US 20020039534A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2002/0039534 A1

Moroi et al. (43) Pub. Date: Apr. 4, 2002

(54) SCROLL COMPRESSOR HAVING AN ELECTRIC MOTOR INCORPORATED

(75) Inventors: **Takahiro Moroi**, Kariya-shi (JP); **Toshiro Fujii**, Kariya-shi (JP)

Correspondence Address:
Woodcock Washburn Kurtz Mackiewics & Norris LLP
46th Floor
One Liberty Place
Philadelphia, PA 19103 (US)

(73) Assignee: **Kabushiki Kaisha Toyota Jidoshokki**

(21) Appl. No.: **09/961,910**

(22) Filed: **Sep. 24, 2001**

(30) **Foreign Application Priority Data**

Sep. 29, 2000 (JP) 2000-299781

Publication Classification

(51) **Int. Cl.**[7] **F04B 35/04**; F04B 39/06; F04B 39/02

(52) **U.S. Cl.** **417/372**; 417/410.5

(57) **ABSTRACT**

In a scroll compressor with an electric motor incorporated of the present invention, a housing is provided with a cooling chamber which is provided adjacently on the outer peripheral side of a motor portion, so that cooling fluid is supplied to the cooling chamber, and a high pressure chamber which is provided adjacently on the outer peripheral side of the cooling chamber so that a gas, compressed by a fixed scroll and a movable scroll, is supplied to the high pressure chamber. Consequently, reduction in the mass flow rate of the discharge gas of the compressor can be suppressed, and it is possible to cool both the discharge gas and the motor portion by the single cooling chamber.

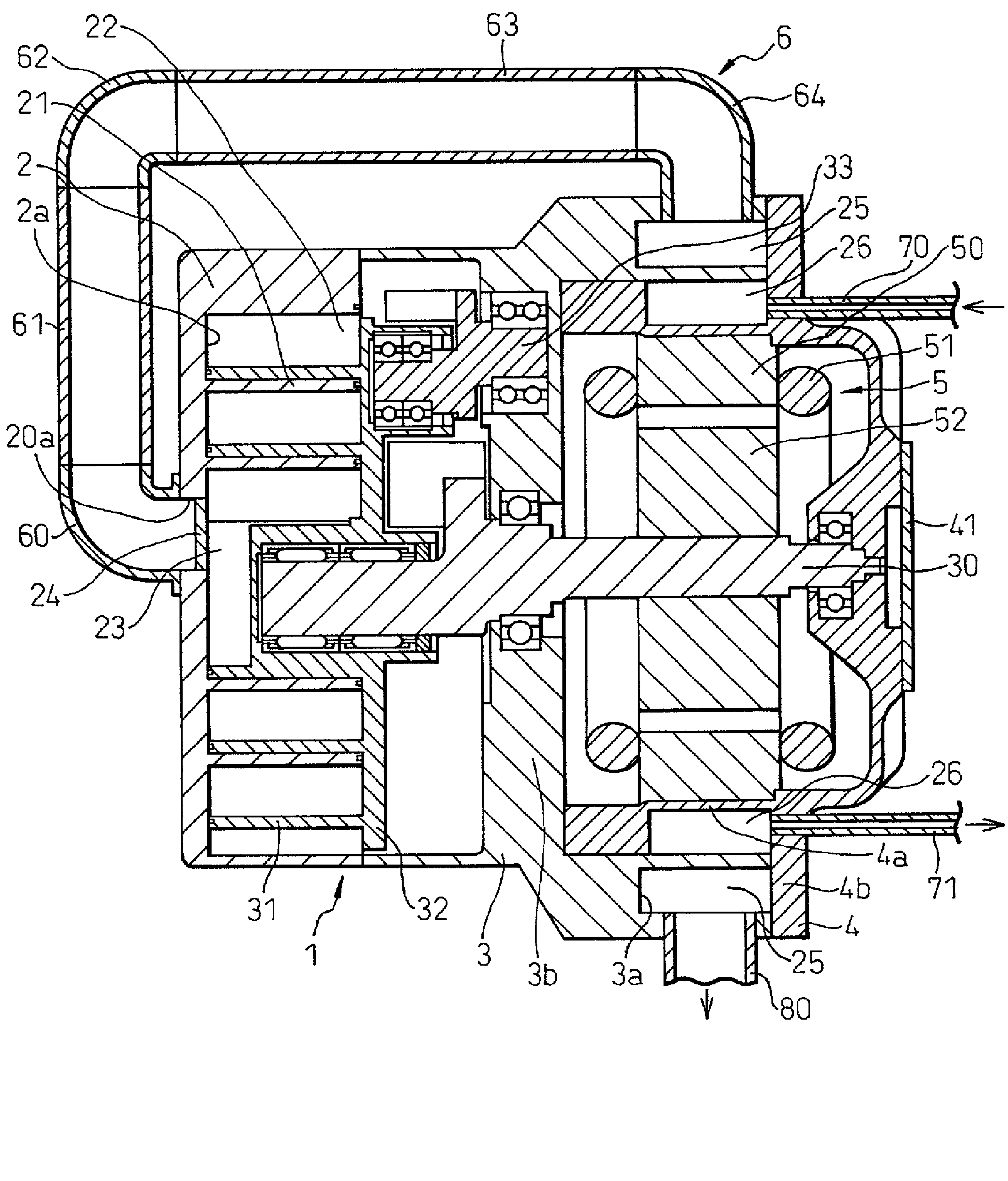


Fig.1

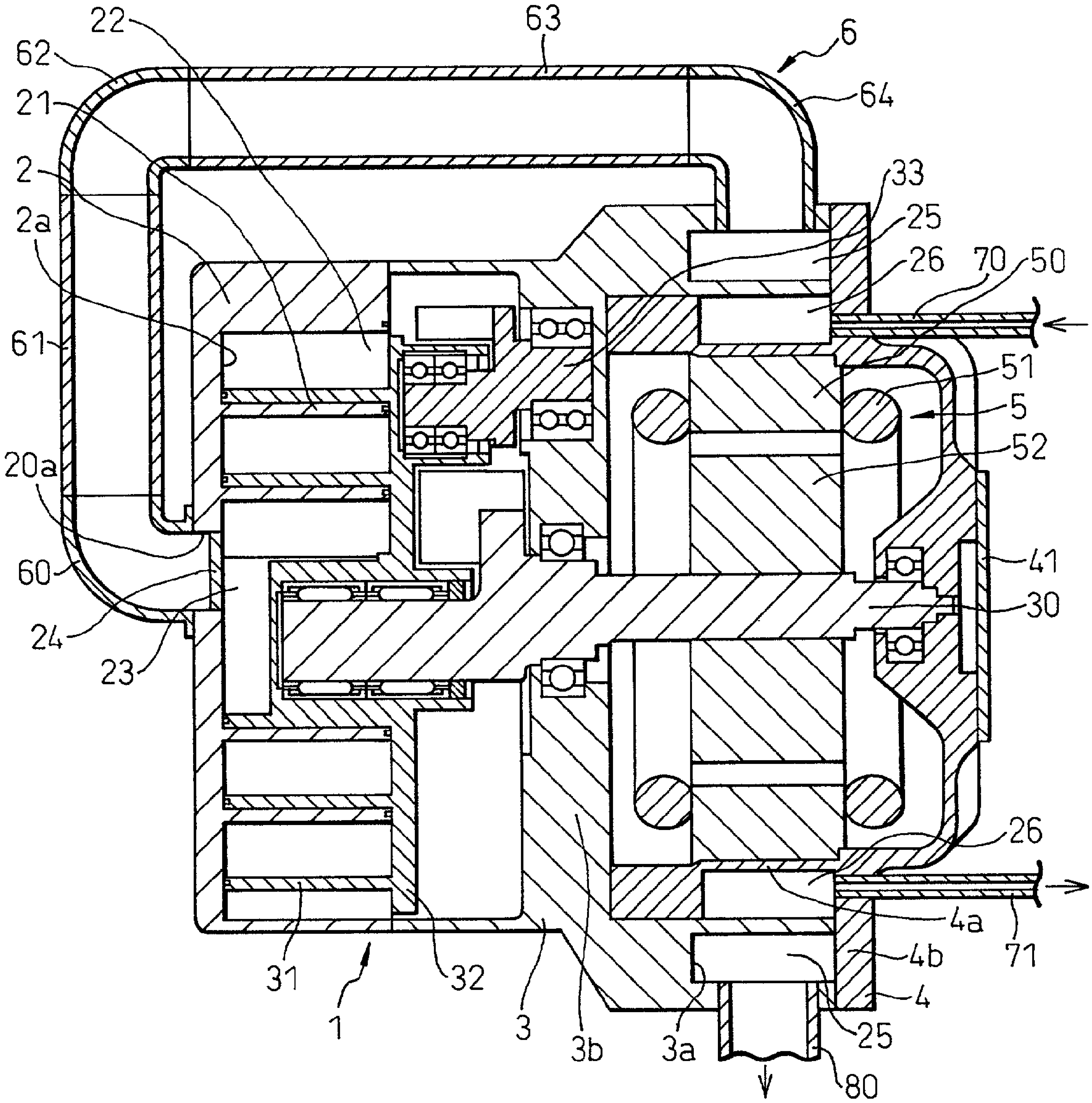
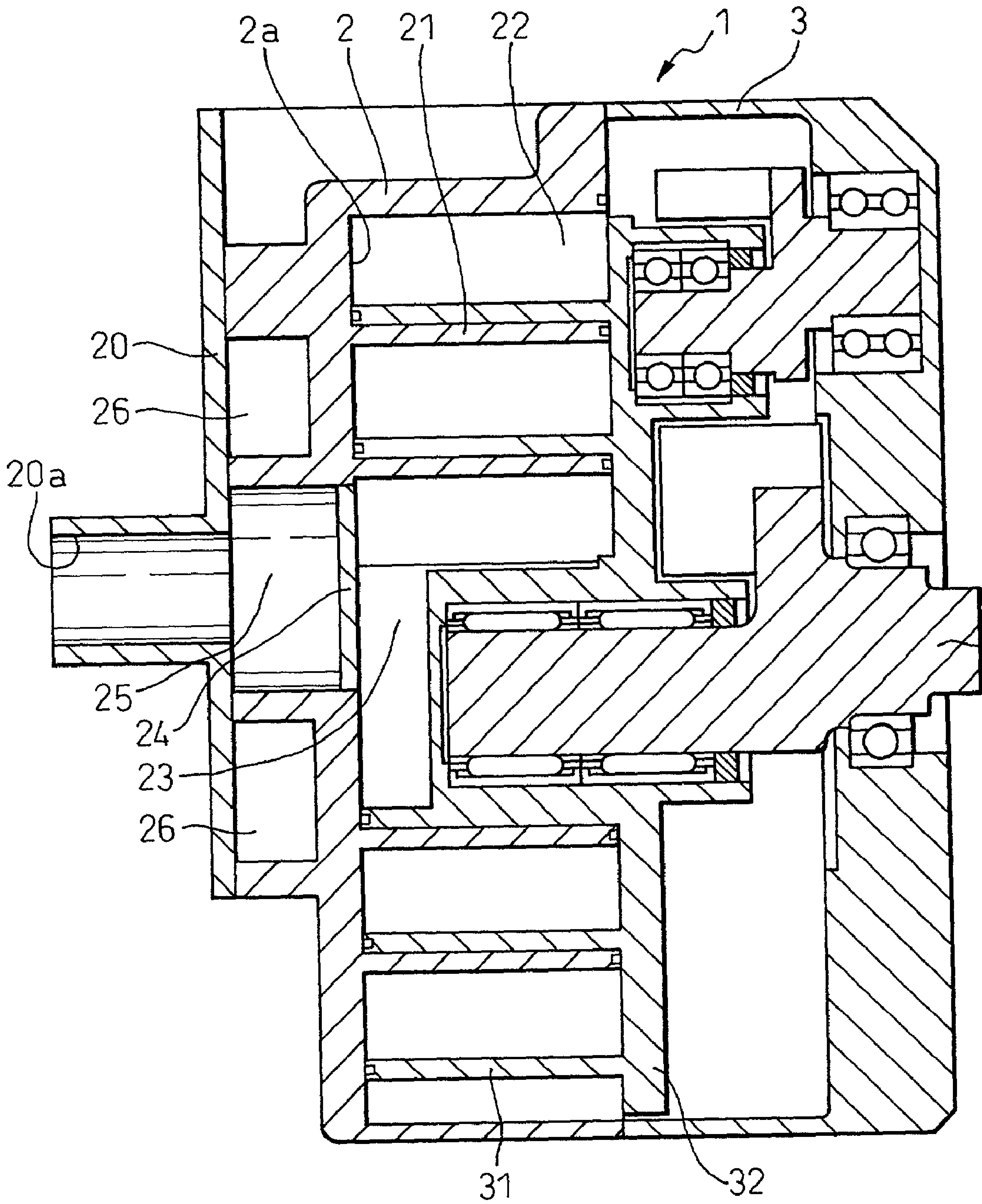

63
6
62
22
64
21
2
2a
33
25
26
70
50
51
61
5
52
20a
60
41
24
30
23
26
4a
71
4b
31
32
4
1
3
3b
3a
25
80

Fig.2



SCROLL COMPRESSOR HAVING AN ELECTRIC MOTOR INCORPORATED

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a scroll compressor and, more specifically, it relates to a scroll compressor having an electric motor incorporated for compressing a gas to be supplied to a fuel cell.

[0003] 2. Description of the Related Art

[0004] In recent years, the automobile industry has increasingly been placing emphasis on electric motor cars in the hope of reducing the consumption of petroleum resources. A fuel cell, as a drive source for an electric motor car, exhibits high energy conversion efficiency and is environmentally friendly because only nontoxic reaction products, such as water or carbon dioxide, are produced and, hence, it is expected that the demand for fuel cell system will increase. A scroll compressor which can be made small and light is suitable as a compressor to compress gases to be supplied to the fuel cell.

[0005] It is preferable that the rise in temperature of the air is restricted so that the work load of the scroll compressor is small. To this end, as in a scroll compressor disclosed in Japanese Unexamined Patent Publication (Kokai) No. 8-247056, a cooling chamber is provided around a high-pressure chamber to circulate cooling water, to thereby restrict a rise in temperature of the highly pressurized air.

[0006] **FIG. 2** shows an axial sectional view of a known scroll compressor. In the known scroll compressor, a housing **1** is comprised of a front casing **2**, a rear casing **3** and an end plate **20**. The front casing **2** has a small diameter portion at a front side thereof, having a recess at a front end surface of the small diameter portion, and a large diameter portion at a rear side thereof. The end plate **20** is provided at the front side of the front casing **2**, and the rear casing **3** is provided at the rear side of the front casing **2**.

[0007] A fixed scroll **21** which extends in the axial direction is provided at a boundary surface **2***a* in the front casing **2**. A suction portion **22** is formed on the outer peripheral portion of the fixed scroll **21**, and a discharge portion **25** is formed on the inner peripheral portion of the fixed scroll **21**. A discharge valve **24** and a high pressure chamber **25** are formed in front of the discharge portion **23**. A crank-shaped drive shaft **30** is rotatably supported at its one end (rear end) of the rear casing **3**. An end plate **32**, which is provided with an axially extending movable scroll **31**, is rotatably connected to the other end of the drive shaft **30**.

[0008] When the drive shaft **30** rotates to make orbital movement of the movable scroll **31**, the space defined between the fixed scroll **21** and the movable scroll **31** is reduced in volume and hence the air in the space is gradually compressed and is moved toward the discharge portion **23**. The air reaching the discharge portion **23** is discharged to the outside of the compressor from a discharge port **20***a* through the discharge valve **24** and the high pressure chamber **25**.

[0009] The cooling water is introduced into a cooling chamber **26** through an inlet port not shown. The cooling chamber **26** is located adjacent the high pressure chamber **25**. Consequently, the temperature of the cooling water is increased due to heat transferred from the highly pressurized air in the high pressure chamber **25**. The cooling water whose temperature has been increased is discharged to the outside of the compressor from an outlet port not shown. In a known scroll compressor, the discharged gas, i.e., the highly pressurized air is cooled in the way mentioned above.

[0010] It is necessary to provide an electric motor or the like as a drive means in the scroll compressor. In a scroll compressor with a motor integrally incorporated therein, the compressor system including the motor can be entirely made small. Therefore, the scroll compressor with an electric motor incorporated is particularly advantageously used as a compressor for supplying a gas to a fuel cell which is in a remarkably restricted accommodation space. In a scroll compressor with an electric motor incorporated, it is necessary to remove heat generated from a rotor or the like which rotates at high speed, in the motor. To this end, a cooler such as a fan is provided in the motor, in addition to the cooling chamber for cooling the highly pressurized air.

[0011] The gas to be supplied to the fuel cell, i.e., the discharge gas of the compressor must be humidified to some extent. To this end, a vapor exchange diaphragm is provided in the vicinity of the discharge port of the compressor to humidify the discharged gas. The heat-resistance critical temperature of the vapor exchange diaphragm is approximately 140° C. Therefore, the temperature of the discharge gas must be cooled to below the critical temperature. From only the viewpoint of cooling of the discharge gas, a conventional compressor having a cooling chamber could be used for the fuel cell.

[0012] However, if the conventional scroll compressor with an electric motor incorporated is used for the fuel cell, the following problems are raised. For the gas to be supplied to the fuel cell, i.e., the discharge gas of the compressor, it is preferable that the mass flow rate is increased because the mass of the gas to be supplied to the fuel cell is increased. However, the cooling chamber of the conventional scroll compressor is formed in front of the end face of the front casing and, hence, the gas introduced into the compressor from the outer peripheral side of the end face can be heated by the cooling water which has been subjected to heat exchange.

[0013] If the suction gas is heated and consequently its volume is increased, the density is reduced but the volume flow rate is constant. Consequently, the mass flow rate of the suction gas is reduced and, accordingly, the mass flow rate of the discharge gas is reduced. Namely, in the conventional compressor in which the cooling chamber is formed at the end face, the mass of the gas to be supplied to the fuel cell is reduced.

[0014] Moreover, as mentioned above, in the conventional scroll compressor with an electric motor incorporated, the cooling means for the motor portion and the cooling means (cooling chamber) for the highly pressurized air are separately provided.

[0015] The inventor of the present invention has discovered that if a high pressure chamber to which the discharge gas after compression is supplied, is provided on the motor side of the housing, and only one cooling chamber as a cooling means is provided adjacent both the high pressure chamber and a motor portion, not only can reduction in the mass flow rate of the discharge gas be suppressed but also the discharge gas and the motor portion can be cooled by the single cooling means.

SUMMARY OF THE INVENTION

[0016] A scroll compressor with an electric motor incorporated of the present invention has been completed, based on the above-mentioned discovery. It is an object of the present invention to prevent the mass flow rate of the discharge gas from being reduced and to make it possible to cool both the discharge gas and the motor portion by a single cooling chamber.

[0017] A scroll compressor with an electric motor incorporated, according to the present invention, comprises a housing accommodating a compressor portion and a motor portion, the motor portion driving a movable scroll, and the compressor portion having a fixed scroll secured to the housing and the movable scroll which is located eccentrically with respect to the fixed scroll so as to orbit with respect to the fixed scroll, a cooling chamber which is provided adjacently on the outer peripheral side of the motor portion, and a high pressure chamber which is provided adjacently on the outer peripheral side of the cooling chamber, so that gas compressed by the fixed scroll and the movable scroll is supplied to the high pressure chamber, wherein a cooling fluid is supplied to the cooling chamber to cool both the gas and the motor portion.

[0018] Namely, the scroll compressor with an electric motor incorporated according to the present invention is characterized in that a high pressure chamber, to which the compressed gas is supplied, is provided on the outer peripheral side of the motor portion and a cooling chamber, to which the cooling fluid is supplied, is provided on the inner peripheral side of the high pressure chamber. In other words, the motor portion, the annular cooling chamber and the annular high pressure chamber are arranged in this order in the radial direction, from the inner peripheral side.

[0019] Since the high pressure chamber and the cooling chamber are provided on the outer peripheral side of the motor portion and the suction port of the gas is provided on the compressor portion side, there is no fear that the suction gas introduced in the compressor portion is heated by the cooling fluid whose temperature has risen in the cooling chamber. Consequently, it is possible to prevent the mass flow rate of the gas to be supplied to the fuel cell from being reduced. Moreover, it is possible to effectively cool both the gas and the motor portion by means of the single cooling chamber.

[0020] The present invention may be more fully understood from the description of preferred embodiments of the invention, as set forth below, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] In the drawings;

[0022] **FIG. 1** is an axial sectional view of a scroll compressor with an electric motor incorporated, according to the present invention; and

[0023] **FIG. 2** is an axial sectional view of a known scroll compressor.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] An embodiment of the invention will be discussed below with reference to the accompanying drawing. In **FIG. 1** shows an axial sectional view of a scroll compressor with an electric motor incorporated, according to an embodiment of the invention. A compression portion is provided in a housing **1**. The housing **1** is constituted by a cup-shaped front casing **2** of an aluminum alloy, a cylindrical rear casing **3** of an aluminum alloy, a cup-shaped motor casing **4** of an aluminum alloy and a bottom plate **41** of an aluminum alloy. The front casing **2** is provided at its bottom center portion with a discharge port **20***a*. The rear casing **3** is located at an open end of the front casing **2** and is provided with a small diameter portion, a large diameter portion with an end recess **3***a*, and a disc-shaped separation portion **3***b* between the small diameter portion and the large diameter portion. The motor casing **4** is provided on its outer peripheral surface with an annular recess **4***a* and an annular projection **4***b* adjacent thereto and is provided on its bottom center portion with a hole. An open end of the motor casing **4** is fitted in the inner peripheral surface of the large diameter portion of the rear casing **3**. The bottom plate **41** is attached to the motor casing **4** to cover the bottom hole thereof.

[0025] A high pressure chamber **25** is defined by closing the recess **3***a*, which is formed in the large diameter portion of the rear casing **3** with the projection **4***b* on the outer peripheral surface of the motor casing **4**, in assembling the motor casing **4** to fit in the inner peripheral surface of the large diameter portion of the rear casing **3**.

[0026] A gas passage **6** for highly pressurized gas extends between the high pressure chamber **25** and the discharge port **20***a* of the front casing **2**. The gas passage **6** is provided with a steel cylindrical elbow **60** connected to the discharge port **20***a*, a steel pipe **61** connected to the elbow **60**, a steel elbow **62** connected to the steel pipe **61**, a steel pipe **63** connected to the elbow **62**, and a steel elbow **64** connected to the steel pipe **63**. The steel pipe **63** is fitted at the other end in the large diameter portion of the rear casing **3** and opens into the high pressure chamber **25**. A discharge pipe **80** is inserted in the large diameter portion of the rear casing **3** and opens to the high pressure chamber **25**.

[0027] In assembling the motor casing **4** to fit in the inner peripheral surface of the large diameter portion of the rear casing **3**, the inner peripheral surface of the large diameter portion of the rear casing **3** covers the recess **4***a* of the motor casing **4** in the axial direction to define an annular cooling chamber **26**. A steel inlet pipe **70** and a steel outlet pipe **71** extend through the projection **4***b* of the motor casing **4** and open to the cooling chamber **26**.

[0028] A motor portion **5** is provided in the motor casing **4** and is constituted by an annular stator **50** on the inner peripheral surface of the motor casing **4**, a coil **51** wound in a slit (not shown) of the stator **50**, an annular rotor **52** made of a magnetic material and arranged at the inner side of the stator **50**, a part of the drive shaft extending in the axial direction at the center portion of the rotor **52**, and a ball bearing which rotatably supports the drive shaft **30** at the bottom portion of the motor casing **4**.

[0029] The basic structure of the compressor portion of the scroll compressor with an electric motor incorporated in the illustrated embodiment is substantially described in **FIG. 2**.

[0030] In FIG. 3 of the embodiment of the invention, no end plate 20 is provided; the cooling chamber 26 and the high pressure chamber 25 are provided on the outer peripheral side of the motor portion 5; the drive shaft 30 extends to the motor portion 5; and the rear casing 3 is different in shape from the rear casing in FIG. 2.

[0031] The flow of air, as the gas for the scroll compressor with an electric motor incorporated in the illustrated embodiment, will be discussed below.

[0032] When the drive shaft is rotated by driving the electric motor and a movable scroll 31 orbits. Air closed in a suction portion 22 at the outer peripheral side of the movable scroll 31 is gradually transferred to the center side of the movable scroll 31 and is compressed due to the orbit of the movable scroll 31 by decreasing the volume of the space closing the air.

[0033] The air compressed by the fixed scroll 21 and the movable scroll 31 is discharged into the high pressure gas passage 6 from the discharge portion 23 through the discharge valve 24. The air passing in the gas passage 6 is introduced in the annular high pressure chamber 25. The air circulates in the high pressure chamber 25 and is discharged to the outside of the compressor through the discharge pipe 80.

[0034] The flow of water, as the cooling fluid for the scroll compressor with an electric motor incorporated in the illustrated embodiment, will be discussed below.

[0035] The water introduced in the annular cooling chamber 26 through the inlet pipe 70 circulates therein. During the circulation of the water, the heat is transferred to the water from the compressed air in the high pressure chamber 25 provided on the outer peripheral side of the cooling chamber 26, and from the motor portion 5 provided on the inner peripheral side of the cooling chamber 26. Consequently, the water, whose temperature has risen, is discharged to the outside of the compressor from the outlet pipe 71. There are externally provided a radiator which cools the heated water and a pump which feeds the pressurized water, so that the water cooled by the radiator is introduced again into the compressor through the inlet pipe 70, although the details thereof are not shown in the drawings.

[0036] In the illustrated embodiment, the housing is constituted by the front casing 2, the rear casing 3, the motor casing 4, and the bottom plate 41. In place of the housing which is made of an assembly of a plurality of elements, it is alternatively possible to form some of the elements integrally. Moreover, although the fixed scroll 21 is formed at a boundary surface 2*a* of the front casing 2 and is secured to the housing, it is alternatively possible to arrange a separate member having a fixed scroll in the housing. This alternative is included in the concept of securing the fixed scroll to the housing.

[0037] Although air is used as the gas to be compressed by the compressor portion in the illustrated embodiment, the kind of the gas is not limited to a specific one. If further enhanced hermetic sealing of the compressor portion is established, hydrogen gas or the like, which is fuel used for the fuel cell, can be used.

[0038] The size and shape of the cooling chamber are not limited to specific ones. For instance, in an arrangement in which the radiator fins are provided in the cooling chamber, the heat transfer area is increased and, hence, the cooling efficiency is enhanced. Furthermore, it is possible to provide a corrugated separation wall between the cooling chamber and the high pressure chamber and/or between the cooling chamber and the motor portion in order to further increase the heat transfer area.

[0039] In the illustrated embodiment, the cooling chamber 26 is formed by fitting the motor casing 4 in the rear casing 3. With this arrangement, the cooling chamber can be easily formed. However, it is alternatively possible to use a separate member which defines therein a cooling chamber and which is attached to the motor casing. In this alternative, the cooling chamber is highly liquid-tight due to the seamless wall thereof. The separate member which defines therein a cooling chamber forms a part of the housing.

[0040] The material of which the cooling chamber is formed is not limited to a specific material. In the illustrated embodiment, the cooling chamber is formed by a member made of an aluminum alloy. The aluminum alloy exhibits a high heat transfer rate, thus leading to an enhanced cooling efficiency. The cooling chamber can be formed of a die casting.

[0041] Although water is used as the cooling fluid, the kind of the cooling fluid is not limited to specific fluid. Any medium which is liquid at the temperature of the environment in which the compressor is used, and which does not corrode the material of the equipment, can be appropriately selected. It is possible to use pure water, which is produced by the fuel cell, as the cooling fluid.

[0042] Although the special-purpose cooling circuit for the compressor is used in the illustrated embodiment, it is possible to add a cooling chamber to a cooling circuit provided in an automobile or the like to cool other devices therein. Absence of an additional cooling circuit contributes to reduction in the accommodation space and manufacturing cost. Alternatively, it is also possible to discharge the used cooling fluid without recirculating the cooling fluid. Absence of a recirculating circuit of the cooling fluid simplifies the compressor and reduces the accommodation space.

[0043] Although the gas passage for highly pressurized gas is made of a plurality of steel pipes and elbows in the illustrated embodiment, it is possible to form the gas passage of a single piece of pipe. The single piece of pipe contributes to an enhancement of the sealing efficiency. Although the gas passage for highly pressurized gas is provided outside of the housing in the illustrated embodiment, it is possible to provide the gas passage in the housing. If the gas passage is provided in the housing, no interference with other devices, provided in an automobile or the like, occurs so that the reliability can be enhanced and the accommodation space can be reduced.

[0044] The kind and internal structure of the motor are not limited to specific ones. Although an inverter-controlled motor is used in the illustrated embodiment, it is possible to use a DC motor.

[0045] The shape of the rotor and the stator of the motor portion and the arrangement of the coil and the magnetic material therein are not specifically limited. Although the coil is located on the stator side and the magnetic material is located on the rotor side, in the illustrated embodiment, it is possible to use a motor in which the magnetic material is located on the stator side and the coil is located on the rotor side.

[**0046**] Although the rotary shaft of the motor is used as the drive shaft of the movable scroll of the compressor portion in the illustrated embodiment, it is alternatively possible to provide a drive shaft of the movable scroll separate from the rotary shaft of the motor. In this alternative, the drive shaft of the movable scroll and the rotary shaft of the motor are connected by means of a rotation transmission mechanism. The drive shaft in the present invention is constituted by the rotary shaft of the motor, the rotation transmission mechanism and the drive shaft of the movable scroll. In order to change the number of revolutions of the rotary shaft of the motor and the drive shaft of the movable scroll, it is possible to provide a rotation change device in the rotation transmission mechanism.

[**0047**] In a scroll compressor with an electric motor incorporated, according to the present invention, the high pressure chamber and the cooling chamber are provided on the outer peripheral side of the motor portion of the housing, that is, the cooling chamber is provided between the high pressure chamber and the motor portion. Consequently, reduction in the mass flow rate of the discharge gas of the compressor can be suppressed. Furthermore, it is possible to cool both the discharge gas and the motor portion by a single cooling chamber.

[**0048**] While the invention has been described by reference to specific embodiments chosen for purpose of illustration, it should be apparent that numerous modification could be made thereto by those skilled in the art without departing from the basic concept and scope of the invention.

What is claimed is:

1. A scroll compressor, with an electric motor incorporated, comprising:

a housing accommodating a compressor portion and a motor portion, the motor portion driving a movable scroll, and the compressor portion having a fixed scroll secured to the housing and the movable scroll which is located eccentrically with respect to the fixed scroll so as to orbit with respect to the fixed scroll,

a cooling chamber which is provided adjacently on the outer peripheral side of the motor portion, and

a high pressure chamber which is provided adjacently on the outer peripheral side of the cooling chamber, so that gas compressed by the fixed scroll and the movable scroll is supplied to the high pressure chamber,

wherein a cooling fluid is supplied to the cooling chamber to cool both the gas and the motor portion.

2. A scroll compressor according to claim 1, wherein said high pressure chamber and a discharge port of said housing is connected by a gas passage for highly pressurized gas formed at the outside of said housing.

3. A scroll compressor according to claim 1, wherein said cooling chamber and said high pressure chamber are formed annularly around said motor portion.

4. A scroll compressor according to claim 1, wherein said cooling fluid is water.

* * * * *