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

(11) EP 2 441 965 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.04.2012 Bulletin 2012/16

(21) Application number: **10816914.5**

(22) Date of filing: **17.03.2010**

(51) Int Cl.:
F04D 29/44 *(2006.01)* ***F04D 17/10*** *(2006.01)*

(86) International application number:
PCT/JP2010/054505

(87) International publication number:
WO 2011/033800 (24.03.2011 Gazette 2011/12)

(84) Designated Contracting States:
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 SE SI SK SM TR

(30) Priority: **16.09.2009 JP 2009215082**

(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

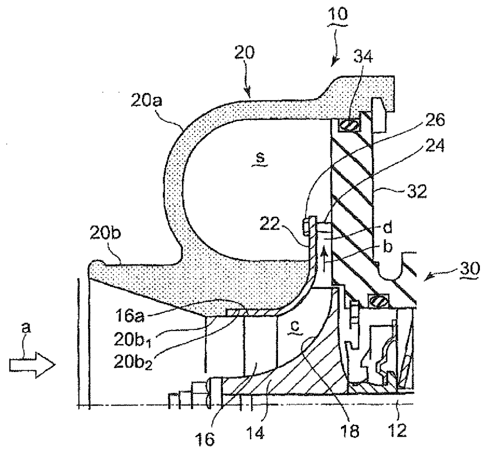
(72) Inventors:
- **IBARAKI, Seiichi**
  Tokyo 108-8215 (JP)
- **TOMITA, Isao**
  Tokyo 108-8215 (JP)
- **JINNAI, Yasuaki**
  Tokyo 108-8215 (JP)
- **MIKOGAMI, Takashi**
  Tokyo 108-8215 (JP)
- **TOJO, Masaki**
  Tokyo 108-8215 (JP)
- **KITADA, Akio**
  Tokyo 108-8215 (JP)

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

(54) CENTRIFUGAL COMPRESSOR

(57) It is intended to provide a centrifugal compressor equipped with a resin housing which does not compression efficiency without offsetting merits such as weight saving and cost reduction. A centrifugal compressor **10** includes a resin housing **20** formed by a volute section **20a** and a path forming section **20b.** An impeller **14** fixed to a rotating shaft **12** in a center of the path forming section **20b.** An annular shroud 22 is arranged in a depression $\mathbf{20b_2}$ carved in an inner wall $\mathbf{20b_1}$ of the path forming section **20b.** The annular shroud **22** forms an outer wall of a flow path **c** for a gas to be compressed and an outer wall of a diffuser **d** (static-pressure increasing region). A downstream end of the annular shroud **22** is fixed via a spacer **24** to a wall **32** by a bolt **6.** The wall **32** constitutes a part of a bearing housing **30.** Even when the resin housing **20** thermally deforms, a clearance **T** between the annular shroud **22** and a curved profile **16a** of the blade **16** can be kept at a set dimension.

FIG. 1



EP 2 441 965 A1

Description

[Technical Field]

[0001] The present invention relates to a centrifugal compressor provided with a housing made of resin which is used in a turbocharger or the like.

[Background Art]

[0002] A turbocharger installed in a vehicle or the like, drives a compressor by a exhaust turbine which is driven by energy of exhaust gas, compresses intake air in the compressor and supplies the compressed air to an engine. This type of turbocharger is provided with a bearing housing between a turbine housing of the exhaust turbine and a compressor housing for a turbo compressor. The bearing housing movably supports the rotating shaft rotatably. On the rotating shaft arranged through the bearing housing, an impeller of the turbo compressor and a wheel of the exhaust turbine are fixed.

[0003] The bearing housing houses a bearing mechanism for movably supporting the rotating shaft rotatably. Between the bearing housing and the compressor housing, a seal wall is interposed to form a flow path for gas which is enclosed in the compressor housing and is to be compressed.

[0004] A spiral-shaped housing such as a housing for a turbocharger, is normally made of cast aluminum, cast iron or the like. In recent years, for the purposes of making the housing lighter and at lower cost, a housing made of resin is used.

Disclosed in Patent Literature 1, is a housing for a turbo charger, which is made of thermoplastic resin. Disclosed in Patent Literature 2, is a housing for a centrifugal compressor, which has a double-wall structure made of thermoset resin and thermoplastic resin.

[0005] Patent Literature 3 discloses the invention to improve compressor efficiency and to prevent an impeller from being damaged. The inner wall of the compressor housing, which faces a flow path of the gas to be compressed, is made of resin material which is highly machinable. A clearance between the inner wall of the compressor housing and a curved profile of the impeller of the compressor is set small to improve compressor efficiency and to prevent the impeller from being damaged when the impeller comes in contact with the inner wall of the compressor housing.

[0006] In Patent Literature 4, an inner wall of a path forming section of a compressor housing of a turbocharger, is made of resin material which is highly machinable so as to reduce a cost thereof.

In Patent Literature 5, for the same reason as Patent Literature 3, an inner wall of a path forming section of a compressor housing of a turbocharger, is made of resin material.

[0007] **FIG.10** is a schematic view of a compressor of a turbo charger **100** provided with a resin housing. **FIG. 10** shows an impeller **104** fixed to a rotating shaft 102 and a plurality of blades **106** extending radially from the impeller **104.** An outer edge of the blade **106** forms a curved profile **106a.** A housing **110** is arranged around the blades **106.** The housing **110** includes a volute section **110a** which forms a volute part s and a path forming section **110b** which forms a flow path c for the gas to be compressed.

[0008] The path forming section **110b** is arranged to surround the blades **106.** The flow path c is formed by a hub face **108** of the impeller and an inner wall of the path forming section **110b.** The flow path c curves from an axial direction of the rotating shaft 102 (a direction of an arrow **a)** into a radial direction of the impeller **104** (a direction of an arrow **b).** A section extending from the flow path c where the blades **106** are arranged to the flow path d which is arranged on an outlet side of the flow path **c,** functions as a diffuser (static-pressure increasing region).

[0009] By rotation of the impeller **104,** the gas to be compressed is drawn into the flow path **c** in the direction of the arrow **a,** and reaches the blades **106** to increase an absolute flow velocity of the gas. The intake gas whose velocity is increased in the flow path **c,** is directed into the direction of the arrow **b** to enter the diffuser **d.** As the intake gas advances in the diffuser **d,** the intake gas is compressed and then exhausted to the volute part **s.**

[0010] The compressor achieves high compression efficiency with a small clearance **T** between the inner wall of the path forming section **110b** and the curved profile **106a** of the impeller **104.** The temperature of the gas to be compressed is raised by compressing the gas in the compressor. In the case of using the housing **110** made of resin, the resin has a higher thermal expansion rate than materials such as metal and thus, the housing **110** expands being exposed to the heat of the gas and thermally deforms in a direction of an arrow e as indicated by a dotted line **110'.** By this, the clearance **T** becomes wider and the gas leaks from the wider clearance **T,** resulting in a decrease in compression efficiency.

[0011] In the resin housing, if the impeller **104** is damaged and broken pieces thereof fly in the housing, it is necessary to prevent the broken pieces from flying out of the housing. To take measures against the issue, it is possible to increase a thickness of the housing **110** or to provide a reinforcing rib **112** in the housing **110.** However, such measures offset advantages of using the resin housing from the perspective of weight saving and cost reducing.

[Citation List]

[Patent Literature]

[0012]

[PTL 1]
DE 10260042 A1

[PTL 2]
EP 1830071 A2
[PTL 3]
JP 9-170442 A
[PTL 4]
JP2001-234753 A
[PTL 5]
JP2002-256878 A

[Summary of Invention]

[Technical Problem]

[0013] It is an object of the present invention to provide a centrifugal compressor equipped with a resin housing, which can obtain advantages such as a weight saving and cost reduction without decreasing compression efficiency.

[Solution to Problem]

[0014] To achieve the above object, the present invention provides a centrifugal compressor which may include, but is not limited to: an impeller which includes a plurality of blades fixed radially to a rotating shaft; a resin housing which is arranged around the impeller and which is made of resin. Between the impeller and the resin housing, a flow path for a gas to be compressed may be formed by an outer periphery of the impeller and an inner wall of a path forming section of the resin housing, the gas flowing in the flow path from an axial direction to a radial direction of the impeller. The inner wall of the path forming section of the resin housing may be carved to form a depression in which an annular shroud is provided, the annular shroud being made of one of a metal and a ceramic material and forming an outer surface of the flow path where the impeller is arranged and an outer surface of a diffuser which is arranged on an outlet side of the flow path. The annular shroud may be fixed to a wall facing the annular shroud at the diffuser.

[0015] According to the present invention, the inner wall of the path forming section of the resin housing is carved to form the depression in which the annular shroud made of metal or ceramic material is provided. The annular shroud forms an outer surface of the flow path where the impeller is arranged and an outer surface of a diffuser which is arranged on an outlet side of the flow path. The annular shroud is made of a material which has a higher strength and a lower thermal expansion rate than resin (engineering plastic), such as aluminum and carbon steel, or ceramic. The annular shroud is fixed to the wall facing the annular shroud at the diffuser.

[0016] The annular shroud is made separately from the resin housing and is not joined to the inner wall of the resin housing. Thus, the thermal deformation of the resin housing does not affect the annular shroud, allowing the space between the annular shroud and the curved profile of the impeller to remain the same. Therefore, the compression efficiency is not affected. With use of the annular shroud, it is not necessary to make the resin housing thicker or to provide a reinforcement rib in the resin housing. As a result, it does not offset merits such as weight saving and cost reduction.

[0017] In the present invention, the centrifugal compressor may be provided with a seal ring housed in a groove which is disposed between a rear face of the annular shroud and the depression of the inner wall of the path forming section. By this, even when the resin housing thermally deforms, leaving a gap between the inner wall of the resin housing and the annular shroud, it is possible to prevent the gas from entering the gap and the gas on the downstream side of the impeller from flowing back to the inlet side of the impeller. As a result, the compression efficiency does not decrease.

[0018] At the inlet of the impeller, the temperature of the gas is low as well as the temperatures of the annular shroud and the inner wall of the path forming section of the resin housing. Thus, an inexpensive rubber O-ring can be used as the seal ring. Further, the diameter of the inlet of the impeller is small and thus, the O-ring of a small diameter can be used. Accordingly, it is possible to achieve the cost reduction of the seal ring.

[0019] In addition to the above structure, the path forming section of the resin housing may be separable at a separating plane into an upstream portion and a downstream portion in a direction of flow of the gas, the separating plane being positioned at the groove for housing the seal ring. By this, it is possible to eliminate a thick-walled portion of the resin housing. This prevents air bubbles or the like remaining in the resin housing during injection molding of the resin housing. As a result, the quality of the resin housing is improved and the yield is improved, thereby preventing cost increase.
Further, by placing the separating plane to the groove for housing the seal ring, there is no need for carving to form the groove and thus, the molding manufacturing of the resin housing becomes easy, resulting in reducing the processing cost.

[0020] In the present invention, the resin housing may have a slit in one of the path forming section and a separated part of the path forming section, the split being formed in an axial direction of the rotating shaft and opening to outside. By this, the thick-walled portion of the resin housing can be eliminated. This eliminates air bubbles or the like remaining in the resin housing during injection molding of the resin housing. As a result, the quality of the resin housing is improved and the yield is enhanced, thereby preventing cost increase.

[0021] In the present invention, between the annular shroud and the path forming section of the resin housing, a circulation space for the gas may be formed, and at least two communication openings may be formed along a flow direction of the gas such that the communication space and the flow path are in communication with each other through the communication openings to allow the gas to flow in the communication space. In this manner, when the flow rate of the gas is low, a portion of the gas enters the communication space through the opening on the downstream side and then returns to the flow path from the opening on the upstream side, thereby forming a circulation flow. As the circulation flow joins the flow of the gas at the inlet of the impeller, it is possible to keep the flow rate of the gas at the inlet of the impeller not less than a stall limit. As a result, it is possible to lower a lower limit of the flow rate of the compressor.

[0022] In contrast, when the flow rate of the gas is high, a portion of the gas enters the communication space from the opening on the upstream side and then returns to the flow path from the opening on the downstream side. Thus, the upper limit of the flow rate of the gas is enhanced. As a result, the upper limit and the lower limit of the flow rate of the gas, which is allowable for operation of the centrifugal compressor, can be expanded.

[0023] In the present invention, the path forming section of the resin housing may be reinforced by an annular reinforcement layer covering an outer wall of the path forming section, the reinforcement layer being made of glass fiber. By providing on the outer wall of the path forming section the reinforcement layer made of glass fiber with high tension strength, when the impeller is damaged, the broken pieces of the impeller or the broken impeller does not penetrate through the wall of the path forming section and thus, the wall thickness of the path forming section, reinforced by the reinforcement layer, can be thinner. As a result, it is possible to reduce the production cost of the resin housing.

[Advantageous Effects of Invention]

[0024] According to the centrifugal compressor of the present invention, the centrifugal compressor is provided with: an impeller which includes a plurality of blades fixed radially to a rotating shaft; a resin housing which is arranged around the impeller and which is made of resin. Between the impeller and the resin housing, a flow path for a gas to be compressed is formed by an outer periphery of the impeller and an inner wall of a path forming section of the resin housing, the gas flowing in the flow path from an axial direction to a radial direction of the impeller. The inner wall of the path forming section of the resin housing is carved to form a depression in which an annular shroud is provided, the annular shroud being made of one of a metal and a ceramic material and forming an outer surface of the flow path where the impeller is arranged and an outer surface of a diffuser which is arranged on an outlet side of the flow path. The annular shroud is fixed to a wall facing the annular shroud at the diffuser.

Therefore, the clearance between the annular shroud and the curved profile of the blade can be kept at a set dimension, thereby maintaining a high compression efficiency, and by providing the annular shroud, there is no need to make the resin housing thicker or to provide a reinforcement rib in the resin housing and thus, the benefits such as a lighter weight or cost reduction of the resin housing can be obtained.

[Brief Description of Drawings]

[0025]

[FIG.1] **FIG.1** is a side view of a centrifugal compressor in relation to a first embodiment, to which the present invention is applied.

[FIG.2] **FIG.2** is a side view of a centrifugal compressor in relation to a second embodiment, to which the present invention is applied

[FIG.3] **FIG.3** is a side view of a centrifugal compressor in relation to a third embodiment, to which the present invention is applied.

[FIG.4] **FIG.4** is a side view of a centrifugal compressor in relation to a fourth embodiment, to which the present invention is applied.

[FIG.5] **FIG.5** is a side view of a centrifugal compressor in relation to a fifth embodiment, to which the present invention is applied.

[FIG.6] **FIG.6** is a side view showing a modified example of the fifth embodiment.

[FIG.7] **FIG.7** is a side view of a centrifugal compressor in relation to a sixth embodiment, to which the present invention is applied.

[FIG.8] **FIG.8** is a side view showing a modified example of the sixth embodiment.

[FIG.9] **FIG.9** is a side view of a centrifugal compressor in relation to a seventh embodiment, to which the present invention is applied.

[FIG.10] **FIG.10** is a side view showing a part of a conventional centrifugal compressor.

[FIG.11] **FIG.11** is a side view of a centrifugal compressor showing a comparison between a thick resin housing and a reinforcement rib.

[Description of Embodiments]

[0026] An embodiment of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, shape, its relative positions and the like shall be interpreted as illustrative only and not limitative of the scope of the present invention.

[FIRST EMBODIMET]

[0027] A first embodiment of a centrifugal compressor to which the present invention is applied is explained in reference to **FIG.1.** In **FIG.1,** a rotating shaft **12** is arranged in a center of a resin housing **20,** and an impeller **14** having a plurality of blades **16** fixed radially is fixed to an outer periphery of the rotating shaft **12.** A hub face **18** of the impeller **14** curves from an inlet side to an outlet side in a flow direction of a gas to be compressed (a direction indicated with an arrow **a)** from an axial direction to a radial direction of the rotating shaft **12.** The resin housing **20** includes a volute section **20a** which forms a volute part **s** and a path forming section **20b** which forms a flow path c for the gas to be compressed.

[0028] The outer edge of the blade forms a curved profile **16a.** Along the curved profile **16a,** an inner wall $\mathbf{20b_1}$ of the path forming section **20b** of the resin housing **20** is formed. The inner wall $\mathbf{20b_1}$ is carved to form a depression $\mathbf{20b_2}$ in which an annular shroud is inserted. The rotating shaft **12** is rotatably and movably supported by a bearing provided in a bearing housing **30.** The bearing is not shown in the drawing. The spiral-shaped volute section **20a** forms a volute part s. A wall **32** constituting a part of the bearing housing **30** is arranged facing the volute part s formed by the spiral-shaped volute section **20a.** An end of the volute section **20a** is fixed to the wall 32 via a seal ring **34.**

[0029] In the depression $\mathbf{20b_2}$ formed in the inner wall $\mathbf{20b_1}$ of the path forming section **20b,** an annular shroud **22** is inserted. A downstream end of the annular shroud **22** which is on a downstream side in a direction of the gas flow, projects into the volute part **s.** The downstream end of the annular shroud **22** is fixed to the wall 32 by a bolt **26** via a spacer **24.** The annular shroud **22** is made of a metal which has a higher strength and a lower thermal expansion rate than resin, such as aluminum and carbon steel, or ceramic. The annular shroud **22** and the resin housing **20** are not connected. The clearance between the annular shroud **22** and the curved profile **16a** of the blade **16** is set as small as possible to maintain decent compression efficiency.

[0030] In this manner, the annular shroud **22** forms an outer surface of the flow path c and an outer surface of the diffuser **d.** The flow path **c** directs the gas from an axial direction of the impeller **14** (the direction of the arrow **a)** into a radial direction of the impeller (a direction of an arrow **b).** The diffuser **d** is arranged on an outlet side of the flow path c to convert the kinetic energy of the gas into a static pressure. An inner surface of the flow path c is formed by the hub face 18 of the impeller **14,** whereas an inner surface of the diffuser **d** is formed by the wall **32.**

[0031] With the above structure, the rotation of the impeller **14** causes the gas to be drawn in from an inlet side of the blade **16,** through the flow path c and the diffuser **d** and then converted into the static pressure. The compressed gas flows through the diffuser d and then enters the volute part **s.** A plurality of bolts **26** are arranged at intervals in the circumferential direction of the rotating shaft **12.** However, the bolts **26** do not interfere with the flow of the gas.

[0032] According to the first embodiment, the annular shroud **22** is fixed to the wall **32** of the bearing housing **30** solely by the bolts **26** and the annular shroud **22** and the resin housing **20** are separated from each other. Thus, heat deformation of the resin housing **20** does not reach the annular shroud **22.** Therefore, even when the resin housing **20** thermally deforms, the clearance between the annular shroud **22** and the blade **16** does not change. As a result, the compression efficiency is not affected.

[0033] By providing the annular shroud **22,** it is no longer necessary to make the resin housing **20** thicker or to provide a reinforcement rib or the like in the resin housing **20.** As a result, it does not offset merits such as a lighter weight and cost reduction.

[SECOND EMBODIMENT]

[0034] A second embodiment of the centrifugal compressor to which the present invention is applied is explained in reference to **FIG.2.** In the second embodiment, as shown in **FIG.2,** the downstream end **22a** of the annular shroud **22** has two bending sections. The annular shroud **22** bends at a first bending section to extend to a position where the downstream end comes in contact with the wall 32 of the bearing housing **30** and bends at a second bending section to form a flange part $\mathbf{22a_1}$**.** The wall **32** is formed with a depression **32a** in which the flange part $\mathbf{22a_1}$ is fitted. The flange part $\mathbf{22a_1}$ is connected to the depression **32a** by a bolt **40.**

[0035] The flange part $\mathbf{22a_1}$ is formed partially around the impeller **14.** Thus, the downstream end **22a** of the shroud **22** does not block the diffuser **d** or interfere with the flow of the gas in the diffuser. The rest of the structure is substantially the same as that of the first embodiment. The same parts are indicated by the same reference numerals.

[0036] According to the second embodiment, the annular shroud **22** is a single-piece member which extends to the flange part $\mathbf{22a_1}$ and is processed by pressure forming. Therefore, in addition to the function effects achieved in the first embodiment, the annular shroud **22** is easy to manufacture by pressure-forming and it is easy to connect the annular shroud **22** to the wall **32** as there is no need for the spacer 24 which is provided in the case of the first embodiment, in order to connect the annular shroud **22** to the wall **32.**

[THIRD EMBODIMENT]

[0037] Next, a third embodiment in which the present invention is applied to a centrifugal compressor is explained in reference to **FIG.3.** In the third embodiment, the depression $\mathbf{20b_2}$ carved in the inner wall $\mathbf{20b_1}$ of the path forming section **20b** of the resin housing **20,** is carved to form a groove 52. In the groove 52, a rubber or resin seal ring 50 is inserted. The rest of the structure is substantially the same as that of the second embodiment.

[0038] According to the third embodiment, even when the resin housing **20** thermally deforms, creating a gap between the depression $\mathbf{20b_2}$ and a rear face of the annular shroud **22,** it is possible to prevent the entry of the gas between the depression $\mathbf{20b_2}$ and the annular shroud **22** by means of the seal ring **50.** Therefore, the compression efficiency of the compressor does not decrease.

[0039] At an inlet of the impeller **14,** the temperature of the gas is approximately the same as the ambient air and is low. At the inlet of the impeller, the temperatures at the annular shroud **22** and the path forming section **20b** are also low and thus, an inexpensive rubber O-ring can be used. Further, at the inlet of the impeller **14,** the gas path in which the gas flows does not curve in the radial direction and the diameter of the impeller **14** is small and thus, the O-ring of a small diameter can be used. Therefore, it is possible to achieve the cost reduction of the seal ring **50.**

[FOURTH EMBODIMENT]

[0040] Next, a fourth embodiment in which the present invention is applied to a centrifugal compressor is explained in reference to **FIG.4. FIG.4** shows the resin housing **20** of the fourth embodiment. The path forming section **20b** of the resin housing **20** is separable into two resin separated portions **60** and **62.** The path forming section **20b** is separated into the separated portions **60** and **62** at a separating plane **64** having a stepped portion **64a** in a center of a thick-walled portion thereof. The separating plane **64** is disposed such that one end there of is positioned at the groove where the seal ring **50** is housed. The rest of the structure is substantially the same as that of the third embodiment.

[0041] According to the fourth embodiment, the path forming section **20b** is separated into the separated portions **60** and **62** and thus, the thickness of the path forming section **20b** is reduced. This prevents, during molding manufacturing of the resin housing **20,** air bubbles from remaining in the path forming section **20b.** Therefore, the quality of the resin housing **20** is improved and with improved yield rate, the production cost of the resin housing is reduced.

Further, by placing the separating plane **64** to the groove **52,** there is no need for carving the path forming section **20b** to form the groove **52,** and a corner of the separated portion **60** is processed and thus, the molding manufacturing of the separated portion **60** becomes easy, resulting in reducing the processing cost.

[FIFTH EMBODIMENT]

[0042] Next, a fifth embodiment in which the present invention is applied to a centrifugal compressor is explained in reference to **FIG.5.** In the fifth embodiment, the thick-walled portion of the path forming section **20b** of the resin housing **20,** has a slit **V** in a direction perpendicular to the thickness of the path forming section, i.e. in a direction approximately parallel to the rotational axis of the impeller **14.** The slit **V** opens to outside. The rest of the structure is substantially the same as that of the third embodiment.

[0043] According to the fifth embodiment, by forming the slit **V** in the path forming section **20b,** the thick-walled portion of the path forming section **20b** can be eliminated. This eliminates air bubbles or the like remaining in the resin housing during injection molding of the resin housing **20.** As a result, the quality of the resin housing **20** is improved and the yield is improved, thereby preventing cost increase.

[0044] A modified example of the fifth preferred embodiment is explained in reference to **FIG.6.** According to the modified example shown in **FIG.6,** the separated portion **60** of the separated portions **60** and **62** of the resin housing **20,** is formed with a slit **Va** inside the thick-walled portion of the path forming section **20b.** The slit **Va** is formed in the direction perpendicular to the thickness of the path forming section, i.e. in the direction approximately parallel to the rotational axis of the impeller **14.** And, an end of the slit **Va** opens to outside. The rest of the structure is substantially the same as that of the fourth embodiment.

[0045] According to the modified example, in addition to the function effects achieved in the fourth embodiment, by providing the slit **Va** in the path forming section **20b** of the separated portion **60,** the thick-walled portion of the separated portion **60** is eliminated. This eliminates air bubbles or the like remaining in the resin housing during injection molding of the separated portion **60** of the resin housing **20.** As a result, the quality of the separated portion 60 is improved and the yield is improved, thereby preventing cost increase.

[SIXTH EMBODIMENT]

[0046] A sixth embodiment in which the present invention is applied to a centrifugal compressor is explained in reference to **FIG.7.** In the sixth embodiment, the inner wall $\mathbf{20b_1}$ of the path forming section **20b** is carved to form the depression $\mathbf{20b_2}$ in the flow path **c** and the depression $\mathbf{20b_2}$ is further carved to form a circulation space **70** on a rear side of the annular shroud **22.** The annular shroud **22** includes an upstream through-hole **72** and a downstream through-hole **74** where the annular shroud faces the circulation space **70.** The rest of the structure is substantially the same as that of the second embodiment.

[0047] According to the sixth embodiment, when the flow rate of the gas is low, a portion of the gas flowing in the flow path **c** enters the circulation space **70** from the downstream through-hole **74** and then returns to the flow path **c** from the upstream through-hole **72,** thereby forming a circulation flow. As the circulation flow joins the flow of the gas at the inlet of the impeller **14,** thereby preventing the impeller **14** from stoll. As a result, it is possible to lower a lower limit of the flow rate of the compressor.

[0048] In contrast, when the flow rate of the gas is high, a portion of the gas flowing in the flow path c enters the circulation space **70** from the upstream through-hole **72** and then returns to the flow path **c** from the downstream through-hole **74.** By this, it is possible to increase an upper limit of the flow rate of the gas. As a result, the range of the flow rate of the gas, which is allowable for operation of the centrifugal compressor, can be expanded.

[0049] Next, a modified example of the sixth embodiment is explained in reference to **FIG.8.** In a manner similar to the sixth embodiment, the circulation space **70** is formed on the rear side of the annular shroud **22.** At the entrance to the flow path **c,** a circular slit opening **76** is formed between an end of the annular shroud **22** which is on an inlet side and the inner wall $\mathbf{20b_1}$ of the path forming section **20b.** On a downstream side of the slit opening **76,** the through-hole **74** which is the same as the through-hole **74** of the sixth embodiment, is formed in the annular shroud **22** path **c.** The rest of the structure is substantially the same as that of the sixth embodiment.

[0050] In comparison with the sixth embodiment, this modified example has an advantage of easier manufacturing of the annular shroud **22** and the path forming section **20b** as the number of through-holes formed in the annular shroud **22** is reduced and there is no need to carve the inner wall surface **20a** of the path forming section **20b** to form the depression $\mathbf{20b_2}$ in which the annular shroud **22** is fit. Further, the annular slit opening **76** is formed and thus, the opening area of the slit opening can be increased and it is easy to form the slit opening.

[SEVENTH EMBODIMENT]

[0051] A seventh embodiment in which the present invention is applied to a centrifugal compressor is explained in reference to **FIG.9.** In the seventh embodiment, the path forming section **20b** of the resin housing 20 is made thinner, and behind the path forming section 20b, an annular glass fiberboard 80 is provided. The rest of the structure is substantially the same as that of the second embodiment.

[0052] When the impeller **14** is damaged, the path forming section **20b** must have enough strength to prevent the broken pieces of the impeller or the broken impeller **14** from breaking through the resin housing **20.** According to the seventh embodiment, the glass fiberboard **80** is provided on the rear side of the path forming section **20b** for reinforcement and thus, the path forming section **20b** can be thin. With reduced thickness of the path forming section **20b,** it is possible to eliminate air bubbles or the like remaining in the resin housing **20** during injection molding of the resin housing **20.** As a result, the quality of the resin housing **20** is improved, thereby improving the yield during the molding manufacturing of the resin housing and preventing cost increase.

[Industrial Applicability]

[0053] According to the present invention, it is possible, in a centrifugal compressor which can be used in a turbocharger or the like, to achieve a lighter weight and cost reduction of the housing without a decrease in compression efficiency even when the housing is thermally deformed.

Claims

1. A centrifugal compressor comprising:

   an impeller which comprises a plurality of blades fixed radially to a rotating shaft; and
   a resin housing which is arranged around the impeller and which is made of resin,
   wherein between the impeller and the resin housing, a flow path for a gas to be compressed is formed by an outer periphery of the impeller and an inner wall of a path forming section of the resin housing, the gas flowing in the flow path from an axial direction to a radial direction of the impeller,
   wherein the inner wall of the path forming section of the resin housing is carved to form a depression in which an annular shroud is provided, the annular shroud being made of one of a metal and a ceramic material and forming an outer surface of the flow path where the impeller is arranged and an outer surface of a diffuser which is arranged on an outlet side of the flow path, and

   wherein the annular shroud is fixed to a wall facing the annular shroud at the diffuser.

2. The centrifugal compressor according to claim 1, further comprising:

   a seal ring housed in a groove which is disposed between a rear face of the annular shroud and the depression of the inner wall of the path forming section.

3. The centrifugal compressor according to claim 2, wherein the path forming section of the resin housing is separable at a separating plane into an upstream portion and a downstream portion in a direction of flow of the gas, the separating plane being positioned at the groove for housing the seal ring.

4. The centrifugal compressor according to any one of claims 1 to 3,
   wherein the resin housing has a slit in one of the path forming section and a separated part of the path forming section, the split being formed in an axial direction of the rotating shaft and opening to outside.

5. The centrifugal compressor according to claim 1, wherein between the annular shroud and the path forming section of the resin housing, a circulation space for the gas is formed, and at least two communication openings are formed along a flow direction of the gas such that the communication space and the flow path are in communication with each other through the communication openings to allow the gas to flow in the communication space.

6. The centrifugal compressor according to claim 1, wherein the path forming section of the resin housing is reinforced by an annular reinforcement layer covering an outer wall of the path forming section, the reinforcement layer being made of glass fiber.

FIG. 1

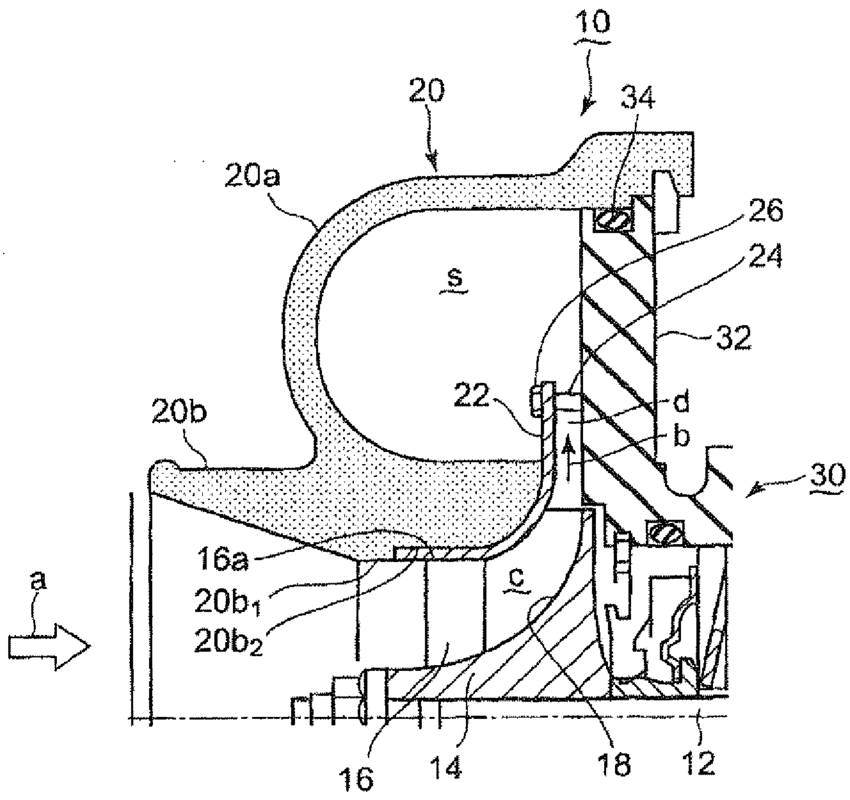


FIG. 2

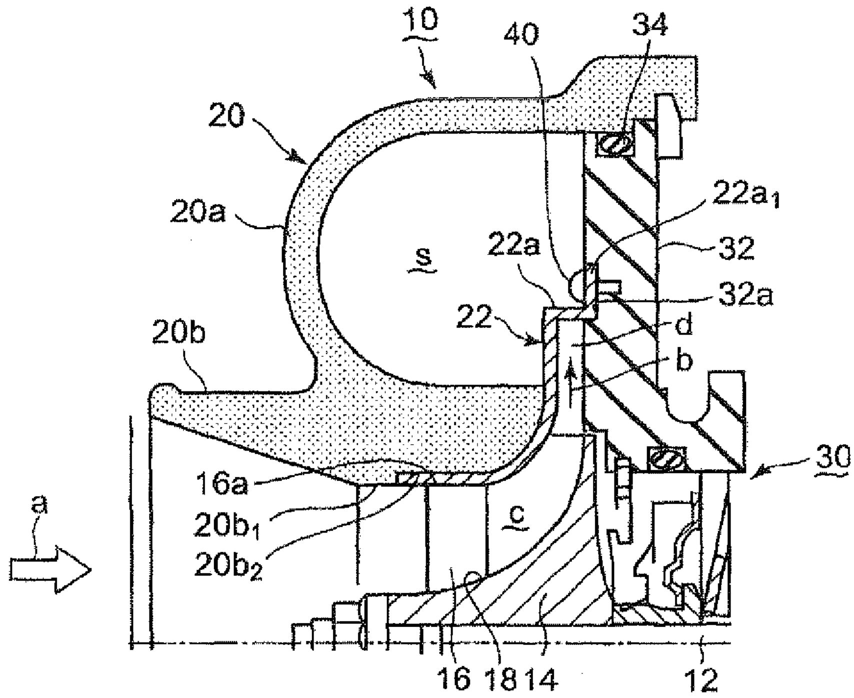

10
40
34
20
20a
22a1
32
s
22a
32a
22
d
20b
b
30
16a
20b1
a
c
20b2
16 18 14
12

FIG. 3

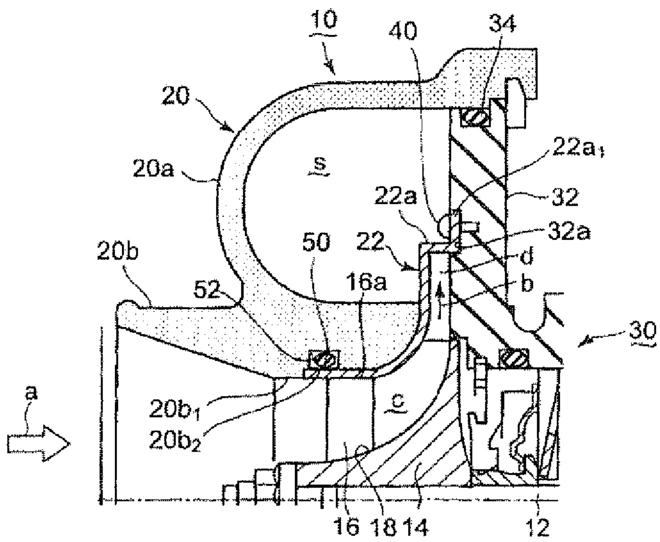

10
40
34
20
22a1
20a
s
32
22a
32a
20b
50
22
d
52
16a
b
30
a
20b1
c
20b2
16
18
14
12

FIG. 4

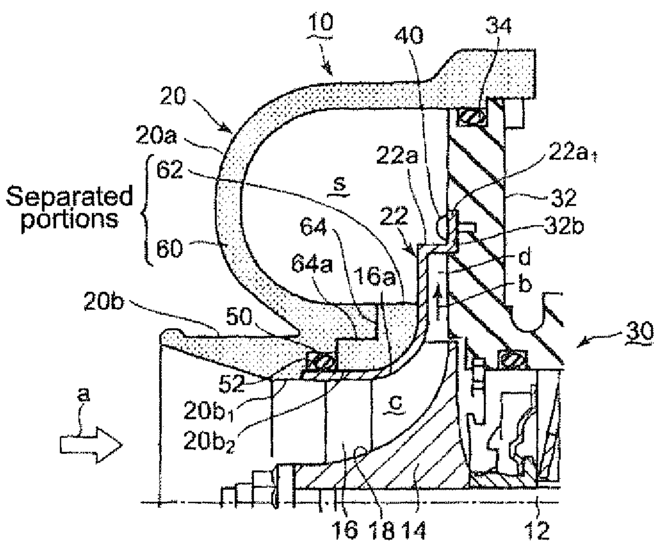

10
40
34
20
22a1
20a
Separated portions
62
s
22a
32
60
64
22
32b
d
64a
16a
b
20b
50
30
52
a
20b1
c
20b2
16
18
14
12

FIG. 5

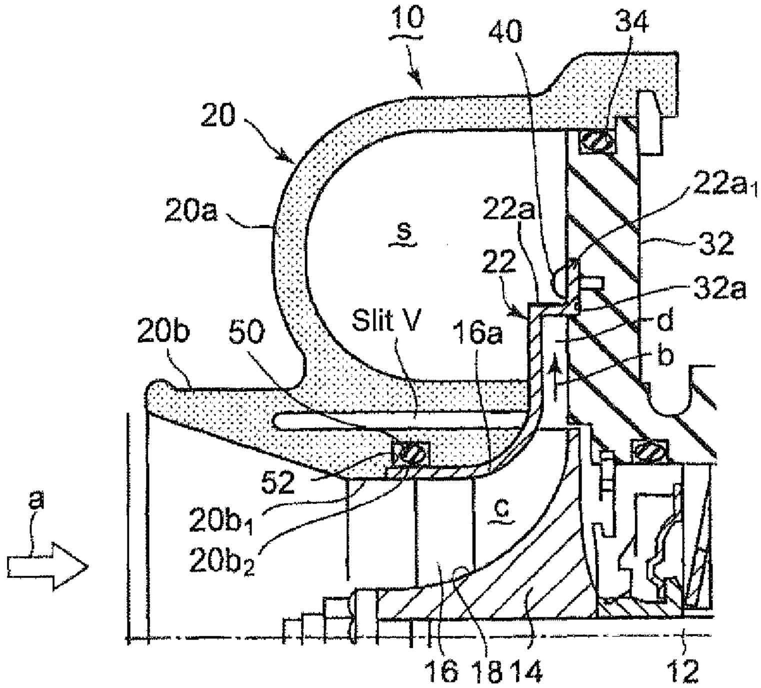

10
40
34
20
22a1
20a
s
22a
32
22
32a
Slit V
d
20b
50
16a
b
52
c
a
20b1
20b2
16 18 14
12

FIG. 6

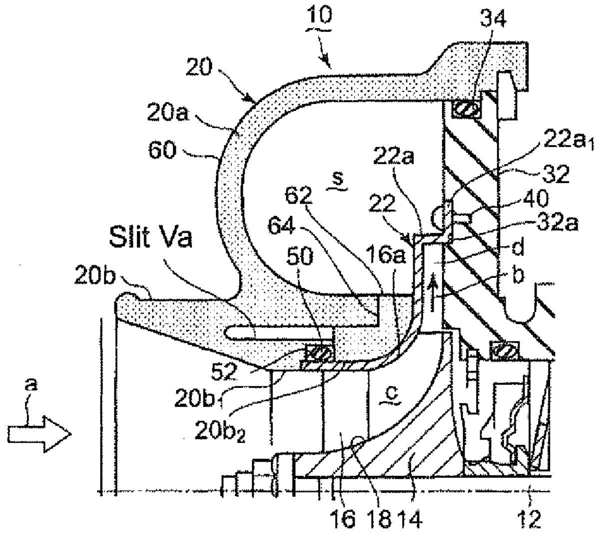

10
34
20
20a
22a1
60
22a
32
s
40
62
22
32a
64
16a
d
Slit Va
50
b
20b
52
20b
c
a
20b2
16 18 14
12

FIG. 7

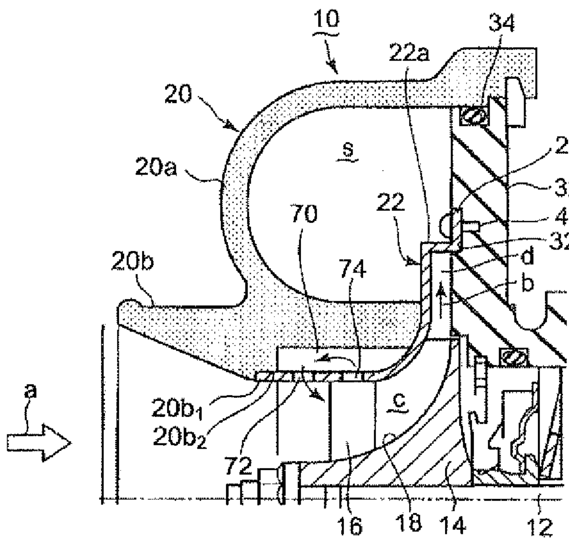

10
34
22a
20
22a1
s
20a
32
40
70
22
32a
20b
74
d
b
a
c
20b1
20b2
72
16
18
14
12

FIG. 8

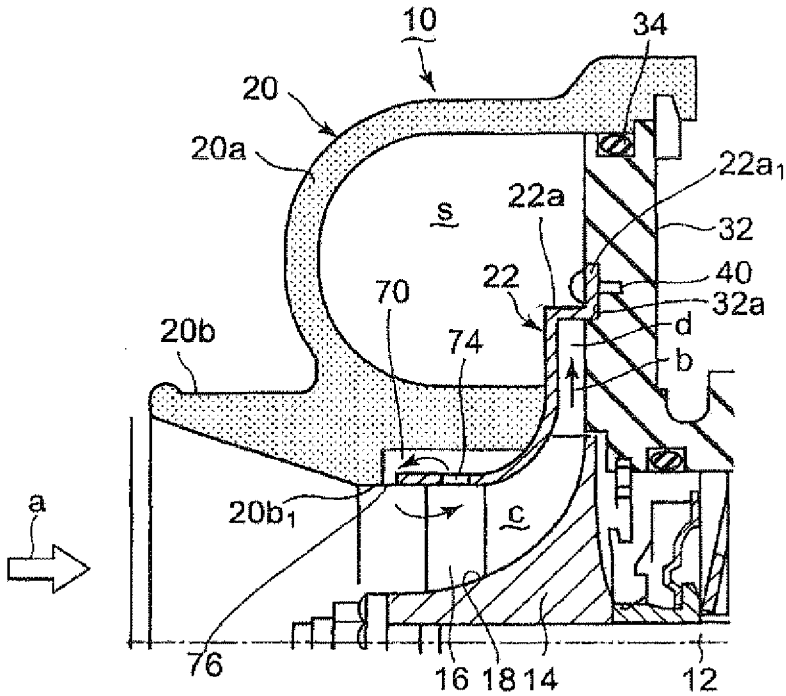

10
34
20
20a
22a1
s
22a
32
70
22
40
32a
20b
74
d
b
a
20b1
c
76
16 18 14
12

FIG. 9

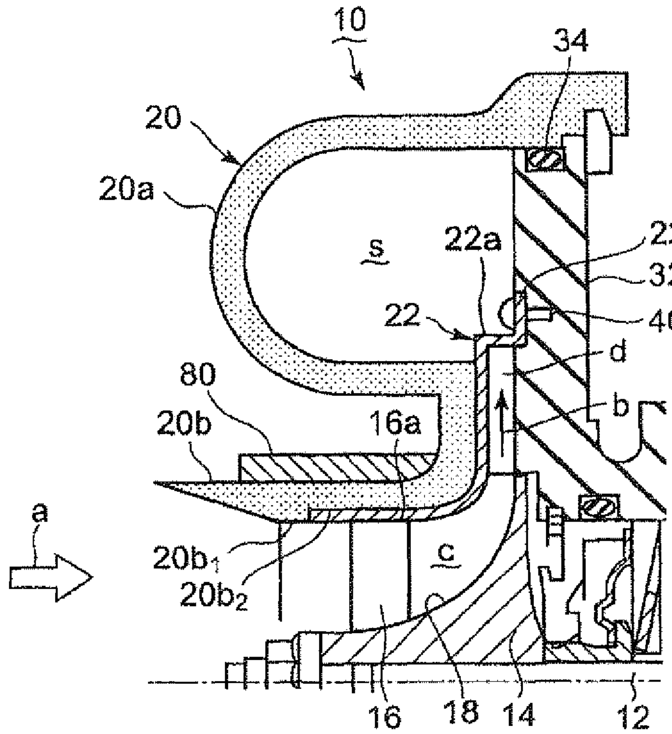
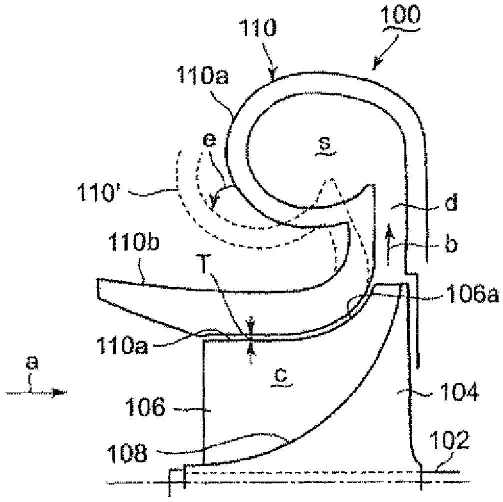
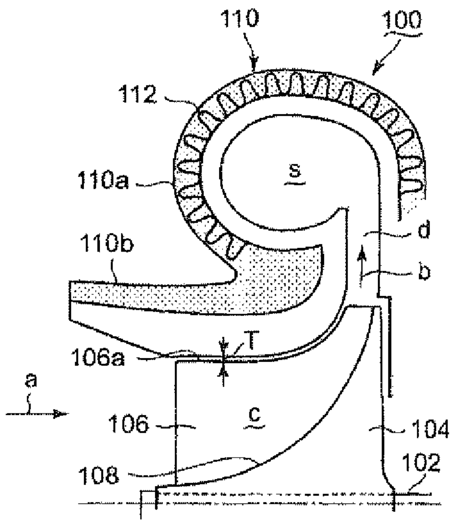

10
34
20
20a
s
22a
$22a_1$
32
22
40
d
80
b
20b
16a
a
c
$20b_1$
$20b_2$
16
18
14
12

FIG. 10



Related Art

FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/054505

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/44(2006.01)i, *F04D17/10*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04D29/44, F04D17/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-322026 A (Shinano Kenshi Co., Ltd.), 14 November 2003 (14.11.2003), entire text; all drawings (Family: none)	1-6
Y	JP 61-79900 A (Nissan Motor Co., Ltd.), 23 April 1986 (23.04.1986), entire text; fig. 3 (Family: none)	1-6

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 June, 2010 (01.06.10)	15 June, 2010 (15.06.10)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/054505

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 40191/1991(Laid-open No. 125633/1992) (Ishikawajima-Harima Heavy Industries Co., Ltd.), 16 November 1992 (16.11.1992), entire text; all drawings (Family: none)	3-5
Y	JP 2004-144029 A (Toyota Central Research and Development Laboratories, Inc.), 20 May 2004 (20.05.2004), entire text; all drawings (Family: none)	3-5
Y	JP 2004-285909 A (Iwaki Co., Ltd.), 14 October 2004 (14.10.2004), entire text; all drawings & US 2004/0184936 A1 & EP 1460272 A2	6
Y	JP 9-52309 A (Ebara Corp.), 25 February 1997 (25.02.1997), entire text; all drawings & US 5989664 A	6

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE 10260042 A1 **[0012]**
- EP 1830071 A2 **[0012]**
- JP 9170442 A **[0012]**
- JP 2001234753 A **[0012]**
- JP 2002256878 A **[0012]**