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(54) **VENTILATOR UNITS, METHODS FOR PROVIDING VENTILATION IN RESPONSE TO HUMIDITY LEVELS, AND WALL UNITS**

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(57) **ABSTRACT**

Ventilator units, and methods for their use, are provided. Each of the ventilator units comprises a first flexible film, a second flexible film disposed opposite the first flexible film and attached to the first flexible film at at least two points, a first swellable portion attached to the first flexible film, and a second swellable portion attached to the second flexible film.

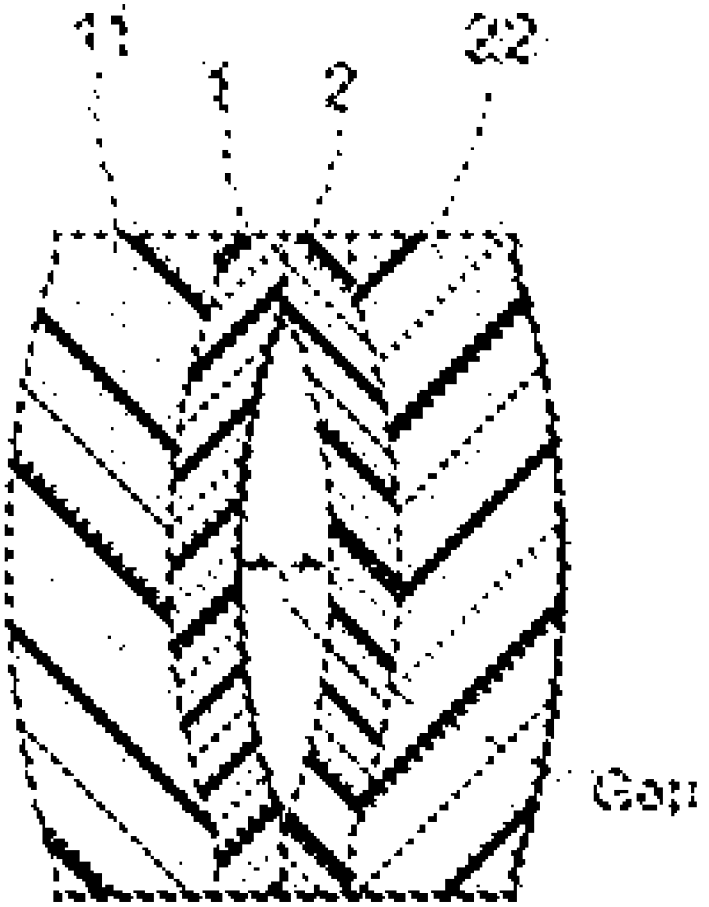
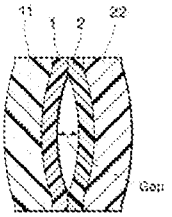


Fig. 1

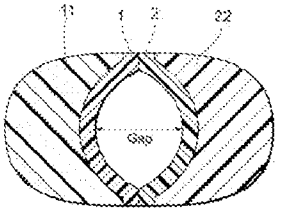
[Fig. 1]

Fig.1



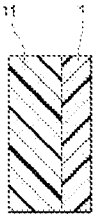
[Fig. 2]

Fig.2



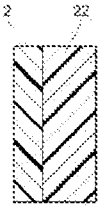
[Fig. 3]

Fig.3



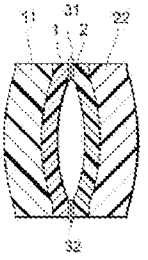
[Fig. 4]

Fig.4



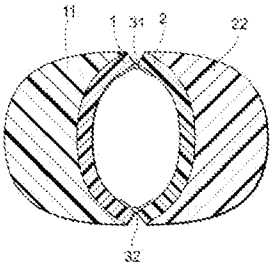
[Fig. 5]

Fig.5



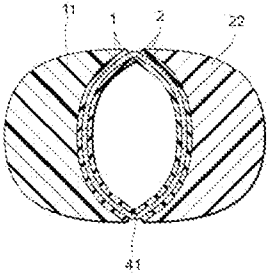
[Fig. 6]

Fig.6



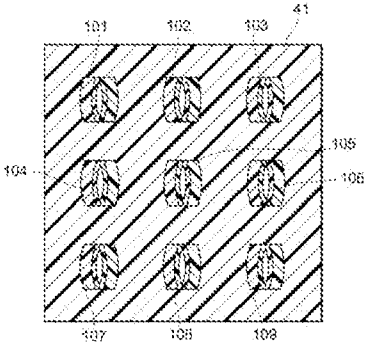
[Fig. 7]

Fig.7



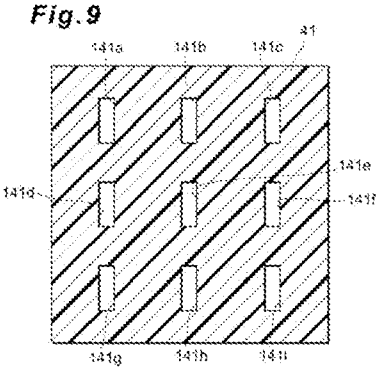
[Fig. 8]

Fig.8



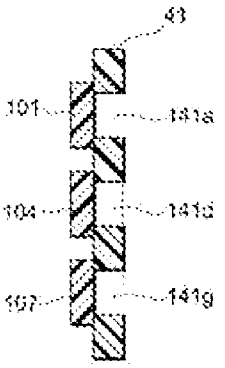
[Fig. 9]

Fig.9



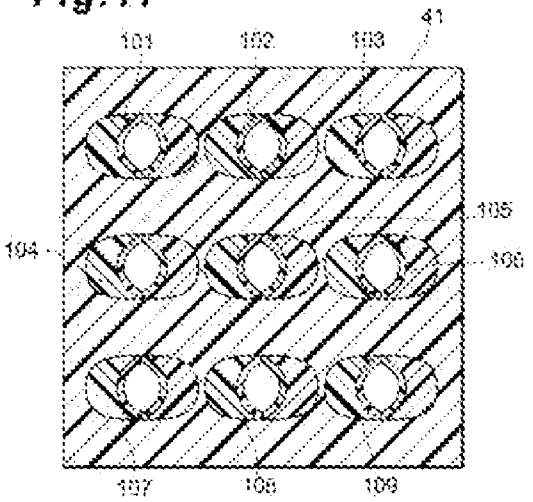
[Fig. 10]

Fig. 10



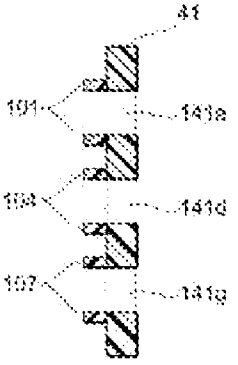
[Fig. 11]

Fig. 11



[Fig. 12]

Fig. 12



VENTILATOR UNITS, METHODS FOR PROVIDING VENTILATION IN RESPONSE TO HUMIDITY LEVELS, AND WALL UNITS

TECHNICAL FIELD

[0001] Ventilator units, methods for providing ventilation in response to humidity levels, and wall units are disclosed.

BACKGROUND

[0002] It is desirable to regulate airflow in response to humidity levels in order to maintain the air quality inside buildings. Conventional ventilators are connected to sensors to detect and respond to humidity levels. Alternatively, conventional ventilators are manually operated by an occupant of the building. Therefore, the conventional ventilators do not spontaneously ventilate the room in response to the humidity levels. Further, the conventional ventilators ventilate the room by using a fan, for example. Therefore, the conventional ventilators consume power and do not operate in the absence of electricity.

SUMMARY

[0003] An aspect of the present disclosure relates to a ventilator unit. The ventilator unit comprises a first flexible film, a second flexible film disposed opposite the first flexible film and attached to the first flexible film at at least two points, a first swellable portion attached to the first flexible film, and a second swellable portion attached to the second flexible film.

[0004] Another aspect of the present disclosure relates to a method for providing ventilation in response to humidity levels. The method comprises: providing a ventilator unit comprising a first flexible film, a second flexible film disposed opposite the first flexible film and attached to the first flexible film at at least two points, a first swellable portion attached to the first flexible film, and a second swellable portion attached to the second flexible film, wherein the first flexible film and the second flexible film define a gap; increasing a distance between the first flexible film and the second flexible film by swelling the first swellable portion and the second swellable portion in response to an increase in humidity; and passing air through the gap.

[0005] Yet another aspect of the present disclosure relates to a wall unit comprising a plurality of ventilator units. Each of the plurality of ventilator units comprises a first flexible film, a second flexible film disposed opposite the first flexible film and attached to the first flexible film at at least two points, a first swellable portion attached to the first flexible film, and a second swellable portion attached to the second flexible film.

BRIEF DESCRIPTION OF DRAWINGS

[0006] FIG. **1** shows a ventilator unit.

[0007] FIG. **2** shows the ventilator unit when a first swellable portion and a second swellable portion swell in response to an increase in humidity.

[0008] FIG. **3** shows a first subunit of the ventilator unit.

[0009] FIG. **4** shows a second subunit of the ventilator unit.

[0010] FIG. **5** shows a ventilator unit having hinges.

[0011] FIG. **6** shows the ventilator unit having hinges when the first swellable portion and the second swellable portion swell in response to an increase in humidity.

[0012] FIG. **7** shows a ventilator unit having a metal portion.

[0013] FIG. **8** shows a wall unit having a plurality of ventilator units.

[0014] FIG. **9** shows a panel of the wall unit.

[0015] FIG. **10** shows a cross-sectional view of the wall unit having the plurality of ventilator units.

[0016] FIG. **11** shows the wall unit having the plurality of ventilator units when the first swellable portions and the second swellable portions swell in response to an increase in humidity.

[0017] FIG. **12** shows a cross-sectional view of the wall unit having the plurality of ventilator units when the first swellable portions and the second swellable portions swell in response to an increase in humidity.

DETAILED DESCRIPTION

[0018] With reference to FIG. **1**, a ventilator unit can include a first flexible film **1**, a second flexible film **2** disposed opposite the first flexible film **1** and attached to the first flexible film **1** at at least two points, a first swellable portion **11** attached to the first flexible film **1**, and a second swellable portion **22** attached to the second flexible film **2**. The first flexible film **1** and the second flexible film **2** define a gap. The first swellable portion **11** is configured to swell in response to an increase in humidity. Also, the second swellable portion **22** is configured to swell in response to an increase in humidity. The ventilator can operate without the use of electricity or other external power sources.

[0019] When the first swellable portion **11** and the second swellable portion **22** swell in response to an increase in humidity, a distance between the first flexible film **1** and the second flexible film **2** increases, as shown in FIG. **2**. Likewise, when the first swellable portion **11** and the second swellable portion **22** contract in response to a decrease in humidity, the distance between the first flexible film **1** and the second flexible film **2** decreases, as shown in FIG. **1**. Therefore, the ventilator unit allows air to pass through the gap between the first flexible film **1** and the second flexible film **2** when the humidity levels are high. However, the ventilator unit prevents the air from passing through the gap between the first flexible film **1** and the second flexible film **2** when the humidity levels are low. Accordingly, a decrease in humidity will cause the distance between the first flexible film **1** and second flexible film **2** to decrease, decreasing or eliminating the flow of air through the gap. An increase in humidity will cause the distance between the first flexible film **1** and second flexible film **2** to increase, increasing or allowing the flow of air through the gap. The ventilator unit can allow the flow of air to be stepwise in an on/off manner, or can allow the flow of air to gradually increase or decrease in response to changes in humidity.

[0020] The first flexible film **1** is configured to not swell in response to an increase in humidity. Also, the second flexible film **2** is configured to not swell in response to an increase in humidity. The first flexible film **1** and second flexible film **2** can generally be made of any material that is flexible but does not swell in response to an increase in humidity. The first flexible film **1** and the second flexible film **2** can be made of the same material, or of different materials. The first flexible film **1** and the second flexible film **2** can generally be made of any type of resin that does not swell in response to an increase in humidity. An example of a suitable resin is polyethylene. Alternatively, each of the first flexible film **1** and the second flexible film **2** contains or is a moisture permeable material having a formability property such as ethylene-vinyl acetate

copolymer, ethylene-vinyl alcohol copolymer, polymethyl methacrylate, polyethylene terephthalate, or a mixture of these compounds, for example.

[0021] The first swellable portion **11** facially makes contact with the first flexible film **1**. Also, the second swellable portion **22** facially makes contact with the second flexible film **2**. The first swellable portion **11** and second swellable portion **22** can generally be made of any material that swells in response to an increase in humidity. The first swellable portion **11** and second swellable portion **22** can be made of the same material, or of different materials. Each of the first swellable portion **11** and the second swellable portion **22** can contain or is a hygroscopic swellable material such as polysaccharide, cellulose derivative, polyacrylic acid, polyacrylate, polyalkylene oxide, polyvinylpyrrolidone, inorganic water absorption material, or a mixture of these compounds, for example. Polyvinylpyrrolidone is a specific example of such a material. When the relative humidity is 60%, polyvinylpyrrolidone can absorb 20% of its own weight of water. When the relative humidity is 80%, polyvinylpyrrolidone can absorb 40% of its own weight of water.

[0022] Examples of suitable polysaccharides include cellulose and starch. Examples of suitable cellulose derivatives include carboxymethyl cellulose and hydroxyethyl cellulose. When the relative humidity is 60%, carboxymethyl cellulose can absorb 30% of its own weight of water. When the relative humidity is 80%, carboxymethyl cellulose can absorb 70% of its own weight of water. Examples of inorganic water absorption materials include active aluminum oxide, clay, kaolin, talc, bentonite, sepiolite, and aluminum silicate.

[0023] Each of the first swellable portion **11** and the second swellable portion **22** can consist of only the hygroscopic swellable materials described above, or can contain additional materials. Alternatively, each of the first swellable portion **11** and the second swellable portion **22** may further contain a moisture permeable material having a formability property such as ethylene-vinyl acetate copolymer, ethylene-vinyl alcohol copolymer, polymethyl methacrylate, polyethylene terephthalate, or a mixture of these compounds, for example. The moisture permeable materials may be mixed into the hygroscopic swellable materials, for example.

[0024] The surface of first flexible film **1** may be applied by various methods such as coating or spraying with the hygroscopic swellable material and the moisture permeable material to form the first swellable portion **11**, for example. Alternatively, the first swellable portion **11** may be formed as a film. Thereafter, the first swellable portion **11** may be laminated with the first flexible film **1**.

[0025] The surface of second flexible film **2** may be applied by various methods such as coating or spraying with the hygroscopic swellable material and the moisture permeable material to form the second swellable portion **22**, for example. Alternatively, the second swellable portion **22** may be formed as a film. Thereafter, the second swellable portion **22** may be laminated with the second flexible film **2**.

[0026] The first flexible film **1** and the first swellable portion **11** constitute a first subunit of the ventilator unit, as shown in FIG. **3**. The second flexible film **2** and the second swellable portion **22** constitute a second subunit of the ventilator unit, as shown in FIG. **4**. With reference again to FIG. **1**, the second subunit is attached to the first subunit at at least two points by various methods such as welding and gluing to define the gap.

[0027] The first swellable portion **11** and the second swellable portion **22** contract when the humidity levels are decreased. In this case, the first flexible film **1** makes contact with or approaches second flexible film **2**. Therefore, the ventilator reduces air flow or prevents the air from passing through the gap between the first flexible film **1** and the second flexible film **2**.

[0028] When the humidity levels are increased, the first swellable portion **11** and the second swellable portion **22** swell upon absorbing water. Therefore, each volume of the first swellable portion **11** and the second swellable portion **22** increases. Although each volume of the first flexible film **1** and the second flexible film **2** does not change in response to the humidity, the first flexible film **1** and the second flexible film **2** are flexible and deformable. Accordingly, when the first swellable portion **11** swells, the first subunit bends away from the second subunit, as shown in FIG. **2**. Also, when the second swellable portion **22** swells, the second subunit bends away from the first subunit. Therefore, the gap between the first subunit and the second subunit spontaneously increases without energy consumption and an aperture is formed. Consequently, the ventilator unit allows air to pass through the aperture.

[0029] The ventilator unit may generally be any size. The ventilator unit may be of a sufficient size for passing air through the gap at high humidity. When the ventilator unit is used as a part of a wall as described below, the ventilator unit may be of a size that is small enough to prevent the interior of the building from being seen from the outside through the aperture of the ventilator unit if privacy is desired. An example of the width of the first flexible film **1** can be about 0.1 mm to about 1.0 mm. Also, an example of the width of the second flexible film **2** can be about 0.1 mm to about 1.0 mm.

[0030] The ratio of the volume of the first swellable portion **11** to the volume of the first flexible film **1** can generally be any ratio. Also, the ratio of the volume of the second swellable portion **22** to the volume of the second flexible film **2** can generally be any ratio. An example ratio of the volume of the first swellable portion **11** to the volume of the first flexible film **1** is from about 3:1 to about 99:1, since the large volume of the first swellable portion **11** makes the ventilator unit sensitive to the humidity. Also, an example ratio of the volume of the second swellable portion **22** to the volume of the second flexible film **2** is from about 3:1 to about 99:1.

[0031] With reference next to FIG. **5** and FIG. **6**, the ventilator unit can further include hinges **31**, **32**. The first flexible film **1** can be attached to the second flexible film **2** through the hinges **31**, **32**. The hinges **31**, **32** assist the first subunit and the second subunit in bending away from each other when there is high humidity. Alternatively, a single hinge may be used to attach the first flexible film **1** with the second flexible film **2** at one point and glue or other adhesive or fusion may be used at another point.

[0032] With reference next to FIG. **7**, the first flexible film **1** can include at least one metal portion **41**. Also, the second flexible film **2** can include at least one metal portion **41**. The metal portion **41** may assist the first subunit and the second subunit in bending away from each other when there is high humidity. The metal portion **41** can generally be made of any type of metal. If two metal portions are used, they can be made of the same or different materials. Examples of suitable metals include aluminum, stainless steel, copper, and shape-memory alloy.

[0033] With reference next to FIG. **8**, a wall unit can include a plurality of ventilator units **101-109**. While referred to herein as a wall unit, this can be used in a variety of structural construction configurations such as a wall configuration, ceiling configuration, roofing configuration, window configuration, and so on. While FIG. **8** depicts nine ventilator units, the wall unit can contain any number of ventilator units. Larger wall units will generally contain more ventilator units than will a smaller wall unit, but the spacing density of ventilator units in the wall unit can vary greatly. For example, the density of the plurality of ventilator units may be from about 10,000 units/m^2 to about 1,000,000 units/m^2. The plurality of ventilator units **101-109** may be arranged as an array on a panel **41**. The array can be a regular ordered array, or can be a random distribution. The wall unit can additionally contain a panel **41** having a plurality of holes **141***a*-**141***i*, as shown in FIG. **9**. The plurality of ventilator units **101-109** can be disposed on the panel **41** to align with or cover the plurality of holes **141***a*-**141***i*, respectively. The plurality of ventilator units **101-109** can be disposed apart from each other, for example, since the first swellable portions and the second swellable portions of the ventilator units **101-109** swell in response to an increase in humidity.

[0034] As shown in FIG. **10**, each of the plurality of ventilator units **101-109** can be attached to the panel **41** at both ends of the first flexible film and the second flexible film by various methods such as welding and gluing, for example. Alternatively, the ends of the first flexible film and second flexible film can be fused together. When the humidity levels are decreased, the plurality of ventilator units **101-109** reduce or prevent the passage of air through the plurality of holes **141***a*-**141***i*, as shown in FIG. **8** and FIG. **10**. Likewise, when the humidity levels are increased, the plurality of ventilator units **101-109** increase or allow the passage of air through the plurality of holes **141***a*-**141***i*, as shown in FIG. **11** and FIG. **12**. Therefore, the wall unit can spontaneously ensure proper airflow without energy consumption at high humidity. The wall unit can be used for any type of residential wall such as an interior wall, an exterior wall, a ceiling and a floor, for example.

[0035] Modifications and variations of the embodiments described above would be thought of by those skilled in the art, in the light of the above teachings. For example, the first flexible film can be or include a shape memory material and bends away from the second flexible film when the first swellable portion swells in response to an increase in humidity. Also, the second flexible film can be or include the shape memory material and bends away from the first flexible film when the second swellable portion swells in response to an increase in humidity. The scope of this disclosure is defined with reference to the following claims.

1. A ventilator unit comprising:
a first flexible film;
a second flexible film disposed opposite the first flexible film and attached to the first flexible film at at least two points;
a first swellable portion attached to the first flexible film; and
a second swellable portion attached to the second flexible film.

2. The ventilator unit of claim **1**, wherein the first swellable portion is configured to swell in response to an increase in humidity, and the second swellable portion is configured to swell in response to an increase in humidity.

3. The ventilator unit of claim **1**, wherein a distance between the first flexible film and the second flexible film increases when the first swellable portion and the second swellable portion swell in response to an increase in humidity.

4. The ventilator unit of claim **1**, wherein a distance between the first flexible film and the second flexible film decreases when the first swellable portion and the second swellable portion contract in response to a decrease in humidity.

5. The ventilator unit of claim **1**, wherein the first flexible film is attached to the second flexible film through at least one hinge.

6. The ventilator unit of claim **1**, wherein the first flexible film comprises shape memory material and is configured to bend away from the second flexible film when the first swellable portion swells in response to an increase in humidity.

7. The ventilator unit of claim **1**, wherein the second flexible film comprises shape memory material and is configured to bend away from the first flexible film when the second swellable portion swells in response to an increase in humidity.

8. The ventilator unit of claim **1**, wherein the first flexible film is configured to not swell in response to an increase in humidity, and the second flexible film is configured to not swell in response to an increase in humidity.

9. The ventilator unit of claim **1**, wherein the first flexible film comprises at least one metal portion, and the second flexible film comprises at least one metal portion.

10. The ventilator unit of claim **1**, wherein the first swellable portion is configured to swell upon absorbing water, and the second swellable portion is configured to swell upon absorbing water.

11. The ventilator unit of claim **1**, wherein the first flexible film and the first swellable portion facially contact, and wherein the second flexible film and the second swellable portion facially contact.

12. The ventilator unit of claim **1**, wherein the width of the first flexible film is about 0.1 mm to about 1.0 mm, and the width of the second flexible film is about 0.1 mm to about 1.0 mm.

13. The ventilator unit of claim **1**, wherein the first swellable portion and the second swellable portion comprise polysaccharide, cellulose derivative, polyacrylic acid, polyacrylate, polyalkylene oxide, polyvinylpyrrolidone, or inorganic material.

14. The ventilator unit of claim **13**, wherein the first swellable portion and the second swellable portion further comprise ethylene-vinyl acetate copolymer, ethylene-vinyl alcohol copolymer, polymethyl methacrylate, or polyethylene terephthalate.

15. The ventilator unit of claim **1**, wherein the first flexible film and the second flexible film comprise polyethylene.

16. A method for providing ventilation in response to humidity levels, the method comprising:
providing a ventilator unit comprising a first flexible film, a second flexible film disposed opposite the first flexible film and attached to the first flexible film at at least two points, a first swellable portion attached to the first flexible film, and a second swellable portion attached to the second flexible film, wherein the first flexible film and the second flexible film define a gap;

increasing a distance between the first flexible film and the second flexible film by swelling the first swellable portion and the second swellable portion in response to an increase in humidity; and

passing air through the gap.

17. The method of claim **16**, further comprising decreasing a distance between the first flexible film and the second flexible film in response to a decrease in humidity.

18. The method of claim **16**, wherein the first flexible film is attached to the second flexible film through at least one hinge.

19. The method of claim **16**, wherein the first flexible film comprises shape memory material and is configured to bend away from the second flexible film when the first swellable portion swells in response to an increase in humidity.

20. The method of claim **16**, wherein the second flexible film comprises shape memory material and is configured to bend away from the first flexible film when the second swellable portion swells in response to an increase in humidity.

21. The method of claim **16**, wherein the first flexible film is configured to not swell in response to an increase in humidity, and the second flexible film is configured to not swell in response to an increase in humidity.

22. The method of claim **16**, wherein the first flexible film comprises at least one metal portion, and the second flexible film comprises at least one metal portion.

23. The method of claim **16**, wherein the first flexible film and the first swellable portion facially contact, and wherein the second flexible film and the second swellable portion facially contact.

24. A wall unit comprising a plurality of ventilator units, wherein each of the plurality of ventilator units comprises:

a first flexible film;

a second flexible film disposed opposite the first flexible film and attached to the first flexible film at at least two points;

a first swellable portion attached to the first flexible film; and

a second swellable portion attached to the second flexible film.

25. The wall unit of claim **24**, wherein the first swellable portion is configured to swell in response to an increase in humidity, and the second swellable portion is configured to swell in response to an increase in humidity.

26. The wall unit of claim **24**, wherein a distance between the first flexible film and the second flexible film increases when the first swellable portion and the second swellable portion swell in response to an increase in humidity.

27. The wall unit of claim **24**, wherein a distance between the first flexible film and the second flexible film decreases when the first swellable portion and the second swellable portion contract in response to a decrease in humidity.

28. The wall unit of claim **24**, wherein the first flexible film is attached to the second flexible film through at least one hinge.

29. The wall unit of claim **24**, wherein the first flexible film comprises shape memory material and is configured to bend away from the second flexible film when the first swellable portion swells in response to an increase in humidity.

30. The wall unit of claim **24**, wherein the second flexible film comprises shape memory material and is configured to bend away from the first flexible film when the second swellable portion swells in response to an increase in humidity.

31. The wall unit of claim **24**, wherein the first flexible film is configured to not swell in response to an increase in humidity, and the second flexible film is configured to not swell in response to an increase in humidity.

32. The wall unit of claim **24**, wherein the first flexible film comprises at least one metal portion, and the second flexible film comprises at least one metal portion.

33. The wall unit of claim **24**, wherein the first swellable portion is configured to swell upon absorbing water, and the second swellable portion is configured to swell upon absorbing water.

34. The wall unit of claim **24**, wherein the first flexible film and the first swellable portion facially contact, and wherein the second flexible film and the second swellable portion facially contact.

35. The wall unit of claim **24**, further comprising a panel having a plurality of holes, wherein the plurality of ventilator units are disposed on the panel to align with or cover the plurality of holes.

* * * * *