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(54) **CENTRIFUGAL COMPRESSOR**

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(57) **ABSTRACT**

A centrifugal compressor that reduces pressure loss of fluid blown out from an impeller to improve efficiency is provided. The centrifugal compressor includes: a rotary shaft **5** rotatably supported by a casing **2**; an impeller **6** provided on the rotary shaft **5** for blowing out fluid sucked from a suction port **10** in a radial direction of the rotary shaft **5**; a return channel **13** for reversing the fluid blown out from the impeller **6** toward an axis line L of the rotary shaft **5**; and a discharge port **16** positioned on the axis line L of the rotary shaft **5** for discharging the fluid having passed through the return channel **13** in a direction along the axis line L.

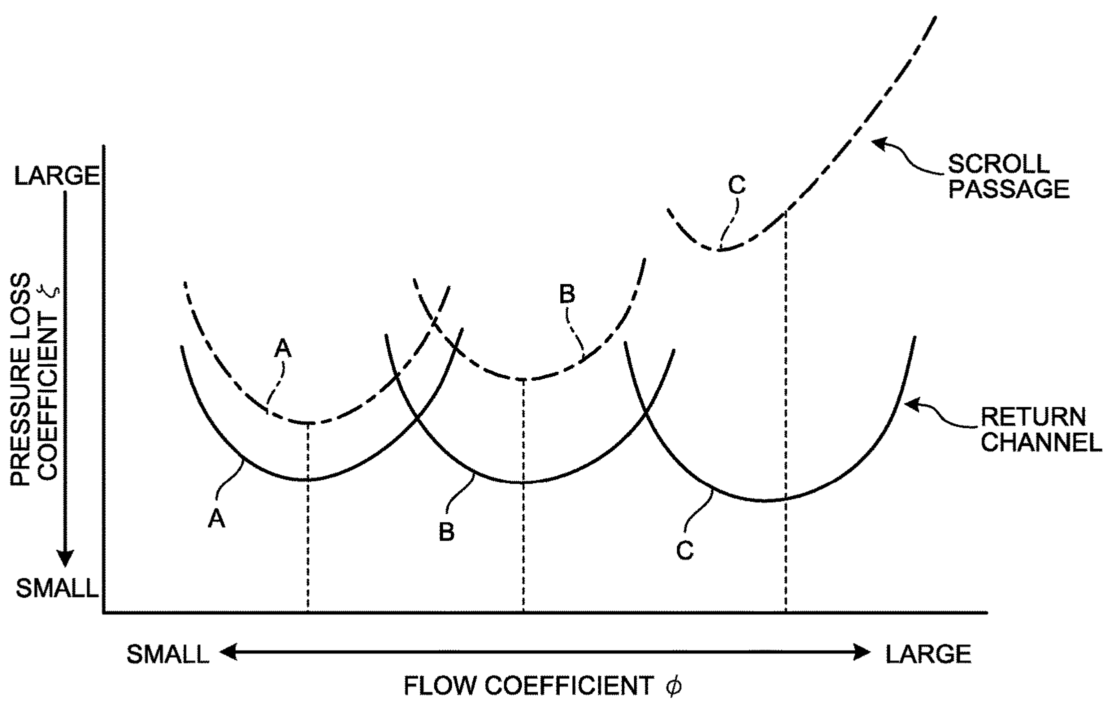


FIG.1

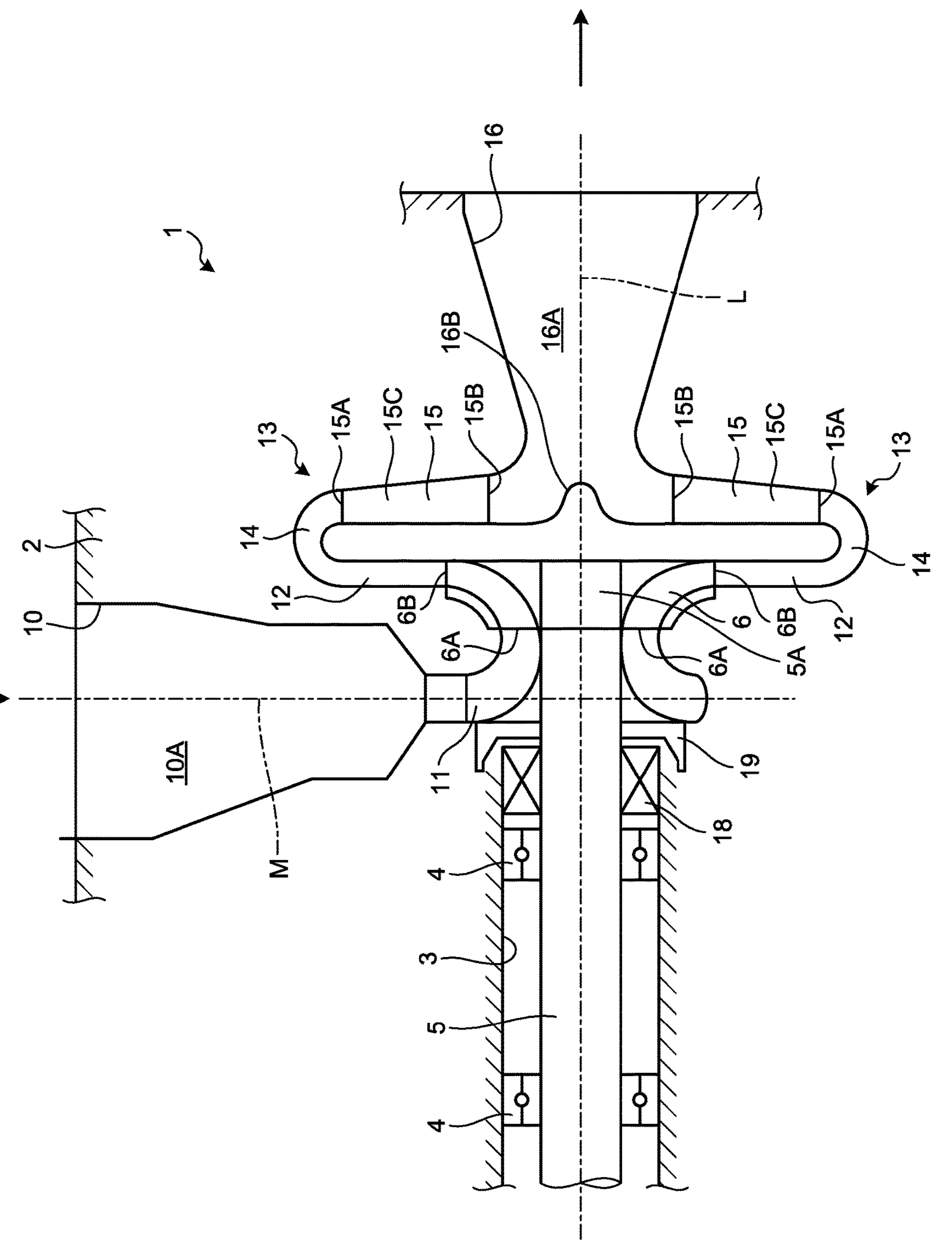
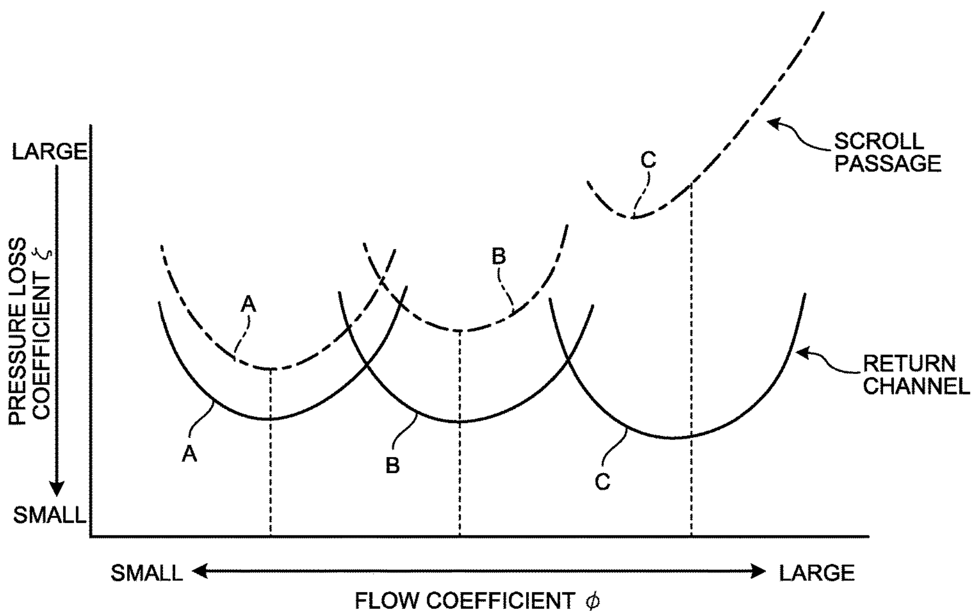

1
2
3
4
5
5A
6
6A
6B
10
10A
11
12
13
14
15
15A
15B
15C
16
16A
16B
18
19
L
M

FIG.2


LARGE
PRESSURE LOSS COEFFICIENT ζ
SMALL
SCROLL PASSAGE
RETURN CHANNEL
A
B
C
A
B
C
SMALL
LARGE
FLOW COEFFICIENT φ

CENTRIFUGAL COMPRESSOR

FIELD

[0001] The present invention relates to a centrifugal compressor.

BACKGROUND

[0002] Centrifugal compressors for industrial use are generally used in petrochemical plants or natural gas plants, for example. In the centrifugal compressors of this type, kinetic energy is given to fluid by the rotation of an impeller, and an increase in pressure due to centrifugal force is obtained by blowing out the fluid in a radially outer direction.

[0003] In the centrifugal compressors of this type, a configuration in which a scroll passage formed in a spiral shape in a circumferential direction is provided on an outlet side of an impeller and fluid blown out from the impeller is discharged to the outside of a casing via the scroll passage has been known in conventional techniques (see Patent Literature 1, for example). The scroll passage is formed so as to have a gradually-increasing cross-sectional area toward an outlet thereof in the circumferential direction, for example. Pressure loss of the fluid can be reduced by causing the fluid to flow through the scroll passage through the use of a circumferential velocity component of the fluid.

CITATION LIST

Patent Literature

[0004] Patent Literature 1: Japanese Patent Application Laid-Open No. 61-66899

SUMMARY

Technical Problem

[0005] By the way, the applications of the centrifugal compressors of this type have a tendency to be specialized in recent years. For example, a low-head centrifugal compressor with a large discharge flow rate has been demanded. In fluid blown out from an impeller, the radial velocity component thereof becomes larger than the circumferential velocity component thereof at a large discharge flow rate. Thus, in the configuration including the scroll passage, an impeller with a larger flow rate has a larger spiral flow in a meridional cross-section of the scroll passage at an inlet of the scroll passage, which is an outlet of a diffuser, due to its increased radial velocity component. Consequently, smooth flow in the scroll passage is hindered, thereby increasing a pressure loss coefficient of the scroll passage and thus deteriorating the efficiency of the centrifugal compressor.

[0006] The present invention has been made in view of such circumstances, and it is an object of the present invention to provide a centrifugal compressor that reduces pressure loss of fluid blown out from an impeller to improve the efficiency thereof.

Solution to Problem

[0007] According to an aspect of the present invention, a centrifugal compressor comprises: a rotary shaft rotatably supported by a casing; an impeller provided on the rotary shaft for blowing out fluid sucked from a suction port in a radial direction of the rotary shaft; a return channel for reversing the fluid blown out from the impeller toward the rotary shaft; and a discharge port positioned on an axis line of the rotary shaft for discharging the fluid having passed through the return channel in a direction along the axis line.

[0008] According to this configuration, the provision of the return channel for reversing the fluid blown out from the impeller toward the rotary shaft and the discharge port positioned on the axis line of the rotary shaft for discharging the fluid having passed through the return channel in the direction along the axis line allows the fluid blown out from the impeller to be guided to the discharge port without using the scroll passage. The scroll passage has a larger pressure loss coefficient than the return channel. A difference between those pressure loss coefficients increases with an increase in flow coefficient. Thus, an impeller with a larger flow coefficient can improve the efficiency of the centrifugal compressor further by changing the scroll passage to the return channel. Moreover, since the discharge port is positioned on the axis line of the rotary shaft and discharges the fluid having passed through the return channels in the direction along the axis line, the fluid having passed through the return channels can be discharged without interfering with each other.

[0009] Advantageously, in the centrifugal compressor, a bearing for pivotally supporting the rotary shaft is provided on a shaft end closer to the discharge port than the bearing. According to this configuration, the impeller is supported by the rotary shaft in a so-called cantilever (referred to also as overhung) state. This eliminates a need to provide a sealing member between the impeller and the discharge port, thus achieving a simplified structure.

[0010] Advantageously, in the centrifugal compressor, the suction port is provided in a direction orthogonal to an axial direction of the rotary shaft. According to this configuration, the suction port can be disposed while preventing interference with the bearing of the rotary shaft, etc. Thus, the size of the casing can be prevented from increasing in the axial direction.

[0011] Advantageously, in the centrifugal compressor, the return channel includes a return vane on an outlet side of the return channel. The return vane has a relatively small pressure loss coefficient as compared to the scroll passage. Thus, the efficiency of the centrifugal compressor can be further improved when the flow rate is increased, for example. Also, in the centrifugal compressor, the impeller may be provided singularly to perform single-stage compression.

Advantageous Effects of Invention

[0012] According to the present invention, the provision of the return channel for reversing the fluid blown out from the impeller toward the rotary shaft and the discharge port positioned on the axis line of the rotary shaft for discharging the fluid having passed through the return channel in the direction along the axis line allows the fluid blown out from the impeller to be guided to the discharge port without using the scroll passage. The scroll passage has a larger pressure loss coefficient than the return channel. A difference between those pressure loss coefficients increases with an increase in flow coefficient. Thus, an impeller with a larger flow coefficient can improve the efficiency of the centrifugal compressor further by changing the scroll passage to the return channel. Moreover, since the discharge port is positioned on the axis line of the rotary shaft and discharges the fluid having passed through the return channels in the direction along the axis line, the fluid having passed through the return channels can be discharged without interfering with each other.

BRIEF DESCRIPTION OF DRAWINGS

[0013] FIG. **1** is a longitudinal cross-sectional view of a centrifugal compressor according to a present embodiment.

[0014] FIG. **2** is a graph comparing relationships between flow coefficients and pressure loss coefficients in a scroll passage and a return channel.

DESCRIPTION OF EMBODIMENTS

[0015] An embodiment of the present invention will be described below with reference to the drawings. Note that this invention is not limited by the following embodiment. Note also that elements in the following embodiment encompass those substitutable by and obvious to a person skilled in the art, or substantially the same elements.

[0016] FIG. **1** is a longitudinal cross-sectional view of a centrifugal compressor of the present embodiment. A centrifugal compressor **1** is used as a low-head (for example, a pressure ratio of about 1.05) compressor for feeding fluid, such as gas or air, at a large flow rate (for example, about 5.0 m^3/s) into a predetermined pressure vessel in a chemical plant, for example.

[0017] As shown in FIG. **1**, the centrifugal compressor **1** includes: a casing **2** formed by the combination of a plurality of parts; a rotary shaft **5** supported so as to be rotatable about an axis line L via bearings **4**, **4** in a space **3** formed in the casing **2**; and a closed type impeller **6** fixed to the rotary shaft **5** so as to rotate integrally with the rotary shaft **5**. In the present embodiment, the impeller **6** is fixed to a shaft end **5**A of the rotary shaft **5** positioned external to the bearings **4** (upper side in FIG. **1**). Thus, the impeller **6** is supported by the rotary shaft **5** in a so-called cantilever (referred to also as overhung) state. Note that the impeller **6** is not limited to the closed type having a blade part and a shroud part integrated together as in the present embodiment. An open type without the shroud part may be employed instead.

[0018] The centrifugal compressor **1** is a single-stage centrifugal compressor including a single impeller **6**. In the centrifugal compressor **1**, the rotary shaft **5** is driven by a driving mechanism (not shown) to rotate the impeller **6**. Consequently, fluid, such as gas or air, to be compressed is sucked into the centrifugal compressor **1** via a suction port **10** provided in the casing **2**.

[0019] The suction port **10** has an opening in a direction along a perpendicular line M perpendicular to the axis line L of the rotary shaft **5**. An intake passage **11** is connected to the suction port **10** via a suction space **10**A formed in the casing **2**. The intake passage **11** curves along the direction of the axis line L of the rotary shaft **5** (axial direction) and has an opening facing an intake port **6**A of the impeller **6**. The centrifugal compressor **1** also includes a vaneless diffuser **12** provided radially to the axis line L of the rotary shaft **5** and a return channel **13** on the side of a blowoff port **6**B of the impeller **6**. The vaneless diffuser **12** constitutes a passage for converting kinetic energy of the fluid having centrifugal force given by the impeller **6** into pressure energy and sending out the pressure energy.

[0020] The return channel **13** is a passage for reversing the direction of the fluid blown out in a radially outer direction by the impeller **6** and the vaneless diffuser **12** toward the rotary shaft **5**, i.e., in a radially inner direction. The return channel **13** includes a return bend **14** continuous with the vaneless diffuser **12**, and a return passage **15**. Outlets **15**B of the return passages **15** are each connected to a discharge space **16**A provided in the casing **2**. The discharge space **16**A is positioned on the axis line L of the rotary shaft **5**. In the discharge space **16**A, a discharge port **16** is opened so as to discharge the fluid along the axis line L.

[0021] The return passage **15** is formed so as to have a gradually-increasing passage area (cross-sectional area) from an inlet **15**A of the return passage **15** toward the outlet **15**B. A return vane **15**C for regulating the flow of the fluid is provided in the return passage **15**.

[0022] The fluid having passed through the vaneless diffuser **12** and flowing into the return channel **13** has a radial velocity component and a circumferential velocity component. In a configuration having a large discharge flow rate as in the present embodiment, the radial velocity component tends to be larger than the circumferential velocity component. The return vane **15**C regulates the flow of the fluid so as to suppress the circumferential velocity component of the fluid flowing into the return channel **13** (return passage **15**). Consequently, the fluid mainly having the radial velocity component flows at the outlet **15**B of the return passage **15**. Thus, no spiral velocity component is wasted as in an outlet of a scroll passage. Such an effect can also reduce pressure loss of the fluid further in the return channel **13**.

[0023] The fluid having flowed through the respective return passages **15** flows into the discharge space **16**A and mixed together in the discharge space **16**A. A guide protrusion **16**B that protrudes toward the discharge port **16** is provided on the axis line L at the bottom of the discharge space **16**A. The guide protrusion **16**B guides the flow of the fluid having flowed into the discharge space **16**A so as to be changed in the direction of the axis line L. The fluid discharged from the discharge port **16** is sent out to a discharge pipe (not shown).

[0024] A shaft seal **18** for keeping airtightness and a balance piston **19** are disposed between the bearing **4** and the intake passage **11** in the space **3** in which the rotary shaft **5** is disposed. The shaft seal **18** prevents the communication between the aforementioned space **3** and a path including the impeller **6**, etc., through which the fluid flows.

[0025] In the present embodiment, the centrifugal compressor **1** includes the return channel **13** for reversing the fluid blown out from the impeller **6** toward the axis line L of the rotary shaft **5**. As mentioned above, in a configuration having a large discharge flow rate, fluid tends to have a radial velocity component larger than its circumferential velocity component. The return vane **15**C provided on the outlet side of the return channel **13** (the return passage **15**) regulates the flow of the fluid so as to suppress the circumferential velocity component of the fluid flowing into the return passage **15**. Consequently, the fluid mainly having the radial velocity component flows at the outlet **15**B of the return passage **15**. In the present embodiment, the centrifugal compressor **1** includes the discharge port **16** positioned on the axis line L of the rotary shaft **5** for discharging the fluid having passed through the return channel **13** in the direction along the axis line L. This allows the fluid having passed through the return channels **13** and each having the radial velocity component to be mixed together without interfering with each other and smoothly discharged from the discharge port **16**.

[0026] According to the present embodiment, the centrifugal compressor **1** includes the bearings **4** for pivotally supporting the rotary shaft **5** and the impeller **6** is provided on the shaft end **5**A closer to the discharge port **16** than the bearings **4**. Thus, the impeller **6** is supported by the rotary shaft **5** in a so-called cantilever state. This eliminates a need to provide a sealing member between the impeller **6** and the discharge port **16**, thus simplifying the structure of the centrifugal compressor **1**.

[0027] According to the present embodiment, the suction port **10** is provided in the direction of the perpendicular line M orthogonal to the axis line L of the rotary shaft **5**. Accordingly, the suction port **10** can be disposed in the casing **2** while preventing interference with the bearing **4** of the rotary shaft **5**, etc. Thus, the size of the casing **2** can be prevented from increasing in the direction of the axis line L.

[0028] According to the present embodiment, the return channel **13** includes the return vane **15**C in the return passage **15** disposed on the outlet side of the return channel **13**. Thus, the return vane **15**C regulates the flow of the fluid so as to suppress the circumferential velocity component of the fluid flowing into the return channel **13** (return passage **15**). Consequently, the fluid mainly having the radial velocity component flows at the outlet **15**B of the return passage **15**. Moreover, the return vane **15**C has a relatively small pressure loss coefficient as compared to the case with the scroll passage. Thus, the efficiency of the centrifugal compressor **1** can be further improved when the flow rate is increased.

[0029] The functions and effects of the centrifugal compressor **1** according to the present embodiment will be described next. FIG. **2** is a graph comparing relationships between flow coefficients and pressure loss coefficients in the scroll passage and the return channel. In FIG. **2**, three kinds of impellers A to C having different flow coefficients ϕ are used. These impellers A to C are provided in conventional centrifugal compressors each including the scroll passage and in the centrifugal compressors **1** of the present embodiment each including the return channel **13**. Pressure loss coefficients ζ when such centrifugal compressors are operated are measured. Here, the flow coefficient ϕ increases in the order of the impeller A, the impeller B, and the impeller C.

[0030] In the configuration including the scroll passage provided on the outlet side of the impellers A to C, it can be seen that the impeller C having a larger flow coefficient ϕ has a larger pressure loss coefficient ζ (see alternate long and short dash lines in FIG. **2**). As mentioned above, the fluid blown out from the impeller has a radial velocity component and a circumferential velocity component. The radial velocity component increases with an increase in flow rate.

[0031] The scroll passage, on the other hand, is a passage formed in a spiral shape in the circumferential direction. Thus, while the fluid of the circumferential velocity component smoothly flows through the scroll passage, the fluid of the radial velocity component hinders the flow in the circumferential direction. Therefore, if the impeller having a large flow rate (flow coefficient ϕ) is employed, pressure loss when flowing through the scroll passage increases, thus resulting in reduced efficiency of the centrifugal compressor as shown in FIG. **2**.

[0032] In the configuration including the return channel provided on the outlet side of the impellers A to C, in contrast, the fluid of the radial velocity component smoothly flows in the return channel **13** as mentioned above. As shown by solid lines in FIG. **2**, the pressure loss coefficient ζ is substantially the same regardless of the magnitude of the flow coefficient ϕ. Furthermore, the return passage **15** on the outlet side of the return channel **13** includes the return vane **15**C, and the return vane **15**C regulates the flow of the circumferential velocity component. Consequently, the fluid mainly having the radial velocity component flows out from the return channel **13**. With the return channel **13**, no hindering of the flow due to a spiral flow in a meridional cross section as in the scroll passage occurs, or no spiral velocity component is wasted at the outlet of the scroll passage. Thus, pressure loss when flowing through the return channel **13** can be reduced, thus improving the efficiency of the centrifugal compressor **1**.

[0033] Another embodiment will be described next. While the centrifugal compressor **1** in the above-described embodiment is configured to include the separately-provided driving mechanism for driving the rotary shaft **5**, the centrifugal compressor **1** may have a sealed structure in which an electric motor as a driving mechanism and a compressor are integrally included in a casing. According to this structure, the electric motor and the compressor are integrally provided in the casing, and the casing is sealed, for example. This eliminates a need to provide a sealing member (see the shaft seal **18** in FIG. **1**) between the electric motor and the impeller **6**, thus simplifying the configuration of the centrifugal compressor.

[0034] While the impeller **6** in the above-described embodiment has the cantilever supporting structure in which the impeller **6** is provided on the shaft end **5**A of the rotary shaft **5**, the present invention is not limited thereto. A bearing for pivotally supporting the rotary shaft **5** may be provided on the shaft end **5**A between the impeller **6** and the discharge space **16**A provided in the casing **2**. In this case, the employment of a magnetic bearing, for example, as the bearing eliminates a need to provide, for example, a lubricating oil path for feeding a lubricating oil to the bearing. Thus, shaft vibration can be reduced while maintaining the simplified device configuration. Note that a general bearing to which a lubricating oil is fed can be used if a space for providing the lubricating oil path can be allocated.

[0035] While the above-described embodiment has described the single-stage compressor including the single impeller **6** provided in the casing **2**, the present invention is not limited thereto. For example, if rotor dynamics permit, a plurality (two or three, for example) of impellers **6** may be disposed on the rotary shaft **5**, and an outlet of the upstream impeller **6** and an inlet of the downstream impeller **6** may be connected with the return channel **13**. Such a configuration can achieve the improvement of efficiency at a large flow rate in the multistage centrifugal compressor **1** as well.

REFERENCE SIGNS LIST

[0036] **1** centrifugal compressor
[0037] **2** casing
[0038] **3** space
[0039] **4** bearing
[0040] **5** rotary shaft
[0041] **5**A shaft end
[0042] **6** impeller

[0043] **6**A intake port

[0044] **6**B blowoff port

[0045] **10** suction port

[0046] **10**A suction space

[0047] **11** intake passage

[0048] **12** vaneless diffuser

[0049] **13** return channel

[0050] **14** return bend

[0051] **15** return passage

[0052] **15**A inlet

[0053] **15**B outlet

[0054] **15**C return vane

[0055] **16** discharge port

[0056] **16**A discharge space

[0057] **16**B guide protrusion

[0058] **18** shaft seal

[0059] **19** balance piston A, B, C impeller L axis line M perpendicular line

1. A centrifugal compressor comprising:

a rotary shaft rotatably supported by a casing;

an impeller provided on the rotary shaft for blowing out fluid sucked from a suction port in a radial direction of the rotary shaft;

a return channel for reversing the fluid blown out from the impeller toward the rotary shaft; and

a discharge port positioned on an axis line of the rotary shaft for discharging the fluid having passed through the return channel in a direction along the axis line; and

a bearing for pivotally supporting the rotary shaft,

wherein the impeller is provided on a shaft end closer to the discharge port than the bearing.

2. (canceled)

3. The centrifugal compressor according to claim **1**, wherein the suction port is provided in a direction orthogonal to an axial direction of the rotary shaft.

4. The centrifugal compressor according to claim **1**, wherein the return channel includes a return vane on an outlet side of the return channel.

5. The centrifugal compressor according to claim **1**, wherein the impeller is provided singularly to perform single-stage compression.

6. The centrifugal compressor according to claim **3**, wherein the return channel includes a return vane on an outlet side of the return channel.

7. The centrifugal compressor according to claim **3**, wherein the impeller is provided singularly to perform single-stage compression.

8. The centrifugal compressor according to claim **4**, wherein the impeller is provided singularly to perform single-stage compression.

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