



(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
07.01.2004 Bulletin 2004/02

(51) Int Cl.7: **F04D 17/04, F04D 29/42**

(21) Application number: **98114422.3**

(22) Date of filing: **31.07.1998**

(54) **Once-through blower**

Querstromlüfter

Ventilateur à courant transversal

(84) Designated Contracting States:
DE ES FR GB IT

(30) Priority: **12.01.1998 JP 360698**

(43) Date of publication of application:
14.07.1999 Bulletin 1999/28

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention generally relates to a once-through blower and, more particularly, to a once-through blower used for sending air purpose, e.g., in an air conditioner.

2. Description of the Prior Art

[0002] A once-through blower has already been used for sending air purpose, e.g., in an air conditioner. Improvements have been made to improve the efficiency of the blower for the purpose of energy saving, to make the blower quiet for the purpose of amenity, and to stabilize an airflow for the purpose of improving blowing characteristics of the blower. With regard to the technique of designing a once-through blower, since the airflow inside a blower is not logically verified, the characteristics of each item of equipment, such as an air conditioner, are improved by trial and error.

[0003] A conventional once-through blower is described in Japanese Patent Application Laid-open No. 5-296479. The blower has a once-through impeller that rotates around a rotary shaft. The blower also has a rear casing and a back nose. The rear casing constitutes an upper rear portion of the once-through blower. The back nose is provided in the vicinity of the once-through impeller so that a stagnation section in which airflow is stagnated is formed at a predetermined portion inside the blower. The foregoing structure eliminates turbulence, such as back flow, reduces noise and improves the efficiency of the blower.

[0004] Further, another conventional once-through blower is described in Japanese Patent Application Laid-open No. 7-305695. The blower has a stabilizer and a scroll casing. The stabilizer is provided so as to face a once-through impeller and to cross at a right angle an imaginary line extending from the edge thereof locating a lower position in front of the impeller to the center of the same. The scroll casing is formed from two circular arcs at the optimum position relative to the position of the stabilizer. The foregoing structure results in improvements in the blower, i.e., an improvement in the amount of discharge and a reduction in noise.

[0005] With regard to the foregoing conventional once-through blowers, although the geometry of a suction or supply opening of the impeller is changed to accomplish improved efficiency, noise reduction, and stable airflow, an improvement to control an airflow in itself is not made. Consequently, because that it is impossible to make essential improvements to the efficiency and noise characteristics of the blower, the blowers are improved in a repetitive trial-and-error manner. The repetitive trial-and-error improvements to equipment such as

an air conditioner impose a problem of deteriorating productivity of the blower.

SUMMARY OF THE INVENTION

[0006] It is a general object of the present invention to provide a novel and useful once-through blower which solves the aforementioned problems.

[0007] A more specific object of the present invention is to provide a once-through blower whose blowing performance is improved by controlling an airflow in itself.

[0008] The above objects of the present invention are achieved by a once-through blower including a once-through impeller producing airflow. The once-through blower includes a blowout duct, a stabilizer, and a scroll casing.

[0009] The blowout duct guides the airflow produced by the once-through impeller. The stabilizer is provided at an end of the blowout duct so as to face the once-through impeller. The scroll casing is provided at the back of the once-through impeller and connected to the blowout duct. The stabilizer has a curved surface which is formed along an arc having the center at the rotation center of the once-through impeller.

[0010] The curved surface extends from the vicinity of a starting point to an ending point. The starting point is a point where an imaginary extension of the blowout duct intersects the arc. The ending point locates apart from the starting point toward the same direction as the rotational direction of the once-through impeller. A clearance between the curved surface and the once-through impeller is set so as to become 3% or more of the radius of the once-through impeller.

[0011] The starting point, the ending point, and the rotational center of the once-through impeller are set so that the perpendicular bisector which is equidistant away from both the starting point and the ending point passes through the rotation center of the once-through impeller. The scroll casing has an interior curved surface which is formed along a casing arc. The casing arc is concentric with the arc center positioned in a triangular area which is defined by the starting point, the end point and the rotation center of the once-through impeller.

[0012] The casing arc has a radius which equals the length of an imaginary line connecting an inflow-side end of the scroll casing to the arc center. A clearance between an outer peripheral point of intersection where the imaginary line intersects the outer periphery of the once-through impeller and the inflow-side end of the scroll casing is set so as to become 3% or more of the diameter of the once-through impeller.

[0013] Other objects and further features of the present invention will be apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a longitudinal cross-sectional view showing an indoor unit of an air conditioner according to a first embodiment of the present invention;
Fig. 2 is an enlarged view for explaining an air flow occurring in the once-through blower shown in Fig. 1;

Fig. 3 is a view similar to Fig. 2, but hypothetically representing the airflow shown in Fig. 2;

Figs. 4 through 8 are views similar to Fig. 2, but showing other states of the airflow shown in Fig. 3;
Fig. 9 is an enlarged perspective view showing the principle element of a vane of the once-through blower;

Fig. 10 is a view similar to Fig. 2, but showing a current of air in a conventional once-through blower;

Fig. 11 is a view similar to Fig. 2, but showing a current of air in a once-through blower according to a second embodiment of the present invention;

Fig. 12 is a view similar to Fig. 2, but showing a current of air in a once-through blower according to a third embodiment of the present invention;

Fig. 13 is a graph for the purpose of explaining a state of current of air in a once-through blower according to a fourth embodiment of the present invention;

Fig. 14 is a view similar to Fig. 2, but showing the state of current of air in a once-through blower that is contrasted with the blower of the fourth embodiment;

Fig. 15 is a view similar to Fig. 2, but showing a current of air in a once-through blower according to a fifth embodiment of the present invention;

Fig. 16 is a longitudinal cross-sectional view showing an indoor unit of the air conditioner shown in Fig. 15 for the purpose of explaining the shape of the scroll casing; and

Fig. 17 is a longitudinal cross-sectional view showing an indoor unit of the air conditioner shown in Fig. 15 for the purpose of explaining another shape of the scroll casing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] In the following, principles and embodiments of the present invention will be described with reference to the accompanying drawings.

First Embodiment

[0016] Figs. 1 through 9 show a first embodiment of the present invention. Fig. 1 shows a longitudinal cross-sectional view indicating an indoor unit of an air conditioner. Fig. 2 shows an enlarged view for explaining an

airflow occurring in the once-through blower shown in Fig. 1. Fig. 3 shows a view similar to Fig. 2 for hypothetically explaining the airflow shown in Fig. 2. Fig. 4 shows a view similar to Fig. 2 for explaining another state of the airflow shown in Fig. 3. Fig. 5 shows a view similar to Fig. 2 for explaining still another state of the airflow shown in Fig. 3. Fig. 6 also shows a view similar to Fig. 2 for explaining another state of the airflow shown in Fig. 3. Fig. 7 shows a view similar to Fig. 2 for explaining another state of the airflow shown in Fig. 3. Fig. 8 also shows a view similar to Fig. 2 for explaining another state of the airflow shown in Fig. 3. Fig. 9 shows an enlarged perspective view of the principle element of a vane of the once-through blower.

[0017] The air conditioner shown in Fig. 1 has a framework 1. The framework 1 has a panel 2 on the front side thereof. A grille 3 is formed in the panel 2 so as to constitute an intake. The framework 1 has an upper inlet port 4 formed in the upper surface thereof so as to constitute an upper intake. The framework 1 also has an air outlet 5 formed in the lower front portion thereof. A heat exchanger 6 is provided in the framework 1 so as to face the grille 3. Further, a drain pan 7 is provided in the framework 1 so as to face the lower edge of the heat exchanger 6, as well as to receive drains of the heat exchanger 6.

[0018] The air conditioner has a once-through impeller 8 in the framework 1. The impeller 8 performs the blowing function of the indoor unit or constitutes the principle element of the once-through blower. A scroll casing 9 is provided in the framework 1 behind the once-through impeller 8. A blowout duct 5 is provided in the framework 1. The duct 5 comprises a lower interior surface 11 and an upper interior surface 12. The lower interior surface 11 is connected at each end thereof to the scroll casing 9 and a lower portion of the outlet 5. The upper interior surface 12 is connected at one end to an upper portion of the outlet 5, and the other end of the interior surface 12 extends to a position in front of the once-through impeller 8.

[0019] A stabilizer 13 is provided at the end of the upper interior surface 12 so as to face the once-through impeller 8. The stabilizer 13 is formed along an arc 15 which has its center at the rotation center 14 of the once-through impeller 8 and whose radius is 103% or more of the radius of the once-through impeller 8. In Fig. 1, a starting point 16 and an ending point are indicated on the arc 15. The starting point 16 is a point where the arc 15 intersects an imaginary extension of the upper interior surface 12. The ending point 17 is a predetermined point that locates closer to the heat exchanger 6 than the starting point 16. The stabilizer 13 has a curved surface 18 facing the once-through impeller 8 and extending to the ending point 17.

[0020] The air conditioner is designed so that the perpendicular bisector - which is equidistant away from both the starting point 16 and the ending point 17 - passes through the rotation center 14 of the once-through

impeller 8. In the other wards, the air conditioner is designed so that the starting point 16, the ending point 17 and the rotating center 14 form an isosceles triangle. An interior curved surface 19 of the scroll casing 9 is formed from a casing arc. In the present embodiment, the casing arc is concentric with the center 21, which is positioned in the isosceles triangle discussed above. Further, the radius of the casing arc equals a length of an imaginary line 22 that connects an inflow-side end 20 of the scroll casing 9 to the center 21 of the same. An outer peripheral crossing point 23 where the imaginary line 22 intersects the outer periphery of the once-through impeller 8 is indicated in Fig. 1. In the present embodiment, a clearance between the point 23 and the inflow-side end 20 is set so as to become 3% or more of the diameter of the once-through impeller 8.

[0021] In Figs. 2 through 8, reference numeral 24 designates a forced vortex, and 25 designates a free vortex. In Fig. 3 through Fig. 8, reference numeral 26 designates the boundary between the forced vortex 24 and the free vortex 25. In Fig. 3 through Fig. 5, reference numeral 27 designates the tip end of the upper interior surface 12 of the blowout duct. In Fig. 6 through Fig. 8, reference numeral 28 designates a primary stabilizer, 29 designates an edge 29 of the primary stabilizer 28; 30 designates an influx drawn into the vortex, and 31 designates an outflow originating from the vortex. Further, in Fig. 9, reference numeral 32 designates a vane of the once-through impeller 8.

[0022] In the once-through blower having the foregoing structure shown in Fig. 1, when the once-through impeller 8 is rotated, an air inflow and an air outflow arise while the stabilizer 3 stands on the border between them. Specifically, the air flows through the heat exchanger 6 by way of the upper inlet port 4, and the thus-sucked air flows to the blowout duct 10 after having passed through the inside of the once-through impeller 8. A combination of the air inflow and outflow results in a Rankine's combined vortex, such as that schematically shown in Fig. 3, being formed in a system having the blowout duct 10. The Rankine's combined vortex shown in Fig. 3 has its center at a position that locates within the once-through impeller 8 and faces the stabilizer 13 shown in Fig. 1.

[0023] In the Rankine's combined vortex, the free vortex 25 is formed outside the forced vortex 24. The blowout duct 10 guides the free vortex 25, thereby a current of air of the blower is produced. Thus, the blowing function of the blower is carried out. In such a blower, when the tip end 27 of the upper interior surface 12 of the blowout duct 10 is positioned on the boundary between the forced vortex 24 and the free vortex 25, a more stable current of air is produced with the highest degree of efficiency.

[0024] Figs. 4 and 5 show other examples in which the tip end 27 of the upper interior surface 12 of the blowout duct 10 is not positioned on the boundary 26. More particularly, Fig. 4 shows a case where the tip end 27 is

positioned in the free vortex 25. The position of the tip end 27 reduces the air outflow. In contrast, Fig. 5 shows a case where the tip end 27 is positioned in the forced vortex 24. The position of the tip end 27 in turn causes turbulence in the vortex, resulting in a loss of airflow and a decrease in the blowing efficiency.

[0025] Next, the relationship between the Rankine's combined vortex and the stabilizer 13 will be described. Fig. 6 shows the relationship between the Rankine's combined vortex and the primary stabilizer 28. The primary stabilizer 28 is a member that is contrasted with the stabilizer 13 of the present embodiment. The primary stabilizer 28 has the function of splitting the free vortex 25 of the Rankine's combined vortex into the influx 30 drawn into the vortex and the outflow 31 originating from the vortex. The free vortex 25 is split by means of the edge 29 of the primary stabilizer 28.

[0026] The air flows which are opposite in direction come close to each other in the vicinity of the edge 29, specifically, at the positions indicated by broken circles shown in Fig. 6. Since the air flows become very unstable at the positions indicated by broken circles, the overall vortex also becomes unstable. Fig. 7 shows a stable air flow produced by a curved surface 18 of the stabilizer 13 added to the edge 29 of the primary stabilizer 27 shown in Fig. 6.

[0027] More specifically, in the case shown in Fig. 7, the curved surface extending into the influx 30 is provided on the primary stabilizer 28 positioned in an unstable air flow. In this case, the influx 30 and the outflow 31 are separated from each other by means of the curved surface 18. Thus, since the air flows which are opposite in direction in the positions indicated by broken circles shown in Fig. 7 are separated from each other, the air flows in the vicinity of the edge 29 becomes stable, rendering the overall current of air stable.

[0028] Fig. 8 shows an air flow produced when the curved surface 18 of the stabilizer 13 is provided on the edge 29 of the primary stabilizer 28 so as to extend into the outflow 31. In this case, the outflow 31 causes a new vortex in the vicinity of the reverse side of the curved surface 18. The reverse side faces the interior of the blowout duct 10. The new vortex results in a loss of outflow and a decrease in the blowing efficiency.

[0029] The scroll casing 9 is positioned in the free vortex 25 of the Rankine's combined vortex. So long as the scroll casing 9 is formed so as to match the stream line of the free vortex 25, a stable current of air is highly efficiently produced with a small loss. The stream line of the free vortex 25 is an arc-shaped stream having a certain radius. As a result of the scroll casing 9 being formed into an arc shape in agreement with the stream line of the free vortex 25, a stable current of air is highly efficiently produced with a small loss of air flow.

[0030] As mentioned previously, in the embodiment shown in Figs. 1 through 9, the air conditioner of the present embodiment has the stabilizer 13 having the curved surface 18. The stabilizer 13 is formed at the end

of the upper interior surface 12 of the blowout duct 10 so as to face the once-through impeller 8. Moreover, the stabilizer 13 is formed along the arc 15 which has its center at the rotation center 14 of the once-through impeller 8 and whose radius is 103% or more of that of the once-through impeller 8. The curved surface 18 extends from near the starting point 16 to the ending point 17. The starting point 16 is a point where the arc 15 intersects the imaginary extension of the upper interior surface 12 of the blowout duct 10. The end point 17 is the predetermined point that locates closer to the heat exchanger 6 than the starting point 16.

[0031] Further, The air conditioner of the present embodiment has a scroll casing 9 having the interior curved surface 19. The interior curved surface 19 is formed from the casing arc that is concentric with the center 21. The air conditioner is designed so that the starting point 16, the ending point 17 and the rotating center 14 form an isosceles triangle. The center 21 is positioned in the isosceles triangle discussed above. Further, the radius of the casing arc equals a length of the imaginary line 22 that connects the inflow-side end 20 of the scroll casing 9 to the center 21 of the same. The clearance between the outer peripheral crossing point 23 and the inflow-side end 20 is set so as to become 3% or more of the diameter of the once-through impeller 8. The outer peripheral crossing point 23 is the point where the imaginary line 22 intersects the outer periphery of the once-through impeller 8.

[0032] With the foregoing configuration, the once-through blower can highly efficiently produce a stable current of air with a small loss of the blowing action. The small loss of the blowing action result in an increase in gas quantity with respect to the rotational speed of the once-through impeller 8. Consequently, the rotational speed of the once-through impeller 8 can be reduced while a constant gas quantity is maintained. For this reason, a reduction arises in a flow rate "w" of the air flowing along the upper surface of the vane 32 of the once-through impeller 8 shown in Fig. 9. As a result, it becomes possible to reduce noise caused by the vane 32, the noise primarily accounting for the noise of the once-through blower. Thus, according to the present embodiment, a once-through blower capable of quietly operating can be provided.

Second Embodiment

[0033] Figs. 10 and 11 show schematic representations for explaining a second embodiment of the present invention. Fig. 10 shows a view similar to Fig. 2 for explaining a current of air in a once-through blower that is contrasted with the once-through blower of the present invention. On the other hand, Fig. 11 shows a view similar to Fig. 2 for explaining another current of air in the once-through blower of the present invention. In other respects, the once-through blowers shown in Figs. 10 and 11 are the same in structure as that of the once-

through blower shown in Figs. 1 through 9. In the drawings, the same reference numerals are assigned to designate elements which are the same as those used in Figs. 1 through 9.

[0034] Reference numeral 33 designates a circulating current of air which corresponds to the forced vortex of the Rankine's combined vortex. Reference numeral 34 designates a through-current which corresponds to the free vortex of the Rankine's combined vortex. Reference numeral 35 shown in Fig. 10 designates a separation area where the separation flow produced by the stabilizer 40 flows in. Further, reference numeral 36 shown in Fig. 11 designates a bulge formed in the vicinity of the starting point 16 on the curved surface 18 of the stabilizer 13.

[0035] In the once-through blower shown in Fig. 10, the stabilizer 40 is not provided with the bulge 36, and the through-current 34 flows into the blowout duct 10 at an angle of attack with respect to the upper interior surface 12. The through-current having the angle of attack causes considerable turbulence in the current of air in the vicinity of the stabilizer 13. As a result, the separation area 35 is formed along the stabilizer 13, rendering the overall current of air unstable, and a loss of air flow and noise increasing.

[0036] The stabilizer 13 shown in Fig. 11 is provided with the bulge 36. The bulge 36 prevents formation of the separation area 35 and eliminating the risk of considerable turbulence arising in the vicinity of the separation area. Accordingly, a loss of influx is reduced, and the through-current 34 becomes stable. In this way, a current of air can be highly efficiently produced with much fewer loss of air flow, and there can be obtained an advantageous result which is the same as that yielded in the embodiment shown in Figs. 1 through 9.

Third Embodiment

[0037] Fig. 12 shows a view similar to Fig. 2 for explaining a current of air produced by a once-through blower of a third embodiment of the present invention. In other respects, the once-through blower shown in Fig. 12 has the same structure as that of the once-through blower of the first embodiment shown in Figs. 1 through 9. The same reference numerals are assigned to designate the elements which are the same as those shown in Figs. 1 through 9. Reference numeral 37 designates the outermost flow which is formed in the outermost area on the boundary 26 between the forced vortex 24 and the free vortex 25 of the Rankine's combined vortex. Reference numeral 42 designates a curved surface which is formed on the stabilizer 13 into an arc shape so as to match the profile of the outermost flow 37.

[0038] In the once-through blower having the foregoing structure, the current of air in the vicinity of the stabilizer 13 is the outermost flow 37. In this embodiment, the curved surface 42 of the stabilizer 13 is formed into an arc shape matching the profile of the outermost flow

37; that is, an arch shape which is concentric with the center 21 of the scroll casing 9. As a result, a loss of the outermost flow 37 is reduced, and a loss of the forced vortex 24 in the vicinity of the stabilizer 13 is also decreased. Consequently, a stable current of air can be highly efficiently produced, whereby superior blowing action is ensured. As described above, the third embodiment also yields the same advantageous result as that yielded by the first embodiment shown in Figs. 1 through 9.

Fourth Embodiment

[0039] Figs. 13 and 14 show schematic representations for explaining a fourth embodiment of the present invention. More particularly, Fig. 13 shows a graph for explaining the state of current of air in a once-through blower. Fig. 14 shows a view similar to Fig. 2 for explaining the state of current of air in the once-through blower of this embodiment. In other respects, the once-through blower shown in Figs. 14 has the same structure as that of the once-through blower of the first embodiment shown in Figs. 1 through 9.

[0040] In the drawings, the same reference numerals are assigned to designate the elements which are the same as those shown in Figs. 1 through 9. Reference numeral 38 designates a stream line of the air flow in the vicinity of the interior curved surface 19 of the scroll casing 9. Hereinafter the length from the center 21 of the scroll casing 9 to a certain point in the once-through blower is referred to as a radius "r". Further, a flow rate of a swirl flow flowing through the inside of the once-through blower is referred to as a peripheral speed.

[0041] The relationship between the peripheral speed $V\theta$ and the radius "r" is expressed as below by using "n" representing a velocity index and Γ representing a circulation constant of the air flow.

$$V\theta \times r^n = \Gamma \quad (\text{Ex. 1})$$

[0042] In this embodiment, the radius "r0" of the interior curved surface 19 of the scroll casing 9 is given by Eq. 1 by setting the velocity index "n" to a value within a range of $0.85 \leq n \leq 1.0$. The range of velocity index is determined based on a certain value of the velocity index at which a vorticity of the free vortex 25 of the Rankine's combined vortex is changed to a negative value from a positive value. Fig. 13 shows a graph indicating the relationship between the radius "r" and the peripheral velocity $V\theta$, as well as the relationship between the radius "r" and the vorticity ζ , of the Rankine's combined vortex. The vorticity ζ can be generally expressed as below by using the radius "r", the circulation constant Γ , and the velocity index "n".

$$\zeta = \Gamma \times (1 - n) \times r^{-(1+n)} \quad (\text{Eq. 2})$$

[0043] Eq. 2 shows that the vorticity ζ becomes negative when $n > 1$. If the radius "r0" of the interior curved surface 19 is set to a value within the range in which the vorticity of the vortex is negative, there arises in the vicinity of the interior curved surface 19 a vortex which rotates in the direction opposite to the direction in which the vortex occurring in the once-through impeller 8 rotates, as shown in Fig. 14. As a result, when the radius "r0" is set by using a velocity index "n" more than one, the air flow suffers considerable damage, thereby resulting in a decrease in the blowing efficiency of the blower.

[0044] In contrast, the vorticity ζ becomes positive when $n < 1$. As shown in Fig. 13, as the radius "r" becomes longer, $V\theta$ simply decreases toward a certain convergent value. For this reason, so long as the radius "r0" is set such that the velocity index "n" approaches one as closely as possible, the loss of air flow which is due to flow rate and is caused by the scroll casing 9 can be reduced, rendering the air flow highly efficiently. When $n = 1$, the vorticity ζ becomes zero. If the radius "r" of the interior curved surface 19 of the scroll casing 9 is set to a value within the range in which the vorticity ζ becomes zero, an air flow can be formed without loss, realizing remarkably high-efficient blowing action.

[0045] In a case where the blower is actually used in the indoor unit 1 of the air conditioner, it is necessary to take into account variations in loss of the air flow in the once-through blower. Thus, it is suitable to set the radius "r0" by using a certain velocity index that is less than and nearly equal to one. According to the foregoing setting, a highly efficient air flow can be produced, and superior blowing action can be accomplished.

[0046] In the fourth embodiment shown in Figs. 13 and 14, the radius "r0" of the interior curved surface 19 of the scroll casing 9 is set such that the velocity index "n" is set to a value within a range of $0.85 \leq n \leq 1.0$. As a result, the interior curved surface 19 matches the stream line 38, and therefore the loss of air flow can be minimized to the limit. Accordingly, the most stable air flow can be highly efficiently produced.

[0047] The proportion of gas quantity to the rotational speed of the once-through impeller 8 increases with a decrease in the loss of blowing action of the once-through blower. Consequently, the rotational speed of the once-through impeller 8 can be reduced while the same gas quantity is maintained. As a result, a decrease arises in the flow rate "w" of current of air flowing along the upper surface of the vane 32 of the once-through impeller 8 shown in Fig. 9, so that it becomes possible to reduce noise caused by the vane 32, the noise primarily accounting for the noise of the once-through blower. Accordingly, the setting of the present embodiment can provide a once-through blower capable of quietly operating.

Fifth Embodiment

[0048] Figs. 15 through 17 show schematic representations for explaining a fifth embodiment of the present invention. More particularly, Fig. 15 shows a view similar to Fig. 2 for explaining the state of current of air in the once-through blower of the present invention. Fig. 16 shows a longitudinal cross-sectional view indicating an indoor unit of an air conditioner for the purpose of explaining the shape of the scroll casing. Fig. 17 also shows a longitudinal cross-sectional view showing an indoor unit of an air conditioner for the purpose of explaining another shape of the scroll casing. In other respects, the once-through blowers shown in Figs. 15 through 17 have the same structure as that of the once-through blower according to the first embodiment shown in Figs. 1 through 9. In the drawings, the same reference numerals are assigned to designate elements which are the same as those used in Figs. 1 through 9.

[0049] In Fig. 15, reference numeral 44 designates an imaginary stream line of air current which may be produced in the vicinity of the interior curved surface 19 when the surface 19 has a larger radius. In this embodiment, the shape of the scroll casing 9 is set by determining the radius "r0" of the interior curved surface 19 in such a way that the radius "r0" and a dimensionless number ζ - which represents the degree of loss of air flow in the once-through blower - change satisfying the relationship shown below.

$$r \propto 1 / \zeta \quad (\text{Eq. 3}).$$

[0050] In other words, in this embodiment, if the loss of air flow of the once-through blower is great, the radius "r0" of the interior curved surface 19 is set to a small value. In contrast, if the loss is small, the radius "r0" is set to a large value.

[0051] Fig. 14 shows the air flow in the case where the loss of air flow in the once-through blower is great. Fig. 15 shows the air flow in the case where the loss of air flow in the once-through blower is small. As shown in Figs. 14 and 15, stream lines having vorticity $\zeta = 0$; that is, the stream lines 38 and 44 having a velocity index "n" = 1, are formed in the free vortex 25 in the vicinity of the scroll casing 9.

[0052] Hereinafter, the distance between the center 21 of the vortex and the stream lines 38 and 44, i.e., the radius used for defining the stream lines 38 and 44 is referred to as a radius "r ζ 0". The radius "r ζ 0" becomes small when the loss of air flow is great. For this reason, when the loss of the air flow is great, the vorticity ζ of the vortex in the vicinity of the interior curved surface 19 becomes negative.

[0053] The vortex - which develops in the vicinity of the interior curved surface and reversely rotates - causes a loss of air flow, resulting in a reduction in the blowing efficiency. In contrast, in a case where the loss of air flow

is small, the radius r ζ 0 becomes great, the flow rate of vortex in the vicinity of the interior curved surface 19 is increased. Therefore, the loss of vortex caused by the increase in the flow rate is increased, resulting in a decrease in the blowing efficiency.

[0054] To prevent such problems, in a case where the loss of air flow is great, the radius "r0" of the interior curved surface 19 had better be set to a small value. On the other hand, if the loss of air flow is small, the radius "r0" had better be increased to prevent such a decrease in the blowing efficiency.

[0055] In a case where the blower is actually used in the indoor unit 1 of the air conditioner, the front grille 3, the upper inlet port 4, and the heat exchanger 6 cause pressure losses in the air flow drawn into the once-through blower. To prevent the pressure losses, the interior curved surface 19 of the scroll casing 9 is formed in such a way as will be described below.

[0056] In short, if there is an increase in the thickness of the heat exchanger 6, the radius "r0" of the interior curved surface 19 is reduced as indicated by a broken line shown in Fig. 16. In contrast, if there is a decrease in the thickness of the heat exchange r6, the radius "r0" of the interior curved surface 19 is increased as indicated by a broken line shown in Fig. 17. As a result, production of a highly efficient air flow and a reduction in noise can be achieved, and there can be provided a once-through blower capable of quietly operating.

[0057] As has been described above, the once-through blower according to the present invention has a stabilizer having a predetermined shape and a scroll casing having a predetermined shape.

[0058] Accordingly, the loss of overall air flow in the once-through blower is reduced while a stable air flow can be highly efficiently produced, yielding the advantage of superior blowing action. Further, the noise of the once-through blower can be reduced, enabling the blower to operate quietly.

[0059] As mentioned previously, according to the present invention, the once-through blower has a bulge on the stabilizer.

[0060] The bulge prevents a formation of a separation area in the vicinity of the stabilizer, particularly, reducing the loss of outflow originating from the vortex. For this reason, a stable flow can be highly efficiently produced, yielding the advantage of superior blowing action. Further, the noise of the once-through blower can be reduced, enabling the blower to operate quietly.

[0061] As mentioned previously, according to the present invention, the curved surface of the stabilizer is formed along an imaginary circle concentric with the center of the scroll casing.

[0062] As a result, the loss of forced vortex in the vicinity of the stabilizer is especially reduced. For this reason, a stable flow can be highly efficiently produced, yielding the advantage of superior blowing action. Further, the noise of the once-through blower can be reduced, enabling the blower to operate quietly.

[0063] As mentioned previously, according to the present invention, the radius of the interior curved surface "r0" is set by using a velocity index "n" which is included in a range of $0.85 \leq n \leq 1.0$.

[0064] As a result, the loss of air flow in the vicinity of the interior curved surface of the scroll casing can be minimized to the limit. Accordingly, the most stable air flow can be highly efficiently produced. For this reason, a more stable flow can be highly efficiently produced, yielding the advantage of superior blowing action. Further, the noise of the once-through blower can be reduced, enabling the blower to operate quietly.

[0065] As mentioned previously, according to the present invention, the radius of the interior curved surface "r0" is set to a small value when the pressure losses of air flow are greater whereas the radius "r0" is set to a large value when the pressure losses of air flow are smaller.

[0066] As a result, the loss of air flow caused by the vortex—which reversely rotates in the vicinity of the interior curved surface—is reduced. Further, the loss of air flow in the vicinity of the interior curved surface of the scroll casing can be minimized to the limit. Accordingly, the most stable air flow can be highly efficiently produced, yielding the advantage of superior blowing action. Further, the noise of the once-through blower can be reduced, enabling the blower to operate quietly.

[0067] As mentioned previously, according to the present invention, the radius "r0" is set based on the pressure losses caused by elements disposed in the intake path of the once-through impeller.

[0068] As a result, the loss of air flow in the vicinity of the interior curved surface can be minimized to the limit by designing the structure of the once-through blower based on the pressure losses caused by the equipment disposed in the intake path of the once-through impeller. Accordingly, the most stable air flow can be highly efficiently produced, yielding the advantage of superior blowing action. Further, the noise of the once-through blower can be reduced, enabling the blower to operate quietly.

[0069] As mentioned previously, according to the present invention, the radius "r0" is set based on the relationship between the radius "r0" and a dimensionless number ζ shown below.

$$r \propto 1 / \zeta.$$

[0070] With the foregoing structure, the loss of air flow in the vicinity of the interior curved surface can be minimized to the limit, without being influenced by the value of the pressure losses developing outside the once-through blower. Accordingly, the most stable air flow can be highly efficiently produced, yielding the advantage of superior blowing action. Further, the noise of the once-through blower can be reduced, enabling the blower to operate quietly.

Claims

1. A once-through blower including a once-through impeller (8) producing an airflow, said once-through blower comprising:

a blowout duct (10) guiding the airflow produced by said once-through impeller (8);
a stabilizer (13) provided at an end of said blowout duct (10) so as to face said once-through impeller (8);
a scroll casing (9) which is provided at the back of said once-through impeller (8) and connected to said blowout duct (10) and which has an interior curved surface (19) which is formed along a casing arc;

characterized in that said stabilizer (13) has a curved surface (18) which is formed along an arc (15) having the center in the vicinity of the rotation center (14) of said once-through impeller (8);

said curved surface (18) extends from the vicinity of a starting point (16) where an imaginary extension of said blowout duct (10) intersects said arc (15) to an ending point (17) which locates apart from the starting point (16) toward the same direction as the rotational direction of said once-through impeller (8);

a clearance between said curved surface (18) and said once-through impeller (8) is set so as to become 3% or more of the radius of the once-through impeller (8);

said starting point (16), said ending point (17), and said rotational center of said once-through impeller (8) are set so that the perpendicular bisector which is equidistant away from both the starting point (16) and the ending point (17) passes through the rotation center (14) of the once-through impeller (8);

said casing arc is concentric with the arc center (21) positioned in a triangular area which is defined by the starting point (16), the ending point (17) and the rotation center of the once-through impeller (8);

said casing arc has a radius which equals the length of an imaginary line (22) connecting an inflow-side end (20) of said scroll casing (9) to the arc center (21); and

a clearance between an outer peripheral point (23) of intersection where said imaginary line (22) intersects the outer periphery of said once-through impeller (8) and the inflow-side end (20) of said scroll casing (9) is set so as to become 3% or more of the diameter of the once-through impeller (8).

2. The once-through blower as defined in claim 1, wherein;

said curved surface (18) of said stabilizer (13) is concentric with the rotational center (14) of said once-through impeller (8); and the diameter of said curved surface (18) is set so as to become 103% or more of that of said once-through impeller (8).

3. The once-through blower as defined in claim 1 or claim 2, wherein a bulge (36) is formed at the vicinity of the starting point (16) of said curved surface (18) of the stabilizer (13).

4. The once-through blower as defined in any one of claims 1 through 3, wherein the curved surface (18) of the stabilizer (13) is formed along an imaginary circle (37) which is centered at the center (21) of said scroll casing (9).

5. The once-through blower as defined in any one of claims 1 through 4, wherein;

taking the radius of the interior curved surface (19) of the scroll casing (9) as "r0", a flow rate of a swirl flow flowing through the inside of the once-through impeller (8.) as $V\theta$, a velocity index as "n", and a circulation constant of the air flow as Γ , there is obtained

$$v\theta \times r0^n = \Gamma,$$

said radius "r0" is given by setting the velocity index "n" to a value within a range of $0.85 \leq n \leq 1.0$ in the relation shown above.

6. The once-through blower as defined in claim 5, wherein the radius "r0" of the interior surface of said scroll casing (9) is set to a smaller value when pressure losses of air flow occurring outside the once-through blower are greater, whereas the radius "r0" is set to a larger value when the pressure losses are smaller.

7. The once-through blower as defined in claim 6, wherein the radius "r0" of the interior surface of said scroll casing (9) is set to a smaller value when pressure losses caused by elements (3, 4, 6) disposed in an intake path of the once-through impeller (8) is greater, whereas the radius "r0" is set to a larger value when the pressure losses are smaller.

8. The once-through blower as defined in claim 6, wherein said radius "r0" of the interior surface of said scroll casing (9) is given so that the radius "r0" and a dimensionless number ζ — which represents the degree of loss of air flow occurring in the once-through blower — satisfy the relation shown below

$$r \propto 1 / \zeta.$$

5 Patentansprüche

1. Querstromlüfter enthaltend ein Querstrom-Flügelrad (8), das einen Luftstrom erzeugt, welcher Querstromlüfter aufweist:

eine Ausblasleitung (10), die einen von dem Querstrom-Flügelrad (8) erzeugten Luftstrom führt;

einen Stabilisator (13), der an einem Ende der Ausblasleitung (10) so vorgesehen ist, dass er dem Querstrom-Flügelrad (8) zugewandt ist;

ein Rollengehäuse (9), das an der Rückseite des Querstrom-Flügelrades (8) vorgesehen und mit der Ausblasleitung (10) verbunden ist, und das eine innere gekrümmte Oberfläche (19) hat, das entlang eines Gehäusebogens ausgebildet ist;

dadurch gekennzeichnet, dass

der Stabilisator (13) eine gekrümmte Oberfläche (18) hat, die entlang eines Bogens (15) ausgebildet ist, dessen Mittelpunkt in der Nähe der Drehmitte (14) des Querstrom-Flügelrades (8) ist;

die besagte gekrümmte Oberfläche (18) sich von der Nähe eines Startpunktes (16), an dem eine imaginäre Verlängerung der Ausblasleitung (10) den Bogen (15) schneidet, zu einem Endpunkt (17), der sich abseits des Startpunktes (16) in der selben Richtung wie der Drehrichtung des Querstrom-Flügelrades (8) befindet, erstreckt; ein Abstand zwischen der besagten gekrümmten Oberfläche (18) und dem Querstrom-Flügelrad (8) so eingestellt ist, dass er 3% oder mehr des Radius des Querstrom-Flügelrades (8) wird;

der Startpunkt (16), der Endpunkt (17) und die Drehmitte des Querstrom-Flügelrades (8) so gesetzt sind, dass die senkrechte Halbierende, die sich in gleichem Abstand sowohl von dem Startpunkt (16) als auch dem Endpunkt (17) befindet, durch die Drehmitte (14) des Querstrom-Flügelrades (8) hindurchgeht;

der Gehäusebogen konzentrisch zu der Bogenmitte (21) ist, die sich in einem Dreiecksbereich befindet, der durch den Startpunkt (16), den Endpunkt (17) und die Drehmitte des Querstrom-Flügelrades (8) definiert ist;

der Gehäusebogen einen Radius hat, der der Länge einer imaginären Linie (22) gleich ist, die ein einströmseitiges Ende (20) des Rollengehäuses (9) mit der Bogenmitte (21) verbindet; und ein Abstand zwischen einem äußeren Umfangspunkt (23) eines

Schnittes, an dem die besagte imaginäre Linie (22) den Außenumfang des Querstrom-Flügelrades (8) schneidet, und dem einströmseitigen Ende (20) des Rollengehäuses (9) so eingestellt wird, dass er 3% oder mehr des Durchmessers des Querstrom-Flügelrades (8) wird.

2. Querstromlüfter nach Anspruch 1, bei welchem:

die gekrümmte Oberfläche (18) des Stabilisators (13) ist konzentrisch zu der Drehmitte (14) des Querstrom-Flügelrades (8); und der Durchmesser der gekrümmten Oberfläche (18) ist so eingestellt, dass er 103% oder mehr von dem des Querstrom-Flügelrades (8) wird.

3. Querstromlüfter nach Anspruch 1 oder Anspruch 2, bei dem eine Ausbauchung (36) der gekrümmten Oberfläche (18) des Stabilisators (13) in der Nähe des Startpunktes (16) ausgebildet ist.

4. Querstromlüfter nach einem der Ansprüche 1 bis 3, bei dem die gekrümmte Oberfläche (18) des Stabilisators (13) entlang eines imaginären Kreises (37) ausgebildet ist, dessen Mittelpunkt in der Mitte (21) des Rollengehäuses (9) ist.

5. Querstromlüfter nach einem der Ansprüche 1 bis 4, bei dem:

wenn der Radius der inneren gekrümmten Oberfläche (19) des Rollengehäuses (9) als "r0", eine Strömungsgeschwindigkeit eines durch das Innere des Querstrom-Flügelrades (8) strömenden Wirbelstroms als v_0 , ein Geschwindigkeitsindex als "n" und eine Zirkulationskonstante als Γ genommen werden, wird

$$v_0 \times r_0^n = \Gamma$$

erhalten, wobei der Radius "r0" gegeben ist durch Setzen des Geschwindigkeitsindex "n" auf einen Wert innerhalb eines Bereichs von $0,85 \leq n \leq 1,0$ in der vorgenannten Beziehung.

6. Querstromlüfter nach Anspruch 5, bei dem der Radius "r0" der inneren Oberfläche des Rollengehäuses (9) auf einen kleineren Wert gesetzt wird, wenn Druckverluste des Luftstroms, die außerhalb des Querstromlüfters auftreten, größer sind, während der Radius "r0" auf einen größeren Wert gesetzt wird, wenn die Druckverluste kleiner sind.

7. Querstromlüfter nach Anspruch 6, bei dem der Radius "r0" der inneren Oberfläche des Rollengehäuses (9) auf einen kleineren Wert gesetzt wird, wenn durch Elemente (3, 4, 6), die sich in einem Einlas-

spfad des Querstrom-Flügelrades (8) befinden, bewirkte Verluste größer sind, während der Radius "r0" auf einen größeren Wert gesetzt wird, wenn die Druckverluste kleiner sind.

8. Querstromlüfter nach Anspruch 6, bei dem der Radius "r0" der inneren Oberfläche des Rollengehäuses (9) so gegeben ist, dass der Radius "r0" und eine dimensionslose Zahl ξ - die den Grad des Verlustes des Luftstroms, der in dem Querstromlüfter auftritt, darstellt - der nachfolgenden Beziehung genügt:

$$r \propto 1/\xi.$$

Revendications

1. Ventilateur de soufflage à passage unique incluant une roue de ventilateur à passage unique (8) produisant un écoulement d'air, ledit ventilateur de soufflage à passage unique comprenant :

un conduit de décharge (10) guidant l'écoulement d'air produit par ladite roue de ventilateur à passage unique (8) ;

un stabilisateur (13) prévu à une extrémité du conduit de décharge (10) afin de faire face à ladite roue de ventilateur à passage unique (8); un carter en forme de volute (9) qui est prévu à l'arrière de ladite roue de ventilateur à passage unique (8) et qui est connecté audit conduit de décharge (10) et qui a une surface incurvée intérieure (19) qui est formée suivant un arc de carter ;

caractérisé en ce que ledit stabilisateur (13) a une surface incurvée (18) qui est formée suivant un arc (15) ayant le centre à proximité du centre de rotation (14) de ladite roue de ventilateur à passage unique (8) ;

ladite surface incurvée (18) s'étend entre le voisinage d'un point de départ (16) où une extension imaginaire dudit conduit de décharge (10) coupe ledit arc (15) et un point d'arrivée (17) qui se situe à distance du point de départ (16) vers la même direction que le sens de rotation de ladite roue de ventilateur à passage unique (8);

un espace libre entre ladite surface incurvée (18) et ladite roue de ventilateur à passage unique (8) est défini afin d'être égal à 3% ou plus du rayon de la roue de ventilateur à passage unique (8) ;

ledit point de départ (16), ledit point d'arrivée (17), et ledit centre de rotation de ladite roue de ventilateur à passage unique (8) sont définis afin que la bissectrice perpendiculaire qui est équidistante par rapport à la fois au point de départ (16) et au

point d'arrivée (17) passe par le centre de rotation (14) de la roue de ventilateur à passage unique (8) ;

ledit arc de carter est concentrique au centre de l'arc (21) positionné dans une zone triangulaire qui est définie par le point de départ (16), le point d'arrivée (17) et le centre de rotation de la roue de ventilateur à passage unique (8) ;

ledit arc de carter a un rayon qui est égal à la longueur d'une ligne imaginaire (22) connectant une extrémité (20) du côté charge dudit carter en forme de volute (9) au centre de l'arc (21) ; et

un espace libre entre un point externe périphérique (23) de l'intersection où ledit axe imaginaire (22) coupe la périphérie externe de ladite roue de ventilateur à passage unique (8) et l'extrémité (20) du côté charge dudit carter en forme de volute (9) est défini afin d'être égal à 3% ou plus du diamètre de la roue de ventilateur à passage unique (8).

2. Ventilateur de soufflage à passage unique selon la revendication 1, dans lequel :

ladite surface incurvée (18) dudit stabilisateur (13) est concentrique au centre de rotation (14) de ladite roue de ventilateur à passage unique (8) ; et

le diamètre de ladite surface incurvée (18) est défini afin d'être égal à 103% ou plus de celui de ladite roue de ventilateur à passage unique (8).

3. Ventilateur de soufflage à passage unique selon la revendication 1 ou la revendication 2, dans lequel une saillie (36) est formée au voisinage du point de départ (16) de ladite surface incurvée (18) du stabilisateur (13).

4. Ventilateur de soufflage à passage unique selon l'une quelconque des revendications 1 à 3, dans lequel la surface incurvée (18) du stabilisateur (13) est formée suivant un cercle imaginaire (37) qui est centré sur le centre (21) dudit carter en forme de volute (9).

5. Ventilateur de soufflage à passage unique selon l'une quelconque des revendications 1 à 4, dans lequel :

en prenant le rayon de la surface incurvée intérieure (19) du carter en forme de volute (9) comme "r0", un débit d'écoulement d'un écoulement tourbillonnaire s'écoulant à l'intérieur de la roue de ventilateur à passage unique (8) comme $v\theta$, un indice de vitesse comme "n" et une constante de circulation de l'écoulement d'air comme Γ , on obtient

$$v\theta \times r0^n = \Gamma,$$

ledit rayon "r0" est déterminé en réglant l'indice de vitesse "n" à une valeur comprise dans une plage telle que $0,85 \leq n \leq 1,0$, dans la relation ci-dessus.

6. Ventilateur de soufflage à passage unique selon la revendication 5, dans lequel le rayon "r0" de la surface intérieure dudit carter en forme de volute (9) est réglé à une valeur plus faible si les pertes de pression de l'écoulement d'air se produisant à l'extérieur du ventilateur de soufflage à passage unique sont plus grandes, alors que le rayon "r0" est réglé à une valeur plus grande si les pertes de pression sont plus petites.
7. Ventilateur de soufflage à passage unique selon la revendication 6, dans lequel le rayon "r0" de la surface intérieure dudit carter en forme de volute (9) est réglé à une valeur plus petite si les pertes de pression provoquées par des éléments (3, 4, 6) disposés dans un chemin d'aspiration de la roue de ventilateur à passage unique (8) sont plus grandes, alors que le rayon "r0" est réglé à une valeur plus grande si les pertes de pression sont plus petites.
8. Ventilateur de soufflage à passage unique selon la revendication 6, dans lequel ledit rayon "r0" de la surface intérieure dudit carter en forme de volute (9) est déterminé afin que le rayon "r0" et un nombre sans dimension ξ - qui représente le degré de perte d'écoulement d'air se produisant dans le ventilateur de soufflage à passage unique - satisfassent la relation ci-dessous

$$r \propto 1 / \xi.$$

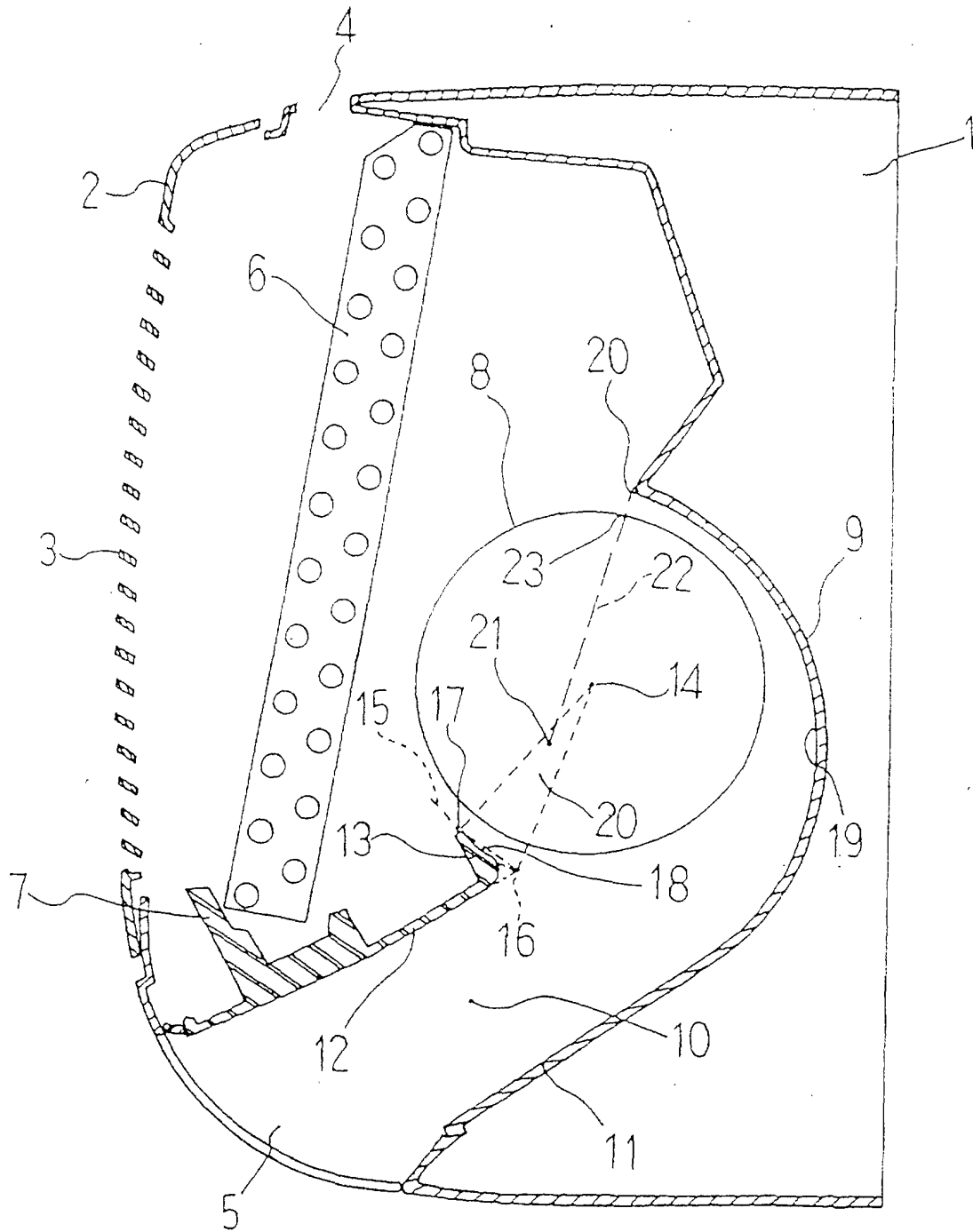


FIG. 1

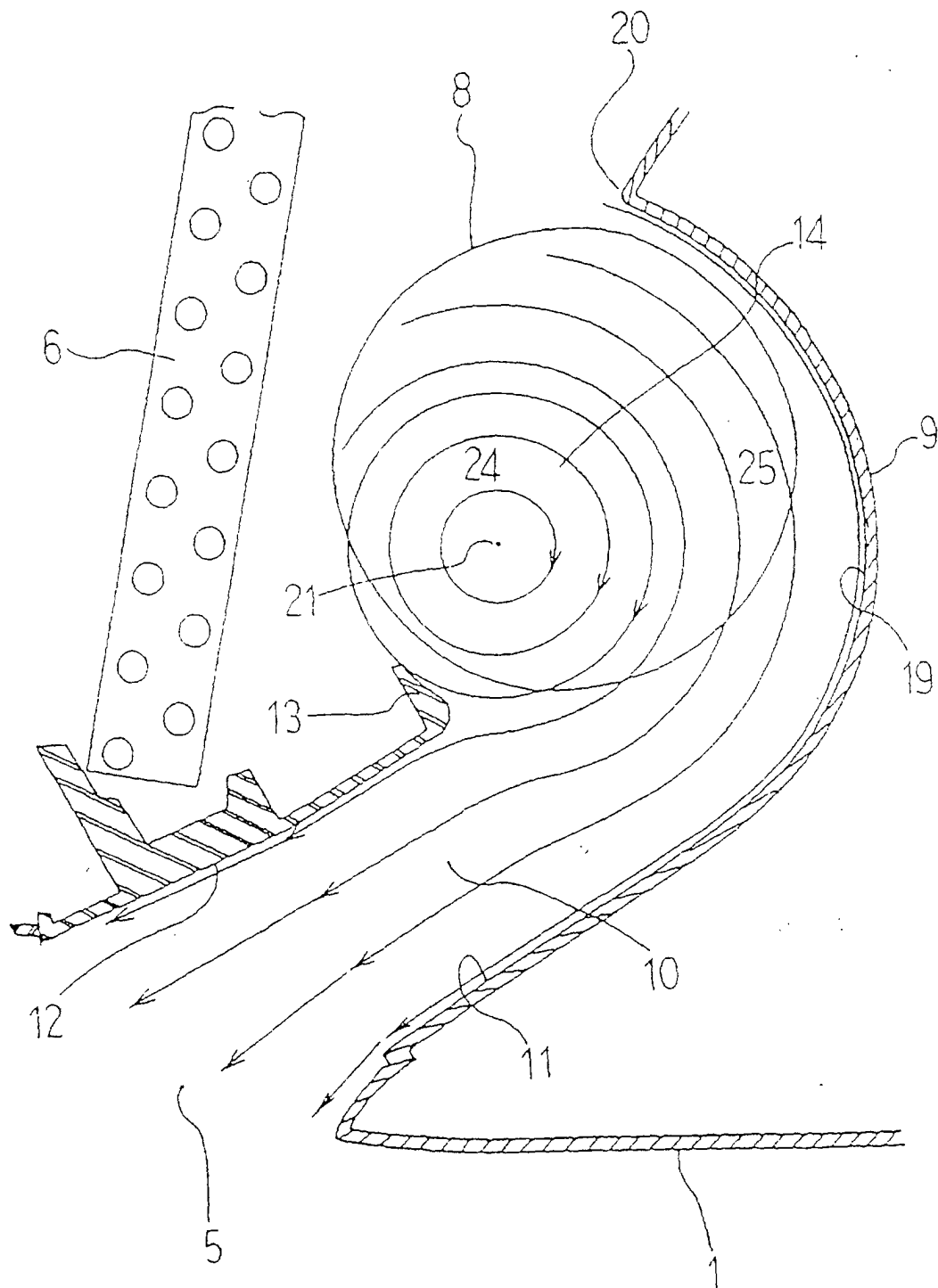


FIG.2

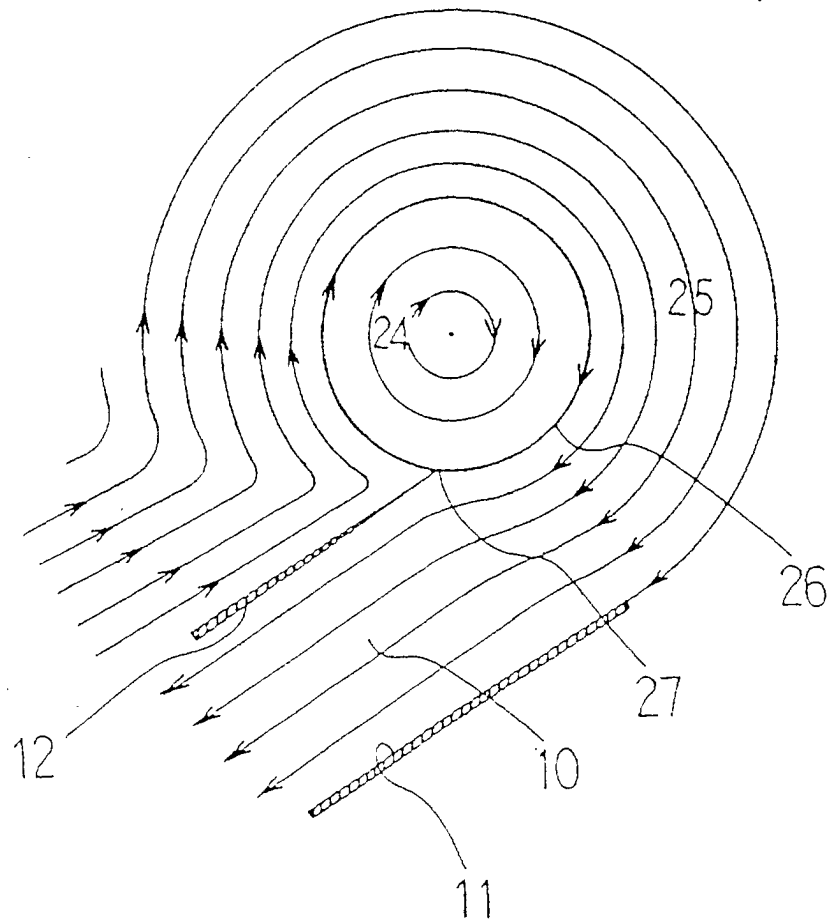


FIG.3

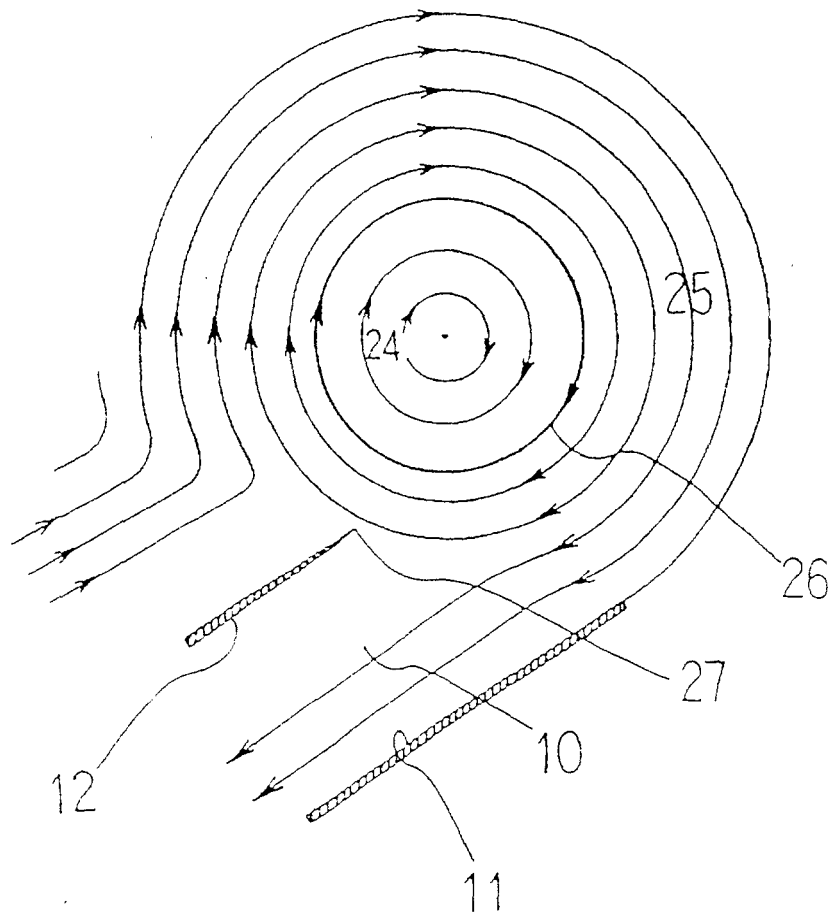


FIG. 4

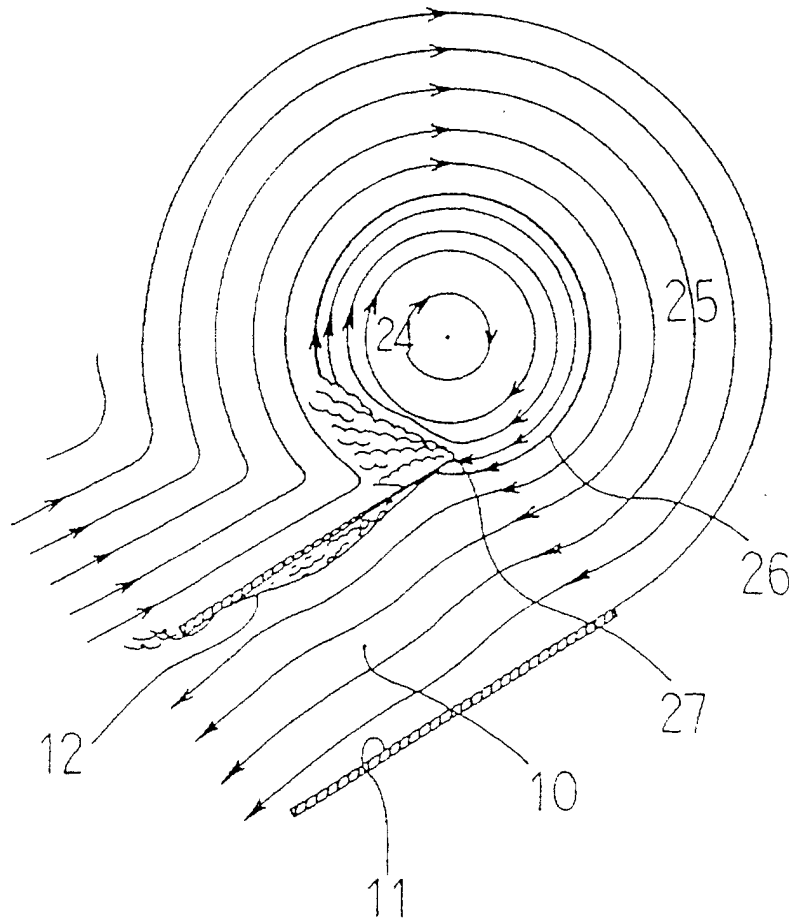


FIG. 5

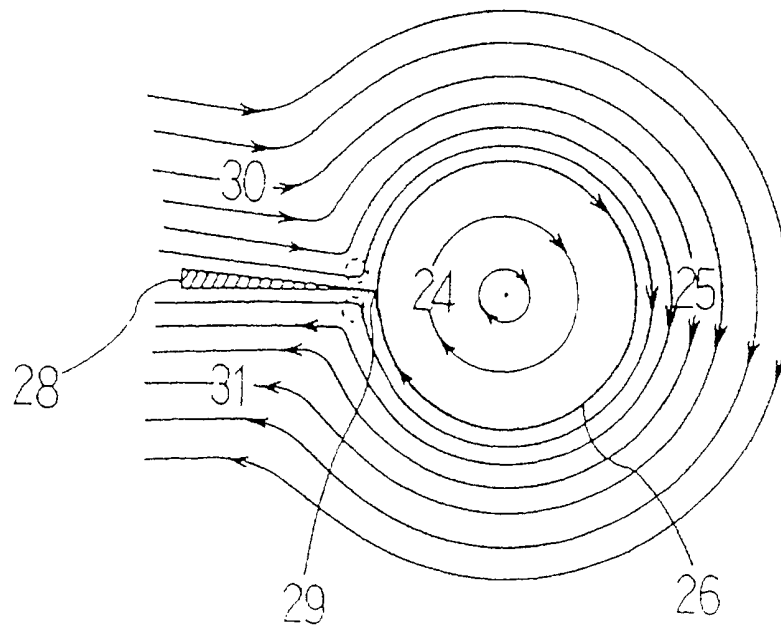


FIG. 6

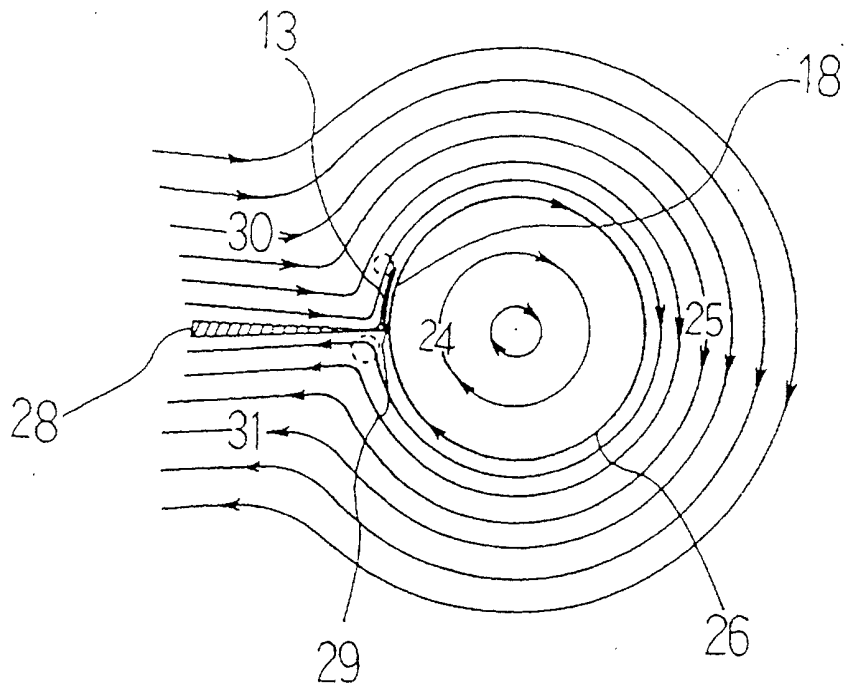


FIG. 7

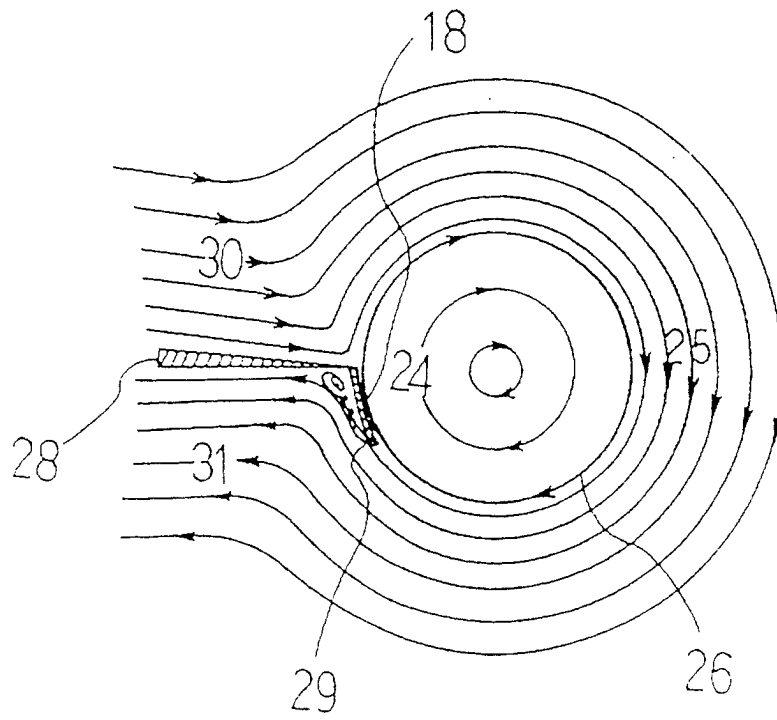


FIG. 8

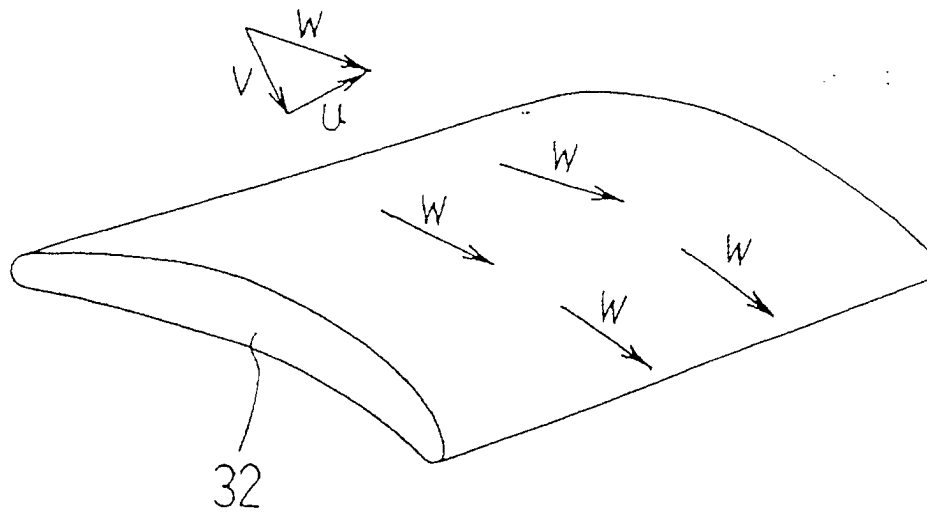


FIG. 9

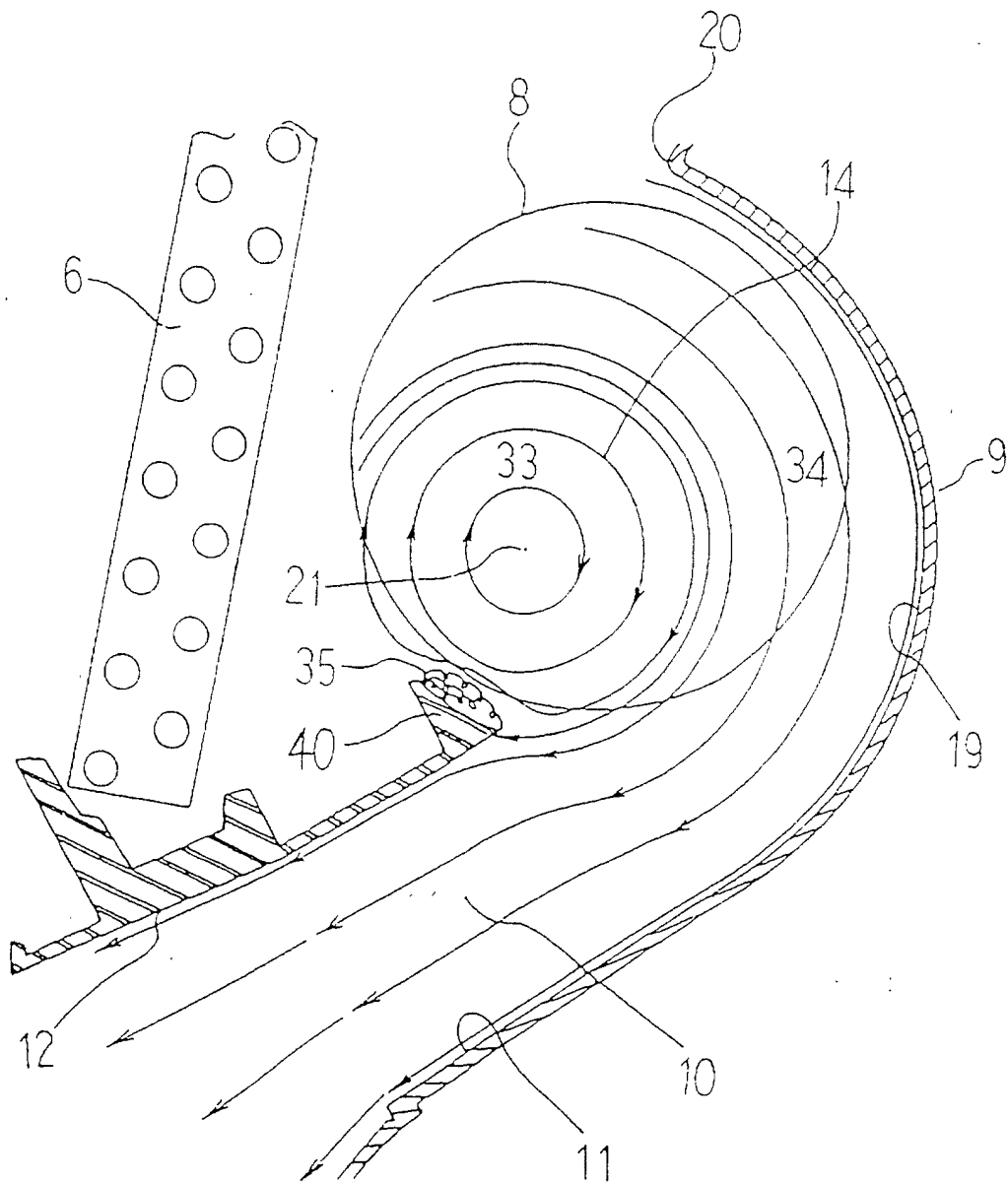


FIG. 10

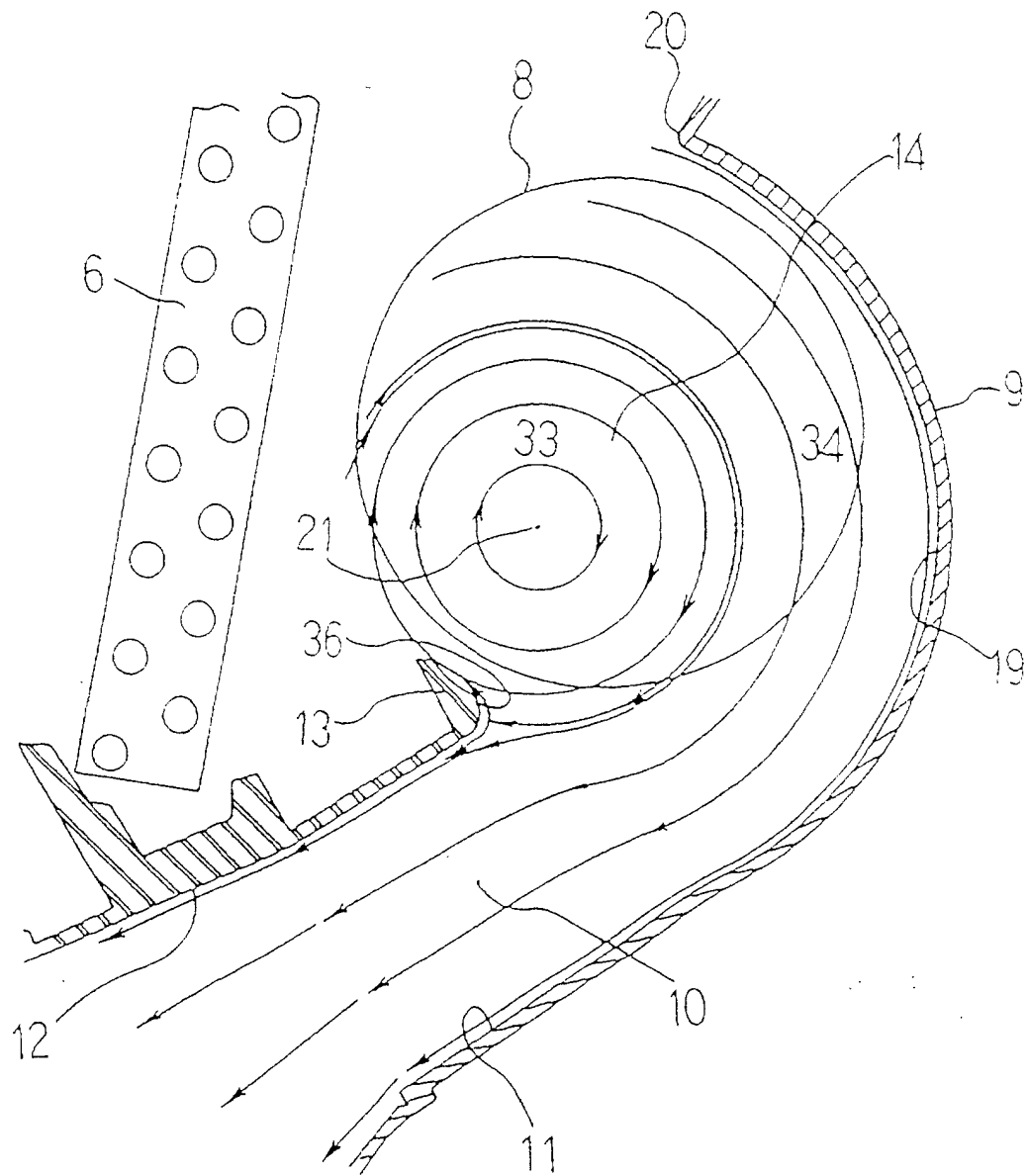


FIG. 11

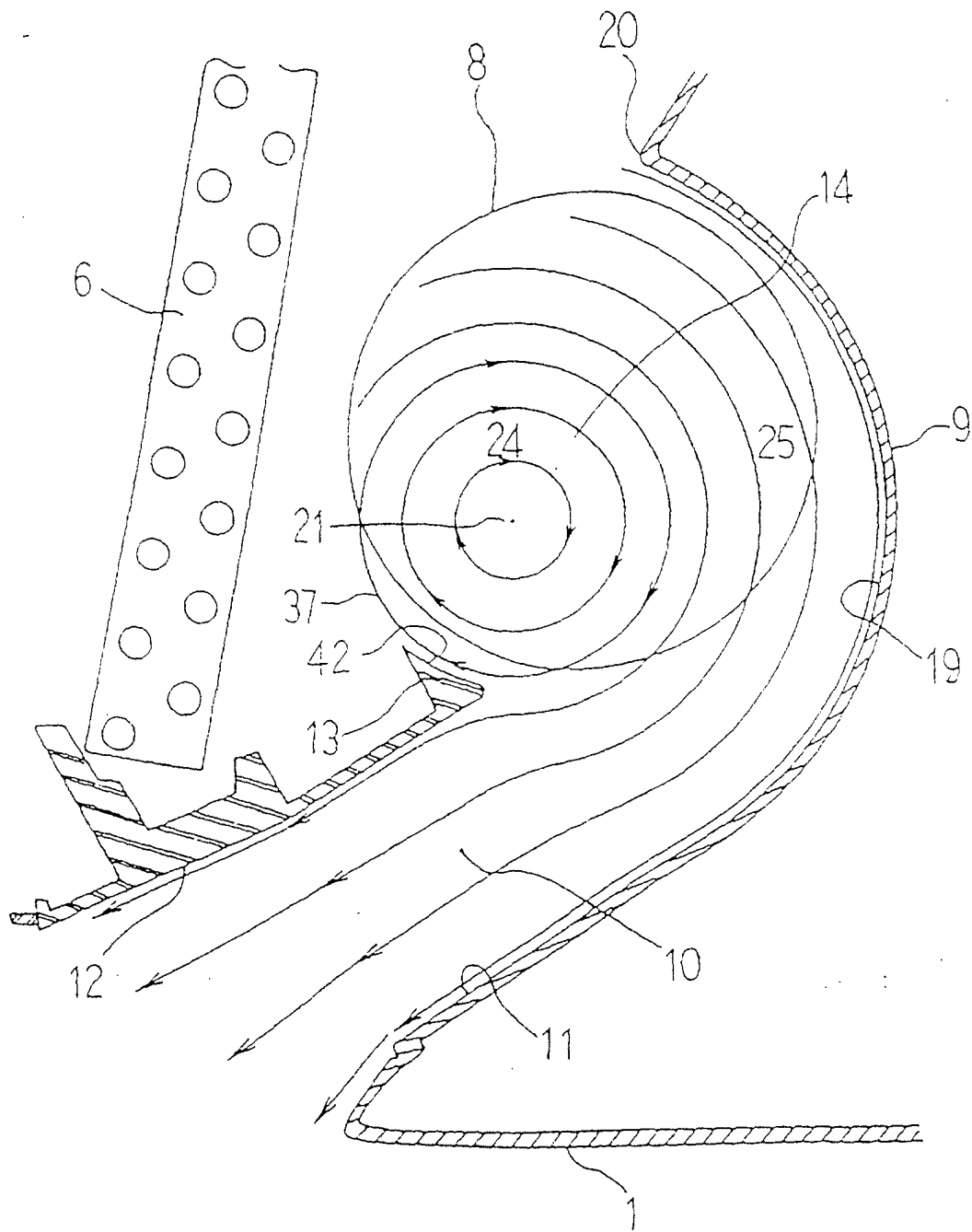


FIG. 12

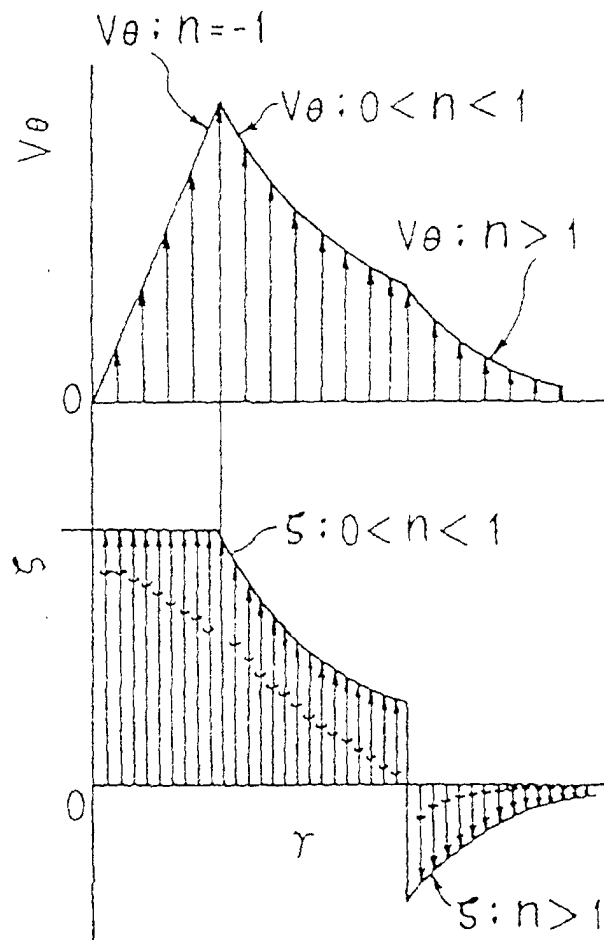


FIG.13

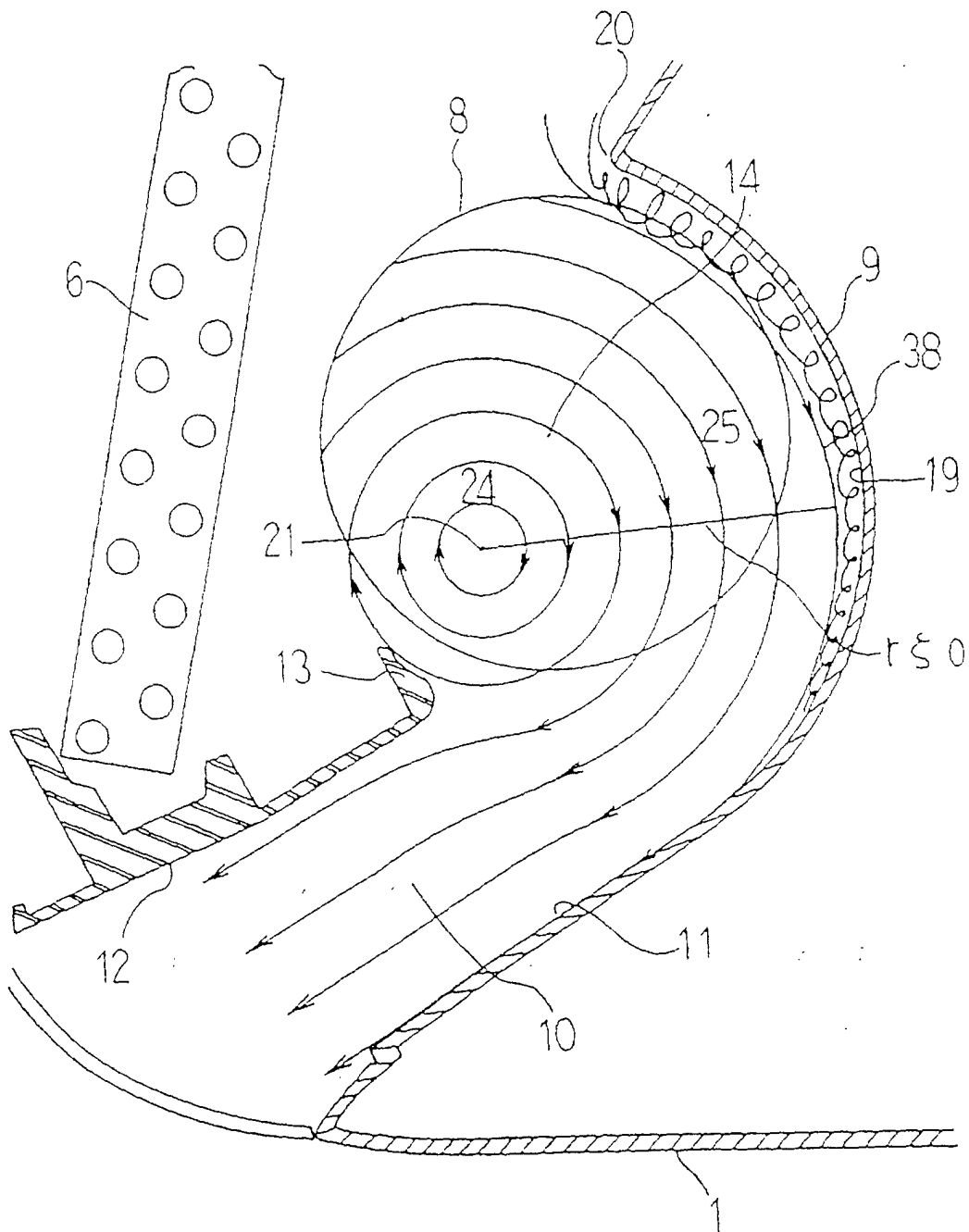


FIG. 14

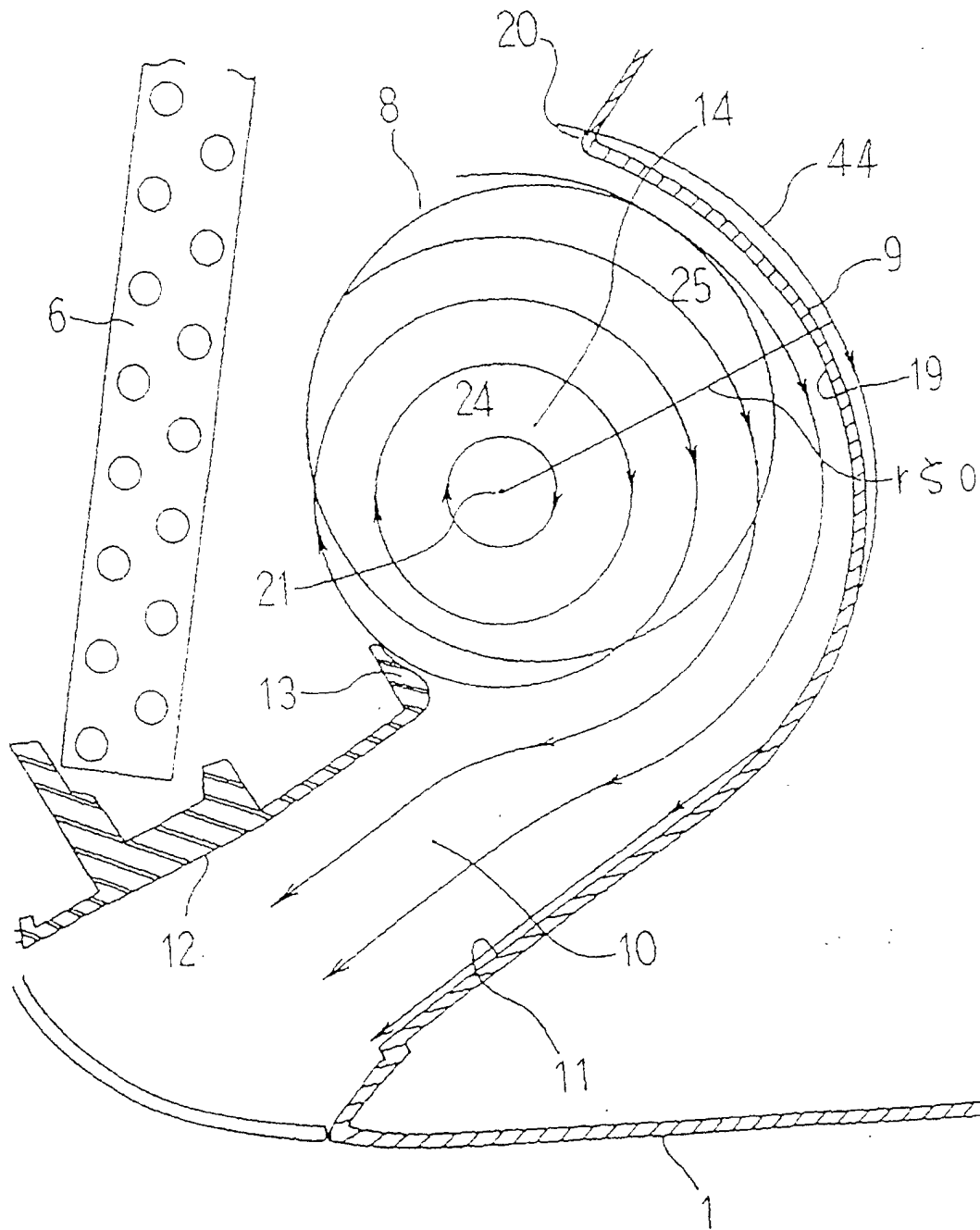
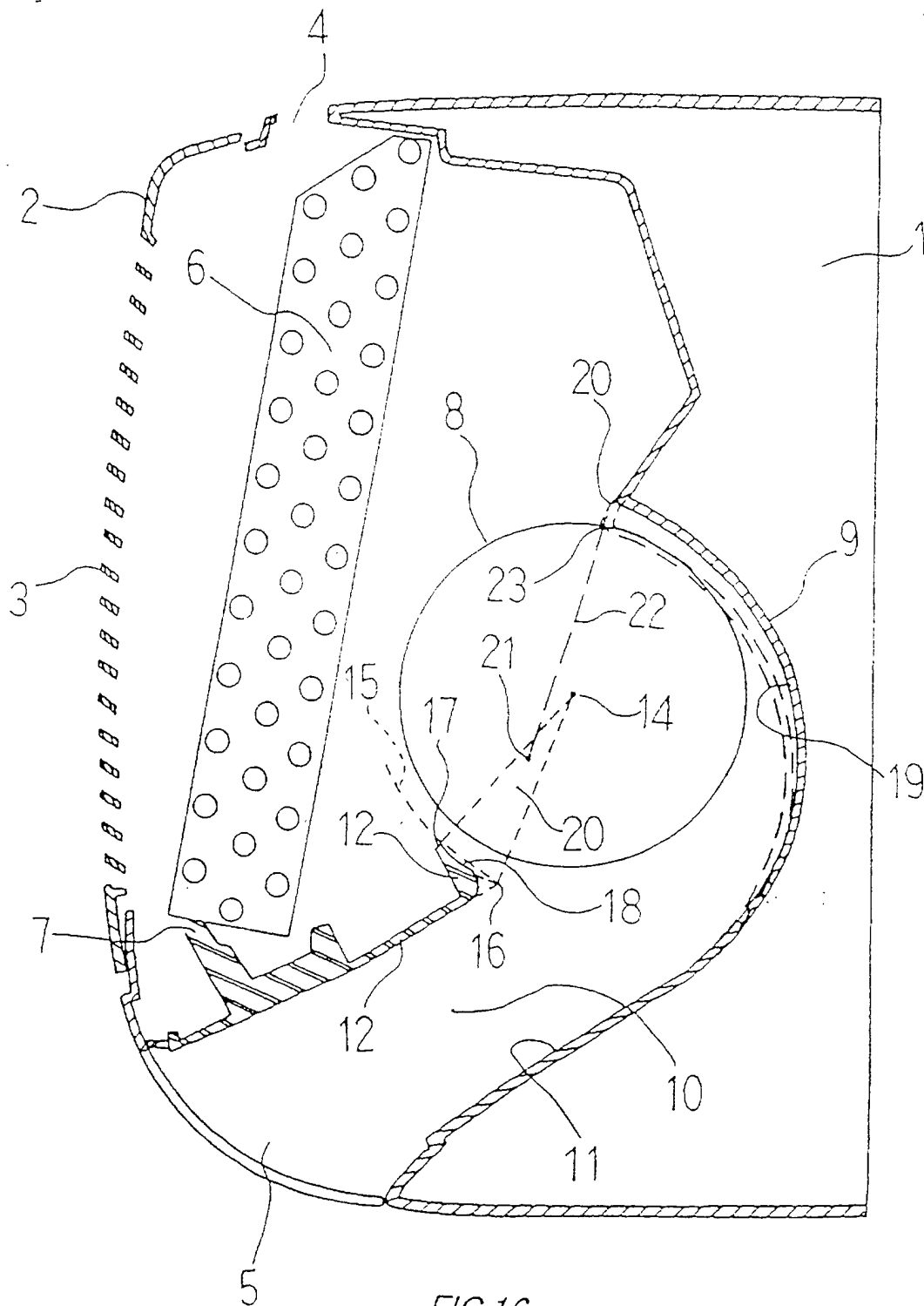


FIG. 15



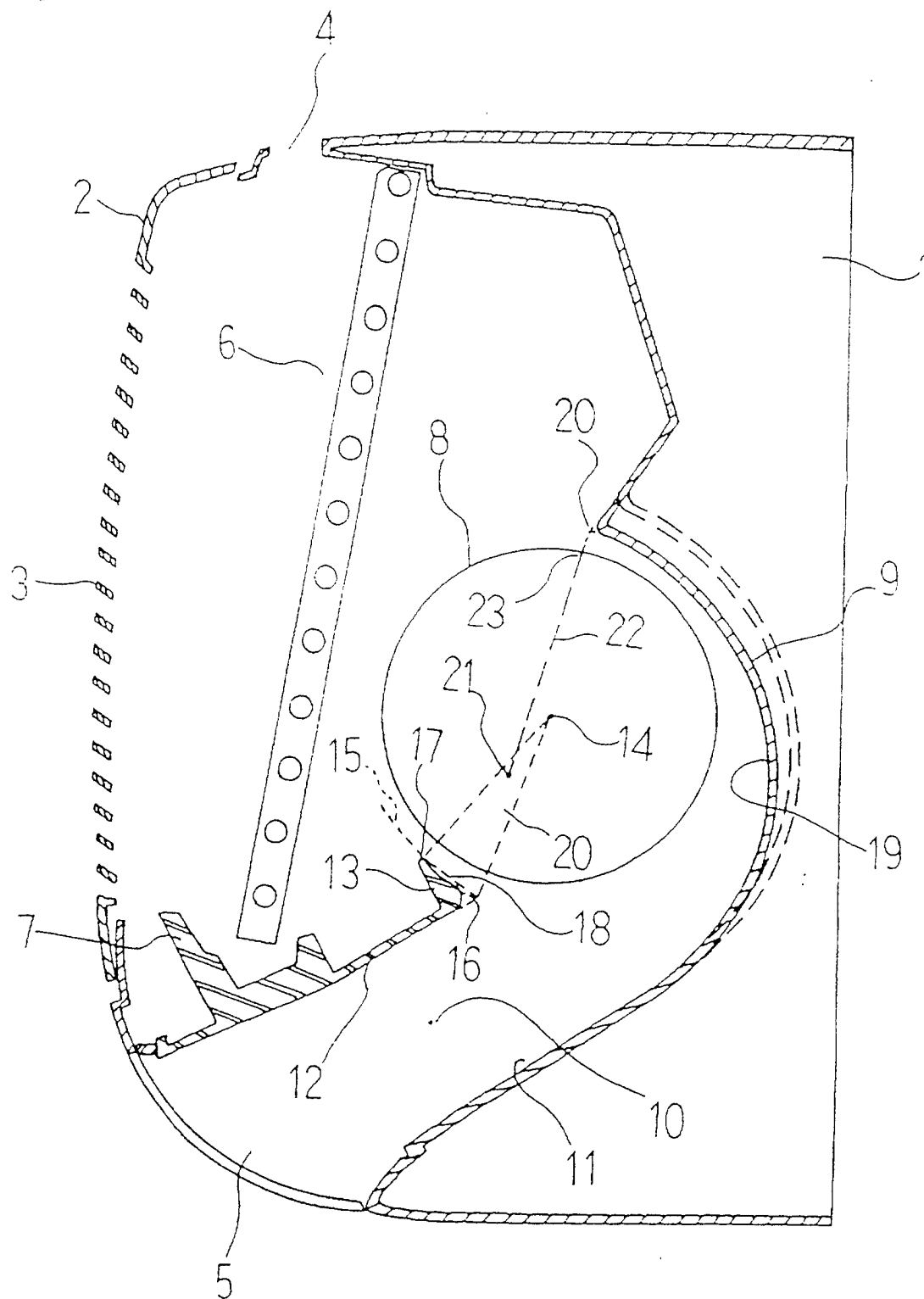


FIG. 17