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Kim

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(54) **FLUID MACHINE**

(71) Applicant: **HANWHA POWER SYSTEMS CO., LTD.**, Changwon-si (KR)

(72) Inventor: **Kil Young Kim**, Changwon-si (KR)

(73) Assignee: **HANWHA POWER SYSTEMS CO., LTD**, Changwon-si (KR)

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F04D 29/52	(2006.01)
F04D 17/10	(2006.01)
F04D 29/28	(2006.01)
F04D 29/42	(2006.01)

(52) **U.S. Cl.**
CPC ***F04D 29/685*** (2013.01); ***F04D 17/10*** (2013.01); ***F04D 29/284*** (2013.01); ***F04D 29/526*** (2013.01); ***F04D 29/665*** (2013.01); *F04D 29/4213* (2013.01); *Y10S 415/914* (2013.01)

(58) **Field of Classification Search**
CPC F04D 29/526; F04D 29/665; F04D 29/685; Y10S 415/914; F05D 2260/96
See application file for complete search history.

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Primary Examiner — Peter J Bertheaud
(74) *Attorney, Agent, or Firm* — Sighrue Mion, PLLC

(57) **ABSTRACT**

A fluid machine includes a rotatable hub; a plurality of blades spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and a shroud extending along a circumferential direction with respect to the rotation center of the hub and covering the plurality of blades. The shroud includes: a flow passage, the flow passage formed to be recessed with respect to an inner surface of the shroud facing the blades; and a plurality of resonators provided in the flow passage.

11 Claims, 10 Drawing Sheets

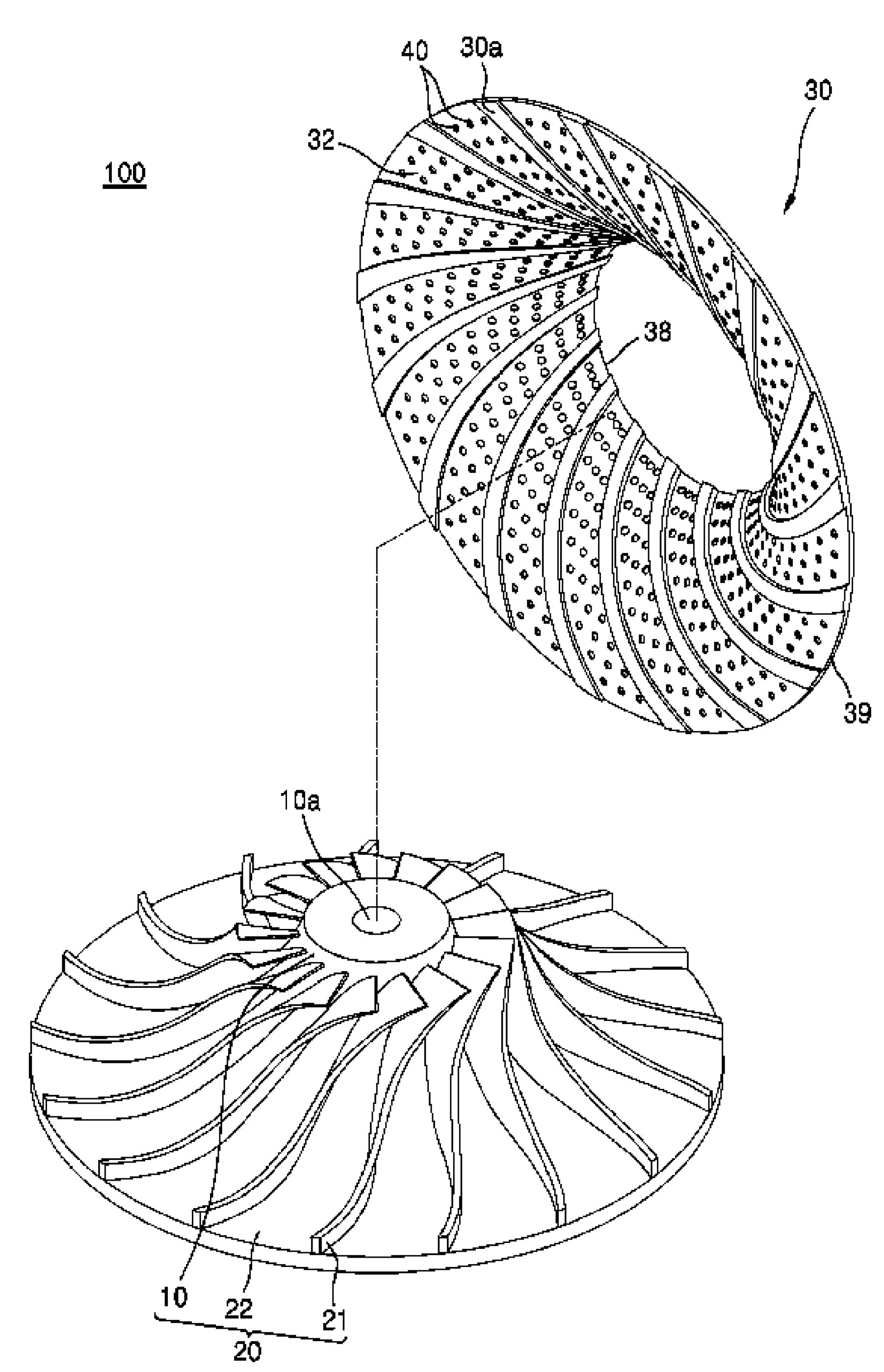

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FIG. 1

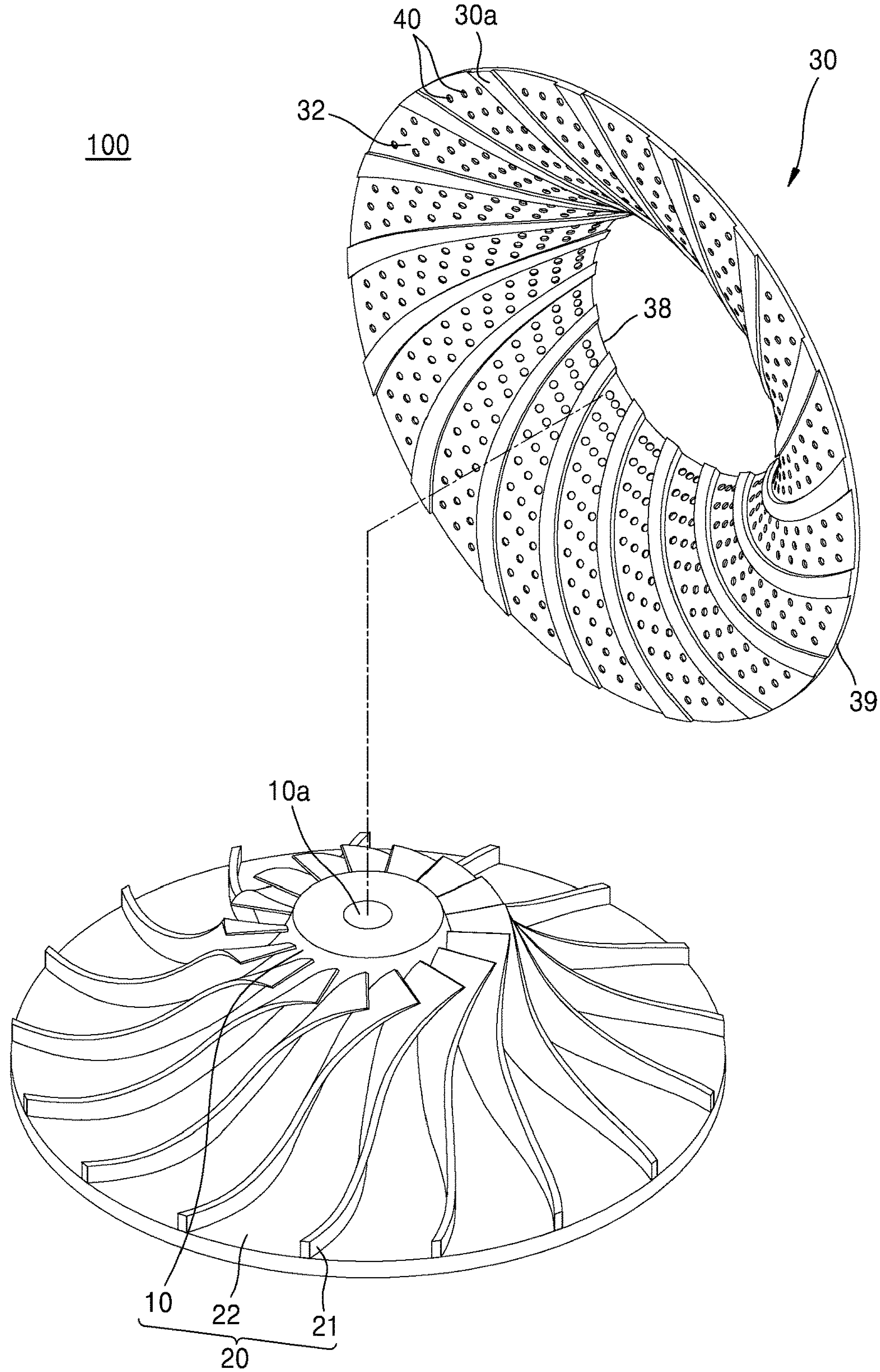


FIG. 2

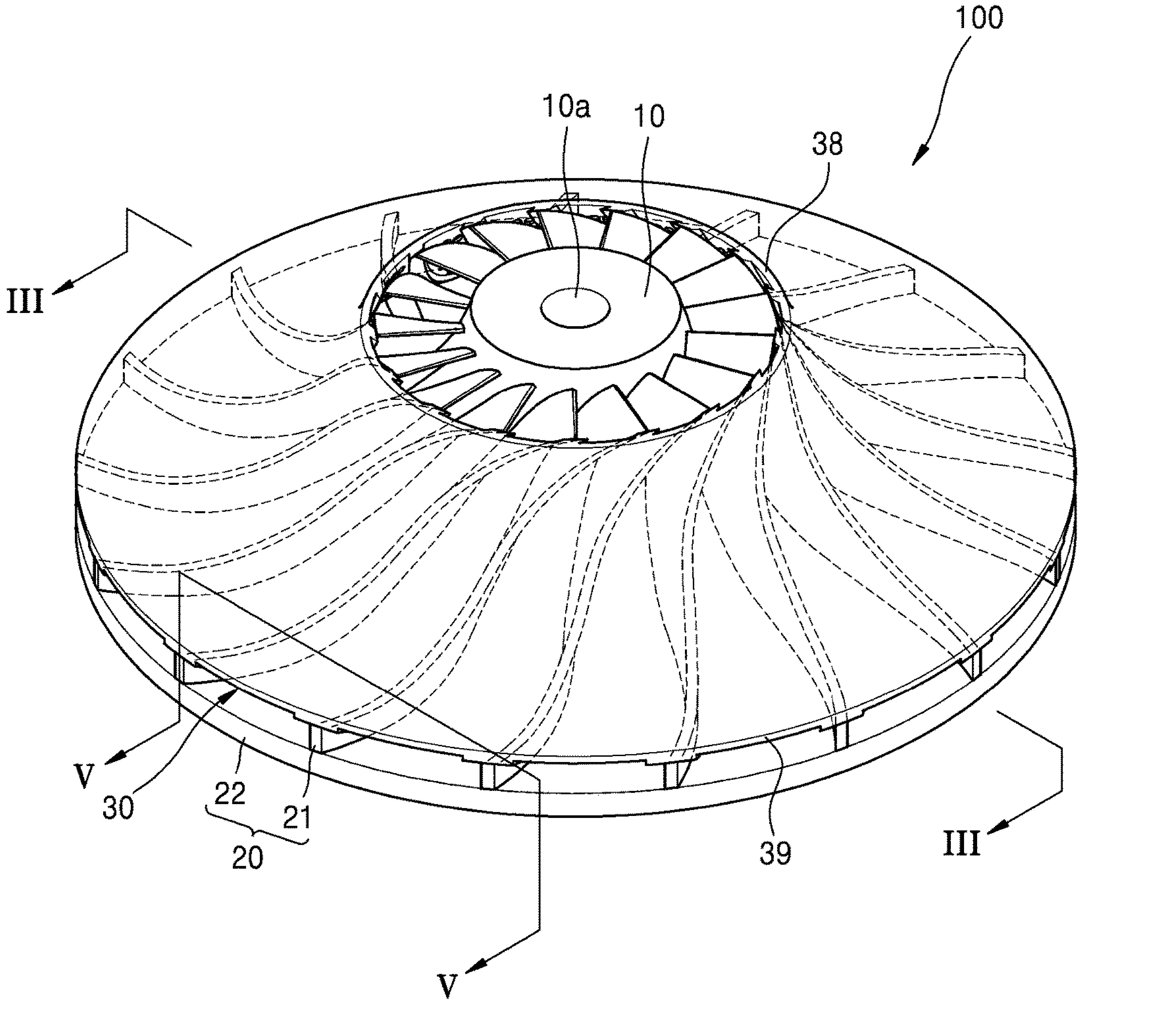


FIG. 3

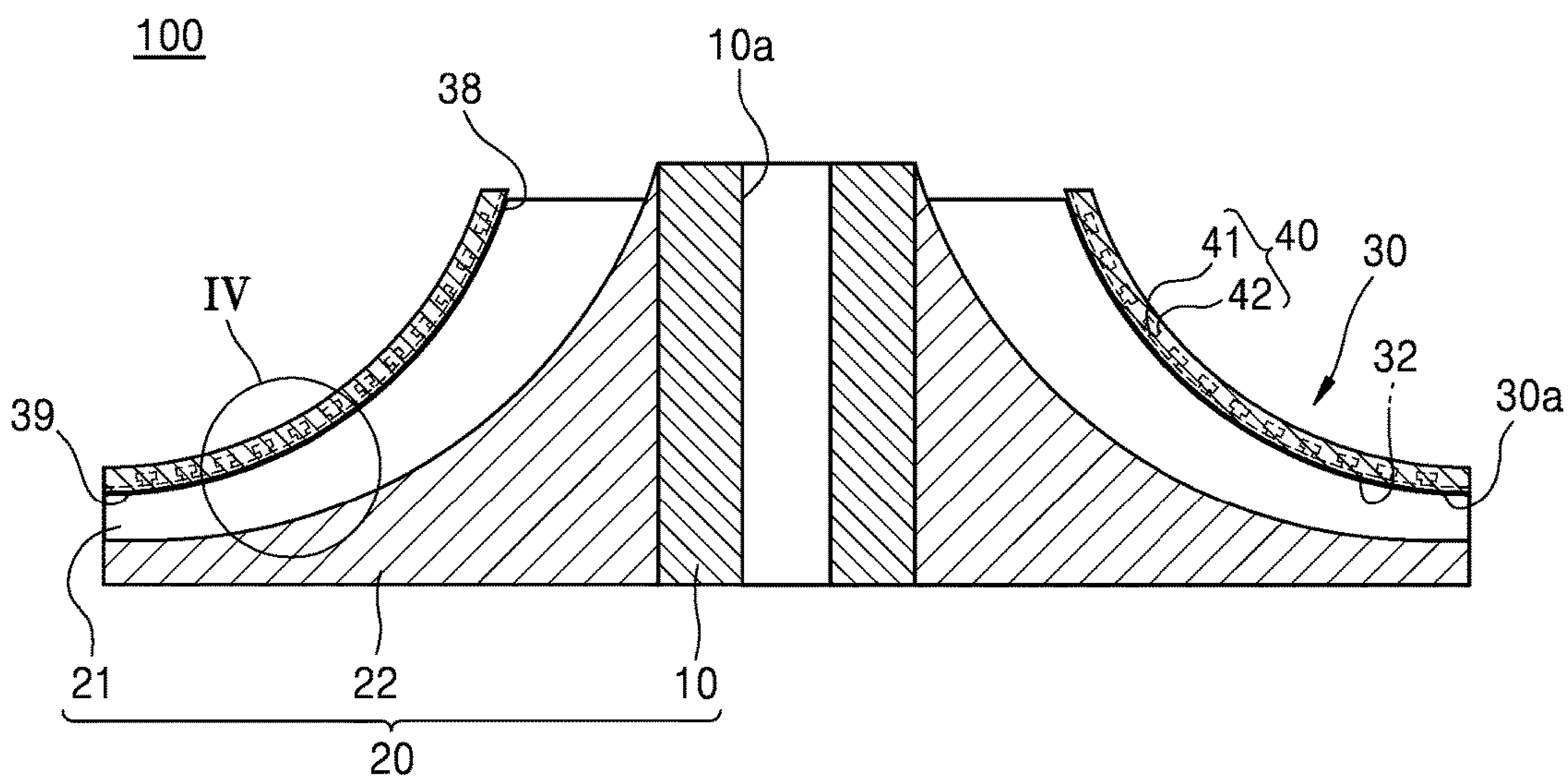

100
38
10a
41
40
30
42
IV
32
39
30a
21
22
10
20

FIG. 4

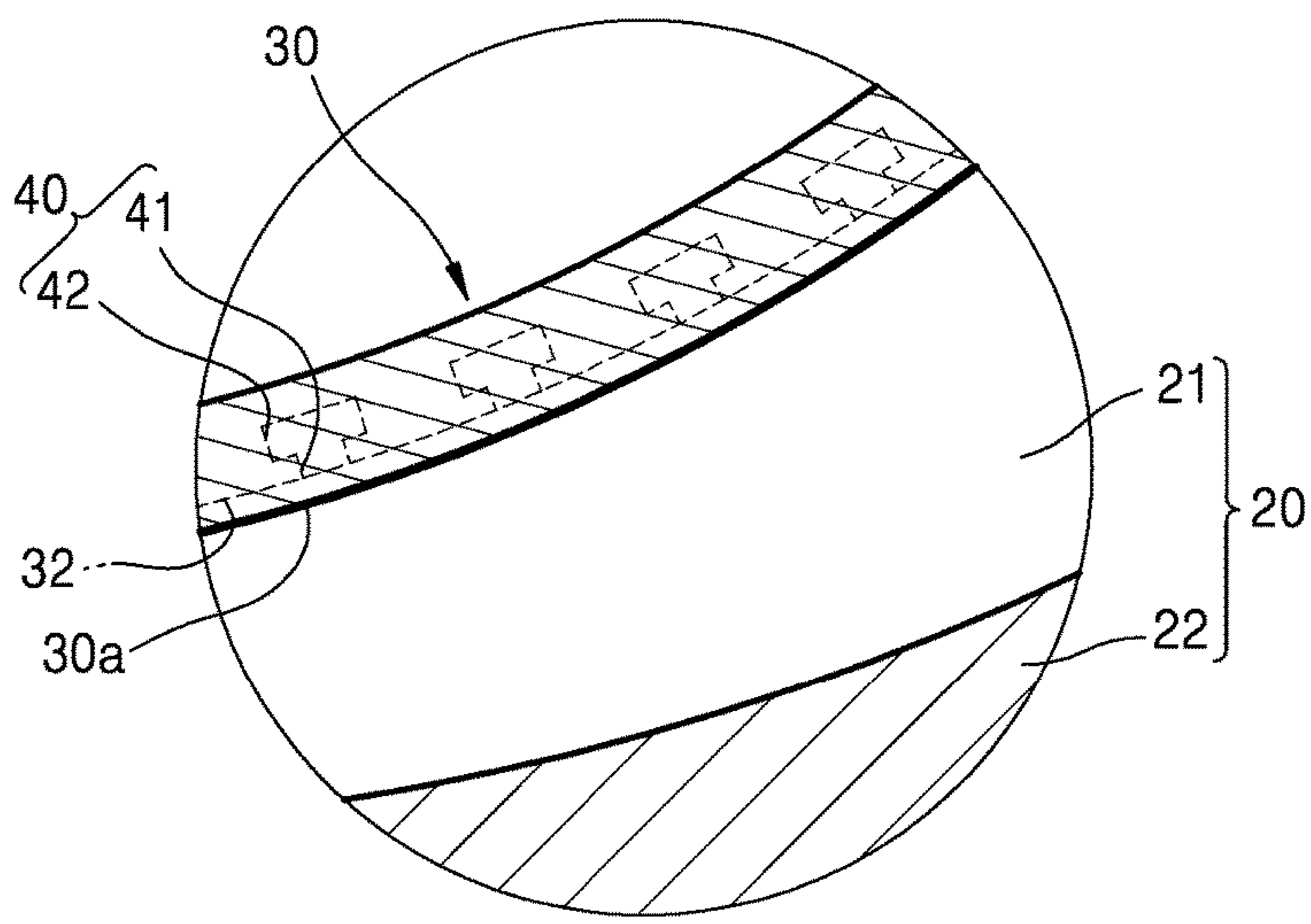

30
40
41
42
21
20
32
30a
22

FIG. 5

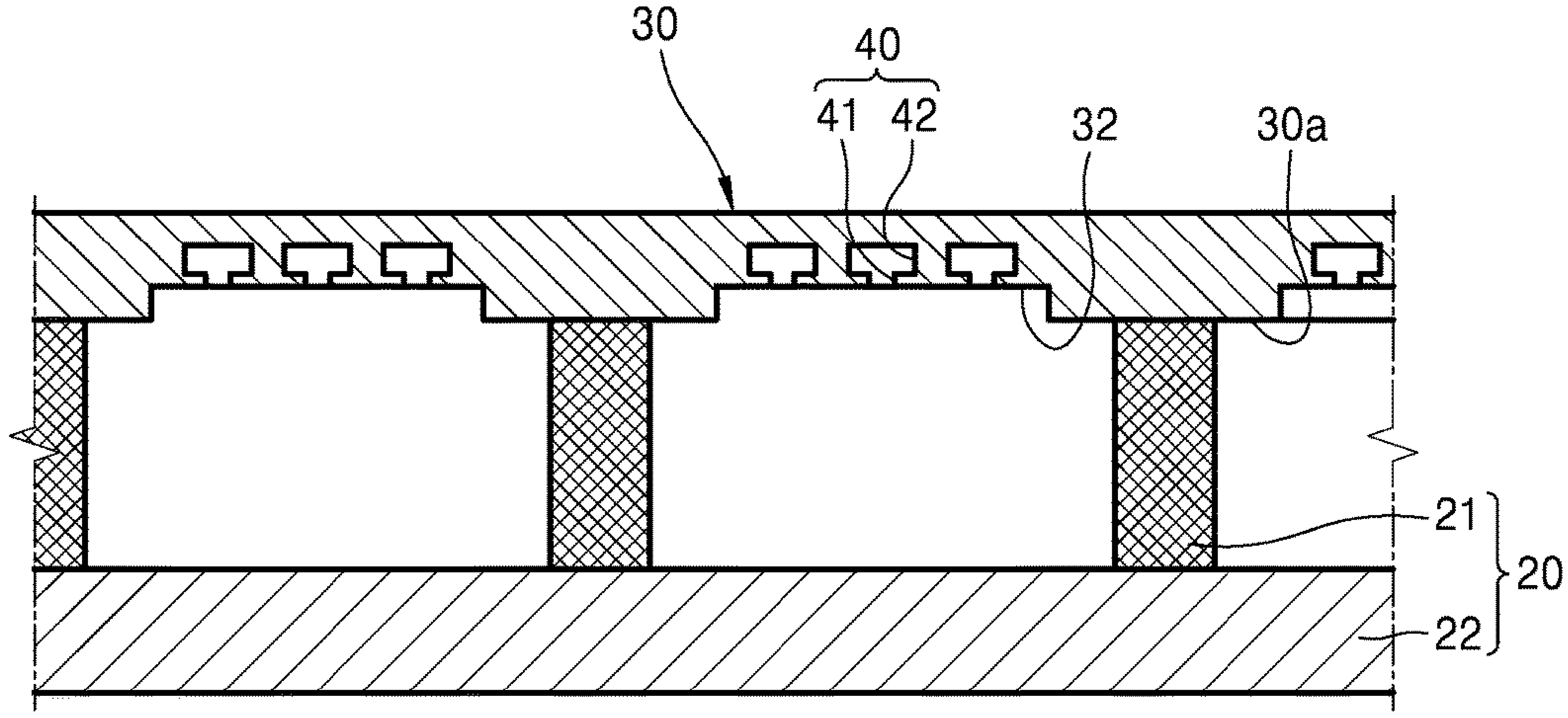


FIG. 6

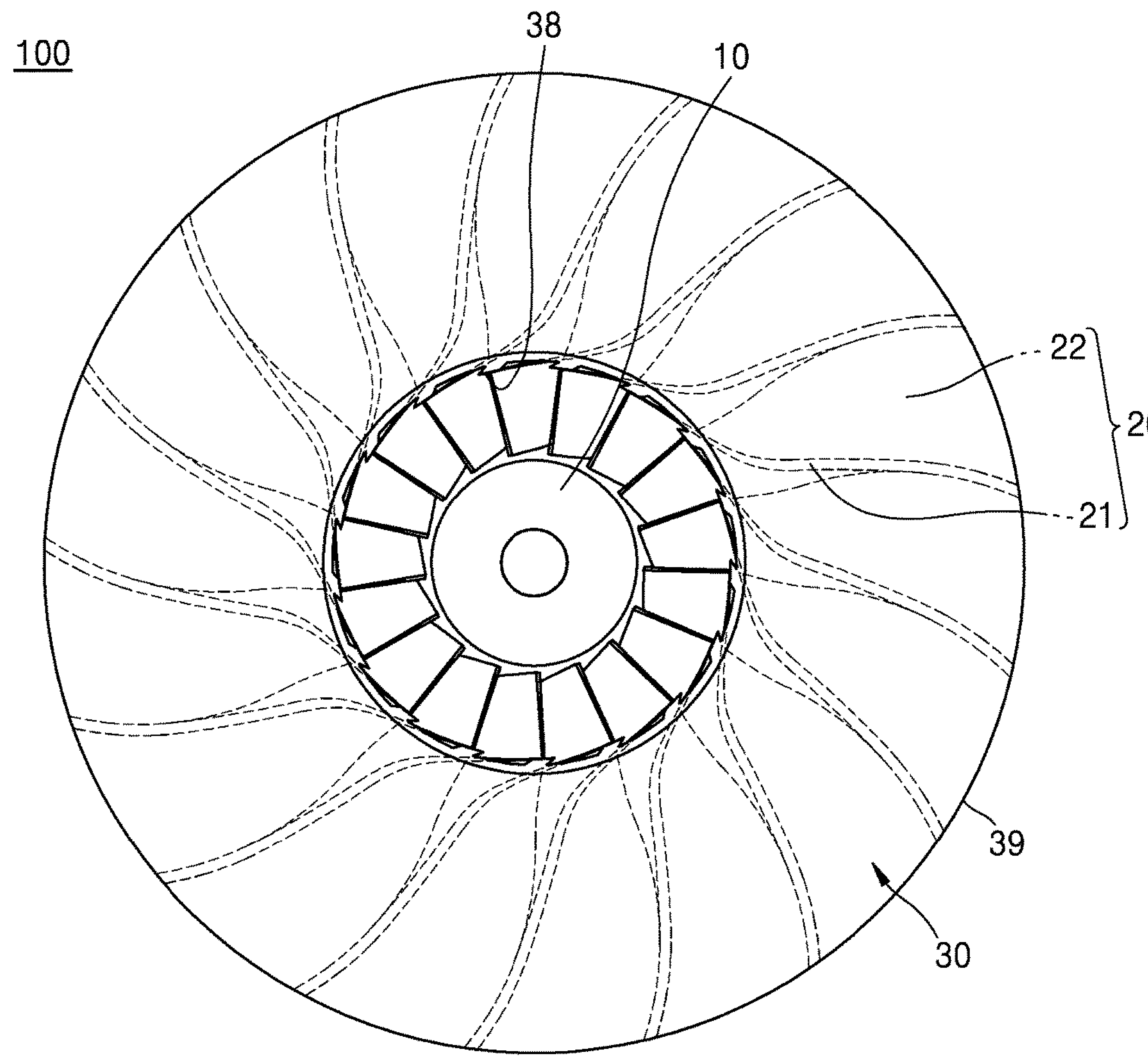


FIG. 7

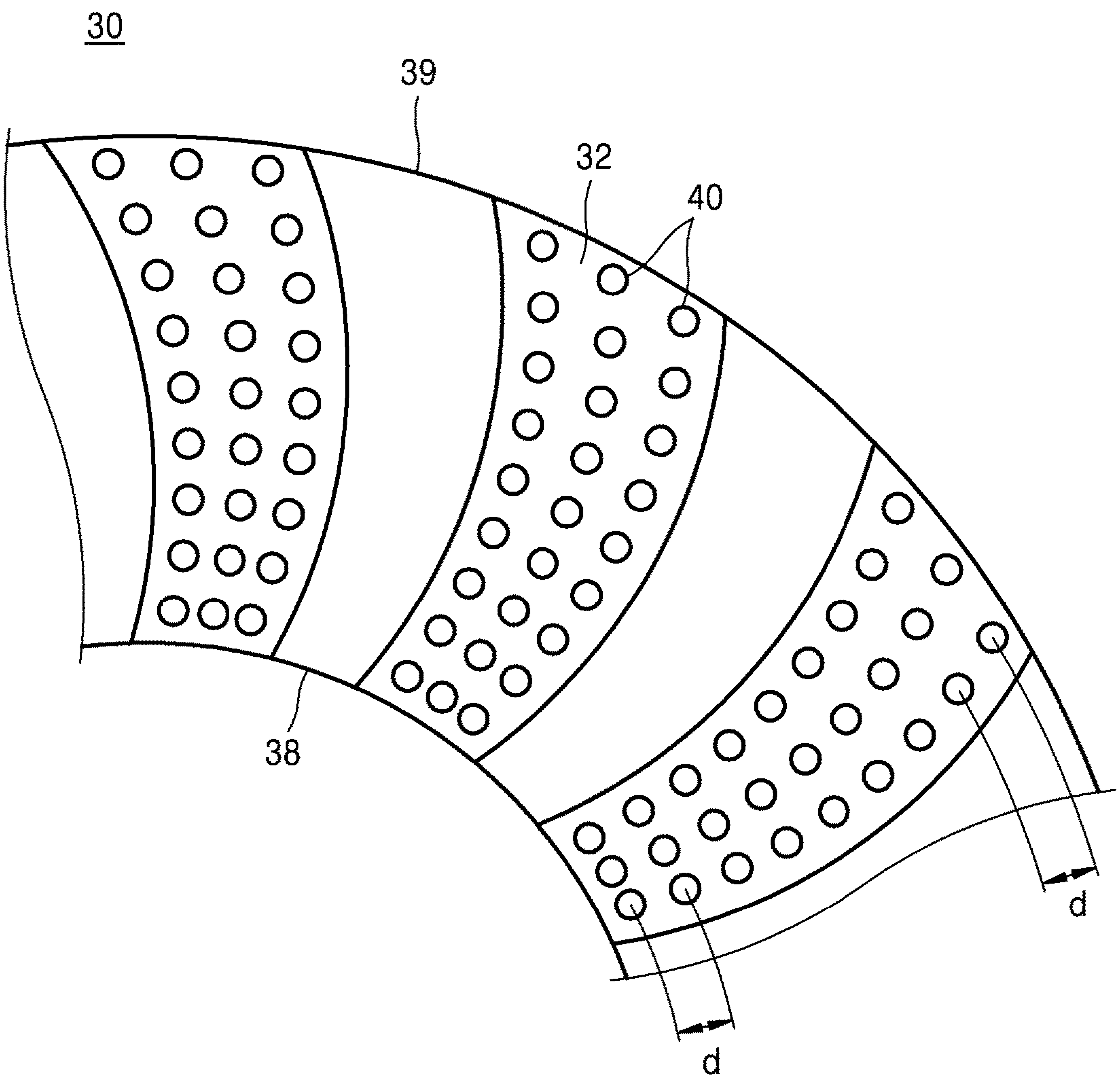


FIG. 8

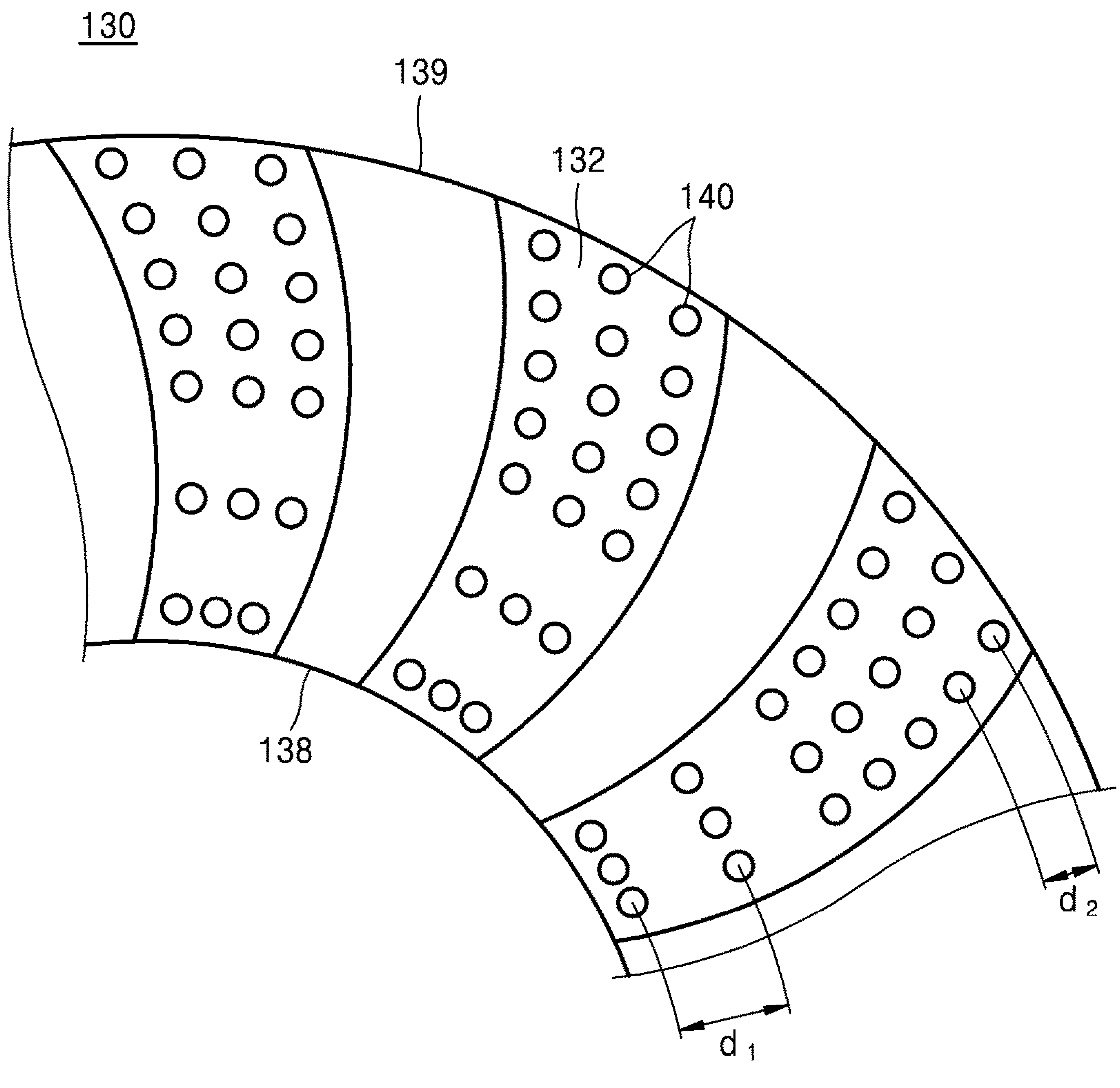


FIG. 9

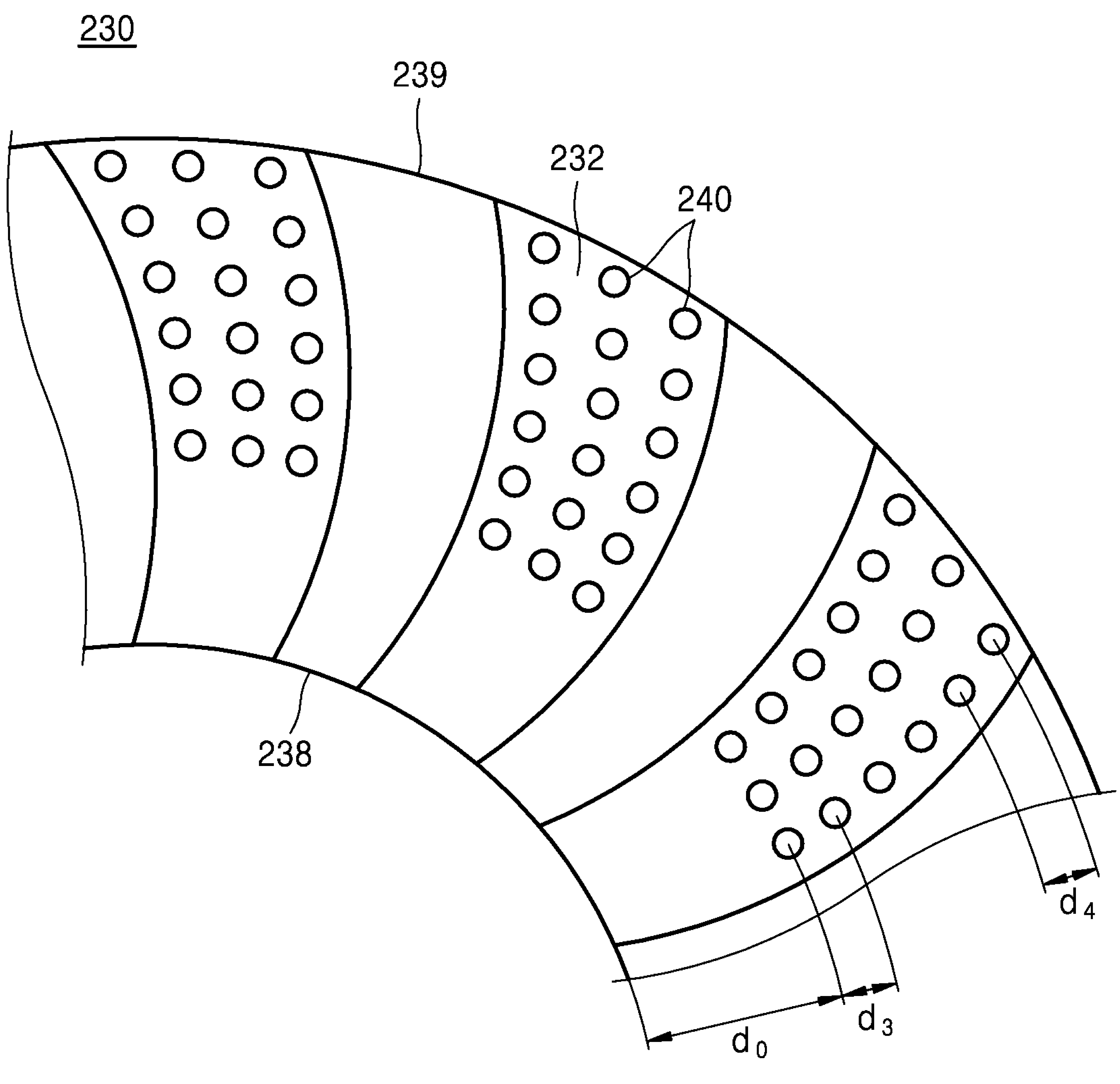


FIG. 10

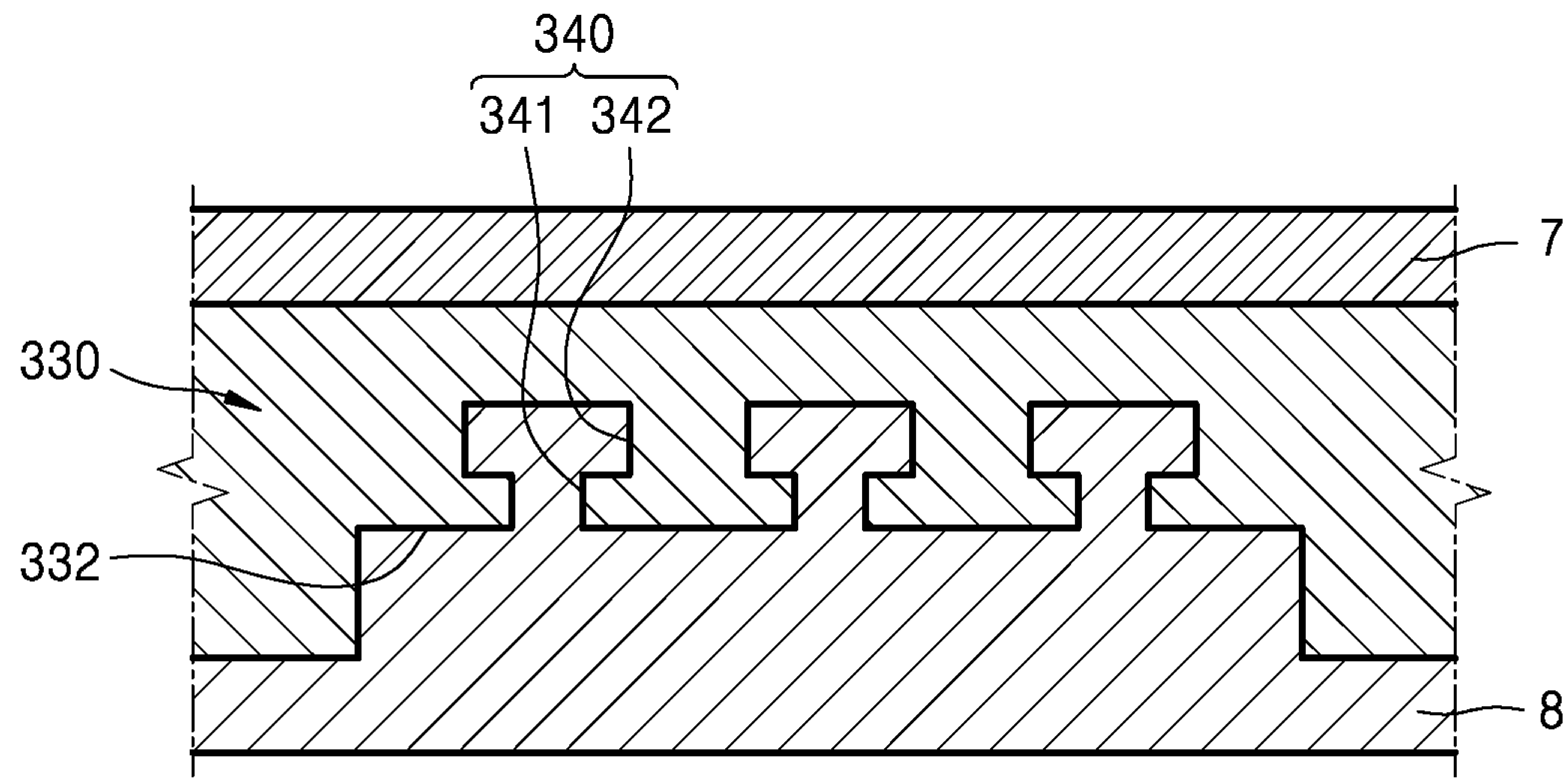


FIG. 11

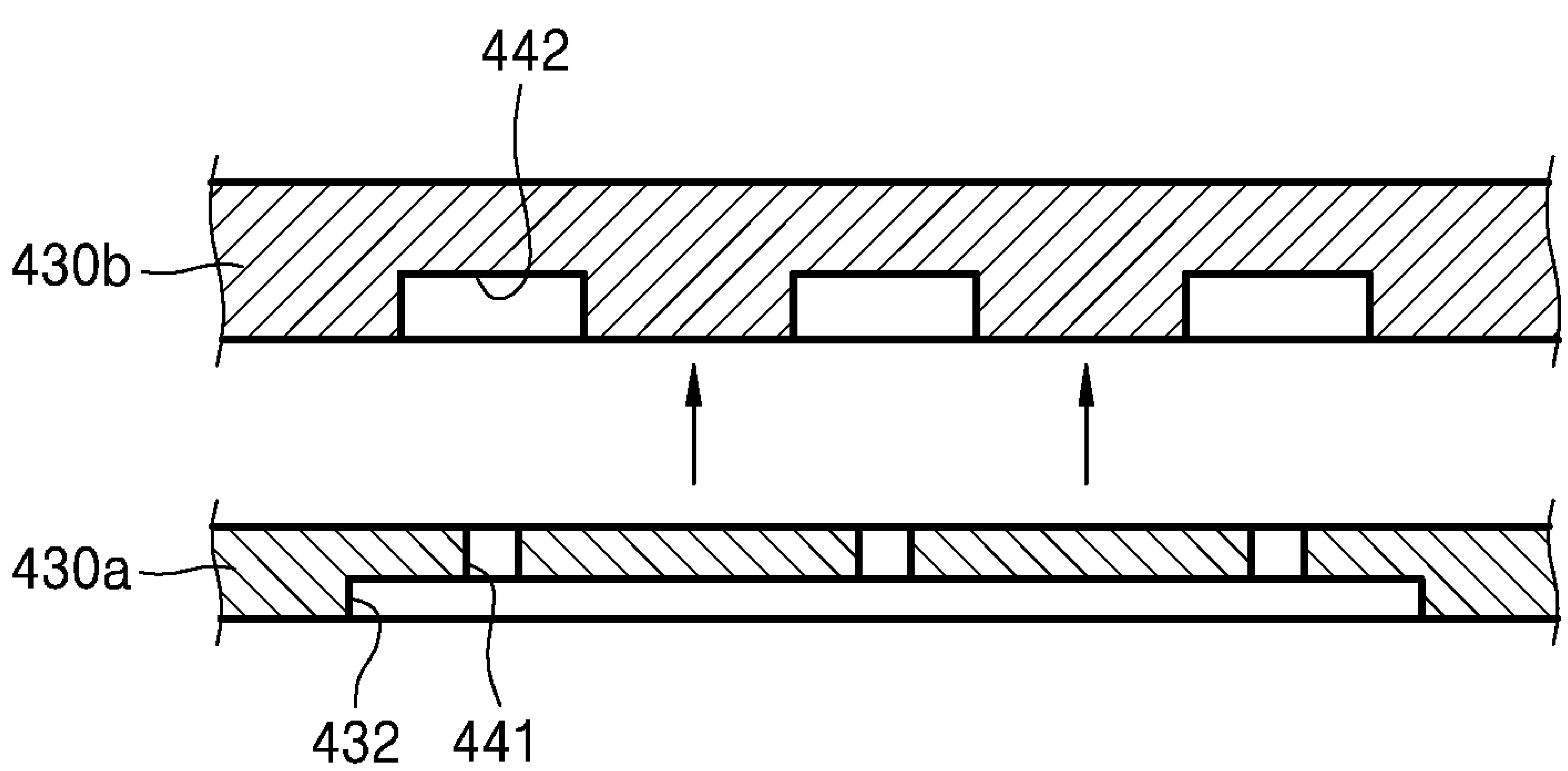


FIG. 12

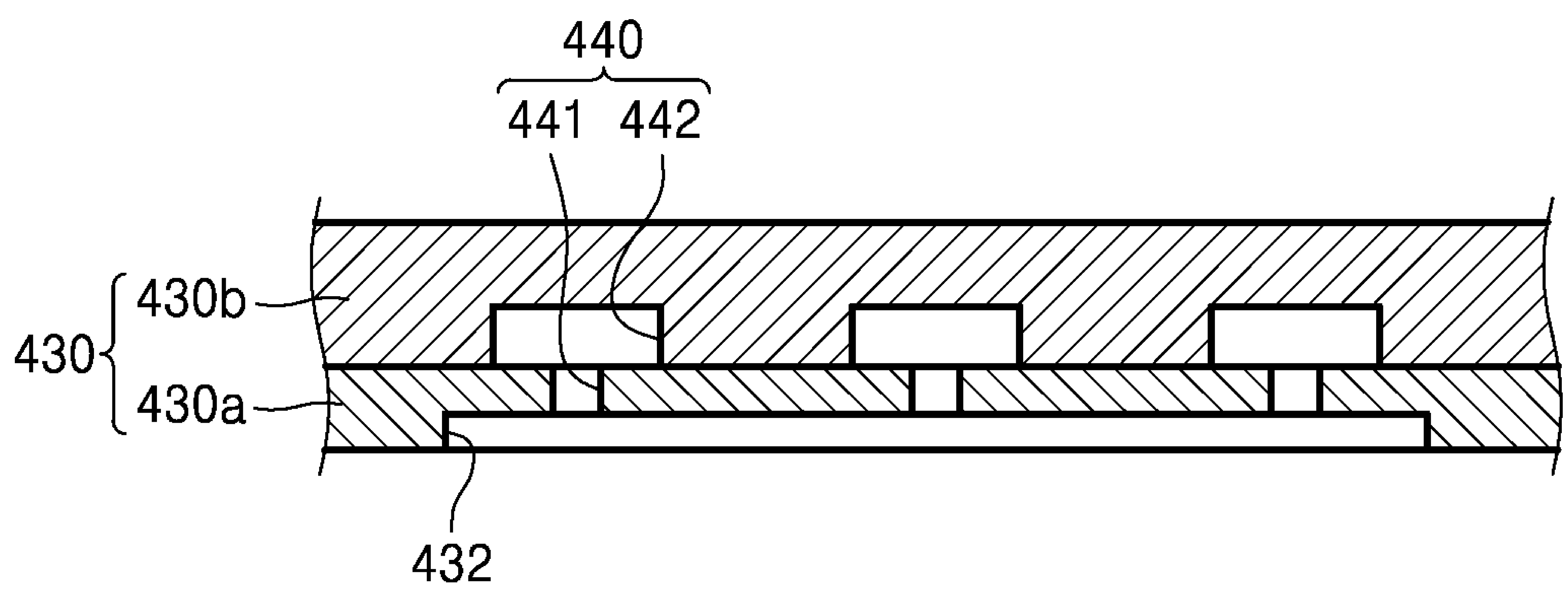
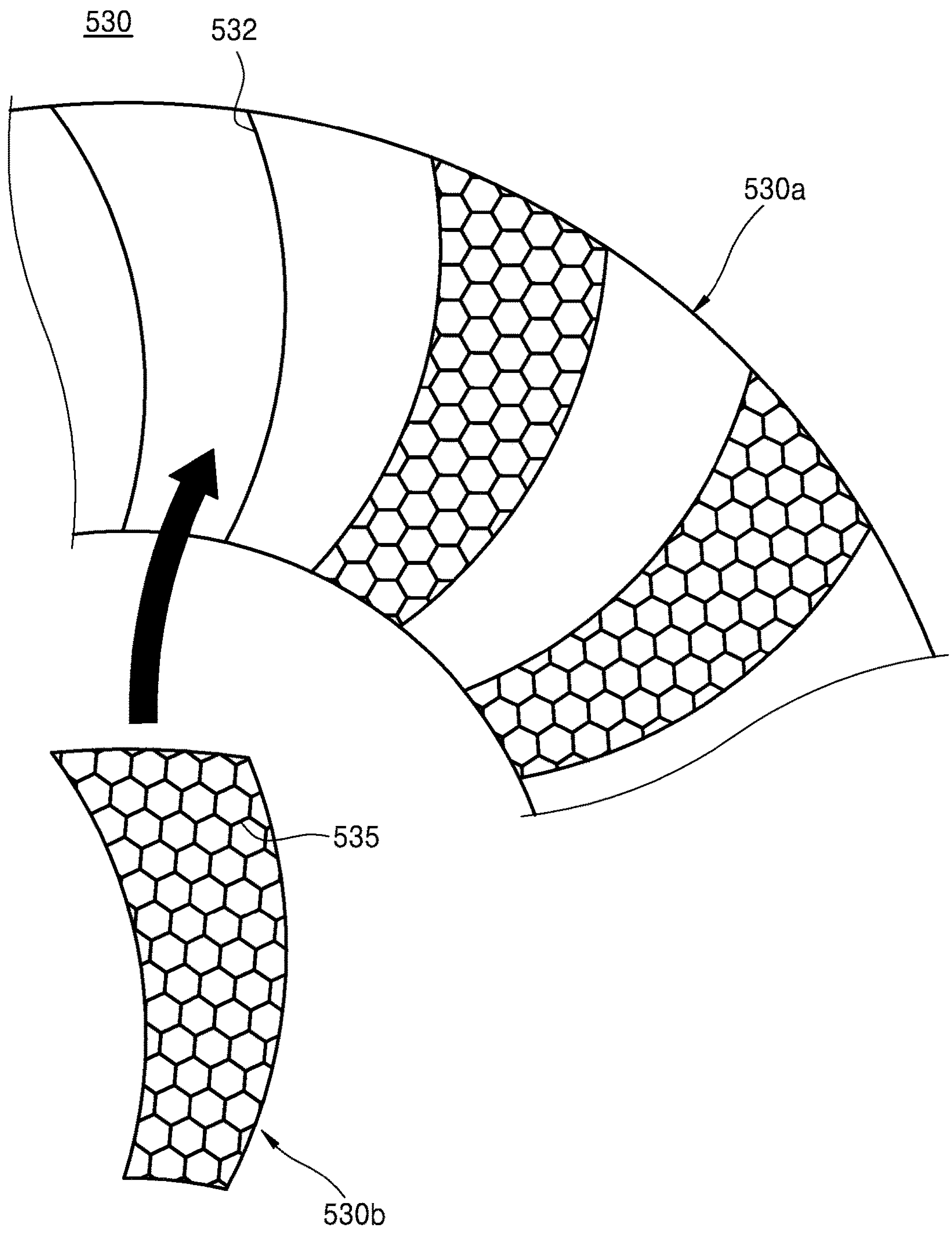


FIG. 13



FLUID MACHINE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority from Korean Patent Application No. 10-2016-0012899, filed on Feb. 2, 2016, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

Apparatuses consistent with exemplary embodiments relate to a fluid machine, and more particularly, to a fluid machine having improved aerodynamics performance and reduced noise generation.

2. Description of the Related Art

Compressors, expanders, or pumps, which compress or expand fluid, have a fluid machine using a rotation element. A fluid machine has an impeller as a rotation element. The impeller transfers rotational dynamic energy to fluid thereby increasing the pressure of fluid. The impeller includes a plurality of blades that guide movement of fluid and transfer energy to the fluid.

A shroud is arranged outside the impeller, and the shroud forms a passage for passing fluid together with the blades. In order to design a fluid machine having superior performance, aerodynamics performance in the passage formed by the impeller and the shroud needs to be enhanced.

However, during an operation of the impeller, high pressure is generated by the fluid such that loud noise is generated between the impeller and the shroud. There have been many trials to reduce noise from operation of the impeller. However, when a separate apparatus is installed on the impeller or the shroud to reduce noise, aerodynamic loss is generated in the fluid machine.

Accordingly, there is a demand for technology to be developed for reducing noise and simultaneously maintaining superior aerodynamics performance in the passage between the impeller and the shroud for passing fluid in the design of a fluid machine.

U.S. Pat. No. 5,256,031 discloses that a groove is formed on a casing wall to reduce vibration. However, a groove-forming technology such as this seriously increases aerodynamic loss.

Japanese Publication No. 2007-218147 discloses technology by which a hole is formed in a shroud to reduce noise. As such, a simple structure in which a hole is formed in a wall of the shroud seriously increases aerodynamic loss.

Japanese Publication No. 2002-537184, Korean Publication No. 1998-0060499, and U.S. Pat. No. 4,540,335 disclose technologies using a hole to improve noise or improve flow rate properties. In these technologies, however, because a structure is used in which a hole is formed at a position of a casing corresponding to a tip (end portion) of a rotating blade, it is difficult to apply the structure to improve aerodynamics performance and reduce noise in a fluid machine using a shroud covering an upper surface of a rotating blade.

SUMMARY

One or more exemplary embodiments provide a fluid machine having reduced noise generation by arranging resonators on a shroud.

One or more exemplary embodiments also provide a fluid machine having resonators for reducing noise and simultaneously having improved aerodynamics performance.

Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented exemplary embodiments.

According to an aspect of an exemplary embodiment, a fluid machine may include a rotatable hub, a plurality of blades arranged around the hub and spaced apart from one another along a circumferential direction with respect to a rotation center of the hub, and a shroud extending along a circumferential direction with respect to the rotation center of the hub and covering the blades, the shroud including a flow passage, the flow passage formed to be concave with respect to an inner surface facing the blades, and a plurality of resonators arranged in the flow passage.

Each of the plurality of resonators may include an opening opened in a surface of the flow passage facing the plurality of blades and a space portion connected to the opening and extending outwardly from the opening, forming a hollow space in the shroud.

The fluid machine may further include a base arranged around the hub, extending along a circumferential direction with respect to the rotation center of the hub and supporting the plurality of blades.

The shroud may include an inlet that guides an inflow of fluid toward the plurality of blades and an outlet that guides discharge of the fluid that has passed through the plurality of blades.

The flow passage may extend from the inlet toward the outlet and may be formed in at least a partial section of the inner surface of the shroud.

The plurality of resonators may be arranged in the flow passage with a uniform density in an entire area of the flow passage from the inlet of the shroud to the outlet.

A density of the plurality of resonators arranged in the flow passage may increase from the inlet of the shroud toward the outlet.

The plurality of resonators may be arranged only in a partial area of an entire area of the flow passage from the inlet of the shroud toward the outlet.

The plurality of resonators may be arranged in an area of the flow passage located at a distance from the inlet of the shroud determined by a preset distance from the inlet of the shroud toward the outlet.

The shroud may include a first plate arranged at a position contacting the plurality of blades and including the flow passage and the opening of each of the plurality of resonators, and a second plate arranged above the first plate and including the space portion of each of the plurality of resonators at a position corresponding to the opening of each of the plurality of resonators.

According to an aspect of another exemplary embodiment, a fluid machine may include a rotatable hub; a plurality of blades spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and a shroud extending along the circumferential direction with respect to the rotation center of the hub and covering the plurality of blades, the shroud may include: a flow passage, the flow passage formed to be recessed with respect to an inner surface of the shroud facing the blades; and a plurality of resonators provided in the flow passage.

Each of the plurality of resonators may include: an opening portion provided on a surface of the flow passage facing the plurality of blades; and a space portion connected to the opening and extending radially from the opening portion, the space portion forming a hollow space in the shroud.

The fluid machine may further include a base arranged around the hub, extending along a circumferential direction with respect to the rotation center of the hub and supporting the plurality of blades.

The shroud may include: an inlet portion configured to guide an inflow of fluid toward the plurality of blades; and an outlet portion configured to guide discharge of the fluid that has passed through the plurality of blades.

The flow passage may extend from the inlet portion toward the outlet portion and is formed in at least a partial section of the inner surface of the shroud.

The plurality of resonators may be arranged in the flow passage with a uniform density in an entire area of the flow passage from the inlet portion of the shroud to the outlet portion.

A density of the plurality of resonators arranged in the flow passage may increase from the inlet portion of the shroud toward the outlet portion.

The plurality of resonators may be arranged only in a partial area of an entire area of the flow passage.

The plurality of resonators may be arranged in an area of the flow passage located at a distance from the inlet portion of the shroud determined by a preset distance from the inlet portion of the shroud toward the outlet.

The shroud may include: a first plate arranged at a position contacting the plurality of blades and including the flow passage and the opening portion of each of the plurality of resonators; and a second plate provided on the first plate and including the space portion of each of the plurality of resonators at a position corresponding to the opening portion of each of the plurality of resonators.

According to an aspect of another exemplary embodiment, a fluid machine may include: a rotatable hub; a base connected to the hub and extending radially from the hub; a plurality of blades provided on the base and spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and a shroud extending along the circumferential direction with respect to the rotation center of the hub and covering the plurality of blades, the shroud including: an inner surface facing the base and contacting the plurality of blades; a flow passage formed to be recessed with respect to the inner surface of the shroud facing the base; and a plurality of resonators provided in the flow passage.

The shroud may include: an inlet portion configured to guide an inflow of fluid toward the plurality of blades; and an outlet portion configured to guide discharge of the fluid that has passed through the plurality of blades.

The flow passage may include: a first region in which the plurality of resonators are arranged; and a second region in which none of the plurality of resonators are provided in the flow passage.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of the exemplary embodiments, taken in conjunction with the accompanying drawings in which:

FIG. **1** is a perspective view of a structure of a fluid machine according to an exemplary embodiment, in which constituent elements are disassembled from each other;

FIG. **2** is a perspective view illustrating an assembled state of the fluid machine of FIG. **1**;

FIG. **3** is a cross-sectional view taken along a line III-III of the fluid machine of FIG. **2**;

FIG. **4** is an enlarged cross-sectional view of a portion IV of the fluid machine of FIG. **3**;

FIG. **5** is a cross-sectional view taken along a line V-V of the fluid machine of FIG. **2**;

FIG. **6** is a plan view of the fluid machine of FIG. **2**;

FIG. **7** is an enlarged view of a portion of a shroud of the fluid machine of FIG. **1**;

FIG. **8** is an enlarged view of a portion of a shroud of a fluid machine according to an exemplary embodiment;

FIG. **9** is an enlarged view of a portion of a shroud of a fluid machine according to an exemplary embodiment;

FIG. **10** is a cross-sectional view of a shroud to illustrate a process of manufacturing the shrouds of the fluid machines of FIGS. **1** to **9**;

FIG. **11** is a cross-sectional view of a shroud to illustrate a process of manufacturing the shrouds of the fluid machines of FIGS. **1** to **9**;

FIG. **12** is a cross-sectional view of the shroud manufactured by the process of FIG. **11**; and

FIG. **13** is an enlarged view of a portion of a shroud of a fluid machine according to an exemplary embodiment.

DETAILED DESCRIPTION

Reference will now be made in detail to exemplary embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the exemplary embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the exemplary embodiments are merely described below, by referring to the figures, to explain aspects of the present description. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

FIG. **1** is a perspective view of a structure of a fluid machine **100** according to an exemplary embodiment, in which constituent elements are disassembled from each other. FIG. **2** is a perspective view illustrating an assembled state of the fluid machine **100** of FIG. **1**. FIG. **3** is a cross-sectional view taken along a line III-III of the fluid machine **100** of FIG. **2**.

The fluid machine **100** according to the exemplary embodiment illustrated in FIGS. **1** to **3** may include a hub **10**, a plurality of blades **21** arranged on and around the hub **10**, and a shroud **30** arranged to cover the blades **21**.

Although rotating machines are implemented by compressors in the exemplary embodiments illustrated in the drawings, the present disclosure is not limited thereto. In other words, a rotating machine according to an exemplary embodiment may be any apparatus capable of changing the pressure and velocity of fluid by a rotation motion of an impeller. For example, a rotating machine according to the exemplary embodiment may be implemented by an expander (turbine) for expanding fluid, a pump, or a blower.

The hub **10** has a cylindrical shape and has a shaft coupling hole **10***a*, in which a rotation shaft may be inserted. A base **22** is arranged around the hub **10**. Outer diameter of the base **22** increases along a vertical direction of the center of the hub **10** from the top to the bottom of the base **22**. The base **22** extends in a circumferential direction with respect to the center of the hub **10**.

The base **22** is coupled to an outer surface of the hub **10** and the outer diameter of the base **22** increases along a vertical direction of the center of the hub **10** from the top to the bottom of the base **22**. Because a surface of the base **22** is an inclined curved surface, the surface of the base **22** forming a bottom surface of a passage for passing fluid is designed to enable a smooth flow of the fluid and to transfer maximum energy to the fluid.

The blades **21** are arranged around the hub **10** to be spaced apart from one another in a preset interval in a circumferential direction with respect to a rotation center of the hub **10**. The blades **21** may be arranged on an upper surface of the base **22** and, as the base **22** is coupled to the outer surface of the hub **10**, the blades **21** may be arranged circumferentially around the hub **10**. The blades **21** extend outwardly from the hub **10** in the radial direction of the hub **10**.

An impeller **20** including the hub **10**, the blades **21**, and the base **22** guides a flow of fluid while simultaneously transferring dynamic energy of the impeller **20** to the fluid.

The shroud **30** has an inlet **38** for the fluid formed at an open upper end portion thereof and an outlet **39** for the fluid radially and downwardly extending from the inlet **38** at the open upper end portion. The shroud **30** forms a ceiling surface of the passage of the fluid. The shroud **30** forms the passage of the fluid with the base **22** and the blades **21**.

Referring to FIG. **3**, as a modified example, when a fluid machine **100** is designed to be an expander (turbine), the inlet **38** may be manufactured to function as an outlet, whereas the outlet **39** may be manufactured to function as an inlet.

The inlet **38** of the shroud **30** guides the fluid to be input toward the blades **21**. Furthermore, the outlet **39** of the shroud **30** guides the fluid moved by the blades **21** to be discharged to the outside of the shroud **30**.

The shroud **30** extends radially from the hub **10** and also extends in a circumferential direction with respect to the rotation center of the hub **10** and is arranged covering upper end portions of the blades **21** as shown in FIG. **2**. The shroud **30** and the blades **21** may be fixed to each other, for example, by a welding process or by using a coupling device such as rivets or bolts. When the shroud **30** and the blades **21** are fixed to each other, the hub **10**, the blades **21**, and the shroud **30** may rotate together.

To maintain a fixed position relative to the hub **10** and the blades **21**, for example, the shroud **30** may be fixed on an external structure instead of the blades **21**. When the shroud **30** is fixed on the external structure, the shroud **30** maintains the fixed position relative to the hub **10** and the blades **21** during the rotation of the hub **10** and the blades **21**, thereby forming part of the passage.

When the impeller **20** performs a rotation motion, the fluid incoming through the inlet **38** of the shroud **30** is discharged to the outside through the outlet **39** of the shroud **30** by a centrifugal force. In other words, the fluid is compressed to a high-pressure state and discharged through the outlet **39** by the centrifugal force according to rotational dynamic energy of the impeller **20**. While the fluid passes through a diffuser (not shown), for example, the velocity of the fluid discharged to the outside of the impeller **20** through the outlet **39** decreases and simultaneously the pressure of the fluid increases to a requested level.

The shroud **30** may include a flow passage (or a flow passage surface; hereinafter "a flow passage") **32** formed to be recessed (or sunken) with respect to an inner surface **30***a* facing the blades **21** as FIG. **1** (and FIG. **4**). The flow passage **32** radially extends from the inlet **38** of the shroud **30** toward the outlet **39**. The shroud **30** may also include a plurality of resonators **40** arranged in the flow passage **32**.

The flow passage **32** formed in the shroud **30** guides a flow of the fluid that is moved and compressed by the rotation motion of the blades **21**, thereby enabling the fluid to move smoothly. The flow passage **32** radially extends from the hub **10** toward the outside in a direction in which the blades **21** are formed, and is formed to be curved in the circumferential direction. As such, aerodynamic loss of the fluid passing between the shroud **30** and the blades **21** may be reduced by the structure of the flow passage **32** formed in the shroud **30**.

FIG. **4** is an enlarged cross-sectional view of a portion IV of the fluid machine **100** of FIG. **3**. FIG. **5** is a cross-sectional view taken along a line V-V of the fluid machine **100** of FIG. **2**. FIG. **6** is a plan view of the fluid machine **100** of FIG. **2**.

Each of the plurality of resonators **40** may include an opening **41** (or an opening portion) opened in a surface of the flow passage **32** facing the blades **21** and a space portion **42** connected to the opening **41** and extending from the opening **41** to the outside, thereby forming an hollow space in the shroud **30**.

Each of the opening **41** and the space portion **42** may have a circular or polygonal cross-section. Furthermore, the size of a cross-section of the space portion **42** is larger than the size of a cross-section of the opening **41** as shown in FIG. **4**.

Because the resonators **40** are formed on the surface of the flow passage **32** that guides the flow of the fluid so that the fluid smoothly flows between the blades **21** and the shroud **30**, noise that may be generated by air compressed at high pressure between the blades **21** and the shroud **30** may be reduced.

A sectional area, a size, and an arrangement position of the opening **41** and the space portion **42** of each of the resonators **40** are designed according to a frequency of noise generated between the shroud **30** and the blades **21**. In other words, values such as the length and the sectional area of the opening **41** formed from the surface of the flow passage **32** to the space portion **42**, and the volume of the space portion **42**, may be experimentally designed according to a resonance frequency that may be generated between the shroud **30** and the blades **21**.

FIG. **7** is an enlarged view of a portion of a shroud of the fluid machine **100** of FIG. **1**.

The flow passage **32** formed in the shroud **30** is formed on an inner surface of in the shroud **30** (facing the base **22**) and extends from the inlet **38** toward the outlet **39**. Although, in the exemplary embodiment of FIG. **7**, the flow passage **32** is formed in the entire section of the inner surface of the shroud **30** from the inlet **38** of the shroud **30** toward the outlet **39**, the length of the flow passage **32** is not limited thereto. For example, the flow passage **32** may be formed only in a partial section of the inner surface of the shroud **30** from the inlet **38** of the shroud **30** toward the outlet **39**.

Referring to FIG. **7**, the resonators **40** are arranged such that the resonators **40** have the uniform density in the entire area of the flow passage **32** from the inlet **38** of the shroud **30** toward the outlet **39**. Accordingly, as illustrated in FIG. **7**, a distance d between the resonators **40** arranged adjacent to the inlet **38** is the same as a distance d between the resonators **40** arranged adjacent to the outlet **39**. Accordingly, a noise reduction effect of the same level may be obtained with respect to the entire area of the flow passage **32** from the inlet **38** of the shroud **30** toward the outlet **39**.

FIG. **8** is an enlarged view of a portion of a shroud **130** of a fluid machine **100** according to an exemplary embodiment.

The shroud **130** of a fluid machine **100** according to the exemplary embodiment has a similar structure to the structure of the shroud **30** of FIG. **7**, except for the arrangement density of a plurality of resonators **140**.

Referring to FIG. **8**, the arrangement density of the resonators **140** varies in the entire area from an inlet **138** of the shroud **130** toward an outlet **139**. The density of the resonators **140** arranged in the flow passage **132** increases from the inlet **138** of the shroud **130** toward the outlet **139**.

As illustrated in FIG. **8**, a distance d_2 between the resonators **140** arranged adjacent to the outlet **139** is less than a distance d_1 between the resonators **140** arranged adjacent to the inlet **138**. Accordingly, the noise reduction effect of the resonators **140** is higher at the outlet **139** than the inlet **138** of the shroud **130**. As such, a structure in which the density of the resonators **140** arranged adjacent to the outlet **139** is higher than the density of the resonators **140** arranged adjacent to the inlet **138** may be applied to a case in which the noise generated at the outlet **139** is greater than the noise generated at the inlet **138**.

FIG. **9** is an enlarged view of a portion of a shroud **230** of a fluid machine **100** according to an exemplary embodiment.

The shroud **230** of a fluid machine **100** according to the exemplary embodiment has a similar structure to the structure of the shroud **30** of FIG. **7**, except for the arrangement position of a plurality of resonators **240**.

Referring to FIG. **9**, the resonators **240** are arranged only in a partial area of the entire area of a flow passage **232** from an inlet **238** of the shroud **230** to an outlet **239**. The resonators **240** are arranged in an area of the flow passage **232** located at a distance from the inlet **238** of the shroud **230** determined by a preset distance d_0 from the inlet **238** of the shroud **230** toward the outlet **239**.

The density at which the resonators **240** are arranged in the flow passage **232** may be set to be uniform in the entire area of the flow passage **232**. When the resonators **240** are arranged so that the density of the resonators **240** is uniform, a distance d_3 between the resonators **240** adjacent to the inlet **238** is the same as a distance d_4 between the resonators **240** adjacent to the outlet **239**.

The present disclosure is not limited to the structure in which the density of the resonators **240** arranged in the flow passage **232** is uniform in the entire area of the flow passage **232** as illustrated in FIG. **9**. For example, the distance d_3 between the resonators **240** adjacent to the inlet **238** may be designed to be different from the distance d_4 between the resonators **240** adjacent to the outlet **239**, by modifying the arrangement of the resonators **240** illustrated in FIG. **9**.

In the above-described structures of the shroud **230** and the resonators **240**, because the resonators **240** are not arranged in an area covered by the preset distance d_0 in a direction from the inlet **238** of the shroud **230** toward the outlet **239**, a smooth flow of fluid may be formed in an area of the flow passage **232** where the resonators **240** are not arranged. Furthermore, the noise reduction effect may be increased by arranging the resonators **240** in an area of the flow passage **232** located at a distance from the inlet **238** of the shroud **230** determined by the preset distance d_0 from the inlet **238** of the shroud **230** toward the outlet **239**, the area corresponding to an area of the entire area of the flow passage **232** in which noise is much increased.

Although in the above-described embodiments the sizes, that is, the diameter, the length, and the volume of the opening, and the volume of the space portion, of the resonators formed in the shroud are described as being constant, the sizes of the resonators may be changed according to the positions of the resonators arranged in the flow passage of the shroud. For example, the sizes of the openings and the space portions of the resonators arranged adjacent to the inlet of the shroud may be designed to be relatively small, whereas the sizes of the openings and the space portions of the resonators arranged adjacent to the outlet of the shroud may be designed to be relatively large. Furthermore, the sizes of the resonators may be modified to be gradually increased or decreased from the inlet of the shroud toward the outlet.

FIG. **10** is a cross-sectional view of a shroud to illustrate a process of manufacturing the shrouds of the fluid machines of FIGS. **1** to **9**.

FIG. **10** illustrates an example of a process of manufacturing a shroud **330** of a fluid machine using a mold. When fluid is injected between an upper mold **7** and a lower mold **8**, which are coupled to each other, and then cured, the shroud **330** having a flow passage **332** formed to be recessed (or sunken) in one surface thereof is completed. Because the lower mold **8** has a shape corresponding to the resonators **340** of the flow passage **332** of the shroud **330**, the resonators **340**, which include an opening **341** in a surface of the flow passage **332** and a space portion **342** extending from the opening **341** to the outside and forming an inner space in the shroud **330**, are formed in a surface of the flow passage **332** of the shroud **330**.

The upper mold **7** and the lower mold **8** are removed after the shroud **330** is cured, and the surface of the shroud **330** is washed out, thereby completing the manufacture of the shroud **330**.

FIG. **11** is a cross-sectional view of a shroud to illustrate a process of manufacturing the shrouds of the fluid machines of FIGS. **1** to **9**. FIG. **12** is a cross-sectional view of the shroud manufactured by the process of FIG. **11**.

FIGS. **11** and **12** illustrate an example of a process of manufacturing a shroud **430** of a fluid machine **100** by a method of combining two metal plates.

Referring to FIG. **11**, the process of manufacturing a shroud **430** may include preparing a first plate **430***a*, preparing a second plate **430***b*, and bonding the first plate **430***a* and the second plate **430***b*.

The first plate **430***a* is a constituent element forming an inner surface of the shroud **430** contacting a blade. The preparing of the first plate **430***a* may include an operation of, for example, forming an opening **441** and a flow passage **432** by preparing a metal plate and applying at least one of various processing methods such as punching, hammering, pressing, and bending, to the metal plate.

The second plate **430***b* is a constituent element forming an outer surface of the shroud **430** opposite to the inner surface contacting the blade. The preparing of the second plate **430***b* may include an operation of, for example, forming a space portion **442** by preparing a metal plate and applying at least one of various processing methods such as punching, hammering, pressing, and bending, to the metal plate.

When the first plate **430***a* and the second plate **430***b* are prepared, the positions of the first plate **430***a* and the second plate **430***b* are aligned to each other such that the opening **441** of the first plate **430***a* and the space portion **442** of the second plate **430***b* correspond to each other, and the first plate **430***a* and the second plate **430***b* are bonded to each other.

The first plate **430***a* and the second plate **430***b* may be bonded to each other by various methods, for example, coating an adhesive between the first plate **430***a* and the second plate **430***b*, using a coupling device such as rivets or bolts penetrating through the first plate **430***a* and the second plate **430***b*, or welding edges of inner sides of the first plate **430***a* and the second plate **430***b*.

The manufacture of the shroud **430**, completed through the above-described operations, is arranged at a position contacting the blade and may include the first plate **430***a* having the flow passage **432** and the opening **441**, and the second plate **430***b* having the space portion **442** at a position corresponding to the opening **441**. In a state in which the first plate **430***a* and the second plate **430***b* are bonded to each other, the opening **441** of the first plate **430***a* and the space portion **442** of the second plate **430***b* are connected to each other so that a plurality of resonators **440** are formed.

FIG. **13** is an enlarged view of a portion of a shroud **530** of a fluid machine **100** according to an exemplary embodiment.

The shroud **530** according to an exemplary embodiment of FIG. **13** may include a first plate **530***a* having a flow passage **532** formed on an inner surface thereof and a second plate **530***b* manufactured to have an outer shape corresponding to the flow passage **532** and having a plurality of holes **535** of a hexagonal shape having a beehive arrangement.

When the second plate **530***b* is coupled to each flow passage **532** of the first plate **530***a*, the shroud **530** is thus completed, and the holes **535** having a hexagonal shape and a beehive arrangement are arranged on a surface of the flow passage **532** of the shroud **530** facing blades.

According to the shroud **530** having the above structure, because the holes **535** in a beehive arrangement are provided on the flow passage **532** that smoothly guides a flow of fluid, a reduction in aerodynamic loss and a noise reduction effect may be obtained simultaneously.

As described above, in the fluid machine according to the above-described exemplary embodiments, aerodynamic loss of fluid passing between the shroud and the blades may be reduced due to the structure of the flow passage formed in the shroud.

Furthermore, because the resonators are arranged in the surface of the flow passage that guides the flow of fluid so that the fluid may smoothly flows between the blades and the shroud, noise that may be generated between the blades and the shroud by air compressed at high pressure may be reduced.

It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

While exemplary embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope as defined by the following claims.

What is claimed is:

1. A fluid machine comprising:

a rotatable hub;

a plurality of blades spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and

a shroud extending along the circumferential direction with respect to the rotation center of the hub and covering the plurality of blades, the shroud comprising:

a flow passage, the flow passage formed to be recessed with respect to an inner surface of the shroud facing the blades; and

a plurality of resonators provided in the flow passage,

wherein the shroud comprises:

an inlet portion configured to guide an inflow of fluid toward the plurality of blades; and

an outlet portion configured to guide discharge of the fluid that has passed through the plurality of blades,

wherein the plurality of resonators are arranged in the flow passage with a uniform density in an entire area of the flow passage from the inlet portion of the shroud to the outlet portion.

2. The fluid machine of claim **1**, wherein each of the plurality of resonators comprises:

an opening portion provided on a surface of the flow passage facing the plurality of blades; and

a space portion connected to the opening portion and extending radially from the opening portion, the space portion forming a hollow space in the shroud.

3. The fluid machine of claim **1** further comprising a base arranged around the hub, extending along a circumferential direction with respect to the rotation center of the hub and supporting the plurality of blades.

4. The fluid machine of claim **1**, wherein the flow passage extends from the inlet portion toward the outlet portion and is formed in at least a partial section of the inner surface of the shroud.

5. A fluid machine comprising:

a rotatable hub;

a plurality of blades spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and

a shroud extending along the circumferential direction with respect to the rotation center of the hub and covering the plurality of blades, the shroud comprising:

a flow passage, the flow passage formed to be recessed with respect to an inner surface of the shroud facing the blades; and

a plurality of resonators provided in the flow passage,

wherein the shroud comprises:

an inlet portion configured to guide an inflow of fluid toward the plurality of blades; and

an outlet portion configured to guide discharge of the fluid that has passed through the plurality of blades, and

wherein a density of the plurality of resonators arranged in the flow passage increases from the inlet portion of the shroud toward the outlet portion.

6. The fluid machine of claim **5**, wherein the plurality of resonators are arranged only in a partial area of an entire area of the flow passage.

7. A fluid machine comprising:

a rotatable hub;

a plurality of blades spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and

a shroud extending along the circumferential direction with respect to the rotation center of the hub and covering the plurality of blades, the shroud comprising:

a flow passage, the flow passage formed to be recessed with respect to an inner surface of the shroud facing the blades; and

a plurality of resonators provided in the flow passage,

wherein the shroud comprises:

an inlet portion configured to guide an inflow of fluid toward the plurality of blades; and

an outlet portion configured to guide discharge of the fluid that has passed through the plurality of blades,

wherein the plurality of resonators are arranged only in a partial area of an entire area of the flow passage, and wherein the plurality of resonators are arranged in an area of the flow passage located at a distance from the inlet portion of the shroud determined by a preset distance from the inlet portion of the shroud toward the outlet portion.

8. A fluid machine comprising:

a rotatable hub;

a plurality of blades spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and

a shroud extending along the circumferential direction with respect to the rotation center of the hub and covering the plurality of blades, the shroud comprising:

a flow passage, the flow passage formed to be recessed with respect to an inner surface of the shroud facing the blades; and

a plurality of resonators provided in the flow passage,

wherein each of the plurality of resonators comprises:

an opening portion provided on a surface of the flow passage facing the plurality of blades; and

a space portion connected to the opening portion and extending radially from the opening portion, the space portion forming a hollow space in the shroud, and

wherein the shroud comprises:

a first plate arranged at a position contacting the plurality of blades and comprising the flow passage and the opening portion of each of the plurality of resonators; and

a second plate provided on the first plate and comprising the space portion of each of the plurality of resonators at a position corresponding to the opening portion of each of the plurality of resonators.

9. A fluid machine comprising:

a rotatable hub;

a base connected to the hub and extending radially from the hub;

a plurality of blades provided on the base and spaced apart from one another along a circumferential direction with respect to a rotation center of the hub; and

a shroud extending along the circumferential direction with respect to the rotation center of the hub and covering the plurality of blades, the shroud comprising:

an inner surface facing the base and contacting the plurality of blades;

a flow passage formed to be recessed with respect to the inner surface of the shroud facing the base; and

a plurality of resonators provided in the flow passage.

10. The fluid machine of claim **9**, wherein the shroud comprises:

an inlet portion configured to guide an inflow of fluid toward the plurality of blades; and

an outlet portion configured to guide discharge of the fluid that has passed through the plurality of blades.

11. The fluid machine of claim **9**, wherein the flow passage comprises:

a first region in which the plurality of resonators are arranged; and

a second region in which none of the plurality of resonators are provided in the flow passage.

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