controls the cabin pressure. The other half is drawn through high efficiency filters, and then is recirculated with fresh outside air, as discussed.

5 For passenger comfort, air flow into the cabin should be quiet, relatively uniform, and generally unobtrusive. However, in addressing these needs, designers must balance weight and complexity with comfort.

SUMMARY

10 Aircraft, air conditioning systems, and air diffusers of the present disclosure may be used to create a quiet, comfortable environment within an aircraft cabin. The systems and apparatuses may be configured to flow air at or above the FAA minimum requirement of **0.55** lbs/min per occupant (about **250** g/min per occupant) while producing a low noise level.

15 Aircraft cabin air diffusers, according to at least some disclosed embodiments, comprise an inlet section to receive air flow, an outlet section to discharge air flow into an aircraft cabin, a neck section to direct air flow from the inlet section to the outlet section, and a flow controller to passively regulate flow and/or pressure, and/or to create a vortex within the air diffuser to distribute flow and/or to reduce air flow noise. The inlet section, the neck section, and the outlet section are operatively coupled to direct air flow from the inlet section to the outlet section. The flow controller may be a
20 passive pressure controller (configured to affect air flow through the passive pressure controller in response to an air pressure differential across the passive pressure controller) and/or a vortex inducer (configured to create a vortex of air downstream of the vortex inducer).

25 In one embodiment there is provided an aircraft cabin air diffuser comprising: an inlet section with an open interior; a neck section with an open interior, downstream of the inlet section; an outlet section with an open interior, wherein the outlet section is downstream of the neck section; and a flow controller within the open interior of the

neck section, wherein the flow controller is a passive pressure controller configured to affect air flow through the passive pressure controller in response to an air pressure differential across the passive pressure controller.

5 In another embodiment there is provided an aircraft cabin air diffuser comprising: an inlet section with an open interior; a neck section with an open interior, downstream of the inlet section; an outlet section with an open interior, wherein the outlet section is downstream of the neck section; and a flow controller within the open interior of the neck section, wherein the flow controller is a vortex inducer with an effective diameter, wherein the air diffuser has an air channel length downstream of
10 the vortex inducer, and wherein a ratio of the effective diameter to the air channel length is less than 20%.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional schematic representation of an aircraft interior.

Fig. 2 is a non-exclusive, illustrative example of air diffusers as installed in an
15 aircraft interior.

Fig. 3 is a schematic representation of an air diffuser.

Fig. 4 is a longitudinal cross-sectional view, perpendicular to the transverse axis, of an illustrative, non-exclusive example of an air diffuser.

Fig. 5 is a longitudinal cross-sectional view, perpendicular to the lateral axis, of an illustrative, non-exclusive example of an air diffuser.

Fig. 6 is detail of an illustrative, non-exclusive example of a flow controller.

Fig. 7 is detail of another illustrative, non-exclusive example of a flow controller.

DESCRIPTION

The present disclosure relates to systems, methods, and apparatuses for diffusing air within an aircraft. Figs. 1-7 are various views of aircraft 10, air conditioning systems 12, air diffusers 14, and associated components. In general, in the drawings, elements that are likely to be included in a given embodiment are illustrated in solid lines, while elements that are optional or alternatives are illustrated in dashed lines. However, elements that are illustrated in solid lines are not essential to all embodiments of the present disclosure, and an element shown in solid lines may be omitted from a particular embodiment without departing from the scope of the present disclosure. Elements that serve a similar, or at least substantially similar, purpose are labeled with numbers consistent among the figures. Like numbers in each of the figures, and the corresponding elements, may not be discussed in detail herein with reference to each of the figures. Similarly, all elements may not be labeled in each of the figures, but reference numerals associated therewith may be used for consistency. Elements, components, and/or features that are discussed with reference to one or more of the figures may be included in and/or used with any of the figures without departing from the scope of the present disclosure.

Fig. 1 is a cross-sectional schematic representation of an aircraft interior illustrating where and how an air diffuser 14 may be employed within an aircraft 10 to

circulate air in an aircraft cabin **16**. Air flow is indicated by arrows **11**. Air diffusers **14** are typically part of an air conditioning system **12**, sometimes referred to as an air conditioning pack, on board the aircraft **10**. The air conditioning system **12** circulates air within the aircraft cabin **16** by providing air flow to air diffusers **14** fluidically coupled to the aircraft cabin **16**. The air may flow into the aircraft cabin **16** through cabin air vents **15**, typically along the side walls, above the stow bins, and/or along the overhead of the aircraft cabin **16**. Further, the air conditioning system **12** may supply air to passenger-controlled gaspers, generally above each seat.

An aircraft **10** may be configured to transport one or more passengers, including crew. For example, commercial aircraft may be configured to transport up to several hundred passengers. Several air diffusers **14**, and any associated cabin air vents **15**, may be distributed along the aircraft cabin **16** to provide relatively uniform flow of fresh air to all occupants.

Air diffusers **14** may be configured to fit within the space constraints of an aircraft **10** and/or aircraft cabin **16**. Typically, an air conditioning system **12** has ducts running along the length of the aircraft **10** fuselage, often near the stow bins and the overhead in commercial transport aircraft **10**. Air diffusers **14** may be connected to the ducts along the fuselage and may redirect some of the air flowing in the ducts into the aircraft cabin **16**. To accommodate this type of air flow within the space constraints, air diffusers **14** may be generally compact and/or curved.

Air diffusers **14** are configured to supply air as part of an air conditioning system **12** at a rate to maintain the comfort and health of occupants. FAA regulations currently require a minimum air flow of **0.55** lbs/min per occupant (about **250** g/min per occupant). When flying, aircraft with pressurized cabins typically maintain the air pressure at the equivalent of about **6,000-8,000** ft. altitude (about **1,800-2,400** m), which is about **0.75-0.80** bar (about **75-80** kPa). At **75** kPa and a comfortable cabin temperature of about **20-25°C**, the FAA requirement corresponds to an air flow of about **10** cubic feet per minute (ft³/min) per occupant (about **280** liters per minute (L/min) per

occupant). An aircraft **10** and/or an air conditioning system **12** may incorporate more than one air diffuser **14** to handle the required air flow and/or to distribute the air flow relatively equally among the occupants. Each air diffuser **14**, and associated air handling components, adds weight and complexity to an aircraft **10**. Hence, an aircraft

5 **10** may be designed to minimize the number of required air diffusers **14** (thus saving weight and, ultimately, fuel and maintenance costs). Since an aircraft **10** is rated for a certain number of occupants, including crew and passengers, a smaller number of air diffusers **14** increases the volumetric and/or mass flow of the air that each air diffuser **14** handles such that at least the minimum flow is achieved. The aircraft **10** may

10 incorporate less than one air diffuser **14** for every two rated occupants, for every three rated occupants, and/or for every four rated occupants. For example, the aircraft **10** may include less than **0.5**, less than **0.4**, less than **0.37**, less than **0.33**, less than **0.30**, less than **0.28**, less than **0.26**, less than **0.24**, less than **0.22**, less than **0.2**, about **0.4**, about **0.37**, about **0.33**, about **0.3**, about **0.25**, and/or about **0.22** air diffusers per rated

15 occupant. Air diffusers **14** may be configured to handle air flow of about the required rate or greater. For example, air diffusers **14** may be configured to flow air at greater than **700 g/min**, greater than **800 g/min**, greater than **900 g/min**, greater than **1,000 g/min**, greater than **1,100 g/min**, greater than **1,200 g/min**, less than **1,500 g/min**, less than **1,200 g/min**, **800-1,200 g/min**, greater than **800 L/min**, greater than **900 L/min**,

20 greater than **1,000 L/min**, greater than **1,100 L/min**, greater than **1,200 L/min**, greater than **1,300 L/min**, less than **1,500 L/min**, less than **1,300 L/min**, and/or **900-1,300 L/min**.

An air diffuser **14** may be employed in an aircraft **10** and/or an air conditioning system **12** to circulate air in an aircraft cabin **16**. Circulating may include supplying air to an aircraft cabin **16** through the air diffuser **14**. The air diffusers **14** may be

25 configured to supply the aircraft cabin **16** with a generally uniform air flow and/or with an air flow of at least **250 g/min** per rated occupant. Further, circulating may include maintaining an air pressure in an aircraft cabin **16** sufficient for safe, comfortable travel. For example, the air pressure may be greater than **60 kPa**, greater than **70 kPa**, greater than **75 kPa**, greater than **80 kPa**, greater than **90 kPa**, greater than **100 kPa**, less than

30 **120 kPa**, less than **100 kPa**, less than **80 kPa**, **70-80 kPa**, **70-90 kPa**, **70-102 kPa**,

about **90 kPa**, about **80 kPa**, and/or about **75 kPa**. Unless stated clearly otherwise, all air pressure values are absolute air pressure values.

Air diffusers **14** may be configured and/or used to establish a relatively quiet aircraft cabin environment by creating a sound level not substantially more than other ambient noise in an aircraft cabin **16**, at least at some frequencies that interfere with speech and/or at high frequencies. At higher flow rates, conventional air conditioning systems may make aircraft cabins noisy. However, the air diffusers **14** of the present disclosure may be configured to provide quiet air flow, even at high flow rates, without compromising the typical space and weight constraints of conventional air diffusers.

Aircraft cabins **16** may have many noise sources, particularly when the aircraft **10** is flying. Air diffusers **14** may be configured to contribute little to the overall sound level in an aircraft cabin **16**. The sound level from an air diffuser **14** in use may be less than **20** decibels (dB), less than **10** dB, less than **5** dB, less than **3** dB, less than **2** dB, or less than **1** dB more than other ambient noise in aircraft cabin **16**, at least at particular frequencies. For comparison, typical ambient noise in an aircraft cabin such as aircraft cabin **16** may be greater than **45** dB, greater than **50** dB, greater than **55** dB, greater than **60** dB, greater than **65** dB, greater than **70** dB, greater than **75** dB, greater than **80** dB, and/or greater than **85** dB. The sound level contribution from an air diffuser **14** may include frequencies of **0.1** kilohertz (kHz), **0.2** kHz, **0.5** kHz, **1** kHz, **2** kHz, **3** kHz, **4** kHz, **5** kHz, **8** kHz, **10** kHz, **12** kHz, **15** kHz, **20** kHz, **0.1-10** kHz, **0.5-4** kHz, **1-4** kHz, **2-4** kHz, **3-10** kHz, **5-10** kHz, greater than **5** kHz, and/or greater than **8** kHz. An alternate measure of interfering sound level is the speech interference level (SIL). The SIL is the arithmetic mean of the sound levels of a noise at three bands with center frequencies of **1** kHz, **2** kHz, and **4** kHz. These bands contain the frequencies that are most important for speech communication. The SIL of an air diffuser **14** in use may be less than **55** dB, less than **52** dB, less than **50** dB, less than **48** dB, less than **46** dB, or less than **44** dB.

Fig. **2** shows an example of two air diffusers **14** as part of an air conditioning system **12**. In the figure, the two air diffusers are arranged to supply air into an aircraft

cabin through one or more cabin air vents **15**. Each air diffuser **14** may be arranged to supply air through a dedicated air vent **15**, as shown in solid line in Fig. **2**, or at least two air diffusers **14** optionally may be arranged to supply air through a single, shared air vent **15** (also called an air rail), as shown in dotted line in Fig. **2**. Air diffusers **14** generally are configured to accept input air flow **11** through an entrance, also called an air diffuser upstream end **17**, to transmit the air flow **11** through the air diffuser, and to spread the air flow **11** through a relatively wide exit, also called an air diffuser downstream end **18**. The air diffusers **14** may be configured, each independently, to supply air at a substantially constant volumetric flow rate, mass flow rate, pressure, and/or flow velocity into the aircraft cabin, provided that the air conditioning system **12** is supplying a minimum threshold of air (volume, mass, and/or pressure) to each air diffuser **14**. Thus, the air conditioning system **12** may be configured to control the supply of air into the aircraft cabin through the configuration of the air diffusers **14** rather than the volume, mass, and/or pressure of air delivered to the air diffusers **14**.

Air diffusers **14** comprise an inlet section **20**, proximate to an air diffuser upstream end **17**, an outlet section **40**, proximate to an air diffuser downstream end **18**, and a neck section **30** that spans between the inlet section **20** and the outlet section **40**. Each of these sections, and the air diffuser **14** as a whole, has an open interior, or a channel, to allow air to flow through the section and air diffuser **14**. Hence, the sections, and the air diffuser **14**, may be described as being hollow, defining a cavity, defining an open volume, and/or being porous. Each of the sections is operatively connected to (and/or extends from) the neighboring section(s) such that air may flow into the inlet section **20**, through the neck section **30**, and out the outlet section **40**. The sections may each be composed of one or more parts. Two or more sections may share component parts. For example, one monolithic piece may include an inlet section **20**, a neck section **30**, and an outlet section **40**. As another example, the inlet section may be one piece, the neck section may be a second piece, and the outlet section may be a third piece of an air diffuser **14** assembly.

Generally, each section has an upstream end (the end configured to receive air flow) and a downstream end (the end configured to emit air flow). The inlet upstream end **21** is proximate to the air diffuser upstream end **17**, the end where air flow **11** is configured to enter the air diffuser **14**. The outlet downstream end **42** is proximate to the air diffuser downstream end **18**, the end where air flow **11** is configured to exit the air diffuser **14**. The inlet section **20** at the inlet downstream end **22** is operatively coupled to the neck section **30** at the neck upstream end **31**. The neck section **30** at the neck downstream end **32** is operatively coupled to the outlet section **40** at the outlet upstream end **41**. As illustrated in Fig. **2**, the sections each independently may be smooth and arcuate (illustrated in solid lines) or angular and boxy (illustrated in dash-dot lines). Additionally or alternatively, the transitions between the sections may be abrupt or smooth.

Air diffusers **14** also comprise a flow controller **50** within the air flow path of the air diffuser **14**. The flow controller **50** is spaced away from the air diffuser upstream end **17** and the air diffuser downstream end **18**, and may be at least partially in the interior of one or more of the inlet section **20**, the neck section **30**, and the outlet section **40**. Generally, the flow controller **50** is located toward the air diffuser upstream end **17**, generally within and/or proximate to the neck section **30**. As discussed further herein, flow controllers **50** may be passive pressure controllers **70** and/or vortex inducers **72**, i.e., flow controllers **50** may affect the speed and/or direction of air flow through the air diffuser **14**. Generally, flow controllers **50** include one or more vanes **54** that separate one or more flow channels **56** that allow air to flow through the flow controller **50** from the flow controller upstream end **51** to the flow controller downstream end **52**.

Air diffusers **14** are three dimensional objects which may be oriented in a variety of ways. To facilitate discussion of features, structures, and components of air diffusers **14**, this disclosure makes reference to three orthogonal directions, indicated by coordinate frame **100**: a longitudinal direction (indicated as the y-direction), a lateral direction (indicated as the x-direction), and a transverse direction (indicated as the z-direction). The longitudinal direction is a direction along the geometric center of the air

diffuser **14** following the direction of bulk air flow through the air diffuser **14**, spanning the air diffuser **14** from the air diffuser upstream end **17** to the air diffuser downstream end **18**. As discussed further herein, air diffusers generally are curved and/or define a curved bulk air flow path, and, hence, the longitudinal direction is likewise curved. The lateral direction is orthogonal to the longitudinal direction and generally traverses the widest portion of the air flow channel within the air diffuser **14**. A dimension of the air diffuser **14** along the lateral direction is referred to as a lateral width. The transverse direction is orthogonal to both the longitudinal direction and the lateral direction. A dimension of the air diffuser **14** along the transverse direction is referred to as a transverse breadth.

Fig. **3** is a schematic representation of an air diffuser **14** illustrating the general structure, location and order of the various subcomponents. Figs. **4-5** are perpendicular cross sections of an illustrative, non-exclusive example of an air diffuser **14**.

With reference to Figs. **3-5**, air diffusers **14** may be characterized by an air channel length **19**, the length of the geometrical center of the bulk air flow path from the air diffuser upstream end **17** to the air diffuser downstream end **18**. Further, air diffusers **14** may be characterized by a characteristic dimension measured perpendicular to the longitudinal direction, for example a lateral width, a transverse breadth, a diameter and/or an effective diameter.

The inlet section **20** of an air diffuser **14** is located proximate to the air diffuser upstream end **17** and may be located at the air diffuser upstream end **17**. The inlet section **20** generally is configured to create a diverging flow, i.e., the inlet section **20** defines an air flow path that is substantially diverging. However, the inlet section **20** may be configured to create a generally straight flow, i.e., the inlet section **20** defines an air flow path that is substantially straight. In one configuration to create a generally diverging air flow path, the inlet upstream end **21** is smaller than the inlet downstream end **22**. Specifically, the inlet section **20** may define an open area, the total cross-

sectional area that may allow a fluid to pass, that is smaller at the inlet upstream end **21** than at the inlet downstream end **22**.

Generally, the inlet section **20** may be tubular, hollow, and/or define an open volume. The inlet section **20** may be a tube, a generally cylindrical shell, and/or a
 5 generally tapered shell. The interior profile (the shape of the cross section of the interior) at the inlet upstream end **21** and/or at the inlet downstream end **22** may be substantially round and/or substantially oval.

The inlet section **20** may be characterized by an inlet central axis **28** between the inlet upstream end **21** and the inlet downstream end **22**. A central axis is a line that
 10 traverses the geometric centroid of each cross section perpendicular to the longitudinal dimension of an object. The central axis generally extends along the longitudinal direction and generally follows the contour of the object. In the inlet section **20**, the inlet central axis **28** generally describes the unobstructed flow of air through the inlet section
 15 **20**. The inlet central axis **28** typically is a substantially straight line between the center of the inlet upstream end **21** and the inlet downstream end **22**. Between the inlet upstream end **21** and the inlet downstream end **22**, and generally along the inlet central axis **28**, the inlet section **20** may be elongated. The length of the central axis **28** may be
 20 greater than **4** millimeters (mm), greater than **6** mm, greater than **8** mm, greater than **10** mm, greater than **12** mm, greater than **15** mm, greater than **20** mm, greater than **25** mm, greater than **30** mm, greater than **40** mm, greater than **50** mm, greater than **60** mm, greater than **80** mm, greater than **100** mm, less than **150** mm, less than **100** mm, less than **80** mm, less than **60** mm, less than **50** mm, **4-100** mm, and/or **10-80** mm.

The inlet section **20** may be configured to direct some air flow away from the
 25 outlet section **40** of the air diffuser **14**. Such flow may be directed to gaspers and/or other components of the air conditioning system **12**. Flow may be directed away from the outlet section **40** by including one or more branching tubes **25** along the inlet section **20**, as best viewed in Fig. 4.

Returning to the broader discussion of Figs. 3-5, the neck section **30** of an air diffuser **14** is generally a transition section between the inlet section **20** and the outlet section **40**. The neck section **30** may include a neck first region **35**, proximate to the neck upstream end **31**, a neck second region **36**, proximate to the neck downstream end **32**, and/or a neck transition region **37** between the neck upstream end **31** and the neck downstream end **32**. The neck first region **35** and/or the neck upstream end **31** may be configured to couple, and/or be operatively coupled, to the inlet downstream end **22**. The neck second region **36** and/or the neck downstream end **32** may be configured to couple, and/or be operatively coupled, to the outlet upstream end **41**.

The neck section **30** may be characterized by a neck central axis **38** between the neck upstream end **31** and the neck downstream end **32**. The neck central axis **38** generally describes the unobstructed flow of air through the neck section **30**. Generally, the neck central axis **38** is continuous with the inlet central axis **28**. The neck central axis **38** may be a substantially straight line or may be a substantially curved line between the center of the neck upstream end **31** and the neck downstream end **32**. Between the neck upstream end **31** and the neck downstream end **32**, and generally along the neck central axis **38**, the neck section **30** may be elongated. The length of the central axis **38** may be greater than **10** mm, greater than **12** mm, greater than **15** mm, greater than **20** mm, greater than **25** mm, greater than **30** mm, greater than **40** mm, greater than **50** mm, greater than **60** mm, greater than **80** mm, greater than **100** mm, greater than **150** mm, greater than **200** mm, greater than **300** mm, greater than **400** mm, greater than **500** mm, less than **500** mm, less than **400** mm, less than **300** mm, less than **200** mm, less than **150** mm, less than **100** mm, less than **80** mm, less than **60** mm, less than **50** mm, **20-500** mm, and/or **50-300** mm.

Generally, the neck section **30** may be tubular, hollow, and/or define an open volume. The neck section **30** may be a tube, a generally cylindrical shell, and/or generally an open box. For example, the neck first region **35** may be a tube and/or a generally cylindrical shell. As another example, the neck second region **36** may be a tube and/or generally an open box. The interior profile at the neck upstream end **31**

may be substantially round and/or substantially oval. The interior profile at the neck downstream end **32** may be substantially round, substantially oval, substantially oblong, and/or substantially rectangular. Generally, the interior profile at the neck upstream end **31** is different than the interior profile at the neck downstream end **32**. Where the profiles differ, the interior profile at the neck downstream end **32** may be larger in one direction (e.g., the lateral direction) and smaller in a perpendicular direction (e.g., the transverse direction) than the interior profile at the neck upstream end **31**. The open area at the neck upstream end **31** may be the same as or different than (e.g., smaller than) the open area at the neck downstream end **32**. Even where the interior profiles differ, the open area at the neck upstream end **31** may be the same as the open area at the neck downstream end **32**. The neck transition region **37**, when present, has a non-uniform interior profile, i.e., an interior profile that changes along the neck central axis **38**.

The interior of the neck section **30** at the neck upstream end **31** may be characterized by a characteristic dimension **80** that is a lateral width, a transverse breadth, a diameter, and/or an effective diameter. The interior of the neck section **30** at the neck downstream end **32** may have a lateral width **81** that is larger than the characteristic dimension **80** of the interior of the neck section **30** at the neck upstream end **31**, as best viewed in Fig. 4. The characteristic dimension **80** may be greater than **20** mm, greater than **30** mm, greater than **40** mm, greater than **50** mm, greater than **70** mm, greater than **100** mm, greater than **150** mm, less than **200** mm, less than **150** mm, less than **100** mm, less than **70** mm, less than **50** mm, **20-150** mm, and/or **50-100** mm. The ratio of the characteristic dimension **80** to the lateral width **81** may be less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, **8-50%**, **8-25%**, about **20%**, about **15%**, and/or about **12%**. The interior of the neck section **30** at the neck downstream end **32** may have a transverse breadth **82** that is about equal to or smaller than the characteristic dimension **80** of the interior of the neck section **30** at the neck upstream end **31**, as best viewed in Fig. 5. The ratio of the transverse breadth **82** to the characteristic dimension **80** may be less than **120%**, less than **100%**, less than **80%**,

less than **60%**, less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, **20-100%**, **30-50%**, about **100%**, about **50%**, about **33%**, and/or about **25%**. The lateral width **81** may be larger than the transverse breadth **82**. The ratio of the transverse breadth **82** to the lateral width **81** may be less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, less than **7%**, less than **6%**, less than **5%**, less than **4%**, **4-40%**, **5-25%**, **10-25%**, about **25%**, about **20%**, about **15%**, and/or about **12%**. The characteristic dimension **80** of the interior of the neck section **30** at the neck upstream end **31** may be greater than **20 mm**, greater than **30 mm**, greater than **40 mm**, greater than **50 mm**, greater than **60 mm**, greater than **80 mm**, greater than **100 mm**, less than **100 mm**, less than **80 mm**, less than **60 mm**, less than **50 mm**, **30-100 mm**, and/or **40-60 mm**. The lateral width **81** may be greater than **100 mm**, greater than **200 mm**, greater than **300 mm**, greater than **400 mm**, greater than **500 mm**, less than **500 mm**, less than **400 mm**, less than **300 mm**, less than **200 mm**, **100-500 mm**, **200-300 mm**, and/or about **280 mm**. The lateral width **81** may be substantially the same as or less than the length of the neck central axis **38**.

Returning to the broader discussion of Figs. **3-5**, the neck section **30** generally defines a smooth air flow path, approximately following the neck central axis **38**, from the neck upstream end **31** to the neck downstream end **32**. The air flow path may be substantially straight or substantially curved. Generally, the neck section **30** is configured to direct air entering the neck upstream end **31** into a different direction upon exiting the neck downstream end **32**. The air flow path may be characterized by the central axis of the air flow. Where the air flow path is curved, the air flow central axis may have a compound curvature, including bends and/or twists in multiple directions. For example, the plane of principal curvature may be substantially orthogonal to the lateral direction, e.g., the direction along the lateral width **81** of the interior of the neck section **30** at the neck downstream end **32**.

Within the interior, the neck section **30** generally has a smooth interior profile. Where the interior profile changes, such as along the neck transition region **37**, the

interior may have few to no features that could cause significant turbulence and/or undesired turbulence. For example, the interior of the neck section **30** may have arcuate surfaces, rounded corners, no sharp corners, and/or be essentially free of sharp corners. Additionally or alternatively, the neck section **30** may have an angular interior profile and/or an angular interior section which may cause significant turbulence.

The neck section **30** may include neck sound dampening material **39** to reduce noise generated by air flowing through the air diffuser **14**. The neck sound dampening material **39** may include a material and/or structure that attenuates, reflects, and/or redirects sound, at least at particular frequencies. The neck sound dampening material **39** may be essentially free of volatile substances and/or particulates that may circulate with the air flow. The neck sound dampening material **39** may be essentially fire resistant and/or resist formation of smoke, vapors, and/or particulate. For example, the neck sound dampening material may include aramid fibers, e.g., products sold under the trade names NOMEX, KEVLAR, TWARON, and TECHNORA ("Nomex" and "Kevlar" are registered trademarks of E. I. du Pont de Nemours and Company of Wilmington, Delaware; "Twaron" is a registered trademark of Teijin Aramid B.V. LLC of Arnhem, The Netherlands; and "Technora" is a registered trademark of Teijin Techno Products Limited Corp. of Osaka, Japan). Generally, the neck sound dampening material **39** is located along the interior surface(s) of the neck section **30** and may be directly or indirectly coupled to an interior surface of the neck section **30**. The neck sound dampening material **39** may be composed of a continuous section of material and/or a patchwork of material sections. The neck sound dampening material **39** may cover all, substantially all, most, and/or a majority of the interior of the neck section **30**. For example, the neck sound dampening material **39** may cover greater than **20%**, greater than **40%**, greater than **50%**, greater than **60%**, greater than **75%**, greater than **90%**, about **50%**, about **75%**, or about **100%** of the interior surface area of the neck section **30**. The neck section **30** may be completely free or selectively free of neck sound dampening material **39**. For example, where the interior of the neck section **30** generally has a transverse surface **88** and a lateral surface **87** (as best viewed in Figs. **4** and **5** respectively), the lateral surface **87** may be substantially covered by neck sound

dampening material **39** and/or the transverse surface **88** may be substantially free of neck sound dampening material **39**.

Returning to the broader discussion of Figs. **3-5**, the outlet section **40** of an air diffuser **14** is located proximate to the air diffuser downstream end **18** and may be located at the air diffuser downstream end **18**. The outlet section **40** generally is configured to create a broad, uniform flow, at the volume and/or mass flow rates described herein with respect to the air diffuser **14** as a whole, at the outlet downstream end **42**.

The outlet section **40** may be characterized by an outlet central axis **48** between the outlet upstream end **41** and the outlet downstream end **42**. The outlet central axis **48** generally describes the unobstructed flow of air through the outlet section **40**. Generally, the outlet central axis **48** is continuous with the neck central axis **38**. The outlet central axis **48** may be a substantially straight line or may be a substantially curved line between the center of the outlet upstream end **41** and the outlet downstream end **42**. Between the outlet upstream end **41** and the outlet downstream end **42**, and generally along the outlet central axis **48**, the outlet section **40** may be elongated. The length of the central axis **48** may be greater than **10** mm, greater than **12** mm, greater than **15** mm, greater than **20** mm, greater than **25** mm, greater than **30** mm, greater than **40** mm, greater than **50** mm, greater than **60** mm, greater than **80** mm, greater than **100** mm, greater than **150** mm, greater than **200** mm, greater than **300** mm, greater than **400** mm, greater than **500** mm, less than **500** mm, less than **400** mm, less than **300** mm, less than **200** mm, less than **150** mm, less than **100** mm, less than **80** mm, less than **60** mm, less than **50** mm, **10-300** mm, and/or **20-100** mm.

Generally, the outlet section **40** may be tubular, hollow, and/or define an open volume. The outlet section **40** may be a tube, generally an open box, and/or generally an open tapered box. The interior profile at the outlet upstream end **41** and/or the outlet downstream end **42** may be substantially round, substantially oval, substantially oblong, and/or substantially rectangular.

The interior of the outlet section **40** at the outlet upstream end **41** may be non-cylindrically symmetric and may have a lateral width **83** (as best view in Fig. **4**) that is larger than the transverse breadth **84** (as best viewed in Fig. **5**). Similarly, the interior of the outlet section **40** at the outlet downstream end **42** may be non-cylindrically symmetric and may have a lateral width **85** (as best viewed in Fig. **4**) that is larger than the transverse breadth **86** (as best viewed in Fig. **5**). The ratio of the transverse breadth **84** at the outlet upstream end **41** to the lateral width **83** at the outlet upstream end **41** may be less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, less than **7%**, less than **6%**, less than **5%**, less than **4%**, **4-40%**, **5-25%**, **10-25%**, about **25%**, about **20%**, about **15%**, and/or about **12%**. The ratio of the transverse breadth **86** at the outlet downstream end **42** to the lateral width **85** at the outlet downstream end **42** may be less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, less than **7%**, less than **6%**, less than **5%**, less than **4%**, **4-40%**, **5-25%**, **10-25%**, about **25%**, about **20%**, about **15%**, and/or about **12%**. The lateral width **83** at the outlet upstream end **41** and/or the lateral width **85** at the outlet downstream end **42** may be greater than **100 mm**, greater than **200 mm**, greater than **300 mm**, greater than **400 mm**, greater than **500 mm**, less than **500 mm**, less than **400 mm**, less than **300 mm**, less than **200 mm**, **100-500 mm**, **200-300 mm**, and/or about **280 mm**. The lateral width **83** at the outlet upstream end **41** is generally about the same as the lateral width **85** at the outlet downstream end **42**. The transverse breadth **84** at the outlet upstream end **41** and/or the transverse breadth **86** at the outlet downstream end **42** may be greater than **10 mm**, greater than **20 mm**, greater than **30 mm**, greater than **40 mm**, greater than **50 mm**, greater than **70 mm**, greater than **100 mm**, greater than **150 mm**, less than **200 mm**, less than **150 mm**, less than **100 mm**, less than **70 mm**, less than **50 mm**, less than **40 mm**, less than **30 mm**, less than **20 mm**, **10-200 mm**, **20-100 mm**, **20-70 mm**, about **20 mm**, and/or about **50 mm**. The transverse breadth **84** at the outlet upstream end **41** is generally greater than and/or about equal to the transverse breadth **86** at the outlet downstream end **42**. The length of the outlet central axis **48** may be less than **80%**, less than **60%**, less than

50%, less than 40%, less than 30%, less than 25%, less than 20%, 20-80%, 25-60%, about 60%, about 50%, and/or about 40% of the lateral width 85 at the outlet downstream end 42.

Returning to the broader discussion of Figs. 3-5, the outlet section 40 generally defines an air flow path, approximately following the outlet central axis 48, from the outlet upstream end 41 to the outlet downstream end 42. The air flow path may be substantially straight or substantially curved. Generally, the outlet section 40 may be configured to direct air entering the outlet upstream end 41 into a different direction upon exiting the outlet downstream end 42. The air flow path may be characterized by the central axis of the air flow. Where the air flow path is curved, the air flow central axis may have a compound curvature, including bends and/or twists in multiple directions. For example, the plane of principal curvature may be substantially orthogonal to the lateral direction, e.g., the direction along the lateral width 83 of the interior of the outlet section 40 at the outlet upstream end 41.

The air flow may converge within the outlet section 40. In one configuration to create a generally converging air flow path, the outlet upstream end 41 is larger than the outlet downstream end 42. Specifically, the outlet section may have an open area at the outlet upstream end 41 that is larger than the open area at the outlet downstream end 41.

The outlet section 40 may include outlet sound dampening material 49 to reduce noise generated by air flow through the air diffuser 14. The outlet sound dampening material 49 may be the same material as optional neck sound dampening material 39, may have similar characteristics as the optional neck sound dampening material 39, and/or may be continuous with the optional neck sound dampening material 39. Generally, the outlet sound dampening material 49 is located along the interior surface(s) of the outlet section 40 and may be directly or indirectly coupled to an interior surface of the outlet section 40. The outlet sound dampening material 49 may be composed of a continuous section of material and/or a patchwork of material sections.

The outlet sound dampening material **49** may cover all, substantially all, most, and/or a majority of the interior of the outlet section **40**. For example, the outlet sound dampening material **49** may cover greater than **20%**, greater than **40%**, greater than **50%**, greater than **60%**, greater than **75%**, greater than **90%**, about **50%**, about **75%**, or about **100%** of the interior of the outlet section **40**. The outlet section **40** may be completely free or selectively free of outlet sound dampening material **49**. For example, where the interior of the outlet section **40** generally has a transverse surface **90** and a lateral surface **89** (as best viewed in Figs. **4** and **5** respectively), the lateral surface **89** may be substantially covered by outlet sound dampening material **49** and/or the transverse surface **90** may be substantially free of outlet sound dampening material **49**.

Returning to the broader discussion of Figs. **3-5**, the air diffuser **14** also comprises a flow controller **50**, which is located generally in the interior of air diffuser **14**, typically within the inlet section **20**, the neck section **30**, and/or the interface between the inlet section **20** and the neck section **30**. The flow controller **50** may be proximate to the inlet downstream end **22** and the neck upstream end **31**. Further, the flow controller **50** may be configured to couple, and/or be operatively coupled, to the inlet section **20** and/or the neck section **30**.

The flow controller **50** may be configured to create an air pressure differential, thereby regulating the downstream air pressure within and/or exiting the air diffuser **14**. The pressure differential, when present, is generated within and/or by the flow controller **50**. Hence, the flow controller may be configured to create and/or maintain a pressure differential from the air diffuser upstream end **17**, the inlet upstream end **21**, and/or the flow controller upstream end **51** (generally the high pressure end) to the inlet downstream end **22**, the flow controller downstream end **52**, the neck downstream end **32**, the outlet downstream end **42**, and/or the air diffuser downstream end **18** (generally the low pressure end). The pressure differential may be a pressure above a predetermined threshold, a pressure range, and/or a differential pressure of greater than **2 kPa**, greater than **4 kPa**, greater than **6 kPa**, greater than **8 kPa**, greater than

10 kPa, greater than 15 kPa, greater than 20 kPa, less than 20 kPa, less than 15 kPa, less than 10 kPa, less than 8 kPa, less than 6 kPa, less than 4 kPa, and/or 2-10 kPa.

The flow controller **50** may be configured to create flow resistance, thereby regulating the total flow (e.g., regulating the volumetric flow, the mass flow, and/or the pressure) of air within, and/or into, the air diffuser **14**. The flow resistance, when present, is generated across the flow controller **50** from the upstream end **51** to the downstream end **52**. Hence, the flow controller **50** may be configured to restrict air flow from the air diffuser upstream end **17** and/or the inlet upstream end **21** to the inlet downstream end **22**, the neck downstream end **32**, the outlet downstream end **42**, and/or the air diffuser downstream end **18**. Additionally or alternatively, the flow controller **50** may be configured to create backpressure at the air diffuser upstream end **17** and/or the inlet upstream end **21**. The backpressure may be used to regulate and/or restrict air flow through the air diffuser **14** and/or may be used to direct air flow through auxiliary air conditioning system components, e.g., through optional branching tube **25** (which may ultimately direct air to personal air outlets, e.g., gaspers). Where the inlet section **20** defines a diverging air flow path, the expansion of the air flow volume upstream of the flow controller **50** may increase the static air pressure in that region (relative to no expansion). The static pressure may be used to direct air flow through auxiliary air conditioning system components.

The flow controller **50** generally includes one or more vanes **54** that define one or more flow channels **56** that are configured to transmit air through the flow controller **50**. Vanes **54** generally are oriented to direct air through the flow channels **56**. Vanes **54** also may be described as a blade, a membrane, a diaphragm, a flap, a leaf, a leaflet, a fin, a ridge, a nodule, a baffle, a louver, a disc, and/or a poppet. The flow controller **50** may include **1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 2-12, 4-12, 6-10**, at least **5**, at least **8**, and/or at least **12** vanes **54**. The vanes **54** may define **1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 2-12, 4-12, 6-10**, at least **5**, at least **8**, and/or at least **12** flow channels **56**.

Generally, the flow controller **50** is configured to fit within the air diffuser **14**, typically within the inlet section **20** and/or the neck section **30**, the flow controller **50** having a profile substantially the same as the interior of the nearby section. The flow controller **50** may have a characteristic dimension, i.e., a lateral width, a transverse breadth, a diameter, and/or an effective diameter, that is greater than **30** mm, greater than **40** mm, greater than **50** mm, greater than **60** mm, greater than **80** mm, greater than **100** mm, less than **100** mm, less than **80** mm, less than **60** mm, less than **50** mm, **30-100** mm, and/or **40-60** mm. The flow controller **50** may have a thickness that is less than **8** mm, less than **6** mm, less than **4** mm, less than **3** mm, less than **2** mm, greater than **1** mm, greater than **2** mm, greater than **3** mm, greater than **4** mm, **1-8** mm, and/or **2-4** mm. The flow controller **50** may be spaced away from the air diffuser upstream end **17** by greater than **4** mm, greater than **6** mm, greater than **8** mm, greater than **10** mm, greater than **12** mm, greater than **15** mm, greater than **20** mm, greater than **25** mm, greater than **30** mm, greater than **40** mm, greater than **50** mm, greater than **60** mm, greater than **80** mm, greater than **100** mm, less than **150** mm, less than **100** mm, less than **80** mm, less than **60** mm, less than **50** mm, **4-100** mm, and/or **10-80** mm. The flow controller **50** may be spaced away from the air diffuser downstream end **18** by greater than **20** mm, greater than **25** mm, greater than **30** mm, greater than **40** mm, greater than **50** mm, greater than **60** mm, greater than **80** mm, greater than **100** mm, greater than **150** mm, greater than **200** mm, greater than **300** mm, greater than **400** mm, greater than **500** mm, less than **500** mm, less than **400** mm, less than **300** mm, less than **200** mm, less than **150** mm, less than **100** mm, less than **80** mm, less than **60** mm, less than **50** mm, **50-500** mm, and/or **100-300** mm. The distance between the flow controller **50** and the air diffuser downstream end **18** along the longitudinal direction is also called the air channel length **79** downstream of the flow controller **50**.

The flow controller **50** may include, and optionally may be, a passive pressure controller **70**. The passive pressure controller **70**, when present, is a passive device that, in response to conditions within the air diffuser **14**, changes its configuration, conformation, geometry, etc. The changes to the passive pressure controller **70** are induced by the conditions without resort to an actuator or external control. For example,

the passive pressure controller **70** may be directly or indirectly actuated by air pressure in the inlet section **20** (e.g., by air velocity changes through the passive pressure controller **70** that result in air pressure changes in the inlet section **20**). Generally, the passive pressure controller **70** may be regarded as a normally-open passive valve that partially closes in response to air flow through the valve and/or air pressure upstream of the valve. For example, the passive pressure controller **70** may include, and optionally may be, a normally-open valve, a poppet valve, a butterfly valve, a diaphragm valve, and/or a pressure regulator.

The passive pressure controller **70** may be configured to affect air flow through the passive pressure controller **70** in response to a pressure differential across the passive pressure controller **70**. For example, the passive pressure controller **70** may be configured to maintain a substantially constant air flow through the passive pressure controller **70** when an air pressure in the inlet section **20** is greater than a predefined threshold. The substantially constant air flow may be greater than **700 g/min**, greater than **800 g/min**, greater than **900 g/min**, greater than **1,000 g/min**, greater than **1,100 g/min**, greater than **1,200 g/min**, less than **1,500 g/min**, less than **1,200 g/min**, **800-1,200 g/min**, greater than **800 L/min**, greater than **900 L/min**, greater than **1,000 L/min**, greater than **1,100 L/min**, greater than **1,200 L/min**, greater than **1,300 L/min**, less than **1,500 L/min**, less than **1,300 L/min**, and/or **900-1,300 L/min**. The related predefined threshold pressure may be greater than **60 kPa**, greater than **70 kPa**, greater than **75 kPa**, greater than **80 kPa**, greater than **90 kPa**, greater than **100 kPa**, less than **120 kPa**, less than **100 kPa**, **70-120 kPa**, **70-102 kPa**, **70-90 kPa**, about **90 kPa**, about **80 kPa**, and/or about **75 kPa**.

By maintaining a substantially constant flow through the passive pressure controller **70**, and, therefore, the air diffuser **14**, air diffusers **14** are configured to reject excess upstream air flow in the associated air conditioning system **12**. An air conditioning system **12** with plural air diffusers **14** (as shown in the example of Fig. **2**) may thus be configured to distribute air flow to substantially all the air diffusers **14**, and to distribute the air flow substantially evenly between the plurality of air diffusers **14**.

Additionally or alternatively, the air flow through each air diffuser **14** may be substantially controlled by the passive pressure controller **70** rather than the air flow **11** into the air diffuser upstream end **17** and/or air flow distributed by the associated air conditioning system **12**.

5 The passive pressure controller **70** generally includes vanes **54** that are mobile and/or elastically deformable. The vanes **54** of the passive pressure controller **70** respond to air pressure differentials across the passive pressure controller **70**. The air pressure differential across the passive pressure controller **70** may be due to the air flow through the passive pressure controller **70**. As the vanes **54** respond to air
10 pressure differentials, the flow channels **56** are opened and/or closed. Generally, the vanes **54** are biased to maintain one or more of the flow channels **56** in an open state in the absence of an air pressure differential greater than a predetermined threshold. As the air pressure differential increases (e.g., due to increased air flow velocity), one or more of the flow channels **56** is at least partially closed. The momentum change of the
15 air as it passes through the flow channels **56** in the passive pressure controller **70** may cause a pressure differential and provide the reactive force to at least partially close at least one flow channel **56**. In the illustrative, non-exclusive example of a passive pressure controller **70** with a plurality of flow channels **56**, a fraction of the flow channels
20 **56** may close and/or an open area of one or more (and optionally all) of the flow channels **56** may decrease in response to a sufficiently high pressure differential.

 Vanes **54** of the passive pressure controller **70** may be (each independently) elastically deformable and/or elastically coupled to the interior of the air diffuser **14** (e.g., to neck section interior **34**). The vanes **54** may be configured to be displaced (e.g., elastically deform, rotate, etc.) in response to the pressure differentials described with
25 respect to the opening and closing of flow channels **56**. The vanes **54** may be relatively thin and/or may have a thickness of less than **6** mm, less than **4** mm, less than **3** mm, less than **2** mm, less than **1** mm, greater than **0.5** mm, greater than **1** mm, greater than **2** mm, greater than **3** mm, greater than **4** mm, **1-6** mm, and/or **0.5-4** mm.

Pressure differentials that may affect the vanes **54** and/or the passive pressure controller **70** as described herein may be a pressure differential from the air diffuser upstream end **17**, the inlet upstream end **21**, and/or the flow controller upstream end **51** to the inlet downstream end **22**, the flow controller downstream end **52**, the neck downstream end **32**, the outlet downstream end **42**, and/or the air diffuser downstream end **18**. The pressure differential may be a pressure above a predetermined threshold, a pressure range, and/or a pressure differential of greater than **2 kPa**, greater than **4 kPa**, greater than **6 kPa**, greater than **8 kPa**, greater than **10 kPa**, greater than **15 kPa**, greater than **20 kPa**, less than **20 kPa**, less than **15 kPa**, less than **10 kPa**, less than **8 kPa**, less than **6 kPa**, less than **4 kPa**, and/or **2-10 kPa**.

Additionally or alternatively, the flow controller **50** may include, and optionally may be, a vortex inducer **72**. The vortex inducer **72**, when present, is configured to induce some tangential air flow **11** as air passes through the vortex inducer **72**. That is, the generally axial flow that flows through the inlet section **20** and to the vortex inducer **72** is redirected, in the vortex inducer **72**, to swirl around the central axis **78** of the vortex inducer **72**. The tangential flow component of the air flow **11** may be a substantial fraction of the axial flow component of the air flow **11** as the air flow exits the vortex inducer **72**. For example, the ratio of tangential air flow to axial air flow is at least **0.2**, at least **0.3**, at least **0.4**, at least **0.5**, at least **0.8**, at least **1**, at least **1.2**, at most **5**, at most **3**, at most **2**, at most **1.5**, **0.2-5**, **0.3-3**, **0.4-3**, **0.5-3**, **0.5-1.5**, **0.8-3**, and/or **0.8-1.5**. The ratio of tangential air flow to axial air flow may be determined at the downstream end of the vortex inducer **72** (i.e., the downstream end **52** of the flow controller **50**) and/or in the neck section **30** downstream of the vortex inducer **72**. The ratio may be the velocity ratio or the mass flow ratio. The vortex inducer **72** may be configured to create a vortex of air in the neck section **30** and/or a vortex of air that extends from the vortex inducer **72** into the outlet section **40** and/or to, or beyond, the air diffuser downstream end **18**.

Generally, the vortex inducer **72** may be described with a central axis **78**. The central axis **78** of the vortex inducer **72** may be continuous with the inlet central axis **28**

and/or the neck central axis **38**. The vortex inducer **72** may have characteristic transverse and/or lateral dimensions corresponding to the characteristic dimensions of the proximate interior of the air diffuser **14** and/or related to the longitudinal dimension of at least one of the air diffuser **14**, the inlet section **20**, neck section **30**, and outlet section **40**. For example, a lateral width, a transverse breadth, a diameter, and/or an effective diameter of the vortex inducer **72** may be less than **50%**, less than **20%**, less than **15%**, less than **10%**, less than **8%**, less than **5%**, less than **4%**, less than **2%**, greater than **1%**, greater than **2%**, greater than **4%**, greater than **5%**, greater than **8%**, greater than **10%**, greater than **15%**, and/or greater than **20%** of the air channel length **19** of the air diffuser **14** and/or the air channel length **79** downstream of the vortex inducer **72**.

The vortex inducer **72** may define and/or include one or more vanes **54** that are configured to allow air to pass through the vortex inducer **72** in a helical manner. The vanes **54** of the vortex inducer **72** may define one or more angled flow channels **76**. The vanes **54** and/or the angled flow channels **76** may be curved and/or helical. The vanes **54** and/or the angled flow channels **76** may have a pitch, an average pitch, an effective pitch, and/or an angle, relative to the central axis **78** of the vortex inducer **72**, of about **10°**, about **20°**, about **30°**, about **40°**, about **45°**, about **50°**, about **60°**, about **70°**, about **80°**, about **90°**, **20°-70°**, **30°-70°**, **30°-60°**, **40°-70°**, and/or **40°-60°**. The vanes **54** of the vortex inducer **72** may be connected together at a central point or component, e.g., a central hub **74**. For example, the hub **74** may connect to one, at least one, two, at least two, or all of the vanes **54**. Alternatively, the vortex inducer **72** may not include a hub **74**. The hub **74**, when present, generally occludes all, or substantially all, air flow through the hub **74**, i.e., the hub **74** generally has no flow channel **56**. Where one or more vanes **54** do not connect to a hub **74**, the vanes **54** may protrude from the interior of the air diffuser **14** and into the air flow path. The angled flow channels **76** defined by protruding vanes **54** may merge with a central flow channel **56** that generally follows the central axis **78**. Protruding vanes **54** may only partially occlude the interior of the air diffuser **14** and/or may have a radial length that is less than half a characteristic lateral and/or transverse dimension (e.g., a lateral width, a

transverse breadth, a diameter, and/or an effective diameter) of the vortex inducer **72**. For example, the radial length of protruding vanes **54** may be less than **50%**, less than **20%**, less than **15%**, less than **10%**, less than **8%**, less than **5%**, less than **4%**, less than **2%**, greater than **1%**, greater than **2%**, greater than **4%**, greater than **5%**, greater than **8%**, greater than **10%**, greater than **15%**, and/or greater than **20%** of a characteristic lateral and/or transverse dimension of the vortex inducer **72**.

The vanes **54** of the vortex inducer **72** and/or the angled flow channels **76** may be arranged in a radial pattern (arranged like rays or radii) and/or a circumferential pattern (arranged like segments of a circumference). In such patterns, the individual vanes **54** and/or angled flow channels **76** may be described as angularly and/or radially spaced apart. Typically, such patterns are centered on and/or arranged around the central axis **78** and/or the hub **74**.

Illustrative, non-exclusive examples of flow controllers **50** are shown in Figs. **6-7**. For example, Fig. **6** depicts a flow controller **50** that is in the form of a fixed fan (a fan shape that does not rotate about its central axis). The fixed fan includes a plurality of vanes **54** and a plurality of angled flow channels **76** that are configured to impart circular motion (around the longitudinal axis) to the generally longitudinal air flow **11** that enters the flow controller **50**. Hence, the embodiment shown in Fig. **6** is also a vortex inducer **72**. The vanes **54** may be elastically deformable and/or elastically coupled to the interior of the air diffuser **14** and/or the central hub **74**. The arrangement of vanes **54** shown allows the vanes to elastically deform to close the angled flow channels **76** in response to an increase in the pressure differential across the flow controller **50**. Hence, the embodiment shown in Fig. **6** also may be a passive pressure controller **70**.

Fig. **7** depicts a flow controller **50** that is in the form of a helix. The helix is a single helical vane **54** that defines an angled flow channel **76**. As with Fig. **6**, the flow controller **50** of Fig. **7** is a vortex inducer **72** and may be a passive pressure controller **70** (when the vane **54** is elastically deformable and/or elastically coupled to the interior of the air diffuser **14** and/or the central hub **74**). Other optional embodiments of flow

controllers **50** may include louvers and/or orifice plates. For example, a plate with angle orifices may be configured as a vortex inducer **72**. As another example, louvers may redirect air entering and/or exiting a flow controller **50** such that the flow controller **50** imparts tangential air flow and is a vortex inducer **72**.

5 Returning to the broader discussion of Figs. **3-5**, the air diffuser **14** also may comprise an optional baffle **60**, which is located generally in the interior of air diffuser **14**, typically within the neck section **30**, the outlet section **40**, and/or the interface between the neck section **30** and the outlet section **40**. The baffle **60**, when present, is located downstream of the flow controller **50**, and hence is generally toward the air
10 diffuser downstream end **18**. The baffle **60** may be proximate to the neck downstream end **32** and the outlet upstream end **41**. Further, the baffle **60** may be configured to couple, and/or be operatively coupled, to the neck section **30** and/or the outlet section **40**.

 Generally, the baffle **60** is substantially perpendicular to or oblique to, the neck
15 central axis **38** and/or the outlet central axis **48**. The relationship between the baffle **60** and the neck central axis **38** and/or the outlet central axis **48** may be characterized by an angle **92**, as best viewed in Fig. **5**. The angle **92** between the baffle **60** and the neck central axis **38** and/or between the baffle **60** and the outlet central axis **48** may be greater than **10°**, greater than **15°**, greater than **20°**, greater than **25°**, greater than **30°**,
20 greater than **35°**, greater than **40°**, greater than **45°**, greater than **50°**, greater than **55°**, greater than **60°**, greater than **65°**, greater than **70°**, greater than **75°**, greater than **85°**, less than **90°**, less than **75°**, less than **70°**, less than **65°**, less than **60°**, less than **55°**, less than **50°**, less than **45°**, less than **40°**, less than **35°**, less than **30°**, less than **25°**, less than **20°**, less than **15°**, **10°-50°**, **15°-45°**, **20°-45°**, **25°-35°**, about **90°**, about **75°**,
25 about **60°**, about **45°**, about **30°**, and/or about **15°**.

The baffle **60** may be configured to create flow resistance and/or create backpressure within the air diffuser **14**. The flow resistance is generally between the neck upstream end **31** and the outlet downstream end **42**. The backpressure is

generally backpressure at the neck upstream end **31**. Generally, the baffle **60** may be configured to spread air flow across the lateral width **85** of the outlet section **40** at the outlet downstream end **42**. One configuration, which may spread the air flow and maintain a quiet air flow, includes a tortuous air flow path from the neck upstream end **31** to the outlet downstream end **42**. Generally, the flow restriction of the baffle **60** prevents direct transmission of upstream noise and redirects the air flow to interact with the interior of the neck section, the interior of the outlet section, the optional neck sound dampening material **39**, and/or the optional outlet sound dampening material **49**.

The baffle **60** may be a baffle plate **64** characterized by a first end **66**, a second end **67**. The baffle plate **64** may substantially span the lateral width **81** of the interior of the neck section **30** at the neck downstream end **32** and/or the lateral width **83** of the interior of the outlet section **40** at the outlet upstream end **41**. Additionally or alternatively, the baffle plate **64** may substantially span the interior of the neck section **30** and/or the outlet section **40** across the lateral direction. The baffle plate **60** may be substantially flat, may include flat regions, curved regions, and/or rounded regions.

Generally, the baffle plate **64** is configured to substantially restrict air flow near the first end **66** and/or the second end **67**. For example, the first end **66** and/or the second end **67** may be coupled close to one or more interior surfaces of the neck section **30** and/or the outlet section **40**, for example the transverse surface **88** of the interior of the neck section **30** and/or the transverse surface **90** of the interior of the outlet section **40**. Where the first end **66** and/or the second end **67** are near an interior surface of the air diffuser **14**, the interior surface may include sound dampening material, e.g., neck sound dampening material **39** and outlet sound dampening material **49**, or may be essentially free of sound dampening material proximate the first end **66** and/or the second end **67**. Where the neck section **30** includes neck sound dampening material **39**, the neck sound dampening material **39** may define a material gap near the first end **66** and/or the second end **67**, e.g., along a transverse surface **88** of the interior of the neck section **30**. Where the outlet section **40** includes sound dampening material **49**, the outlet sound dampening material **49** may define a material gap near the

first end **66** and/or the second end **67**, e.g., along a transverse surface **90** of the interior of the outlet section **40**.

Generally, the baffle plate **64** defines one or more gaps **65** between the baffle plate **64** and the interior of the neck section **30** and/or the outlet section **40**. The gap **65** may substantially span the interior of the neck section **30** and/or the outlet section **40** across the lateral direction, in which case the gap **65** would be between the baffle plate **64** and a lateral surface **87** of the interior of the neck section **30** and/or a lateral surface **89** of the interior of the outlet section **40**. The gap **65** may have a lateral width approximately the same as the lateral width **81** at the neck downstream end **32** and/or the lateral width **83** at the outlet upstream end **41**. The gap **65** may have an open area that is less than **50%**, less than **40%**, less than **35%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, greater than **5%**, greater than **8%**, greater than **10%**, greater than **12%**, greater than **15%**, greater than **20%**, greater than **25%**, greater than **30%**, greater than **35%**, greater than **40%**, **5-50%**, **8-30%**, **8-20%**, **10-35%**, about **8%**, about **10%**, about **12%**, about **15%**, about **20%**, about **25%**, about **30%**, and/or about **33%** of the open area of the outlet downstream end **42**. The interior surface of the neck section **30** and/or the outlet section **40** near the gap **65** may be substantially flat near the gap **65**, may have a curvature away from the baffle plate **64**, and/or may have a curvature toward the baffle plate **64**.

The baffle plate **64** may have a third end **68** near the gap **65** and fourth end **69** opposite the third end **68**. The third end **68** may be configured to smoothly split air flow and may be wedge-shaped, rounded and/or bulbous. The third end **68** may be upstream or downstream of the fourth end **69**. The fourth end **69** is generally near the interior surface of the neck section **30** and/or the outlet section **40**, and may be operatively coupled to the neck section **30** and/or the outlet section **40**. For example, the fourth end **69** may be near a lateral surface **87** of the interior of the neck section **30** and/or near a lateral surface **89** of the interior of the outlet section **40**. Further, the baffle plate **64**, may define a dead volume, a volume where air may enter and exit

essentially from one direction, between the fourth end **69** and the interior surface of the neck section **30** and/or the interior surface of the outlet section **40**.

Further examples of aircraft, aircraft air conditioning systems, air diffusers, general design considerations, and use thereof are disclosed in applicant's U.S. Patent Application No. **14/010,775**, filed August **27, 2013**, published on March 5, 2015 as US 2015/0063995 A1.

Generally in one embodiment, there is provided an aircraft cabin air diffuser. The air diffuser includes an inlet section with an open interior, a neck section with an open interior, downstream of the inlet section, an outlet section with an open interior, wherein the outlet section is downstream of the neck section, and a flow controller within the open interior of the neck section.

The inlet section may have an interior profile that is substantially round and/or substantially oval.

The inlet section may have an interior profile and the outlet section has an interior profile that is different, optionally substantially different, than the interior profile of the inlet section.

The outlet section may have an interior profile that is substantially oblong and/or substantially rectangular.

The flow controller may be configured to create an air pressure differential of greater than **2 kPa**, greater than **4 kPa**, greater than **6 kPa**, greater than **8 kPa**, greater than **10 kPa**, greater than **15 kPa**, greater than **20 kPa**, less than **20 kPa**, less than **15 kPa**, less than **10 kPa**, less than **8 kPa**, less than **6 kPa**, less than **4 kPa**, and/or **2-10 kPa**.

The air pressure differential may be from the inlet section to the outlet section.

The air pressure differential may be from an upstream end of the flow controller to a downstream end of the flow controller.

The flow controller may be configured to restrict air flow from the inlet section to the outlet section.

The flow controller may be proximate the inlet section.

5 The flow controller may be operatively coupled to the inlet section and/or the neck section.

The flow controller may include, and optionally is, a passive pressure controller, optionally configured to affect air flow through the passive pressure controller in response to an air pressure differential across the passive pressure controller.

10 The passive pressure controller may be configured to maintain a substantially constant air flow through the passive pressure controller when an air pressure in the inlet section may be greater than a predefined threshold, optionally wherein the substantially constant air flow may be greater than **700 g/min**, greater than **800 g/min**, greater than **900 g/min**, greater than **1,000 g/min**, greater than **1,100 g/min**, greater than **1,200 g/min**, less than **1,500 g/min**, less than **1,200 g/min**, **800-1,200 g/min**, greater than **800 L/min**, greater than **900 L/min**, greater than **1,000 L/min**, greater than **1,100 L/min**, greater than **1,200 L/min**, greater than **1,300 L/min**, less than **1,500 L/min**, less than **1,300 L/min**, and/or **900-1,300 L/min**, and optionally wherein the predefined threshold may be greater than **60 kPa**, greater than **70 kPa**, greater than **75 kPa**, greater than **80 kPa**, greater than **90 kPa**, greater than **100 kPa**, less than **120 kPa**, less than **100 kPa**, **70-120 kPa**, **70-102 kPa**, **70-90 kPa**, about **90 kPa**, about **80 kPa**, and/or about **75 kPa**.

The passive pressure controller may be configured to be actuated by air pressure in the inlet section and/or by air velocity through the passive pressure controller.

25 The passive pressure controller may include one or more vanes that define one or more flow channels.

The one or more vanes may be configured to decrease an open area of the one or more flow channels in response to an increase in an air pressure differential from the inlet section to the outlet section.

5 The one or more vanes may be biased to maintain the one or more flow channels in an open state in the absence of an air pressure differential between the inlet section and the outlet section.

At least one vane, optionally all vanes, may be elastically coupled to the interior of the neck section.

10 At least one vane, optionally all vanes, may be configured to elastically deform in response to an air pressure differential from the inlet section to the outlet section of greater than **2 kPa**, greater than **4 kPa**, greater than **6 kPa**, greater than **8 kPa**, greater than **10 kPa**, greater than **15 kPa**, greater than **20 kPa**, less than **20 kPa**, less than **15 kPa**, less than **10 kPa**, less than **8 kPa**, less than **6 kPa**, less than **4 kPa**, and/or **2-10 kPa**.

15 The passive pressure controller may have an upstream end and a downstream end and wherein at least one vane, optionally all vanes, may be configured to elastically deform in response to an air pressure differential, from the upstream end of the passive pressure controller to the downstream end of the passive pressure controller, of greater than **2 kPa**, greater than **4 kPa**, greater than **6 kPa**, greater than **8 kPa**, greater than
20 **10 kPa**, greater than **15 kPa**, greater than **20 kPa**, less than **20 kPa**, less than **15 kPa**, less than **10 kPa**, less than **8 kPa**, less than **6 kPa**, less than **4 kPa**, and/or **2-10 kPa**.

A thickness of at least one vane, optionally all vanes, may be less than **6 mm**, less than **4 mm**, less than **3 mm**, less than **2 mm**, less than **1 mm**, greater than **0.5 mm**, greater than **1 mm**, greater than **2 mm**, greater than **3 mm**, greater than **4 mm**, **1-6 mm**,
25 and/or **0.5-4 mm**.

At least one vane, optionally all vanes, may include, optionally may be, a blade, a membrane, a diaphragm, a flap, a leaf, a leaflet, a fin, a ridge, a nodule, a baffle, a louver, a disc, and/or a poppet.

The passive pressure controller may include, optionally is, a normally-open valve,
5 a poppet valve, a butterfly valve, a diaphragm valve, and/or a pressure regulator.

The flow controller may include, and optionally may be, a vortex inducer.

The vortex inducer may be configured to induce tangential air flow as air passes through the vortex inducer, optionally wherein a ratio of tangential air flow to axial air flow is at least **0.2**, at least **0.3**, at least **0.4**, at least **0.5**, at least **0.8**, at least **1**, at
10 least **1.2**, at most **5**, at most **3**, at most **2**, at most **1.5**, **0.2-5**, **0.3-3**, **0.4-3**, **0.5-3**, **0.5-1.5**, **0.8-3**, and/or **0.8-1.5**.

The vortex inducer may be configured to create a vortex of air in the neck section, optionally a vortex of air that extends from the vortex inducer into the outlet section.

15 The vortex inducer may have a characteristic dimension that is a lateral width, a transverse breadth, a diameter, and/or an effective diameter, the air diffuser may have an air channel length, optionally downstream of the vortex inducer, and wherein the ratio of the characteristic dimension to the air channel length is less than **50%**, less than
20 **20%**, less than **15%**, less than **10%**, less than **8%**, less than **5%**, less than **4%**, less than **2%**, greater than **1%**, greater than **2%**, greater than **4%**, greater than **5%**, greater than **8%**, greater than **10%**, greater than **15%**, and/or greater than **20%**.

The vortex inducer may include a central axis, optionally wherein the central axis of the vortex inducer may be continuous with an/the inlet central axis, and optionally wherein the central axis of the vortex inducer may be continuous with a/the neck central
25 axis.

The vortex inducer may include one or more, optionally a plurality of, vanes that define one or more, optionally a plurality of, angled flow channels.

The plurality of angled flow channels may be arranged in a radial pattern and/or a circumferential pattern, optionally around a central axis of the vortex inducer and/or a
5 hub of the vortex inducer.

The vortex inducer may include **1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 2-12, 4-12, 6-10**, at least **5**, at least **8**, and/or at least **12** vanes.

The one or more vanes may define **1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 2-12, 4-12, 6-10**, at least **5**, at least **8**, and/or at least **12** angled flow channels.

10 The angled flow channels may be angled about **10°**, about **20°**, about **30°**, about **40°**, about **45°**, about **50°**, about **60°**, about **70°**, about **80°**, about **90°**, **20°-70°**, **30°-70°**, **30°-60°**, **40°-70°**, and/or **40°-60°** from a/the central axis of the vortex inducer.

The vanes and/or the angled flow channels may be curved and/or helical.

15 At least two, optionally all, of the angled flow channels may be radially and/or angularly spaced apart.

The vortex inducer may include a central hub, optionally that connects to at least one vane.

The central hub may connect at least two, and optionally all of the, vanes together.

20 At least one vane, optionally all vanes, may be coupled to the interior of the neck section.

At least one vane, optionally all vanes, may include, optionally may be, a blade, a membrane, a diaphragm, a flap, a leaf, a leaflet, a fin, a ridge, a nodule, a baffle, a louver, a disc, and/or a poppet.

The vortex inducer may include, optionally is, a fixed fan, a helix, an orifice plate, and/or a louver.

5 The inlet section may have an inlet upstream end and an inlet downstream end, optionally wherein the inlet section may have an open area at the inlet upstream end that is smaller than an open area at the inlet downstream end.

The inlet section may be a tube, a generally cylindrical shell, and/or a generally tapered shell.

The interior profile of the inlet section may be an interior profile at an/the inlet upstream end and/or an interior profile at an/the inlet downstream end.

10 The inlet section may be elongated between an/the inlet upstream end and an/the inlet downstream end.

The inlet section may have an inlet central axis between an/the inlet upstream end and an/the inlet downstream end, optionally wherein the inlet central axis may be substantially straight.

15 The interior of the inlet section may define an air flow path that is substantially straight and/or substantially diverging.

The inlet section may include a branching tube configured to create an air flow path directed away from an/the inlet downstream end.

20 The neck section may have a neck upstream end and a neck downstream end, optionally wherein the neck section has a first region, proximate to the neck upstream end, that is a tube and/or a generally cylindrical shell.

The neck section may have a second region, proximate to a/the neck downstream end, that is a tube and/or generally an open box.

The neck section may have a transition region between a/the neck upstream end and a/the neck downstream end, wherein the transition region has a non-uniform interior profile, optionally wherein the interior of the transition region may define a smooth air flow path, has arcuate surfaces, has rounded corners, has no sharp corners, and/or is essentially free of sharp corners.

The neck section at the neck upstream end may have an interior profile that is substantially round and/or substantially oval.

The neck section at a/the neck downstream end may have an interior profile that is substantially round, substantially oval, substantially oblong, and/or substantially rectangular.

The neck section may have a first interior profile at a/the neck upstream end and a second interior profile at a/the neck downstream end, wherein the first interior profile and the second interior profile may be different.

The neck section may be elongated between a/the neck upstream end and a/the neck downstream end.

The neck section may have a neck central axis between a/the neck upstream end and a/the neck downstream end, optionally wherein the neck central axis may be substantially straight or substantially curved, and optionally wherein the neck central axis may be continuous with an/the inlet central axis.

The interior of the neck section may define a substantially straight air flow path.

The interior of the neck section may define a substantially curved air flow path.

A plane of principal curvature of the air flow path may be substantially orthogonal to a lateral width of the interior of the neck section at a/the neck downstream end.

The neck section may be configured to direct air entering a/the neck upstream end into a different direction upon exiting a/the neck downstream end.

The neck section may include a neck sound dampening material, optionally wherein the neck sound dampening material includes fire resistant materials and/or aramid fibers.

5 The neck sound dampening material may be coupled to an interior surface of the neck section.

The neck sound dampening material may be continuous within the neck section.

The neck sound dampening material may cover most, a majority and/or substantially all, of the interior of the neck section.

10 The neck sound dampening material may cover a fraction of the interior of the neck section, and wherein the fraction is greater than **20%**, greater than **40%** greater than **50%**, greater than **60%**, greater than **75%**, greater than **90%**, about **50%**, about **75%**, or about **100%**.

15 The interior of the neck section at a/the neck downstream end may have a lateral surface and a transverse surface, wherein the lateral surface is substantially covered by neck sound dampening material, and optionally wherein the transverse surface is substantially free of neck sound dampening material.

The neck section may have an open area at a/the neck upstream end that is smaller than an open area at a/the neck downstream end.

20 The interior of the neck section at a/the neck downstream end may have a lateral width that is larger than a characteristic dimension of the interior of the neck section at a/the neck upstream end, wherein the characteristic dimension may be a lateral width, a transverse breadth, a diameter, and/or an effective diameter, and optionally wherein the ratio of the characteristic dimension to the lateral width may be less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, **8-50%**, **8-25%**, about **20%**, about **15%**, and/or about **12%**.

25

The interior of the neck section at a/the neck downstream end may have a transverse breadth that is about equal to or smaller than a characteristic dimension of the interior of the neck section at a/the neck upstream end, wherein the characteristic dimension may be a lateral width, a transverse breadth, a diameter, and/or an effective diameter, optionally wherein the ratio of the transverse breadth to the characteristic dimension is less than **120%**, less than **100%**, less than **80%**, less than **60%**, less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, **20-100%**, **30-50%**, about **100%**, about **50%**, about **33%**, and/or about **25%**.

The interior of the neck section at a/the neck downstream end may have a lateral width and a transverse breadth, wherein the lateral width may be larger than the transverse breadth, and optionally wherein the ratio of the transverse breadth to the lateral width may be less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, less than **7%**, less than **6%**, less than **5%**, less than **4%**, **4-40%**, **5-25%**, **10-25%**, about **25%**, about **20%**, about **15%**, and/or about **12%**.

A characteristic dimension of the interior of the neck section at a/the neck upstream end may be greater than **20 mm**, greater than **30 mm**, greater than **40 mm**, greater than **50 mm**, greater than **60 mm**, greater than **80 mm**, greater than **100 mm**, less than **100 mm**, less than **80 mm**, less than **60 mm**, less than **50 mm**, **30-100 mm**, and/or **40-60 mm**, and wherein the characteristic dimension may be a lateral width, a transverse breadth, a diameter, and/or an effective diameter.

A lateral width of the interior of the neck section at a/the neck downstream end may be greater than **100 mm**, greater than **200 mm**, greater than **300 mm**, greater than **400 mm**, greater than **500 mm**, less than **500 mm**, less than **400 mm**, less than **300 mm**, less than **200 mm**, **100-500 mm**, **200-300 mm**, and/or about **280 mm**.

A lateral width of the interior of the neck section at a/the neck downstream end may be substantially the same as or less than a length of a/the neck central axis.

The outlet section may be a tube, generally an open box, and/or generally an open tapered box.

The outlet section may include an outlet downstream end, wherein the interior profile of the outlet section may be an interior profile at the outlet downstream end.

- 5 The outlet section may include an outlet upstream end, wherein the outlet section may have an interior profile at the outlet upstream end that is substantially round, substantially oval, substantially oblong, and/or substantially rectangular.

The outlet section may be elongated between an/the outlet upstream end and an/the outlet downstream end.

- 10 The outlet section may have an outlet central axis between an/the outlet upstream end and an/the outlet downstream end, optionally wherein the outlet central axis may be substantially straight or substantially curved, and optionally wherein the outlet central axis may be continuous with a/the neck central axis.

- 15 The interior of the outlet section may define an air flow path that is substantially straight and/or substantially converging.

The interior of the outlet section may define a substantially curved air flow path.

A plane of principal curvature of the air flow path may be substantially orthogonal to a lateral width of the interior of the outlet section at an/the outlet upstream end.

- 20 The outlet section may be configured to direct air entering an/the outlet upstream end into a different direction upon exiting an/the outlet downstream end.

The outlet section may include an outlet sound dampening material, optionally wherein the outlet sound dampening material may include fire resistant materials and/or aramid fibers.

The outlet sound dampening material may be coupled to an interior surface of the outlet section.

The outlet sound dampening material may be continuous within the outlet section.

- 5 The outlet sound dampening material may cover most, a majority and/or substantially all, of the interior of the outlet section.

10 The outlet sound dampening material may cover a fraction of the interior of the outlet section, and wherein the fraction may be greater than **20%**, greater than **40%**, greater than **50%**, greater than **60%**, greater than **75%**, greater than **90%**, about **50%**, about **75%**, or about **100%**.

The interior of the outlet section at an/the outlet upstream end may have a lateral surface and a transverse surface, wherein the lateral surface may be substantially covered by outlet sound dampening material, and optionally wherein the transverse surface may be substantially free of outlet sound dampening material.

- 15 The outlet section may have an open area at an/the outlet upstream end that is larger than an open area at an/the outlet downstream end.

20 The interior of the outlet section at an/the outlet upstream end may have a lateral width and a transverse breadth, wherein the lateral width may be larger than the transverse breadth, and optionally wherein the ratio of the transverse breadth to the lateral width may be less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, less than **7%**, less than **6%**, less than **5%**, less than **4%**, **4-40%**, **5-25%**, **10-25%**, about **25%**, about **20%**, about **15%**, and/or about **12%**.

25 A lateral width of the interior of the outlet section at an/the outlet upstream end may be greater than **100 mm**, greater than **200 mm**, greater than **300 mm**, greater than

400 mm, greater than 500 mm, less than 500 mm, less than 400 mm, less than 300 mm, less than 200 mm, 100-500 mm, 200-300 mm, and/or about 280 mm.

A transverse breadth of the interior of the outlet section at an/the outlet upstream end may be greater than **10 mm, greater than 20 mm, greater than 30 mm, greater than 40 mm, greater than 50 mm, greater than 70 mm, greater than 100 mm, greater than 150 mm, less than 200 mm, less than 150 mm, less than 100 mm, less than 70 mm, less than 50 mm, less than 40 mm, less than 30 mm, less than 20 mm, 10-200 mm, 20-100 mm, 20-70 mm, about 20 mm, and/or about 50 mm.**

The interior of the outlet section at an/the outlet downstream end may have a lateral width and a transverse breadth, wherein the lateral width may be larger than the transverse breadth, and optionally wherein the ratio of the transverse breadth to the lateral width may be less than **50%, less than 40%, less than 30%, less than 25%, less than 20%, less than 15%, less than 12%, less than 10%, less than 8%, less than 7%, less than 6%, less than 5%, less than 4%, 4-40%, 5-25%, 10-25%, about 25%, about 20%, about 15%, and/or about 12%.**

A lateral width of the interior of the outlet section at an/the outlet downstream end may be greater than **100 mm, greater than 200 mm, greater than 300 mm, greater than 400 mm, greater than 500 mm, less than 500 mm, less than 400 mm, less than 300 mm, less than 200 mm, 100-500 mm, 200-300 mm, and/or about 280 mm.**

A transverse breadth of the interior of the outlet section at an/the outlet downstream end may be greater than **10 mm, greater than 20 mm, greater than 30 mm, greater than 40 mm, greater than 50 mm, greater than 70 mm, greater than 100 mm, greater than 150 mm, less than 200 mm, less than 150 mm, less than 100 mm, less than 70 mm, less than 50 mm, less than 40 mm, less than 30 mm, less than 20 mm, 10-200 mm, 20-100 mm, 20-70 mm, about 20 mm, and/or about 50 mm.**

A lateral width of the interior of the outlet section at an/the outlet downstream end may be greater than a length of a/the outlet central axis, optionally wherein the ratio of

the length to the lateral width may be less than **80%**, less than **60%**, less than **50%**, less than **40%**, less than **30%**, less than **25%**, less than **20%**, **20-80%**, **25-60%**, about **60%**, about **50%**, and/or about **40%**.

5 The air diffuser may include an interior baffle that is downstream of the flow controller.

The interior baffle may be configured to restrict air flow from a/the neck upstream end to an/the outlet downstream end.

The interior baffle may be configured to create backpressure at a/the neck upstream end.

10 The interior baffle may be configured to spread air flow across a lateral width of the interior of an/the outlet downstream end.

The interior baffle may be configured to create a tortuous air flow path within the air diffuser.

15 The interior baffle may be configured to prevent direct transmission of upstream noise.

The interior baffle may be configured to redirect air flow to interact with the interior of the neck section, the interior of the outlet section, a/the neck sound dampening material, and/or a/the outlet sound dampening material.

20 The interior baffle may be proximate to a/the neck downstream end and proximate to an/the outlet upstream end.

The interior baffle may be operatively coupled to the neck section and/or the outlet section.

The interior baffle may be substantially perpendicular to or oblique to, a/the neck central axis, optionally wherein an angle between the interior baffle and the neck central

axis may be greater than **10°**, greater than **15°**, greater than **20°**, greater than **25°**, greater than **30°**, greater than **35°**, greater than **40°**, greater than **45°**, greater than **50°**, greater than **55°**, greater than **60°**, greater than **65°**, greater than **70°**, greater than **75°**, greater than **85°**, less than **90°**, less than **75°**, less than **70°**, less than **65°**, less than **60°**, less than **55°**, less than **50°**, less than **45°**, less than **40°**, less than **35°**, less than **30°**, less than **25°**, less than **20°**, less than **15°**, **10°-50°**, **15°-45°**, **20°-45°**, **25°-35°**, about **90°**, about **75°**, about **60°**, about **45°**, about **30°**, and/or about **15°**.

The interior baffle may be substantially perpendicular to or oblique to, an/the outlet central axis, optionally wherein an angle between the interior baffle and the outlet central axis is greater than **10°**, greater than **15°**, greater than **20°**, greater than **25°**, greater than **30°**, greater than **35°**, greater than **40°**, greater than **45°**, greater than **50°**, greater than **55°**, greater than **60°**, greater than **65°**, greater than **70°**, greater than **75°**, greater than **85°**, less than **90°**, less than **75°**, less than **70°**, less than **65°**, less than **60°**, less than **55°**, less than **50°**, less than **45°**, less than **40°**, less than **35°**, less than **30°**, less than **25°**, less than **20°**, less than **15°**, **10°-50°**, **15°-45°**, **20°-45°**, **25°-35°**, about **90°**, about **75°**, about **60°**, about **45°**, about **30°**, and/or about **15°**.

The interior baffle may be a baffle plate with a first end and a second end.

The baffle plate may be substantially flat.

The baffle plate may substantially span a lateral width of the interior of the neck section and/or a lateral width of the interior of the outlet section.

The baffle plate may be configured to substantially restrict air flow near the first end and/or the second end.

When the neck section includes neck sound dampening material, the neck sound dampening material may define a material gap near the first end of the baffle plate and/or near the second end of the baffle plate.

When the outlet section includes outlet sound dampening material, the outlet sound dampening material may define a material gap near the first end of the baffle plate and/or near the second end of the baffle plate.

5 The baffle plate may define a gap, optionally one gap, in the interior of the neck section and/or the interior of the outlet section.

The gap may substantially span a lateral width of the interior of the neck section and/or a lateral width of the interior of the outlet section.

10 The gap may have an open area that may be less than **50%**, less than **40%**, less than **35%**, less than **30%**, less than **25%**, less than **20%**, less than **15%**, less than **12%**, less than **10%**, less than **8%**, greater than **5%**, greater than **8%**, greater than **10%**, greater than **12%**, greater than **15%**, greater than **20%**, greater than **25%**, greater than **30%**, greater than **35%**, greater than **40%**, **5-50%**, **8-30%**, **8-20%**, **10-35%**, about **8%**, about **10%**, about **12%**, about **15%**, about **20%**, about **25%**, about **30%**, and/or about **33%** of an open area of a/the outlet downstream end.

15 The gap may be proximate to an interior surface of the neck section and/or an interior surface of the outlet section, optionally wherein the interior surface of the neck section and/or the interior surface of the outlet section may be substantially flat near the gap, has a curvature away from the baffle plate, and/or has a curvature toward the baffle plate.

20 The baffle plate may have a third end near the gap and a fourth end opposite the third end, wherein the third end is upstream or downstream of the fourth end.

The baffle plate may have a third end near the gap that is configured to smoothly split air flow.

25 The baffle plate may have a third end near the gap that is wedge-shaped, rounded and/or bulbous.

The air diffuser may be configured to flow air at greater than **700 g/min**, greater than **800 g/min**, greater than **900 g/min**, greater than **1,000 g/min**, greater than **1,100 g/min**, greater than **1,200 g/min**, less than **1,500 g/min**, less than **1,200 g/min**, **800-1,200 g/min**, greater than **800 L/min**, greater than **900 L/min**, greater than **1,000 L/min**, greater than **1,100 L/min**, greater than **1,200 L/min**, greater than **1,300 L/min**, less than **1,500 L/min**, less than **1,300 L/min**, and/or **900-1,300 L/min**.

The air diffuser may be configured to generate a sound level that is less than **20 dB**, less than **10 dB**, less than **5 dB**, less than **3 dB**, less than **2 dB**, or less than **1 dB** more than ambient aircraft cabin noise when air flows through the inlet section to the outlet section, and optionally wherein the sound level may include the sound level at frequencies of **0.1 kHz**, **0.2 kHz**, **0.5 Hz**, **1 kHz**, **2 kHz**, **3 kHz**, **4 kHz**, **5 kHz**, **8 kHz**, **10 kHz**, **12 kHz**, **15 kHz**, **20 kHz**, **0.1-10 kHz**, **0.5-4 kHz**, **1-4 kHz**, **2-4 kHz**, **3-10 kHz**, **5-10 kHz**, greater than **5 kHz**, and/or greater than **8 kHz**.

The air diffuser may be configured to generate a speech interference level of less than **55 dB**, less than **52 dB**, less than **50 dB**, less than **48 dB**, less than **46 dB**, or less than **44 dB** when air flows through the inlet section to the outlet section.

In another embodiment, there is provided an aircraft air conditioning system which may include the aircraft cabin air diffuser, as described above. The aircraft air conditioning system may be configured to supply air through the aircraft cabin air diffuser.

In another embodiment, there is provided an aircraft comprising a plurality of the aircraft cabin air diffusers of any described above.

The aircraft may include less than one aircraft cabin air diffuser for every two rated occupants, for every three rated occupants, and/or for every four rated occupants, and optionally wherein the aircraft includes less than **0.5**, less than **0.4**, less than **0.37**, less than **0.33**, less than **0.30**, less than **0.28**, less than **0.26**, less than **0.24**, less than

0.22, less than **0.2**, about **0.4**, about **0.37**, about **0.33**, about **0.3**, about **0.25**, and/or about **0.22** air diffusers per rated occupant.

The aircraft may be configured to maintain an aircraft cabin pressure of greater than **60 kPa**, greater than **70 kPa**, greater than **75 kPa**, greater than **80 kPa**, greater than **90 kPa**, greater than **100 kPa**, less than **120 kPa**, less than **100 kPa**, less than **80 kPa**, **70-80 kPa**, **70-90 kPa**, **70-102 kPa**, about **90 kPa**, about **80 kPa**, and/or about **75 kPa**.

In another embodiment, there is provided a method of supplying air to an aircraft cabin, including supplying air through the aircraft cabin air diffuser as described of.

10 The supplying may include supplying while the aircraft is in flight.

The supplying may include flowing air through the aircraft cabin air diffuser at greater than **700 g/min**, greater than **800 g/min**, greater than **900 g/min**, greater than **1,000 g/min**, greater than **1,100 g/min**, greater than **1,200 g/min**, less than **1,500 g/min**, less than **1,200 g/min**, **800-1,200 g/min**, greater than **800 L/min**, greater than **900 L/min**, 15 greater than **1,000 L/min**, greater than **1,100 L/min**, greater than **1,200 L/min**, greater than **1,300 L/min**, less than **1,500 L/min**, less than **1,300 L/min**, and/or **900-1,300 L/min**.

The supplying may include supplying with a sound level less than **20 dB**, less than **10 dB**, less than **5 dB**, less than **3 dB**, less than **2 dB**, or less than **1 dB** more than ambient aircraft cabin noise, and optionally wherein the sound level includes 20 frequencies of **0.1 kHz**, **0.2 kHz**, **0.5 kHz**, **1 kHz**, **2 kHz**, **3 kHz**, **4 kHz**, **5 kHz**, **8 kHz**, **10 kHz**, **12 kHz**, **15 kHz**, **20 kHz**, **0.1-10 kHz**, **0.5-4 kHz**, **1-4 kHz**, **2-4 kHz**, **3-10 kHz**, **5-10 kHz**, greater than **5 kHz**, and/or greater than **8 kHz**.

The supplying may include supplying with a speech interference level less than **55 dB**, less than **52 dB**, less than **50 dB**, less than **48 dB**, less than **46 dB**, or less than 25 **44 dB**.

The aircraft cabin may include occupants, and wherein the supplying may include using less than one aircraft cabin air diffuser for every two occupants, for every three occupants, and/or for every four occupants, and optionally wherein the aircraft may include less than **0.5**, less than **0.4**, less than **0.37**, less than **0.33**, less than **0.30**, less than **0.28**, less than **0.26**, less than **0.24**, less than **0.22**, less than **0.2**, about **0.4**, about **0.37**, about **0.33**, about **0.3**, about **0.25**, and/or about **0.22** air diffusers per rated occupant.

The method may involve maintaining a pressure in the aircraft cabin of greater than about **60 kPa**, greater than **70 kPa**, greater than **75 kPa**, greater than **80 kPa**, greater than **90 kPa**, greater than **100 kPa**, less than **120 kPa**, less than **100 kPa**, less than **80 kPa**, **70-80 kPa**, **70-90 kPa**, **70-102 kPa**, about **90 kPa**, about **80 kPa**, and/or about **75 kPa**.

As used herein, the terms “adapted” and “configured” mean that the element, component, or other subject matter is designed and/or intended to perform a given function. Thus, the use of the terms “adapted” and “configured” should not be construed to mean that a given element, component, or other subject matter is simply “capable of” performing a given function but that the element, component, and/or other subject matter is specifically selected, created, implemented, utilized, programmed, and/or designed for the purpose of performing the function. It is also within the scope of the present disclosure that elements, components, and/or other recited subject matter that is recited as being adapted to perform a particular function may additionally or alternatively be described as being configured to perform that function, and vice versa. Similarly, subject matter that is recited as being configured to perform a particular function may additionally or alternatively be described as being operative to perform that function. Further, as used herein, the singular forms “a”, “an” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise.

The various disclosed elements of apparatuses and steps of methods disclosed herein are not required of all apparatuses and methods according to the present

disclosure, and the present disclosure includes all novel and non-obvious combinations and subcombinations of the various elements and steps disclosed herein. Moreover, one or more of the various elements and steps disclosed herein may define independent inventive subject matter that is separate and apart from the whole of a disclosed apparatus or method. Accordingly, such inventive subject matter is not required to be associated with the specific apparatuses and methods that are expressly disclosed herein, and such inventive subject matter may find utility in apparatuses and/or methods that are not expressly disclosed herein.

In the event that any patents or patent applications are incorporated by reference herein and (1) define a term in a manner and/or (2) are otherwise inconsistent with either the non-incorporated portion of the present disclosure or with any of the other incorporated references, the non-incorporated portion of the present disclosure shall control, and the term or incorporated disclosure therein shall only control with respect to the reference in which the term is defined and/or the incorporated disclosure was originally present.

EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An aircraft cabin air diffuser comprising:

an inlet section with an open interior;

5 a neck section with an open interior, downstream of the inlet section;

an outlet section with an open interior, wherein the outlet section is downstream of the neck section; and

10 a flow controller within the open interior of the neck section, wherein the flow controller is a passive pressure controller configured to affect air flow through the passive pressure controller in response to an air pressure differential across the passive pressure controller.

15 2. The air diffuser of claim 1, wherein the passive pressure controller is configured to maintain a substantially constant air flow of greater than **700** grams per minute (g/min) through the passive pressure controller when an air pressure in the inlet section is greater than a predefined threshold of greater than **60** kilopascals (kPa).

3. The air diffuser of claim 1 or 2, wherein the passive pressure controller is configured to be actuated by air pressure in the inlet section.

20 4. The air diffuser of any one of claims 1 to 3, wherein the passive pressure controller is configured to be actuated by air velocity through the passive pressure controller.

5. The air diffuser of any one of claims 1 to 4, wherein the passive pressure controller defines one or more flow channels.

6. The air diffuser of any one of claims 1 to 4, wherein the passive pressure controller includes one or more vanes that define one or more flow channels.
7. The air diffuser of claim 6, wherein the one or more vanes are configured to decrease an open area of the one or more flow channels in response to an increase in an air pressure differential from the inlet section to the outlet section.
8. The air diffuser of claim 6 or 7, wherein the one or more vanes are biased to maintain the one or more flow channels in an open state in the absence of an air pressure differential between the inlet section and the outlet section.
9. The air diffuser of any one of claims 6 to 8, wherein the passive pressure controller has an upstream end and a downstream end, wherein at least one vane is configured to elastically deform in response to an air pressure differential, from the upstream end of the passive pressure controller to the downstream end of the passive pressure controller, of 2-10 kPa.
10. The air diffuser of any one of claims 1 to 9, wherein the flow controller is configured to create an air pressure differential of 2-10 kPa from an upstream end of the flow controller to a downstream end of the flow controller.
11. The air diffuser of any one of claims 1 to 10, wherein the air diffuser is configured to generate a speech interference level of less than 50 decibels (dB) when air flows through the inlet section to the outlet section at a rate of greater than 700 g/min.
12. The air diffuser of any one of claims 1 to 11, wherein the inlet section has an open interior profile that is substantially round, and wherein the outlet section has an open interior profile that is substantially oblong.
13. The air diffuser of any one of claims 1 to 12, wherein the flow controller is a vortex inducer.

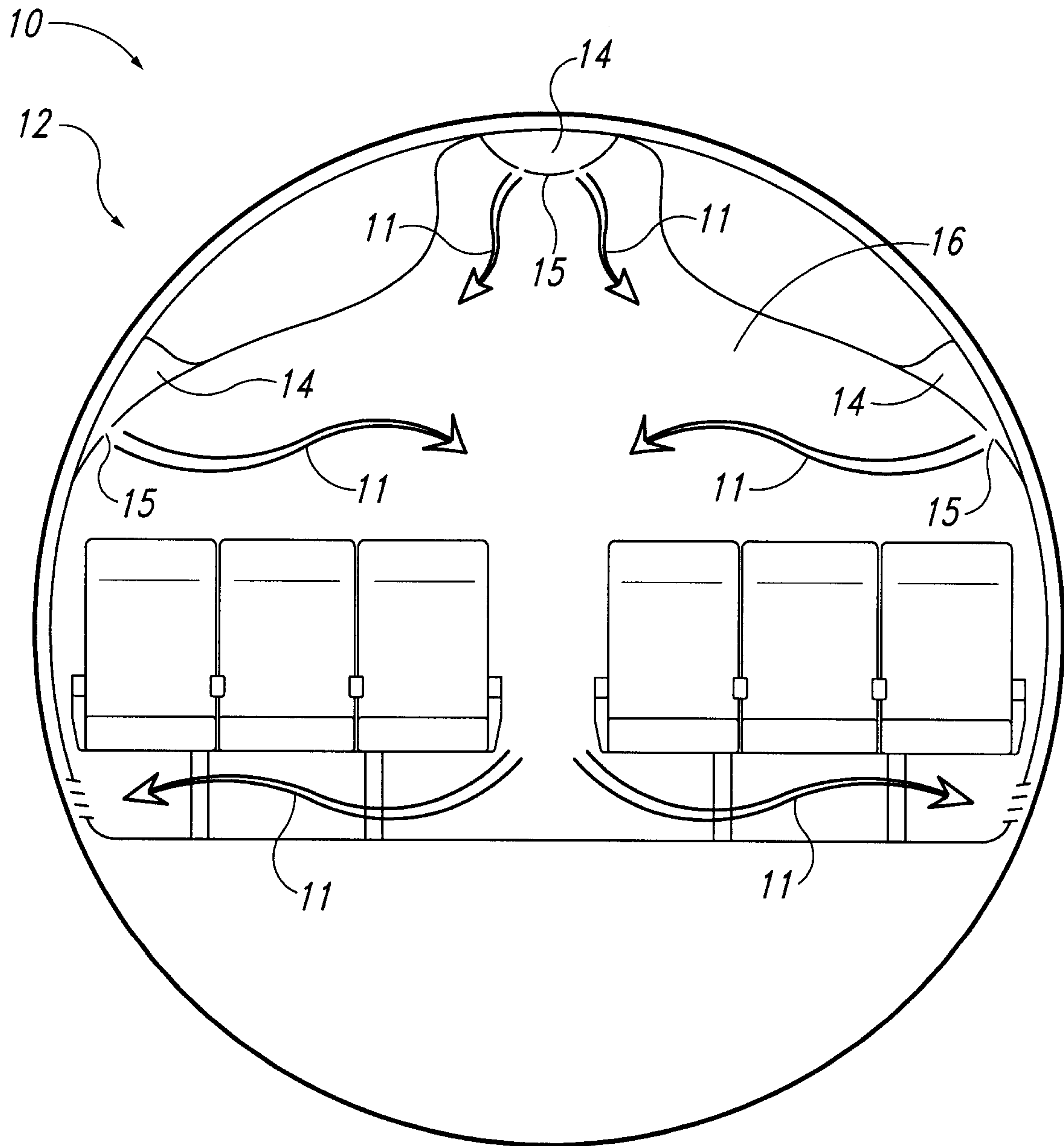
14. The air diffuser of claim **13**, wherein the vortex inducer is configured to create a vortex of air in the neck section.
15. The air diffuser of claim **13** or **14**, wherein the vortex inducer is configured to induce tangential air flow as air passes through the vortex inducer.
- 5 16. The air diffuser of any one of claims **13** to **15**, wherein the vortex inducer has an effective diameter, wherein the air diffuser has an air channel length downstream of the vortex inducer, and wherein a ratio of the effective diameter to the air channel length is less than **20%**.
- 10 17. An aircraft comprising a plurality of the aircraft cabin air diffusers of any one of claims **1** to **16**, wherein the air diffusers are configured to flow air at a rate of greater than **700** g/min with a speech interference level less than **50** dB.
18. The aircraft of claim **17**, wherein the aircraft is configured to maintain an aircraft cabin pressure of **70-102** kPa.
19. An aircraft cabin air diffuser comprising:
 - 15 an inlet section with an open interior;
 - a neck section with an open interior, downstream of the inlet section;
 - an outlet section with an open interior, wherein the outlet section is downstream of the neck section; and
 - 20 a flow controller within the open interior of the neck section, wherein the flow controller is a vortex inducer with an effective diameter, wherein the air diffuser has an air channel length downstream of the vortex inducer, and wherein a ratio of the effective diameter to the air channel length is less than **20%**.

20. The air diffuser of claim **19**, wherein the vortex inducer is configured to create a vortex of air in the neck section.

21. The air diffuser of claim **19** or **20**, wherein the vortex inducer is configured to induce tangential air flow as air passes through the vortex inducer, wherein a ratio of tangential air flow to axial air flow is at least **0.2**.

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*Fig. 1*

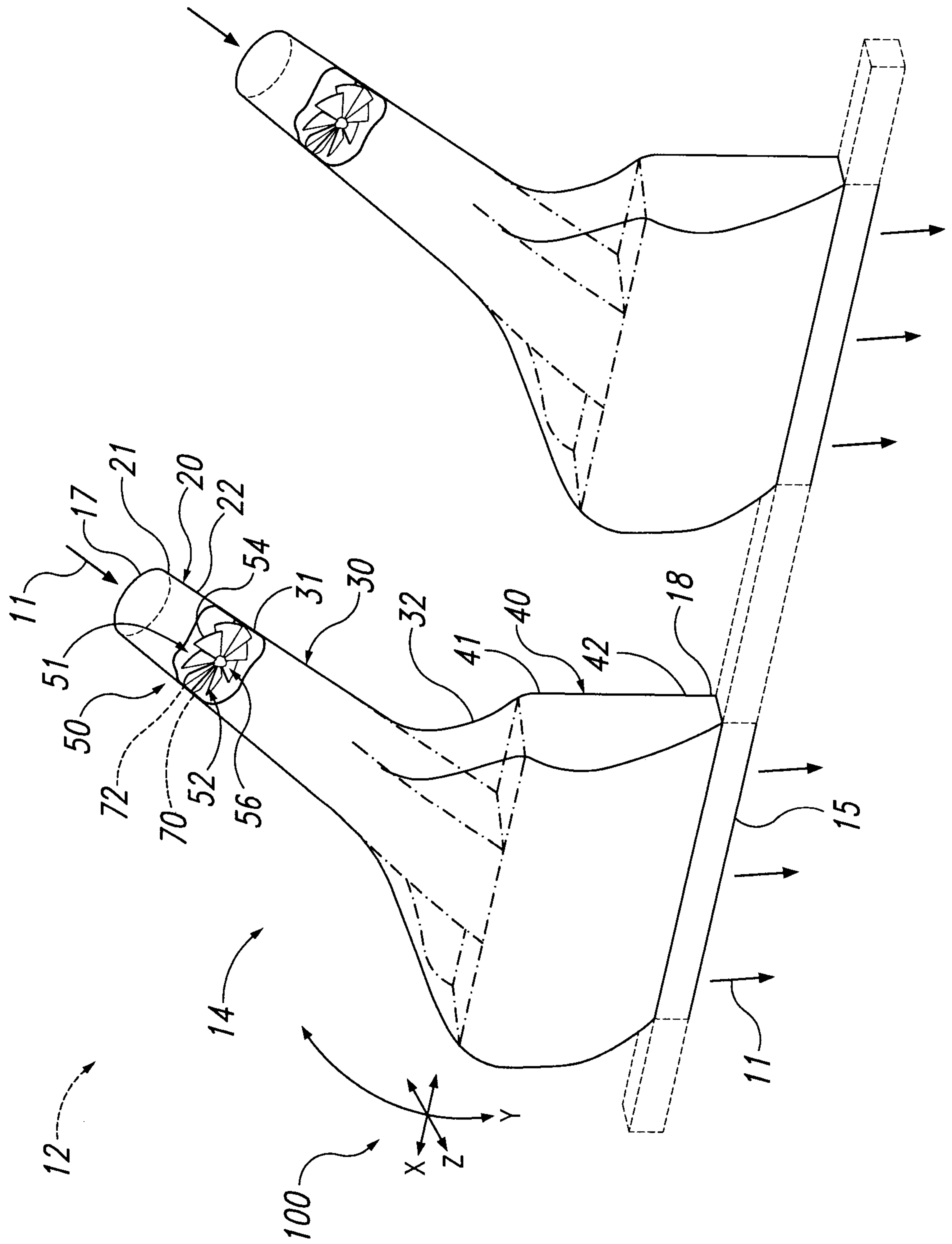


Fig. 2

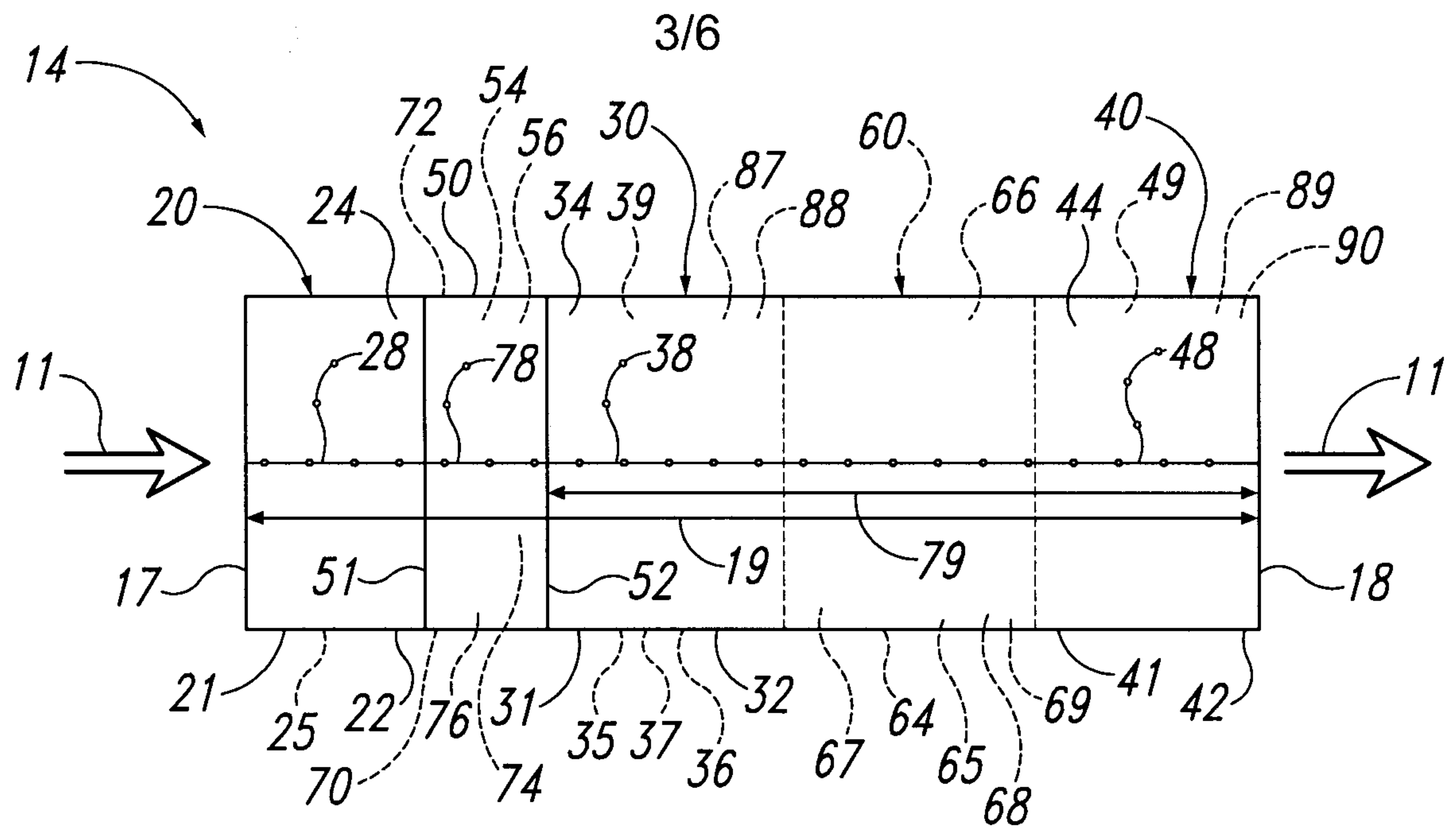


Fig. 3

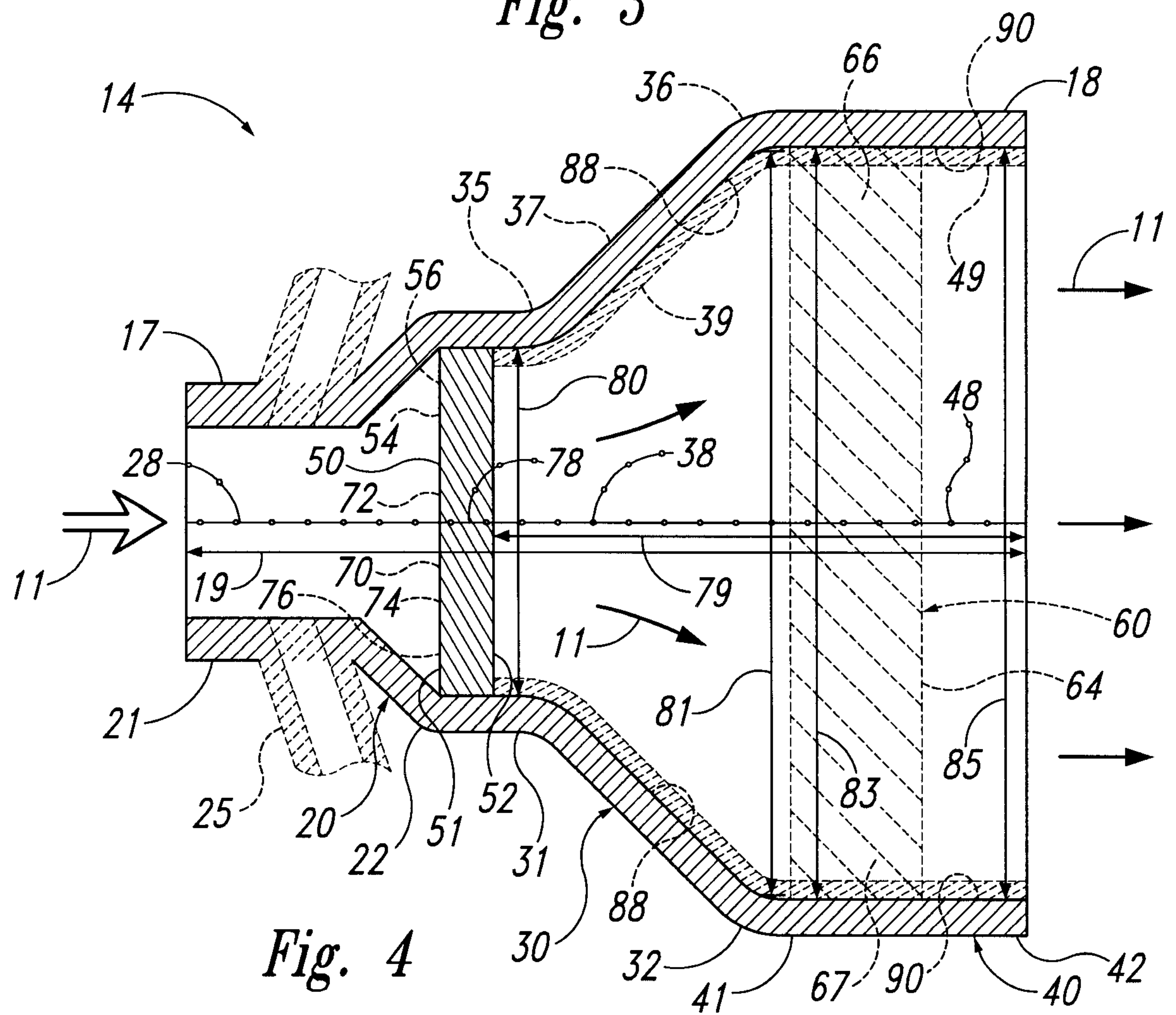


Fig. 4

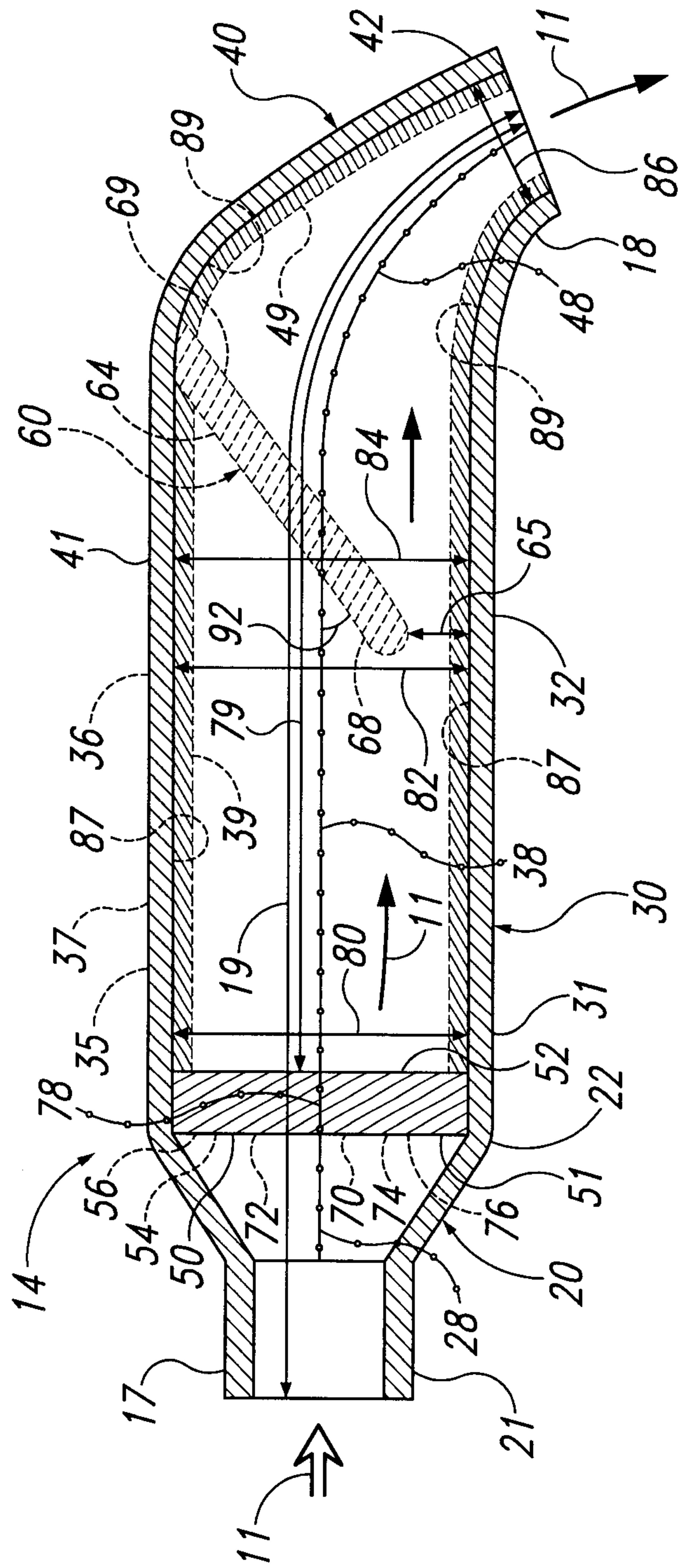
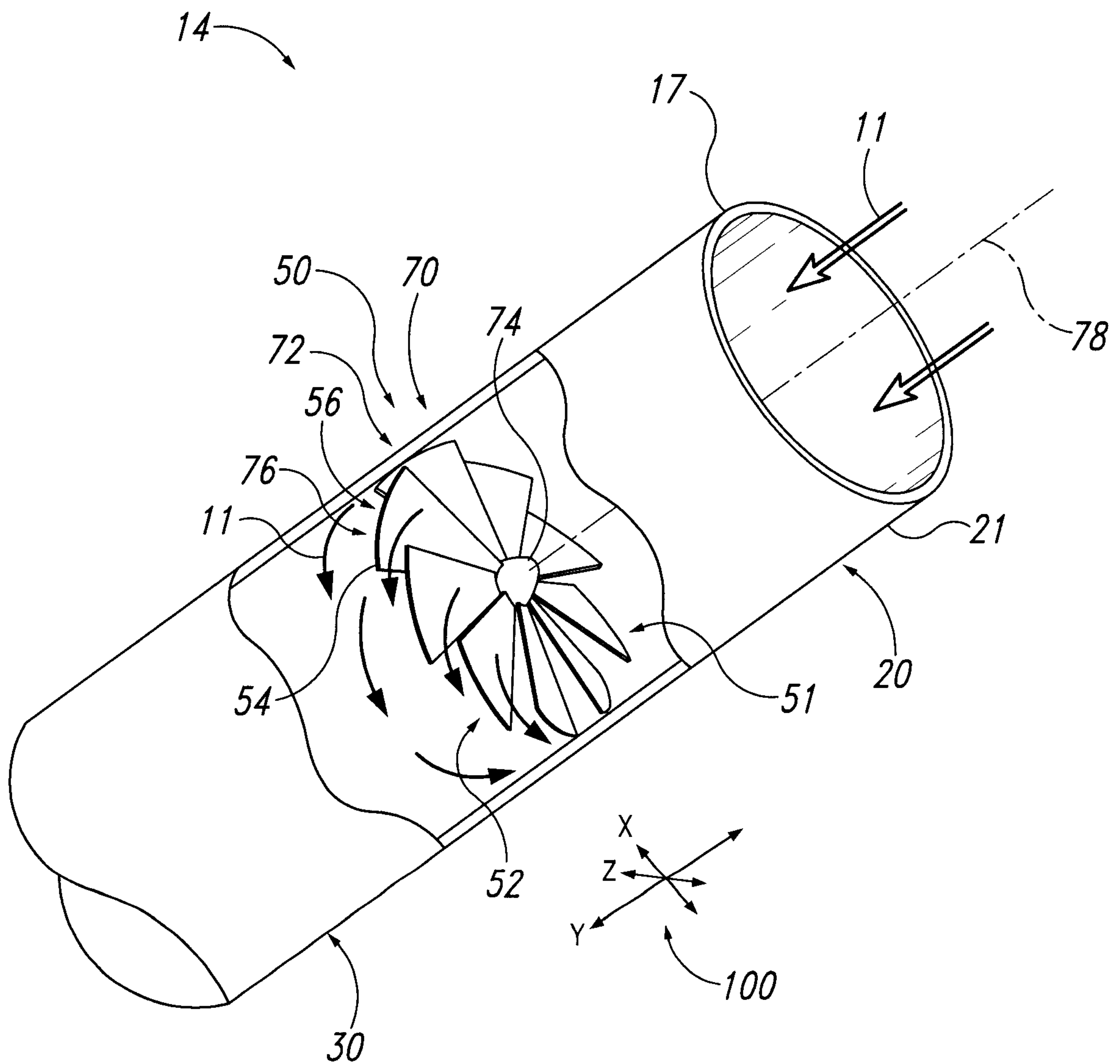
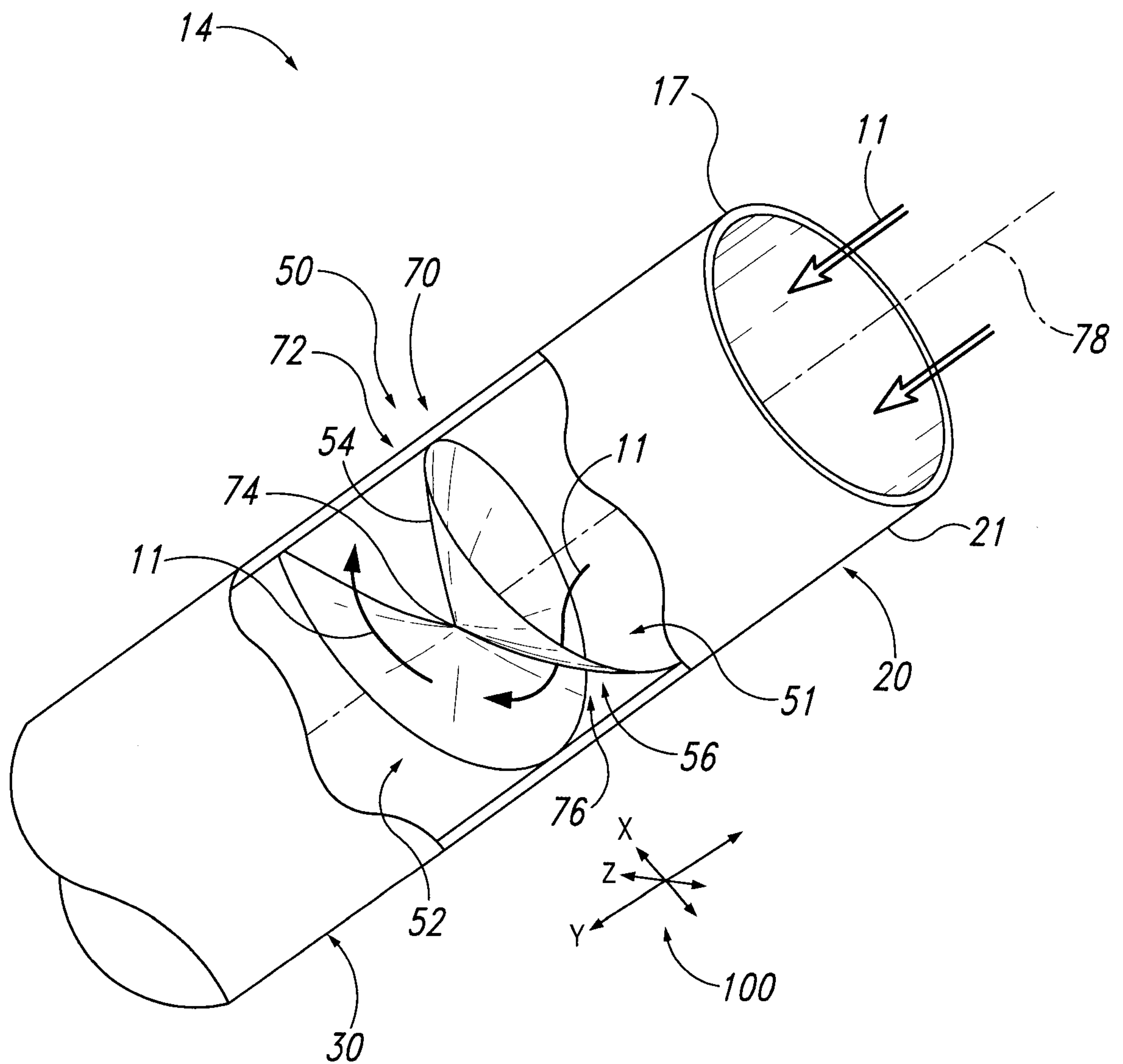


Fig. 5

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*Fig. 6*

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*Fig. 7*

