(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 503 159 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.09.2012 Bulletin 2012/39

(51) Int Cl.:
F04D 29/52 *(2006.01)* ***F04D 29/68*** *(2006.01)*

(21) Application number: **12160575.2**

(22) Date of filing: **21.03.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **22.03.2011 JP 2011063107**

(71) Applicant: **Fujitsu Limited**
Kawasaki-shi, Kanagawa 211-8588 (JP)

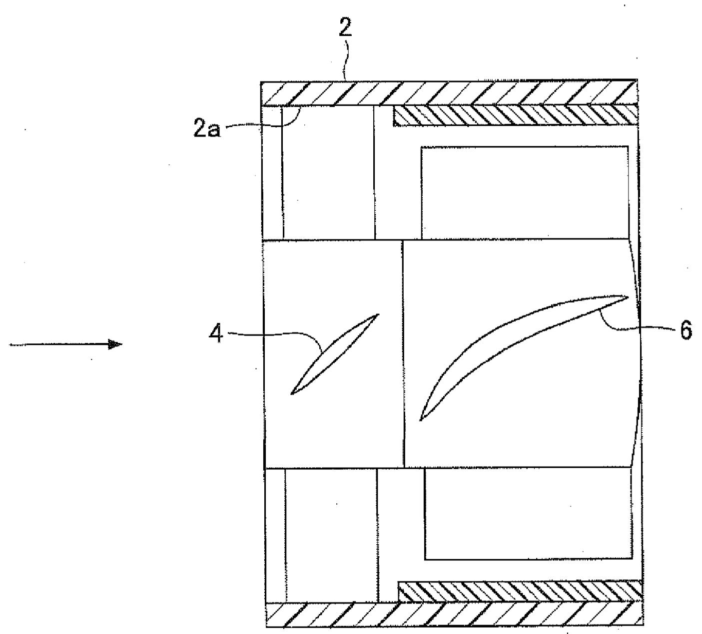
(72) Inventors:
- **Nitta, Kazuhiro**
  Kanagawa, 211-8588 (JP)
- **Ueda, Akira**
  Kanagawa, 211-8588 (JP)
- **Yamaguchi, Atsushi**
  Kanagawa, 211-8588 (JP)
- **Otsuka, Akihiro**
  Kanagawa, 211-8588 (JP)
- **Katsui, Tadashi**
  Kanagawa, 211-8588 (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) Axial blower

(57) An axial blower includes a moving vane generating air flow by rotation, a casing accommodating said moving vane, and an adapter detachably attached to the casing. The adapter includes a fitting part to be fit to an inner surface of the casing. The adapter forms a protrusion or a step on the inner surface of the casing.

FIG.1



EP 2 503 159 A2

Description

FIELD

[0001] The embodiment discussed herein is directed to an axial blower.

BACKGROUND

[0002] An axial blower is used for cooling electronic equipments in many cases. An amount of heat generated by parts incorporated in an electronic equipment tends to increase, and it is necessary to improve a cooling effect of an axial blower. In order to improve a cooling effect, it is suggested to increase a revolution speed of the axial blower or stacking a plurality of axial blowers in an axial direction to increase a fan pressure or velocity pressure.

[0003] It is known that an operation sound generated by an axial blower, when the axial blower is operated, increases in proportion to a fifth or sixth power of a revolution speed. Accordingly, if the revolution speed of the axial flower is increased, the operation sound is also increased.

[0004] Here, when an electronic equipment is used in an ordinary office or home, there may be a problem that an operation sound of an axial blower incorporated in the electronic equipment causes an undesirable noise. Thus, it is desirable to reduce an operation sound of an axial blower. Therefore, it is suggested to reduce an operation sound by adopting an axial blower of a contra-rotating type and devising shapes of a moving vane and a stationary vane (for example, refer to Japanese Patent Publication No. 4128194).

[0005] Generally, an axial blower is designed to be operated at a target operating point which is set in accordance with a system impedance of the equipment into which the axial blower is incorporated. The target operating point is an operating condition acquired as an intersection of the system impedance of the equipment into which the axial blower is incorporated and a static pressure-air flow amount characteristic of the axial blower. When the axial blower is operating at the target operating point, the aerodynamic property of the axial blower is at the highest. Thus, the operation sound is made as small as possible by using an axial blower of which operation sound becomes small when the axial blower is operated at the target operating point.

[0006] However, in a case where a system impedance of the equipment slightly varies when the axial blower is incorporated into the equipment, the actual operating point of the axial blower is shifted from the target operating point. As a result, it is possible that the operation sound of the axial blower is increased. Such a shift of the actual operating point can be adjusted by changing a structure of the axial blower to cause the operating point of the axial blower to match the actual system impedance of the equipment. For example, the target operating point can be shifted by changing the shapes of a moving vane and/or a stationary vane.

[0007] However, in order to change the shapes of the moving vane and the stationary vane of an axial blower to match a system impedance of an equipment, it is necessary to prepare many moving vanes having different shapes and many casings constituting stationary vane having different shapes so as to perform an adjustment while incorporating axial blowers equipped with moving vanes and stationary vanes having different shapes. Such an operation takes a long time, thereby increasing a cost. Additionally, it is necessary to prepare many molds for molding the moving vanes and the casings to prepare the moving vanes and stationary vanes having different shapes, which may require an extremely large cost.

[0008] Accordingly, it is desirable to develop a technique which can reduce a noise of an axial blower with a simple change in a structure of the axial blower.

SUMMARY

[0009] According to an aspect of the invention, an axial blower includes: a moving vane generating air flow by rotation; a casing accommodating said moving vane; and an adapter detachably attached to the casing, the adapter including a fitting part to be fit to an inner surface of the casing, the adapter forming a protrusion or a step on the inner surface of the casing.

[0010] According to the above-mentioned invention, the adaptor is detachably attached to the casing. Thus, there is no need to change the blower body for each equipment. Because a reduction in a noise can be attempted by selecting an adaptor suitable for each equipment, a cost reduction can be made for the equipment.

[0011] The object and advantages of the embodiment will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

[0012] It is to be understood that both the foregoing general description and the following detailed description are exemplary explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

[0013]

FIG. 1 is a cross-sectional view of an axial blower provided with a turbulence generating step;
FIG. 2 is a cross-sectional view illustrating a state before incorporating an adapter into an axial blower;
FIG. 3 is a cross-sectional view of the axial blower after the adapter is incorporated;
FIG. 4 is a perspective view illustrating a state before incorporating the adapter into the axial blower;
FIG. 5A is an illustration of an example of a fitting part of the adaptor;
FIG. 5B is an illustration of another example of the

fitting part of the adaptor;

FIG. 6 is a cross-sectional view illustrating a state before incorporating the adapter from an open side of the axial blower;

FIG. 7A is a plan view of the adapter illustrated in FIG. 6;

FIG. 7B is a side view of the adapter illustrated in FIG. 6;

FIG. 8A is a plan view of an adapter provided with slits;

FIG. 8B is a side view of the adapter provided with slits;

FIG. 9A is a plan view of an adapter provided with slanted slits;

FIG. 9B is a side view of the adapter provided with slanted slits;

FIG. 10 is a side view of an adapter provided with a finger guard;

FIG. 11 is a flowchart of a procedure of selecting an adapter to be incorporated into an axial blower;

FIG. 12A is an illustration indicating four kinds of turbulence generating steps and sound pressure levels generated by the turbulence generating steps when a target operating point is not changed;

FIG. 12B is a graph indicating a static pressure-air flow amount characteristic of each condition indicated in FIG. 12A;

FIG. 13A is an illustration indicating four kinds of turbulence generating steps and sound pressure levels generated by the turbulence generating steps when a target operating point is changed; and

FIG. 13B is a graph indicating a static pressure-air flow amount characteristic of each condition indicated in FIG. 13A.

DESCRIPTION OF EMBODIMENT(S)

[0014] Preferred embodiments of the present invention will be explained with reference to the accompanying drawings.

[0015] The inventors found that an operation sound generated by an axial blower such as, for example, an axial fan can be reduced by generating turbulence in air flow inside a casing of the axial blower by providing a protrusion or step on an inner surface of the casing. FIG. 1 is a cross-sectional view of an axial blower provided with a turbulence generating step.

[0016] In FIG. 1, a stationary vane 4 and a moving vane 6 are provided in a casing 2 having a cylindrical shape. An air flow is generated in a direction of arrow in FIG 1 by rotation of the moving vane 6.

[0017] In the axial blower illustrated in FIG. 1, a step (or a protrusion or a bump) is provided in an inner surface 2a of the casing 2, the inner surface 2a being normally an cylindrical inner surface. The step provided on the inner surface 2a causes the air flow in the casing 2 to generate turbulence. Thereby, a static pressure-air flow amount characteristic of the axial blower is changed, which results in a reduction in an operation sound generated by the axial blower. It is considered that the operation sound of the axial blower is changed (reduced) due to the change in the static pressure-air flow amount characteristic of the axial blower because the turbulence is generated by the air flow hitting a portion of the step or protrusion inside the casing 2 and the moving vane 6 rotates within the turbulence.

[0018] The step or protrusion for generating turbulence can be provided by, for example, molding the casing 2 so that the step or protrusion is formed in the inner surface 2a of the casing 2. However, when the step or protrusion is integrally formed as a part of the casing 2, the entire casing 2 must be replaced with a different casing in order to change a shape of the protrusion or a height (level difference) of the step. Thus, the inventors considered that such an inconvenience can be omitted by providing the protrusion or step by attaching an adapter on the inner surface 2a of the casing 2 while maintaining the inner surface 2a of the casing 2 to be a cylindrical form.

[0019] FIG. 2 is a cross-sectional view illustrating a state before incorporating an adapter for providing a step into an axial blower. FIG. 3 is a cross-sectional view of the axial blower after incorporating the adapter. FIG. 4 is a perspective view of the axial blower before incorporating the adapter into the axial blower.

[0020] The axial blower 10 illustrated in FIG. 2 through FIG. 4 has a structure in which a support part 14 is attached to an inner surface 12a of the casing 12 having a cylindrical shape and an axis of a moving vane 16 is supported on a central part of the support part 14. When the moving vane 16 rotates, an air flow is generated in a direction of arrow indicated in the figures.

[0021] In the structure illustrated in FIG. 2 through FIG. 4, the adapter 20 is fitted to the inner surface 12a of the casing 12 from the side of the support part 14. The adapter 20 includes a fitting part 20a of a cylindrical shape to be fitted into the inner surface 12a of the casing 12 and a stopper part 20b extending perpendicular to the fitting part 20a on one end side of the fitting part 20a. The stopper 20b has substantially the same shape as a flange part 10a on one end side of the axial blower 10. The stopper 20b has pin holes 20c into which pins 10b are inserted. Moreover, the fitting part 20a is provided with notch parts 20a for avoiding parts that extend from the casing 12 to fix the support part 14.

[0022] When the fitting part 20a of the adapter 20 is fitted to the inner surface 12a of the casing 12 as illustrated in FIG. 3, the stopper part 20b bumps into the flange part 10a of the axial blower 10. In this state, the tip of the fitting part 20a is positioned in the vicinity of the moving vane 16, resulting in formation of a turbulence generating step by the tip of the fitting part 20a. Turbulence is generated by the thus-formed step in the vicinity of the moving vane 16.

[0023] The position of the tip of the fitting part 20a is a position where the stopper part 20b bumps into the flange part 10a of the axial blower 10. Thus, by providing the stopper part 20b on one end side of the fitting part 20a, the tip of the fitting part 20a can be positioned with high accuracy in the casing 12. That is, by merely inserting the fitting part 20a into the casing 12 until the stopper part 20b bumps into the flange 10a of the axial blower 10, the tip of the fitting part 20a can be positioned with high accuracy, thereby forming the step at an accurate position on the inner surface 12a of the casing 12.

[0024] The height and shape of the step are not limited to that illustrated in FIGS. 2 and 3, and may be changed while observing turbulence generated by the step. Because the height of the step corresponds to the thickness of the fitting part 20a of the adapter 20, the height of the step can be adjusted by changing the thickness of the fitting part 20a. Moreover, because the shape of the step corresponds to the shape of the tip of the fitting part 20a, the shape of the step can be changed by making the tip of the fitting part 20a into a slanting surface as illustrated in FIG. 5 or a curved surface as illustrated in FIG. 5B.

[0025] Although the adapter 20 illustrated in FIG. 2 and FIG. 3 has a shape, which is insertable into the casing 12 from the side of the axial blower 10 where the support part 14 is formed, the adapter 20 may be made into a shape, which is insertable from the opposite side.

[0026] FIG. 6 is a cross-sectional view illustrating a state where the adapter 20 is inserted into the casing 12 from the open side of the axial blower 10. The adapter 20A illustrated in FIG. 6 has a shape, which is insertable from the open side (a side through which air flows in). Specifically, the fitting part 20Aa, which is fitted to the inner surface 12a of the casing 12, is shorter than the fitting part 20a of the adapter 20 illustrated in FIGS. 2 and 3. Because a support part is not provided on the open side of the axial blower 10, the length of the fitting portion 20Aa is set shorter than the length of the fitting part 20a by a portion corresponding to the support part so that the tip of the fitting part 20Aa is located at a predetermined position close to the moving vane 16. Moreover, because there is no need to cause the fitting part 20Aa to pass through the support part 14 when inserting the fitting part 20Aa into the casing 12, there is no need to provide notch parts to the fitting part 20Aa and the fitting part 20Aa can be mere a cylindrical shape.

[0027] FIG. 7A is a plan view of the adapter 20A, and FIG. 7B is a side view of the adapter 20A. Similar to the adapter 20, the adapter 20A has a stopper part 20Ab. The tip of the fitting part 20Aa is located at a predetermined position, when inserting the fitting part 20Aa into the casing 12, by the stopper part 20Ab being brought into contact with the open side end of the casing 12.

[0028] FIG. 8A is a plan view of an adapter 20B, which is a variation of the adapter 20 illustrated in FIGS. 2 and 3. FIG. 8B is a side vie of the adapter 208. A fitting part 20Ba of the adapter 20B has notch parts 20d similar to the adapter 20. However, in addition to the notch parts 20d, the fitting part 20Ba is provided with slits 20Be having the same shape as the notch parts 20d. Accordingly, the fitting part 20Ba of the adapter 20B is formed by a plurality of stripe parts 20Bf extending from the stopper part 20Bb.

[0029] Here, a turning flow of air may be generated in the vicinity of the inner surface 12a of the casing 12 due to rotation of the moving vane 16. In such a case, if the strip parts 20Bf are formed by the slits 20Be extending in the axial direction as is in the adapter 20B illustrated in FIG. 8B, the turning flow interferes with the strip parts 20Bf, which may be a cause of generation of a noise. Thus, as illustrated in FIGS. 9A and 9B, slits 20C, which are slanted relative to the axial direction, are provided to form slanted strip parts 20Cf in the adapter 20C. The slant angle of the strip parts 20Cf may be determined based on an angle of the spirally turning flow generated by rotation of the moving vane 16 so that interference between the turning flow and the strip parts 20Cf is suppressed, which suppresses generation of a noise due to the turning flow.

[0030] It should be noted that, as illustrated in FIG. 10, the adapter may be provided with a finger guard function by providing a finger guard 30 to the above mentioned adapters (for example, the adapter 20A) so that fingers cannot enter the interior of the axial blower.

[0031] A description is given below, with reference to FIG. 11, of a procedure of selecting an adapter to be incorporated into an axial blower. FIG. 11 is a flowchart of a procedure of selecting an adapter to be incorporated into an axial blower.

[0032] First, a characteristic of an axial blower to be incorporated into an equipment is acquired (step S1), and a system impedance of the equipment (a resistance loss with respect to an air flow in the equipment) is acquired (step S2). Then, an operating point, at which the axial blower is operated when the axial blower is incorporated in the equipment, is acquired, and an operation sound (noise) of the axial blower being operated at the acquired operating point is acquired (step S3). Then, it is determined whether the operation sound acquired in the step S3 is equal to or smaller than an allowable value (step S4). If the operation sound is equal to or smaller than the allowable value, a determination is made that there is no need to improve the operation sound (noise) and the axial blower is made as a completed product without change (step S5). On the other hand, if the operation sound exceeds the allowable value, a determination is made that an improvement in the operating sound (noise) is necessary and the above-mentioned turbulence generating step or protrusion is formed (step S7). In this connection, various adapters for forming the turbulence generating step or protrusion are prepared beforehand (step S6). After attaching one of the adapters to the axial blower, the axial blower is incorporated into the equipment and an operation sound is checked. If the operation sound (noise) is equal to or smaller than the allowable value, the axial blower in which the adapter has been incorporated is made as a completed product (step S5).

[0033] According to the above-mentioned procedure of selecting an adapter, adapters having various shapes are prepared beforehand, and an optimum one of the adapters can be found by checking an operation sound while changing the adapters incorporated in the axial blower. At this time, the turbulence generating step or protrusion can be formed easily at an accurate position by merely inserting and attaching the adapters to the casing of the axial blower. Moreover, because the adapters are merely inserted into and fitted to the casing, the adapter can be exchanged easily to the adapter having a different shape, which enables easy selection of an appropriate adapter within a short time.

[0034] A description is given of an effect of formation of the above-mentioned turbulence generating step or protrusion on the inner surface of the casing. In the above-mentioned embodiment, the turbulence generating step or protrusion is formed in a single stage axial blower (a single fan) as an axial blower. However, the turbulence generating step may be formed in a contra-rotating type axial blower (contra-rotating type fan) having moving vanes arranged in two stages in an axial direction. For example, turbulence may be generated in the vicinity of the moving vane of the second (rear) stage by forming the turbulence generating step or protrusion at a position between the moving vanes that rotates opposite directions to each other in the contra-rotating type axial blower in order to reduce an operation sound of the contra-rotating type axial blower. Usually, the contra-rotating type axial blower can be divided between a front stage blower and a rear stage blower. In such a case, the adapter may be inserted into the rear stage blower having the rear stage moving vane from a side of a support part. Alternatively, the adapter may be inserted into the rear stage blower having the rear stage moving vane from an open side (a side through which air flows out).

[0035] FIG. 12A indicates values of operating sound measured when four kinds ((b) through (e)) of turbulence generating step are formed in a contra-rotating type axial blower (normal (a)), which is designed to have a target operating point of an air flow amount of 0.45 m^3/min and a static pressure of 300 Pa, without changing the target operating point. FIG. 12B is a graph illustrating static pressure-air flow amount characteristics of the contra-rotating type axial blower set in the conditions indicated in FIG. 12A.

[0036] In FIG. 12A, "convex 1 mm" means that a size of the turbulence generating step (difference in height in a radial direction) is 1 mm. As illustrated in FIG. 12A, in the contra-rotating type axial blower provided with a front stage impeller (vane), a rear stage impeller (vane) and a middle stage stationary part so that an operation sound at the target operating point becomes a predetermined sound pressure level, providing the turbulence generating protruding surface (turbulence generating step) may be a cause of increasing an operation sound. In such a case, the target operating point is not changed as indicated in FIG. 12B.

[0037] On the other hand, FIG. 13A indicates values of operation sound measured when four kinds ((b1) through (e1)) of turbulence generating step are formed in a contra-rotating type axial blower (normal (a)), which is designed to have a target operating point of an air flow amount of 0.45 m^3/min and a static pressure of 300 Pa, by changing the target operating point to a target operating point of an air flow amount of 0.4 m^3/min and a static pressure of 320 Pa (normal (al)). FIG. 13B is a graph illustrating static pressure-air flow amount characteristics of the contra-rotating type axial blower set in the conditions indicated in FIG. 13A.

[0038] As indicated in FIG. 13A, when using the axial blower by decreasing the air flow amount, the operation sound, when the turbulence generating step having a difference of 0.2 mm in height in a radial direction is formed, is smaller than the operation sound when the turbulence generating step is not provided (normal (al)). Therefore, it can be found that the operation sound can be reduced by merely providing the turbulence generating protruding surface (turbulence generating step) without changing the shapes and sizes of the front stage impeller (vane), the rear stage impeller (vane) and the middle stage stationary part. In other words, it can be appreciated that the operating sound, which may be increased when the target operating point of the axial blower, which has already been designed to be used at a specific target operating point, can be reduced by providing the turbulence generating protruding surface (turbulence generating step).

Claims

1. An axial blower comprising:

a moving vane generating air flow by rotation;
a casing accommodating said moving vane; and
an adapter detachably attached to said casing, the adapter including a fitting part to be fit to an inner surface of said casing, the adapter forming a protrusion or a step on the inner surface of said casing.

2. The axial blower as claimed in claim 1, further comprising a stopper part formed on one end side of said fitting part and extending in a direction perpendicular to an axial direction of said casing.

3. The axial blower as claimed in claim 1 or 2, wherein said fitting part of said adapter includes a plurality of strip parts extending in an axial direction of said casing.

4. The axial blower as claimed in claim 1 or 2, wherein said fitting part of said adapter includes a plurality of strip parts extending in a direction slanted with respect to an axial direction of said casing by a predetermined angle.

5. The axial blower as claimed in one of claims 2 to 4, wherein said stopper part is in contact with an end of said casing from which air flows out of said casing.

6. The axial blower as claimed in one of claims 2 to 4, wherein said stopper part is in contact with an end of said casing through which air flows into said casing.

7. The axial blower as claimed in one of claims 1 to 6, wherein a tip of said fitting part has a slanting surface or a curved surface.

8. The axial blower as claimed in one of claims 1 to 7, wherein said adapter includes a finger guard.

FIG.1

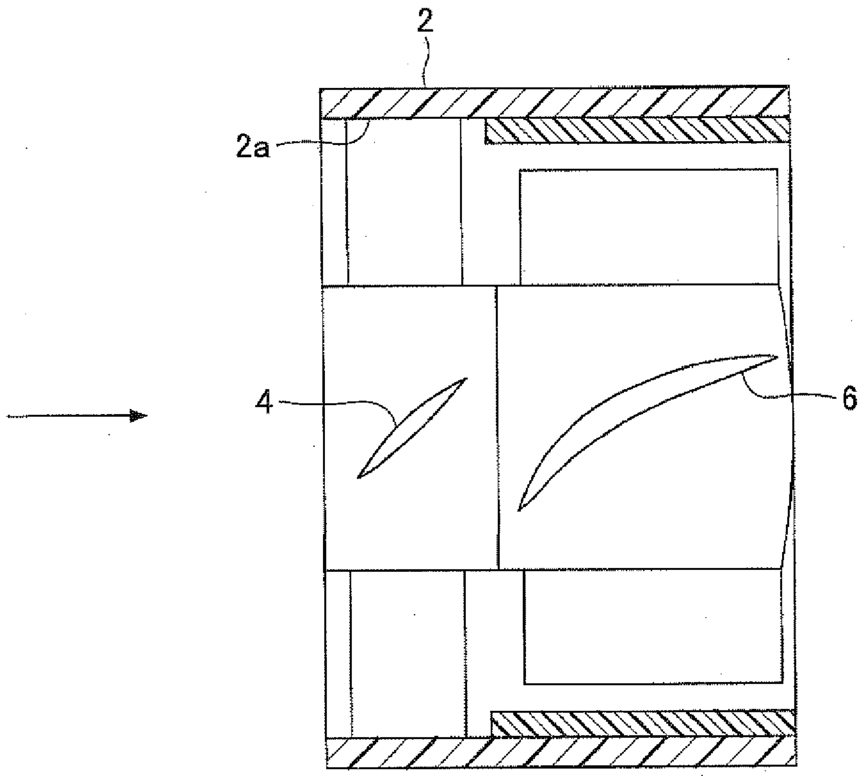


FIG.2

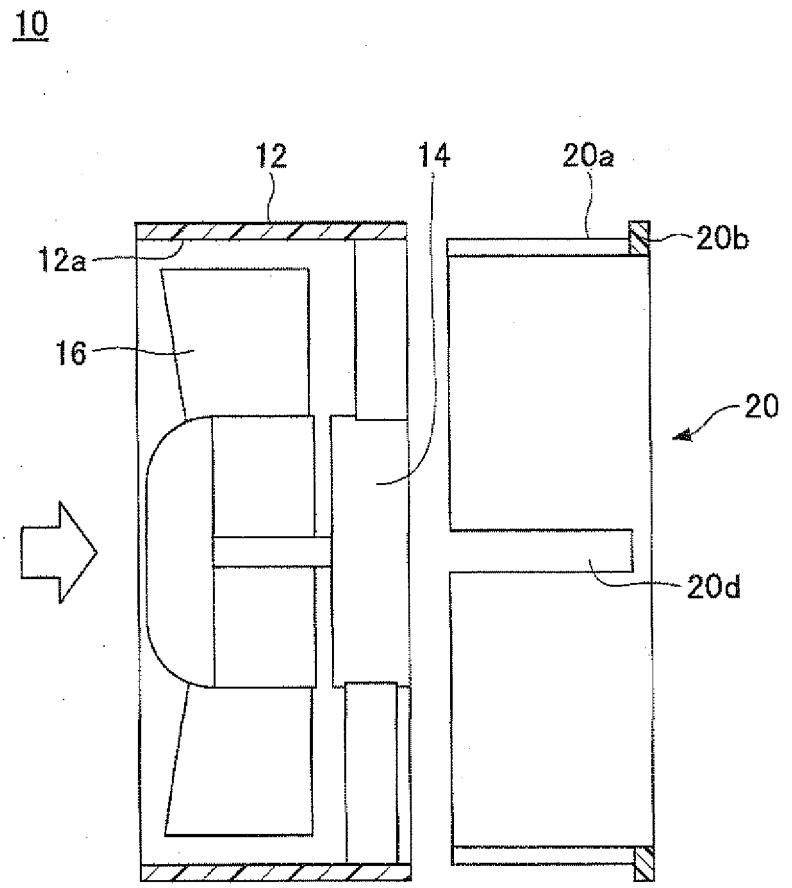


FIG.3

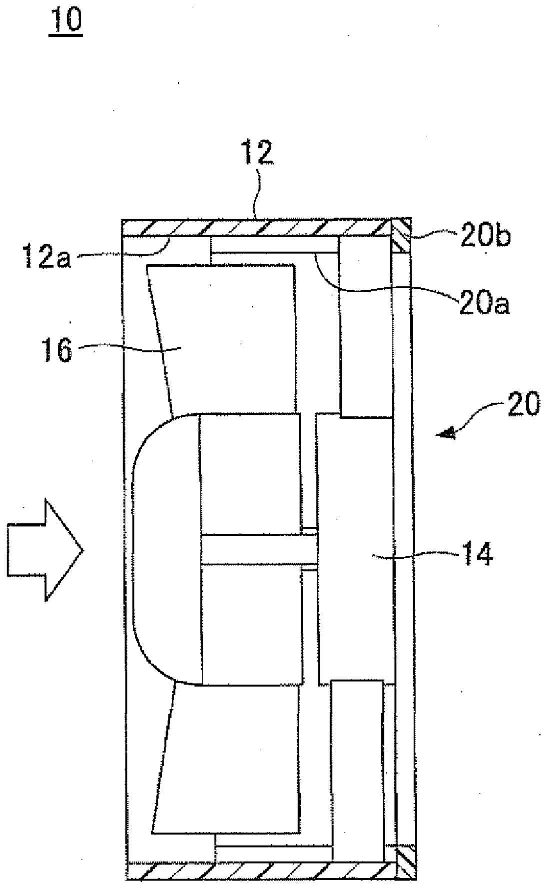


FIG.4

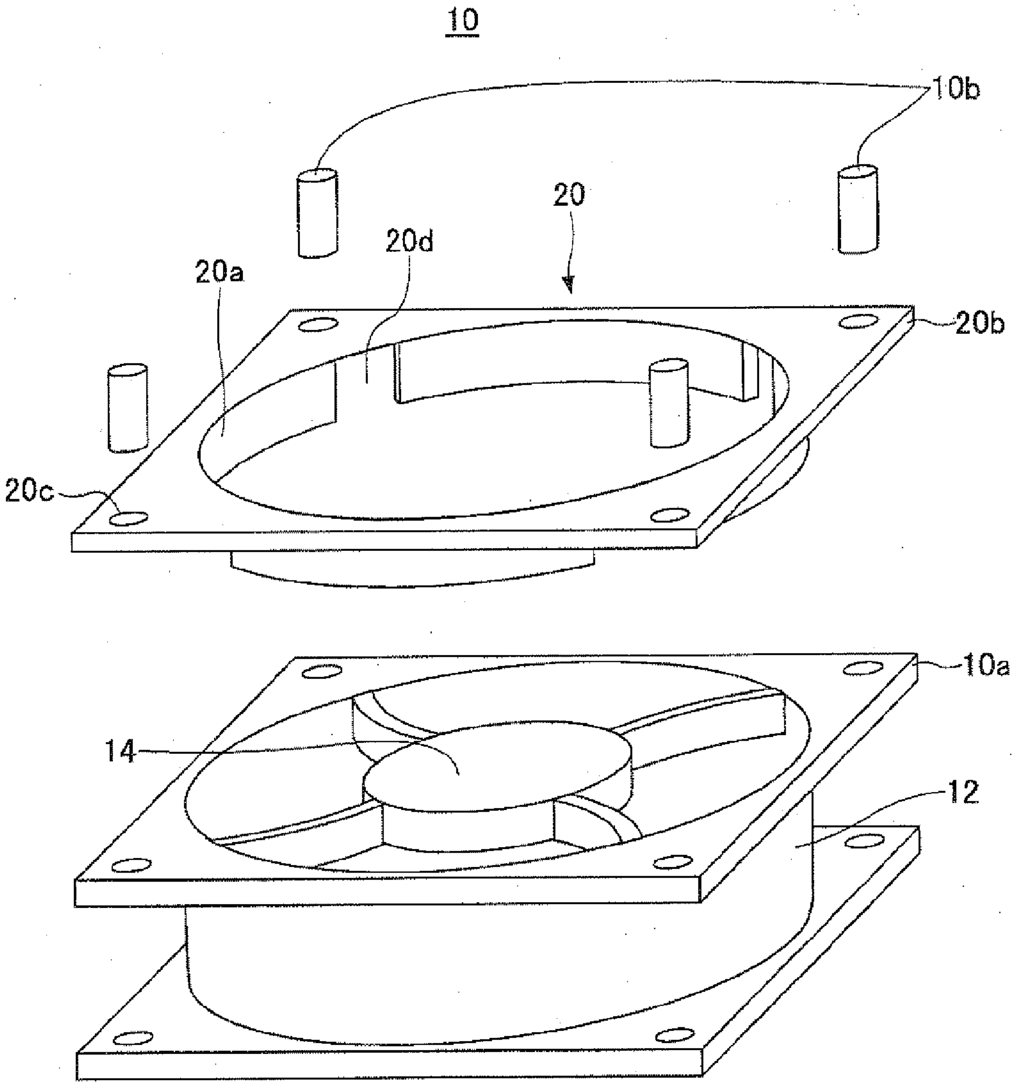


FIG.5A

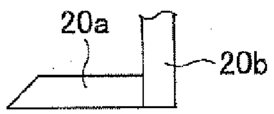


FIG.5B

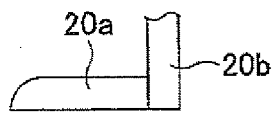


FIG.6

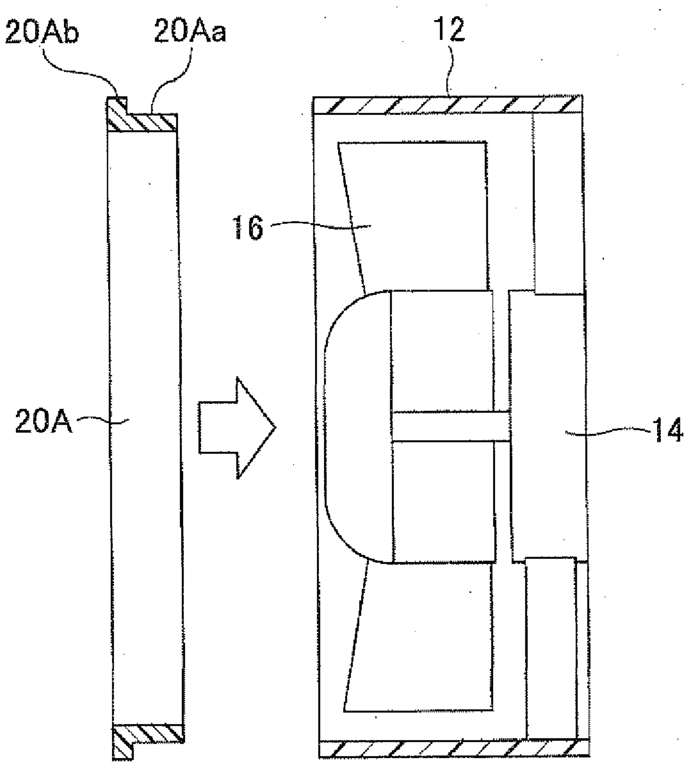


FIG.7A

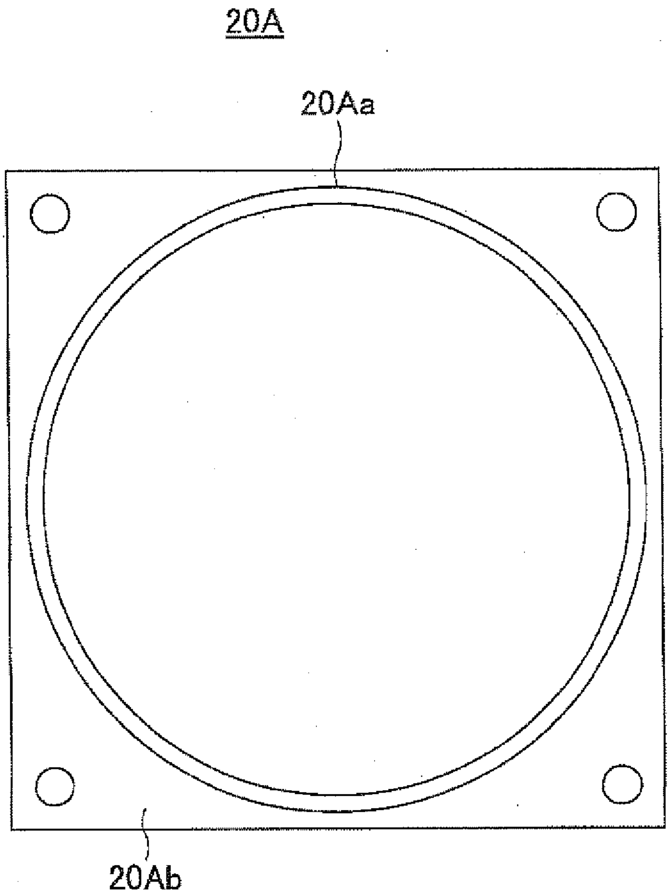
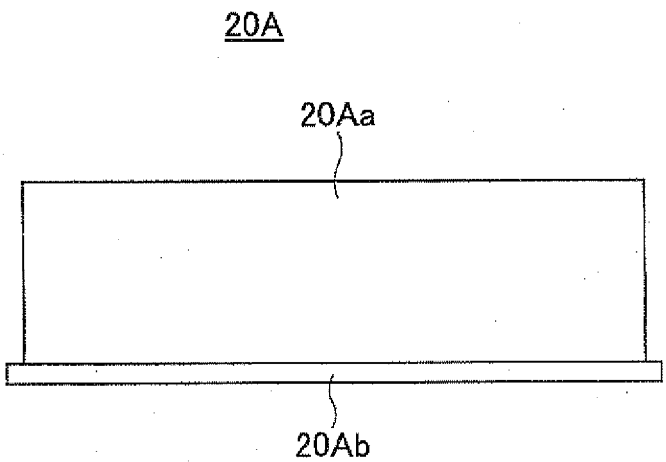


FIG.7B



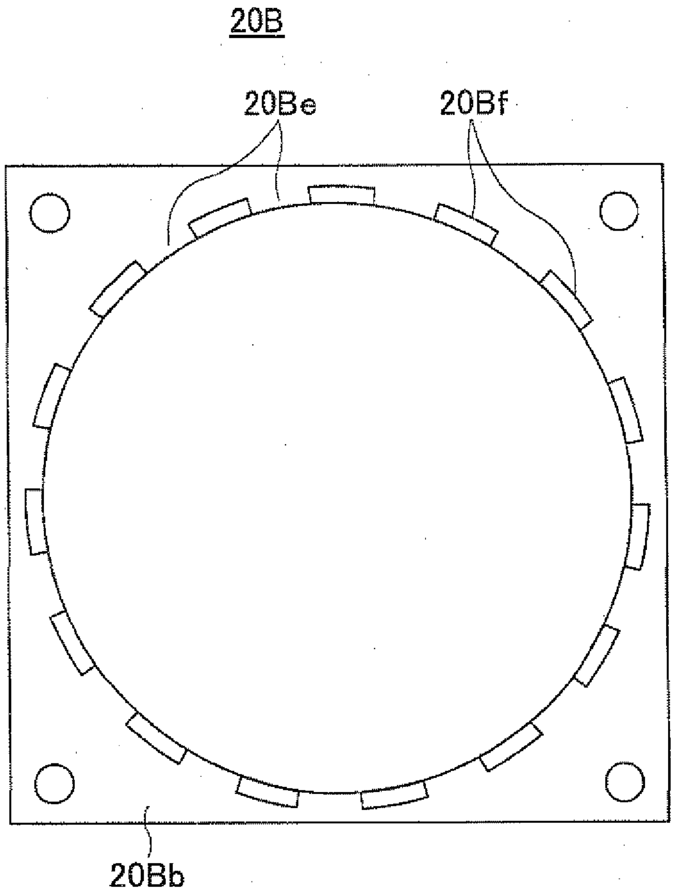


FIG.8A

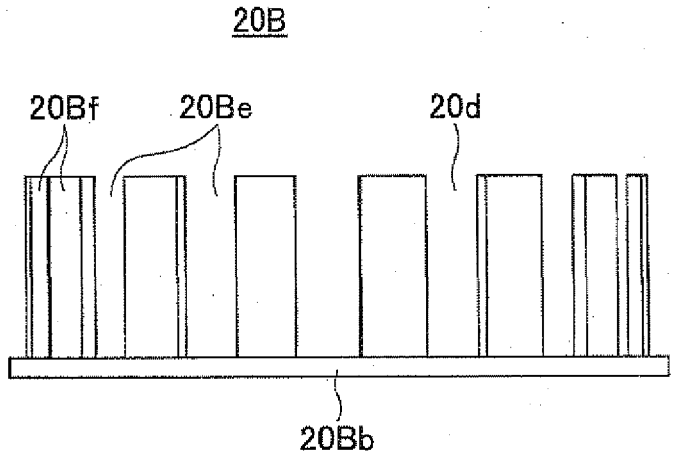


FIG.8B

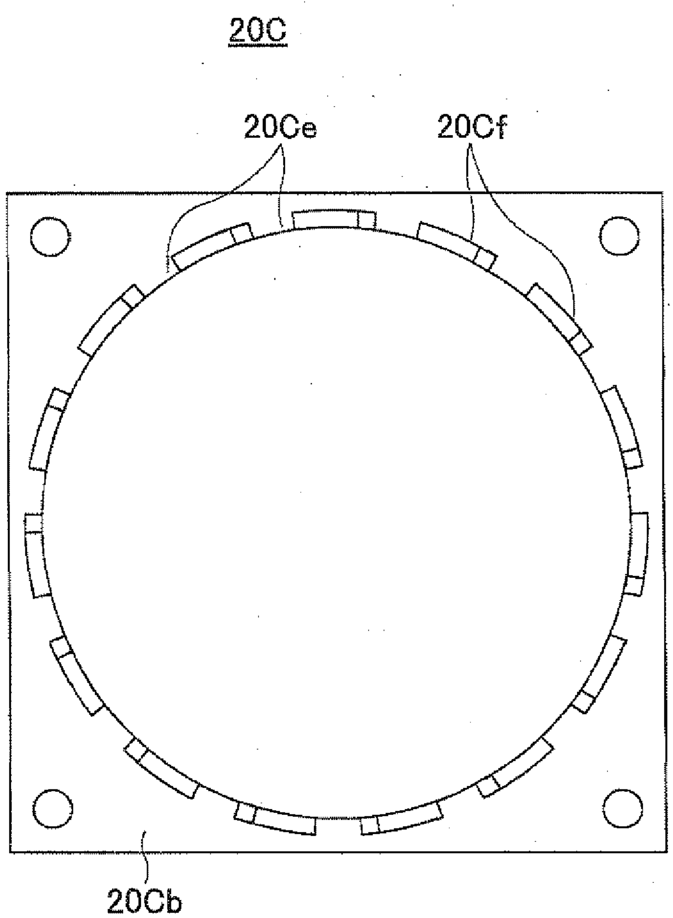


FIG.9A

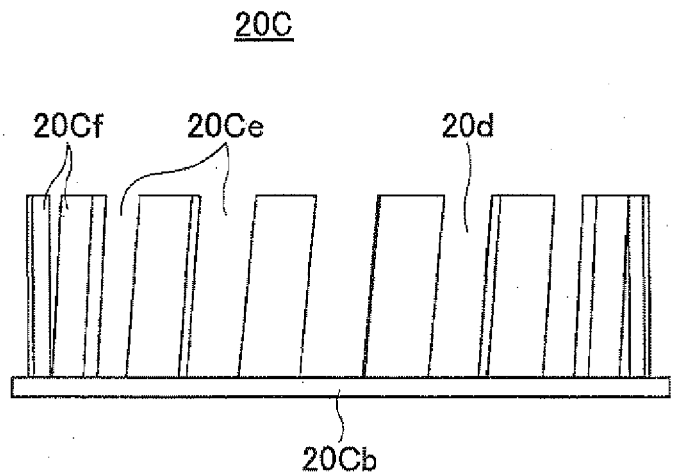
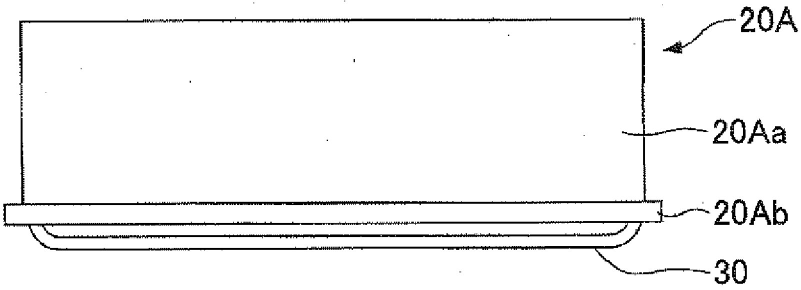


FIG.9B

FIG.10



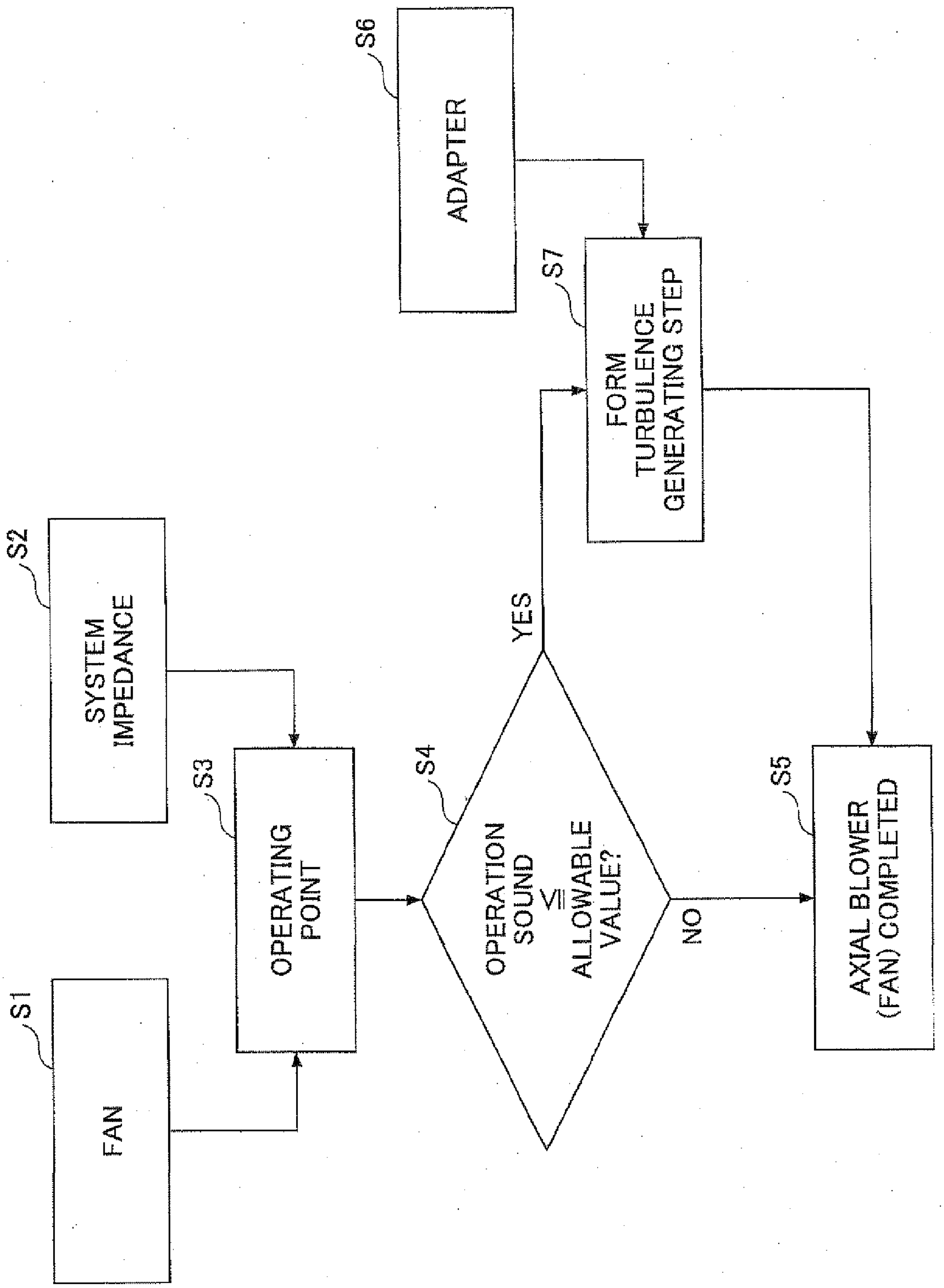
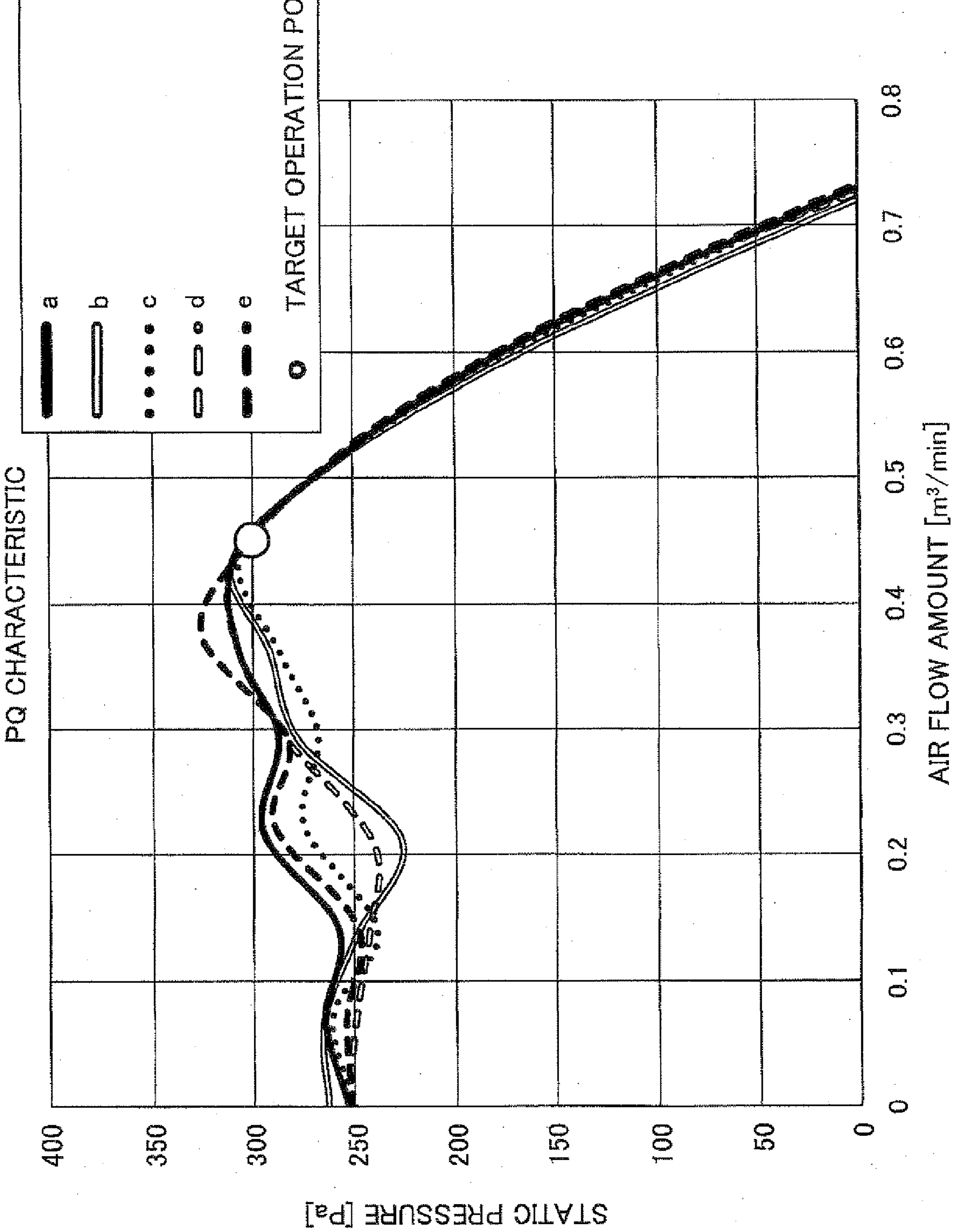

S1
FAN
S2
SYSTEM IMPEDANCE
S3
OPERATING POINT
S4
OPERATION SOUND ≧ ALLOWABLE VALUE?
YES
NO
S5
AXIAL BLOWER (FAN) COMPLETED
S6
ADAPTER
S7
FORM TURBULENCE GENERATING STEP

FIG.11

FIG.12A

STATE OF FAN (CONTENTS OF MEASURES)	0.45 [m^3/min], 300 [Pa] SOUND PRESSURE LEVEL [dB(A)]
NORMAL (a)	54.8
ADD CONVEX 1mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (b)	57.3
ADD CONVEX 0.6mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (c)	55.5
ADD CONVEX 0.4mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (d)	55.5
ADD CONVEX 0.2mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (e)	55.1



PQ CHARACTERISTIC
a
b
c
d
e
TARGET OPERATION POINT
STATIC PRESSURE [Pa]
400
350
300
250
200
150
100
50
0
AIR FLOW AMOUNT [m³/min]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

FIG.12B

FIG.13A

STATE OF FAN (CONTENTS OF MEASURES)	0.4 [m^3/min], 320 [Pa] SOUND PRESSURE LEVEL [dB(A)]
NORMAL (a1)	56.5
ADD CONVEX 1mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (b1)	58.4
ADD CONVEX 0.6mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (c1)	57.2
ADD CONVEX 0.4mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (d1)	56.6
ADD CONVEX 0.2mm BETWEEN REAR STAGE MOVING VANE AND STATIONARY VANE (e1)	56.1

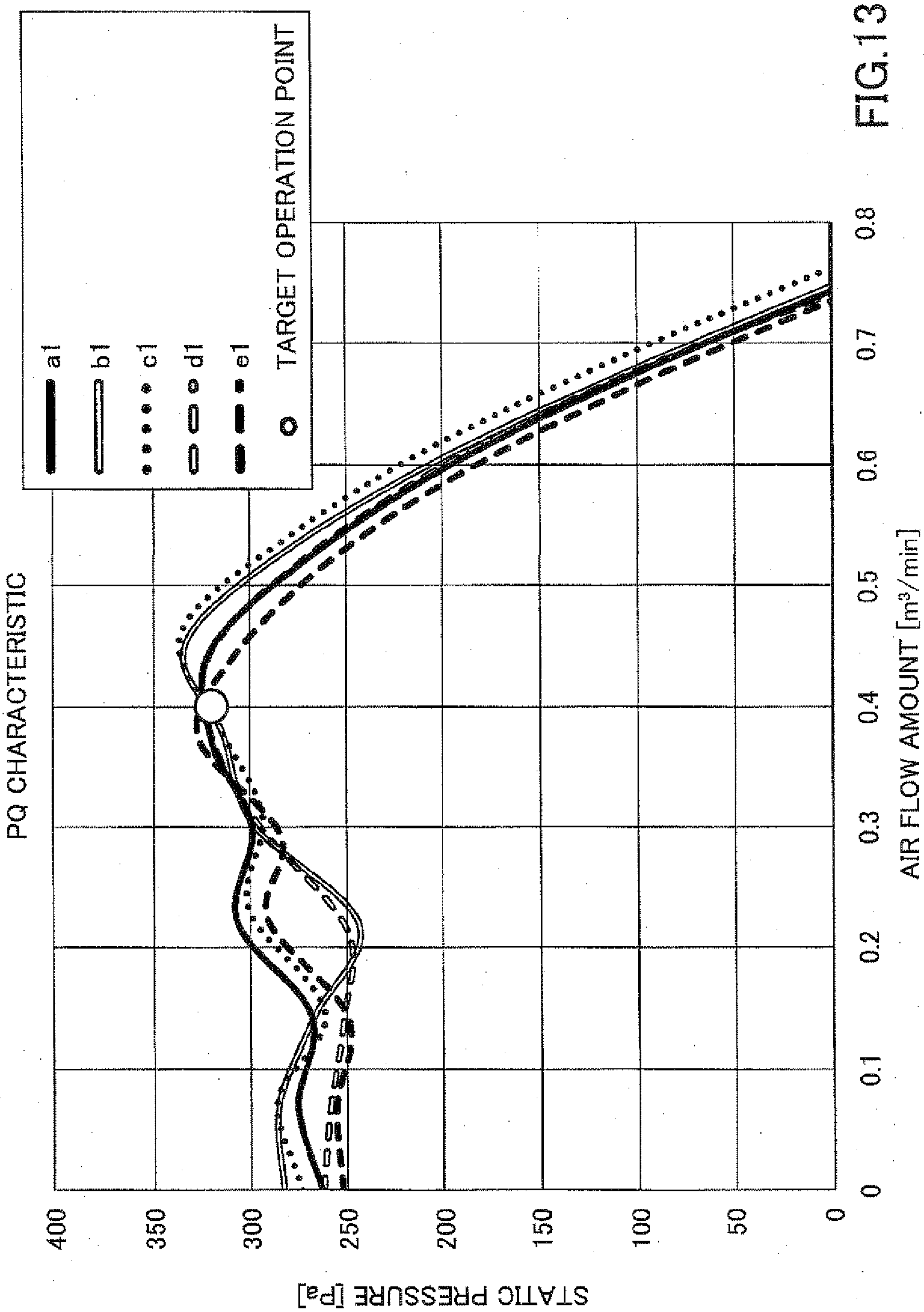

PQ CHARACTERISTIC
a1
b1
c1
d1
e1
TARGET OPERATION POINT
STATIC PRESSURE [Pa]
400
350
300
250
200
150
100
50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
AIR FLOW AMOUNT [m3/min]

FIG.13B

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 4128194 B **[0004]**