In an electric vacuum pump, a pump housing and a lower-end cover member respectively include positioning retainers respectively formed on outer peripheries of the pump housing and the lower-end cover member. A case includes positioning retainers each protruding inward from an inner peripheral surface of the case. The positioning retainers are in contact with the positioning protrusions, thereby positioning the pump housing and the lower-end cover member with respect to the case. The positioning protrusions are formed with screw holes.
FIG. 1

1 BRAKE PEDAL
10
12 BRAKE BOOSTER
14 MASTER CYLINDER
16 NEGATIVE PRESSURE SENSOR
20 L1
22 L2
26: INTAKE PIPE PRESSURE DETECTING UNIT
22 ELECTRIC VP
32 TO ENGINE
34
FIG. 2

ECU

NEGATIVE PRESSURE SENSOR

ENGINE STOP DETERMINING UNIT

26: INTAKE PIPE PRESSURE DETECTING UNIT

PUMP PART

120

12V

36

110

18

24

28

16
FIG. 10
FIG. 11
ELECTRIC VACUUM PUMP

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Applications No. 2013-040766 filed Mar. 1, 2013 and No. 2013-177796 filed Aug. 29, 2013, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a vacuum pump for generating negative pressure to be used in a brake booster of a vehicle such as a car.

[0004] 2. Related Art

[0005] A brake device for a car is provided with a brake booster for amplifying a braking force by utilizing negative pressure in an intake pipe (“intake-pipe negative pressure”) of an engine. In recent years, pumping loss is reduced in response to demands for low-fuel consumption and thus the negative pressure in the intake pipe tends to decrease. Furthermore, for a hybrid vehicle, an electric vehicle, or a vehicle with an idling stop function, there is a case where the intake-pipe negative pressure of an engine could not be obtained.

[0006] Accordingly, the negative pressure to be supplied to a brake booster is generated by use of an electric vacuum pump. In a vehicle mounting a diesel engine that generates no intake-pipe negative pressure, negative pressure is also generated by use of an electric vacuum pump.

[0007] One example of such a vacuum pump is disclosed in, for example, Patent Document 1. In this vane pump, a cam ring and a bearing, which are internally mounted in a casing, are formed with cutouts in alignment with each other on respective outer peripheral surfaces and thus are positioned in place with respect to the casing by a pin inserted in the cutouts. The casing is mounted together with a front cover placed on one end side in a housing placed on the other end side through a joint bolt.

RELATED ART DOCUMENTS

Patent Documents


SUMMARY OF INVENTION

Problems to be Solved by the Invention

[0009] However the vane pump disclosed in Patent Document 1 is configured such that a screw hole for a bolt to integrally assemble the casing and the housing is provided in an annular bracket of a motor. A portion for positioning the cam ring and the baring with respect to the casing and a portion through which the bolt is formed to integrally assemble the casing and the housing are formed in different positions so that they are displaced in a radial direction of the vane pump. This causes an increase in cross sectional area of the vane pump in the radial direction, resulting in a large sized vane pump.

[0010] The present invention has been made to solve the above problems and has a purpose to provide an electric vacuum pump capable of achieving reduced size and improved accuracy of assembling components to constitute a pump chamber.

Means of Solving the Problems

[0011] To achieve the above purpose, one aspect of the invention provides an electric vacuum pump including: a case having internal space; a motor part placed in the internal space of the case; and a pump part placed in the internal space of the case and to be driven in sync with the motor part, wherein the pump part includes: a cylindrical pump housing; a first cover member placed in the pump housing on one end side in a central axis direction of the pump housing; a second cover member placed in the pump housing on the other end in the center axis direction; a pump chamber formed by an inner peripheral surface of the pump housing, the first cover member, and the second cover member; and a rotor housed in the pump chamber and including a plurality of vanes inserted therein, the electric vacuum pump further includes a fastening member passed through a through hole formed in the first cover member and being fastened in a fastening hole formed in the case to fix the first cover member to the case and the pump housing, the pump housing is provided with a positioning retainer formed on an outer periphery and the second cover member is provided with a positioning retainer formed on an outer periphery, the case is provided with a positioning protrusion formed to protrude inward from an inner peripheral surface of the case, the positioning retainers are in contact with the positioning protrusion to position the pump housing and the second cover member with respect to the case, and the fastening hole is formed in the positioning protrusion.

[0012] According to the above configuration, the first cover member is fixed to the case and the pump housing by the fastening member. The fastening hole in which the fastening member is to be fastened is formed in the positioning protrusion formed on the inner peripheral surface of the case. In this way, the positioning protrusion and the fastening hole are formed in the same place in the radial direction. Accordingly, the cross sectional area of the electric vacuum pump in the radial direction is reduced and thus the electric vacuum pump can be reduced in size. When the positioning retainers are in contact with the positioning protrusion, positioning the pump housing and the second cover member with respect to the case, the pump housing and the second cover member can be assembled with the case with high accuracy. In this manner, the electric vacuum pump can achieve size reduction and also improved assembling accuracy of the components to form the pump chamber.

[0013] The pump housing and the second cover member are placed in contact with the case so that the positioning retainers contact with the positioning protrusion. This can enhance heat dissipation property of the electric vacuum pump from the pump part to the outside.

[0014] In the above configuration, preferably, the positioning retainers are formed to respectively protrude from an outer peripheral surface of the pump housing and an outer peripheral surface of the second cover member toward the inner peripheral surface of the case and include grooves engageable with the positioning protrusion.

[0015] According to the above configuration, the grooves of the positioning retainer is in contact engagement with the positioning protrusion of the case, thereby enabling reliable positioning of each of the pump housing and the second cover member with respect to the case. This further improves the
assembling accuracy of the pump housing and the second cover member with respect to the case.

In the above configuration, preferably, the case has an end face on the one end side in the center axis direction of the pump housing, the end face being located in the same position as an end face of the first cover member on the other end side in the center axis direction of the pump housing or located in a position closer to the one end side than the end face of the first cover member on the other end side.

According to the above configuration, a portion of the positioning protrusion surrounding the fastening hole in the radial direction can have sufficient thickness and also the outer peripheral surface of the case and the outer peripheral surface of the positioning protrusion can be made common. This enables further reduction in the cross sectional area of the case in the radial direction and thus further size reduction of the electric vacuum pump.

In the above configuration, preferably, the pump part and the inner peripheral surface of the case form therebetween a space in an area excepting the positioning protrusion and the positioning retainers.

According to the above configuration, the space is generated around the pump part. Since the fastening hole is formed in the positioning protrusion as above, the volume of the space can be increased as large as possible. This can enhance the silencing performance of the electric vacuum pump during operation.

Preferably, the above configuration further includes a member placed in the space to produce at least one of a silencing effect and a cooling effect.

According to the above configuration, the silencing performance and the cooling performance of the electric vacuum pump can be further enhanced. Since the member is set in the space formed between the pump part and the inner peripheral surface of the case, furthermore, assembling the member is easy.

In the above configuration, preferably, the case includes a rib placed in the space and formed to protrude inward from the inner peripheral surface of the case.

According to the above configuration, the case can have high strength.

In the above configuration, preferably, the case is provided with a plurality of the positioning protrusions and a plurality of the fastening holes in two or more and odd-numbered pairs, and one pair of the pairs of positioning protrusions and fastening holes is placed in a position 180° opposite to a center axis of the inner peripheral surface of the pump housing with respect to a rotation center axis of the rotor.

According to the above configuration, the electric vacuum pump can be reduced in size more effectively.

In the above configuration, preferably, the first cover member includes a suction inlet for sucking gas from outside into the pump chamber and a discharge outlet for discharging gas from the pump chamber to the outside, and the pump housing and the first cover member are integrally formed.

The above configuration can provide improved positional accuracy of the suction inlet for sucking gas from outside into the pump chamber and the discharge outlet for discharging gas from the pump chamber to the outside, thus increasing a pump efficiency of the electric vacuum pump.

In the above configuration, preferably, a cover closing the internal space of the case from a side of the pump part, and the cover and the first cover member form therebetween a space.

According to the above configuration, the space is formed in the cover member and thus the silencing performance of the electric vacuum pump during operation can be enhanced.

In the above configuration, preferably, the pump housing has a cylindrical shape of which the outer peripheral surface has a polygonal cross section, the second cover member has a plate-like shape of which the outer peripheral surface has a polygonal cross section, and each of the positioning retainers is a surface defined by a side of the polygonal cross section.

According to the above configuration, the surface defined by one side of the polygonal shape of each of the pump housing and the second cover member is placed in contact with the positioning protrusion of the case, so that the pump housing and the second cover member can be reliably positioned in place with respect to the case. Accordingly, the assembling accuracy of the pump housing and the second cover member with respect to the case can be further improved.

In the above configuration, preferably, the case is made of a metal material.

The above configuration allows the pump housing and the second cover member to be press-fit in the metal case, so that the accuracy for assembling the member to constitute the pump chamber in the radial direction can be enhanced.

Effects of the Invention

The electric vacuum pump according to the invention can achieve reduced size and improved accuracy for assembling components to constitute a pump chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic configuration view of a brake system including an electric vacuum pump in an embodiment;

FIG. 2 is a block diagram showing a control system of the brake system including the electric vacuum pump in the embodiment;

FIG. 3 is a front view of the electric vacuum pump in the embodiment;

FIG. 4 is a top view of the electric vacuum pump in the embodiment;

FIG. 5 is a cross sectional view taken along a line A-A in FIG. 3;

FIG. 6 is a cross sectional view taken along a line B-B in FIG. 5;

FIG. 7 is a perspective exploded view of the electric vacuum pump in the embodiment;

FIG. 8 is a top view of an upper-end cover member;

FIG. 9 is a top view of a pump housing;

FIG. 10 is a top view of a lower-end cover member;

FIG. 11 is a cross sectional view of a modified example, corresponding FIG. 5;

FIG. 12 is one example of a cross sectional view taken along a line C-C in FIG. 11;

FIG. 13 is another example of the cross sectional view taken along the line C-C in FIG. 11;
DESCRIPTION OF EMBODIMENTS

A detailed description of a preferred embodiment of an electric vacuum pump embodying the present invention will now be given referring to the accompanying drawings. In the present embodiment, the electric vacuum pump of the invention applied to a brake system will be explained.

This brake system is first explained referring to FIGS. 1 and 2. FIG. 1 is a schematic configuration view of the brake system including the electric vacuum pump in the present embodiment. FIG. 2 is a block diagram showing a control system of the brake system including the electric vacuum pump in the present embodiment.

A brake system 1 in the present embodiment includes, as shown in FIGS. 1 and 2, a brake pedal 10, a brake booster 12, a master cylinder 14, a negative pressure sensor 16, an electric vacuum pump 18 (labeled “Electric VP” in the figure), a first check valve 20, a second check valve 22, an ECU 24, an intake pipe pressure detection unit 26, an engine stop determination unit 28, and others.

The brake booster 12 is provided between the brake pedal 10 and the master cylinder 14 as shown in FIG. 1. This brake booster 12 generates an assist force at a predetermined boosting ratio to a tread force on the brake pedal 10.

The brake booster 12 is internally partitioned by a diaphragm (not illustrated) into a negative pressure chamber (not shown) close to the master cylinder 14 and a transformer chamber (not shown) allowing introduction of atmospheric air. The negative pressure chamber of the brake booster 12 is connected to an intake pipe 32 of an engine through a first passage L1. Specifically, the first passage L1 is connected to the negative pressure chamber of the brake booster 12 and the intake pipe 32. Accordingly, the negative pressure chamber of the brake booster 12 is supplied with negative pressure generated in the intake pipe 32 through the first passage L1 according to an opening degree of a throttle valve 34 during driving of the engine.

The master cylinder 14 increases oil pressure of a brake main body (not shown) by operation of the brake booster 12, thereby generating a braking force in the brake main body. The negative pressure sensor 16 detects the negative pressure in the negative pressure chamber of the brake booster 12.

The electric vacuum pump 18 is connected to a second passage L2 as shown in FIG. 1. Specifically, a suction port 141 of the electric vacuum pump 18 is connected to the negative pressure chamber of the brake booster 12 through the second passage L2 and the first passage L1. It is to be noted that a discharge port 142 of the electric vacuum pump 18 is connected to the intake pipe 32 upstream of the throttle valve 34 and is open to the atmosphere. Herein, the second passage L2 is a pathway for branching from the first passage L1 at a position on the first passage L1 between the first check valve 20 and the second check valve 22.

The electric vacuum pump 18 is further connected to the ECU 24 through a relay 36 as shown in FIG. 2. Driving of the electric vacuum pump 18 is controlled by ON/OFF operation of the relay 36 by the ECU 24.

The first check valve 20 is provided in the first passage L1 at a position between a branch point to the second passage L2 and the brake booster 12 as shown in FIG. 1. The second check valve 22 is provided in the first passage L1 at a position closer to the intake pipe 32 than the first check valve 20 and between the branch point to the second passage L2 and the intake pipe 32. These first check valve 20 and second check valve 22 are each configured to open only when negative pressure on the side of the intake pipe 32 is higher than the negative pressure on the side of the negative pressure chamber of the brake booster 12 and to permit a fluid to flow only from the negative pressure chamber of the brake booster 12 to the intake pipe 32. In this manner, the brake system 1 can encapsulate negative pressure in the negative pressure chamber of the brake booster 12 by the first check valve 20 and the second check valve 22.

The ECU 24 consists of, for example, a microcomputer and includes a ROM that stores control programs, a rewriteable RAM that stores calculation results and others, a timer, a counter, an input interface, and an output interface. To this ECU 24, as shown in FIG. 2, there are connected the negative pressure sensor 16, the electric vacuum pump 18, the intake pipe pressure detection unit 26, the engine stop determination unit 28, the relay 36, and others.

Next, the electric vacuum pump 18 will be explained referring to FIGS. 3 to 6. FIG. 3 is a front view of the electric vacuum pump in the present embodiment. FIG. 4 is a top view of the electric vacuum pump in the present embodiment. FIG. 5 is a cross sectional view taken along a line A-A in FIG. 3. FIG. 6 is a cross sectional view taken along a line B-B in FIG. 5.

The electric vacuum pump 18 has a cylindrical shape as shown in FIGS. 3 and 4 and is provided with the suction port 141 and the discharge port 142 at an upper end and a connector 118 at a lower end. This electric vacuum pump 18 includes a motor part 110, a pump part 120, a resin case 130, a resin upper cover 140, and a resin lower cover 160. Further, as shown in FIG. 6, the case 130 contains the internal space in which the motor part 110 and the pump part 120 are accommodated. The case 130 containing the motor part 110 and the pump part 120 is closed by the upper cover 140 and the lower cover 160.

The motor part 110 includes an electric motor 112, a metal motor case 114, a rotary shaft 116, and the connector 118. The electric motor 112 is in the motor case 114 and includes a stator 112a and a rotor 112b. The stator 112a is fixed to the motor case 114 so that the rotor 112b is rotatably placed inside the stator 112a with a clearance therefrom.

The rotary shaft 116 is attached to this rotor 112b. The connector 118 including terminals 118a for supplying electric power to the electric motor 112 (the stator 112a) is provided on the lower cover 160.

Accordingly, in the motor part 110, the electric motor 112 is driven by an external power supply connected through the connector 118 to drive the rotary shaft 116 to rotate. The rotary shaft 116 is rotatably supported by a bearing fixed to the motor case 114.
[0070] The pump part 120 is constituted of a vane-type vacuum pump and is placed above the motor part 110 in the case 130. The pump part 120 will be driven in sync with the motor part 110. Herein, the vane-type vacuum pump is configured such that a rotor having a circular columnar shape placed in an eccentric state in a pump chamber is formed with grooves, in which a plurality of vanes are inserted to be movable in a rotor radial direction. When the rotor rotates, the vanes are caused to protrude from the grooves by centrifugal force and slide in contact with the inner peripheral surface of the pump chamber, thereby maintaining hermetical sealing between adjacent small chambers of the pump chamber. In association therewith, the volume of each closed space or small chamber partitioned by the vanes is increased or decreased, thereby causing suction, compression, and discharge of air, so that negative pressure is generated in the pump chamber.

[0071] To be concrete, the pump part 120 is provided with a pump housing 121 having an inner peripheral surface 121a of a nearly cylindrical shape. The inner peripheral surface 121a of a nearly cylindrical shape represents that the cross section of the pump housing is defined in a circular shape surrounded by a curved line without being limited to a perfect circular or elliptical shape. Both ends of the pump housing 121 are closed by an upper-end cover member 122a (see FIG. 7) having a nearly circular disc shape and a lower-end cover member 122b (see FIG. 7) having a nearly circular disc shape formed with a hole 122bb at almost the center. The inner peripheral surface 121a of the pump housing 121, the upper-end cover member 122a, and the lower-end cover member 122b form a pump chamber 123. The pump housing 121 is fixed to the case 130. It is to be noted that the upper-end cover member 122a is one example of a “first cover member” of the invention and the lower-end cover member 122b is one example of a “second cover member” of the invention.

[0072] In the pump chamber 123, a circular columnar rotor 124 is housed to be rotatable about the axis eccentric to the center axis of the pump chamber 123. This rotor 124 is coupled to the rotary shaft 116 of the electric motor 112. Accordingly, the rotor 124 is rotated in sync with rotary driving of the electric motor 112 via the rotary shaft 116.

[0073] The rotor 124 has a plurality of vane grooves. In the vane groove, vanes 125 each formed in a flat plate shape are slidably engaged to be radially movable in and out. A radially outer end of each vane 125 slides in contact with the inner peripheral surface 121a of the pump housing 121 by centrifugal force imparted to the vanes 125 during rotation of the rotor 124. Upper and lower end faces of the vanes 125 are in contact with the cover members 122a and 122b respectively. Thus, the vanes 125 partition the pump chamber 123 into a plurality of small chambers or spaces.

[0074] The pump chamber 123 communicates with the outside through a suction inlet 126 and a discharge outlet 127. The suction inlet 126 is provided in the upper-end cover member 122a to communicate with the pump chamber 123. The suction inlet 126 is hermetically connected to an inlet pipe 141a continuous with the suction port 141 to suck air from pump outside into the pump chamber 123. Similarly, the discharge outlet 127 is also provided in the upper-end cover member 122a to communicate with the pump chamber 123. Exhaust air ejected from the discharge outlet 127 is discharged to the pump outside through the discharge port 142.

[0075] The upper cover 140 is a resin member closing an upper open end of the case 130 accommodating the motor part 110 and the pump part 120. The upper cover 140 is one example of a “cover” of the invention. Specifically, the upper cover 140 closes the case 130 from the pump part side (from above in FIG. 6).

[0076] This upper cover 140 is provided with the suction port 141 to suck air in the pump part 120 from the pump outside, the inlet pipe 141a connected to the suction port 141, a silencer part 143 formed by the space communicating with the discharge outlet 127 of the pump part 120, the discharge port 142 to discharge exhaust air discharged or ejected from the pump part 120 to the pump outside, and a throat part 142a provided in the discharge port 142.

[0077] The silencer part 143 is formed by the internal space of the upper cover 140. Specifically, the silencer part 143 is defined by the space between the upper cover 140 and the upper-end cover member 122a. The throat part 142a is formed in the discharge port 142. Thus, exhaust air discharged or ejected from the discharge outlet 127 of the pump part 120 passes through the silencer part 143 and then is discharged to the pump outside through the throat part 142a. Consequently, the exhaust air can be repeatedly exposed to loads, so that pump operation sound or noise can be reduced to a minimum. In this manner, the electric vacuum pump 18 can be effectively provided with the sound-reducing (silencing) measure with a very simple structure.

[0078] The shape of the throat part 142a is not particularly limited and may be a shape that an entire discharge port is narrowed to form a throat as shown in FIG. 6 or a shape that part of the discharge port is narrowed or constricted.

[0079] The lower cover 160 is a resin member closing a lower open end of the case 130 accommodating the motor part 110 and the pump part 120. The lower cover 160 closes the case 130 from the motor part side (from below in FIG. 6).

[0080] In the electric vacuum pump 18 configured as above, when the electric motor 112 is driven to rotate upon receipt of power from an external source, the rotor 124 is rotated in synchronization therewith. Then, the vanes 125 slide along the vane grooves by centrifugal force, causing the end faces of the vanes 125 to contact with the inner peripheral surface 121a of the pump housing 121. While keeping such a contact state, the vanes 125 are rotated along the inner peripheral surface 121a of the pump housing 121. This rotation of the rotor 124 causes the volume of each small chamber of the pump chamber 123 to expand or contract, thereby sucking air into the pump chamber 123 through the suction inlet 126 and ejection air from the pump chamber 123 through the discharge outlet 127. This operation generates negative pressure in the pump chamber 123.

[0081] Specifically, in the brake system 1, when the relay 36 is turned on based on a drive start signal from the ECU 24, the electric vacuum pump 18 starts operating, thereby supplying negative pressure to the negative pressure chamber of the brake booster 12 through the suction port 141, the second passage 1 and the first passage 1. Furthermore, when the relay 36 is turned off based on a drive stop signal from the ECU 24, the electric vacuum pump 18 stops operating, thereby stopping supplying negative pressure to the negative pressure chamber of the brake booster 12 through the suction port 141, the second passage 1 and the first passage 1.

[0082] In the brake system 1, in a case where the engine is running and negative pressure is generated in the intake pipe, the negative pressure in the intake pipe 32 is supplied to the negative pressure chamber of the brake booster 12 through the first passage 1 to regulate the negative pressure in the nega-
tive pressure chamber of the brake booster 12. In a case where
the engine is stopped or in a case where the ECU 24 deter-
mtes that the negative pressure is insufficient, the ECU 24
turns on the relay 36, thereby driving the electric vacuum
pump 18 to supply the negative pressure to the negative pres-
sure chamber of the brake booster 12 through the second
passage 1.2 and the first passage 1.1. Thus, the negative pres-
sure in the negative pressure chamber of the brake booster 12
can be regulated.

[0083] Herein, an explanation is given to positioning of the
pump housing 121 and the lower-end cover member 122b
with respect to the case 130 and fixing of the upper-end cover
member 122a to the pump housing 121 and the case 130.

[0084] As shown in FIGS. 5 and 6, the pump part 120
includes the pump housing 121, the upper-end cover member
122a, the lower-end cover member 122b, the pump chamber
123, the rotor 124, and others. The upper-end cover member
122a is placed on an upper end of the pump housing 121 in a
center axis direction of the pump housing 121. The lower-end
cover member 122b is placed on a lower end of the pump
housing 121 in the center axis direction of the pump housing
121. The pump chamber 123 is defined by the inner peripheral
surface 121a of the pump housing 121, the upper-end cover
member 122a, and the lower-end cover member 122b.

[0085] In the present embodiment, as shown in FIG. 7,
scres 170 are passed through through holes 172 of the
upper-end cover member 122a and fastened in screw holes
174 formed in the case 130 to thereby fix the upper-end cover
member 122a to the case 130 and the pump housing 121.
Accordingly, the pump housing 121 and the lower-end cover
member 122b are simultaneously fixed to the case 130. The
scres 170 are one example of a “fastening member” of the
invention and the screw holes 174 are one example of a
“fastening hole” of the invention. In FIG. 7, the rotor 124 is
omitted for convenience of explanation.

[0086] The case 130 is provided, on its inner peripheral
surface 130a, with positioning protrusions 176 formed radially
projecting inward in the case 130. Each of the positioning
protrusions 176 is designed so that its outer peripheral
surface 176a has a nearly cylindrical shape. The positioning
protrusions 176 are arranged outside the pump chamber 123
in the radial direction of the case 130. In an example shown in
FIG. 5 and other figures, the case 130 includes three positioning
protrusions 176. Having the nearly cylindrical shape as
each outer peripheral surface 176a represents that the cross
section of each positioning protrusion 176 is not limited to a
perfect circle or an ellipse, but is defined as a circular shape
surrounded by a curved line.

[0087] As shown in FIGS. 5 to 7 and 9, the pump housing
121 is provided with positioning retainers 178 formed on the
outer periphery. Each of the positioning retainers 178 is
formed to protrude from an outer peripheral surface 121b of
the pump housing 121 toward the inner peripheral surface
130a of the case 130 and is provided with a groove 180
engagable with the corresponding positioning protrusion
176. In the example shown in FIG. 5 and others, the pump
housing 121 includes three positioning retainers 178. As
shown in FIG. 5, the grooves 180 of the positioning retainers
178 are in contact engagement with the positioning protrusions
176, so that the pump housing 121 is positioned in place
with respect to the case 130.

[0088] As shown in FIGS. 6, 7, and 10, the lower-end cover
member 122b includes positioning retainers 182 formed on
the outer periphery. Each of the positioning retainers 182 is
formed to protrude from an outer peripheral surface 122ba of
the lower-end cover member 122b toward the inner peripheral
surface 130a of the case 130 and is provided with a groove
184 engagable with the corresponding positioning protrusion
176. In the example shown in FIG. 10 and others, the
lower-end cover member 122b includes three positioning
retainers 182. The grooves 184 of the positioning retainers
182 are in contact engagement with the positioning protrusions
176, so that the lower-end cover member 122b is posi-
tioned in place with respect to the case 130.

[0089] As shown in FIGS. 6 to 8, the upper-end cover
member 122a includes screw stoppers 185 formed on the
outer periphery. Each of the screw stoppers 185 is formed to
protrude from an outer peripheral surface 122aa of the
upper-end cover member 122a toward the inner peripheral
surface 130a of the case 130 and is provided with the through
holes 172 through which the screws 170 are passed. In the example
shown in FIG. 8 and others, the upper-end cover member
122a includes three screw stoppers 185. Since the screws 170
are passed through the through holes 172 and are fastened in
the screw holes 174, the upper-end cover member 122a is
fixed to the case 130. Accordingly, the upper-end cover
member 122a is positioned with respect to the case 130.

[0090] In the present embodiment, the screw holes 174 are
formed one each in the positioning protrusions 176. In this
way, the screw holes 174 and the positioning protrusions 176
are arranged in the same positions in the radial direction of the
case 130. Thus, the cross sectional area of the electric vacuum
pump 18 in the radial direction is small and the electric vacuum
pump 18 can be reduced in size.

[0091] In the present embodiment, as shown in FIG. 6, an
end face 130b of the case 130 on an upper side (on one end
side) in the axial direction of the electric vacuum pump 18,
i.e., in the axial direction of the pump housing 121 (in an up
and down direction in FIG. 6) is located in a position above an
end face 122ab of the upper-end cover member 122a on a lower
side (on the other end side) in the axial direction of the
pump housing 121. Specifically, in the axial direction of the
pump housing 121, the upper end face 130b of the case 130 is
located above the upper end faces 176b of the positioning
protrusions 176.

[0092] In the above manner, while each portion forming the
positioning protrusions 176 surrounding the corresponding
screw holes 174 in the radial direction is thick enough to resist
against fastening forces of the screws 170, an outer peripheral
surface 130c of the case 130 and outer peripheral surfaces
176a of the positioning protrusions 176 are made common.
This can achieve reduction of the cross sectional area of the
case 130 in the radial direction and further size reduction of
the electric vacuum pump 18.

[0093] The inner peripheral surface 130a of the case 130 is
located outside the outer peripheral surface 122aa of the
upper-end cover member 122a, so that the upper-end cover
member 122a is assembled with the pump housing 121 by
being guided by the inner peripheral surface 130a of the case
130. Thus, the assembling accuracy of the upper-end cover
member 122a (positional accuracy of the upper-end cover
member 122a to be assembled) in the radial direction (a right
and left direction in FIG. 6) of the pump housing 121 can be
enhanced.

[0094] In the axial direction of the electric vacuum pump
18, the upper end face 130b of the case 130 may be located on
the same level or position as the lower end face 122ab of the
upper-end cover member 122a.
Silencer parts 186 are formed by space or cavity between the pump part 120 and the inner peripheral surface 130a of the case 130, in an area excepting the positioning protrusions 176, positioning retainers 178, and positioning retainers 182. Each silencer part 186 is communicated with the aforementioned silencer part 143. In the present embodiment in which the screw holes 174 are formed in the positioning protrusions 176, the width δ (see FIG. 5) of each of the positioning retainers 178 and 182 in the circumferential direction of the case 130 can be reduced to the minimum. This increases the volume of the space, i.e., the silencer parts 186, contributing to high silencing performance during operation of the electric vacuum pump 18. For instance, the width 6 in the present embodiment can be reduced as compared with the width 60 of each positioning retainer 202 of an electric vacuum pump 200 in a comparative example shown in FIG. 20. The electric vacuum pump 200 is configured such that positioning protrusions 204 and screw holes 206 are formed in different positions with displacement in the circumferential direction of a case 208.

In a modified example, as shown in FIGS. 11 and 12, members 194 capable of producing at least one of a silencing effect and a cooling effect may be placed in the silencer parts 186. For example, the members 194 are resin filters in the present embodiment. In this manner, since the filters 194 are placed in the silencer parts 186, the silencing performance and the cooling performance of the electric vacuum pump 18 can be further enhanced. Further, since the filters 194 are simply set in the space forming the silencer parts 186, mounting of the filters 194 is easy. The filters 194 may also be filled throughout the entire silencer parts 186. In another modified example, as shown in FIG. 13, the filters 194 may be placed not only in the silencer parts 186 but also in the silencer part 143. FIGS. 12 and 13 illustrate examples of a cross section taken in a line C-C in FIG. 11, showing only the pump part 120 and its surroundings.

As shown in FIG. 5, the positioning protrusions 176 and the screw holes 174 are formed in three pairs so that one of the pairs is arranged in a position 180-degree opposite to the center axis Sp of the inner peripheral surface 121a of the pump housing 121 with respect to the rotation center axis Sr of the rotor 124. This can achieve size reduction of the electric vacuum pump 18. The positioning protrusions 176 and the screw holes 174 may also be formed in two or more and odd-numbered pairs, instead of three pairs.

As another modified example, as shown in FIG. 14, the case 130 may be provided with ribs 196 on the inner peripheral surface 130a. Each of the ribs 196 is formed in a cylindrical shape as with the positioning protrusions 176 so that the direction of the center axis of each rib 196 is the same as the axial direction of the electric vacuum pump 18. The ribs 196 are arranged in the silencer parts 186. In the example shown in FIG. 14, two ribs 196 are provided. However, the number of ribs 196 is not particularly limited thereto. In this manner, the case 130 including the ribs 196 formed on the inner peripheral surface 130a can provide enhanced strength. The ribs 196 may be in contact with the outer peripheral surface 121b of the pump housing 121 and the outer peripheral surface 122b of the lower-end cover member 122b.

As another modified example, the case 130 may be made of metal. As shown in FIG. 15, accordingly, the pump housing 121 and the lower-end cover member 122b can be press-fitted in the case 130. Thus, the pump housing 121 and the lower-end cover member 122b can be assembled with high accuracy in the radial direction of the pump housing 121. FIG. 15 shows a press-fit portion a of the pump housing 121 and the lower-end cover member 122b that are press-fitted in the case 130. In this modified example, the case 130 also serves as the case 114.

The electric vacuum pump 18 in the present embodiment explained in detail above includes the case 130 having the internal space, the motor part 110 placed in the internal space of the case 130, and the pump part 120 placed in the internal space of the case 130 and to be driven in sync with the motor part 110. The pump part 120 includes the cylindrical pump housing 121, the upper-end cover member 122a placed on the upper end of the pump housing 121 in the center axis direction thereof, the lower-end cover member 122b placed on the lower end of the pump housing 121 in the center axis direction thereof, the pump chamber 123 formed by the inner peripheral surface 121b of the pump housing 121, the upper-end cover member 122a, and the lower-end cover member 122b, and the rotor 124 which is in the pump chamber 123 and in which the plurality of vanes 125 are inserted. The screws 170 are passed through the through holes 172 of the upper-end cover member 122a and fastened in the screw holes 174 of the case 130, thereby fixing the upper-end cover member 122a to the case 130 and the pump housing 121. The pump housing 121 includes the positioning retainers 178 formed on the outer periphery of the pump housing 121. The lower-end cover member 122b includes the positioning retainers 182 formed on the outer periphery of the lower-end cover member 122b. The case 130 includes the positioning protrusions 176 formed to protrude inward in the case 130 from the inner peripheral surface 130a of the case 130. Since the positioning retainers 178 and the positioning retainers 182 are in contact with the positioning protrusions 176, the pump housing 121 and the lower-end cover member 122b are positioned in place with respect to the case 130. The positioning protrusions 176 are formed with the screw holes 174.

As above, the screw holes 174 are formed in the positioning protrusions 176 of the case 130. The positioning protrusions 176 and the corresponding screw holes 174 are thus formed in the same places in the radial direction, so that the electric vacuum pump 18 can have a reduced cross sectional area in the radial direction and thus can have a reduced size. Since the positioning retainers 178 and the positioning retainers 182 are in contact with the positioning protrusions 176, thereby positioning the pump housing 121 and the lower-end cover member 122b with respect to the case 130, the assembling accuracy of the pump housing 121 and the lower-end cover member 122b with respect to the case 130 can be enhanced. In the above manner, the electric vacuum pump 18 can achieve size reduction and improved assembling accuracy of the components to form the pump chamber 123.

The pump housing 121 and the lower-end cover member 122b are in contact with the case 130 in such a manner that the positioning retainers 178 and the positioning retainers 182 contact with the positioning protrusions 176. This can improve heat dissipation performance of the electric vacuum pump 18 from the pump part 120 to the outside.

The positioning retainers 178 and the positioning retainers 182 are respectively formed to protrude from the outer peripheral surface 121b of the pump housing 121 and the outer peripheral surface 122b of the lower-end cover member 122b toward the inner peripheral surface 130a of the case 130 and also respectively include the grooves 180 and the grooves 184 engaging with the positioning protrusions.
Accordingly, the grooves 180 and the grooves 184 are in contact engagement with the positioning protrusions 176, thereby ensuring positioning of the pump housing 121 and the lower-end cover member 122b with respect to the case 130. Therefore, the assembling accuracy of the pump housing 121 and the lower-end cover member 122b with respect to the case 130 can be further improved.

In the center axis direction of the pump housing 121, the upper end face 130b of the case 130 is located on the same level or position as the lower end face 122ab of the upper-end cover member 122a or located above the lower end face 122ab of the upper-end cover member 122a. Accordingly, while ensuring the sufficient thickness of the portion of each positioning protrusion 176 surrounding the screw hole 174 in the radial direction, the outer peripheral surface 130c of the case 130 and the outer peripheral surface 176a of each positioning protrusion 176 are made common. This can achieve further reduction of the cross sectional area of the case 130 in the radial direction and thus further size reduction of the electric vacuum pump 18.

The electric vacuum pump 18 is provided with the silencer parts 186 between the pump part 120 and the inner peripheral surface 130a of the case 130, in the area excepting the positioning protrusions 176 and the positioning retainers 178 and 182. Thus, the silencer parts 186 are formed around the pump part 120. Since the positioning protrusions 176 are formed with the screw holes 174 as above, the volume of the silencer parts 186 can be increased as much as possible. This can enhance the silencing performance of the electric vacuum pump 18 during operation.

In the silencer parts 186, there may be placed the filters 194 that exert at least one of the silencing effect and the cooling effect. Accordingly, the silencing performance and the cooling performance of the electric vacuum pump 18 can be further improved. The filters 194 are simply set in the silencer parts 186 defined by the pump part 120 and the inner peripheral surface 130a of the case 130, so that assembling the filters 194 are easy.

The electric vacuum pump 18 may further include the ribs 196 formed in the silencer parts 186 to protrude radially inward from the inner peripheral surface 130a of the case 130. This can enhance the strength of the case 130.

The pairs of the positioning protrusions 176 and the screw holes 174 are formed as two or more and odd-numbered pairs so that one pair of the pairs of the positioning protrusions 176 and the screw holes 174 is placed in a position 180° opposite to the center axis Sp of the inner peripheral surface 121a of the pump housing 121 with respect to the rotation center axis Sr of the rotor 124. This can effectively achieve size reduction of the electric vacuum pump 18.

The electric vacuum pump 18 further includes the upper cover 140 that closes the internal space of the case 130 from the side of the pump part 120. Between the upper cover 140 and the upper-end cover member 122a, the silencer part 143 is formed. Since the space is thus generated in the upper cover 140, the electric vacuum pump 18 can provide improved silencing performance during operation.

In a case where the case 130 is made of metal, the pump housing 121 and the lower-end cover member 122b can be press-fitted in the metal case 130. Thus, the components to form the pump chamber 123 can be assembled with high accuracy in the radial direction of the pump housing 121.

A conceivable modified example is shown in FIGS. 16 and 17. In this modified example shown in FIGS. 16 and 17, a one-piece housing 188 is configured to include the pump housing 121 and the upper-end cover member 122a integrally formed. This can enhance the positional accuracy of the suction inlet 126 and the discharge outlet 127 and improve the pump efficiency of the electric vacuum pump 18. As still another modified example, the pump housing 121 and the lower-end cover member 122b may be formed integrally.

Further, a modified example shown in FIGS. 18 and 19 is also conceived. As shown in FIG. 18, the pump housing 121 is formed in a rectangular cylindrical shape of which the outer peripheral surface 122a has a rectangular cross section (defined by four sides). As shown in FIG. 19, the lower-end cover member 122b is formed in a rectangular plate like shape of which the outer peripheral surface 122b has a rectangular cross section (defined by four sides). This cover member 122b is formed with a hole at the center. Positioning retainers 190 of the pump housing 121 and positioning retainers 192 of the lower-end cover member 122b correspond to surfaces defined by the four sides. Accordingly, the positioning retainers 190 and the positioning retainers 192 are respectively in contact with the positioning protrusions 176, ensuring positioning of each of the pump housing 121 and the lower-end cover member 122b with respect to the case 130. Therefore, the pump housing 121 and the lower-end cover member 122b can be assembled to the case 130 with high accuracy. It is to be noted that the outer shape of each of the pump housing 121 and the lower-end cover member 122b may also be formed in any polygonal shape other than the rectangular shape.

The aforementioned embodiment and examples are mere examples and do not limit the invention. The present invention may be embodied in other specific forms without departing from the essential characteristics thereof.

Reference Sings List

1 Brake system
2 Brake booster
16 Negative pressure sensor
20 First check valve
24 ECU
34 Throttle valve
112 Electric motor
118 Connector
121 Pump housing
121ba Outer peripheral surface
122aa Outer peripheral surface
122b Lower-end cover member
122bb Hole
124 Rotor
10 Brake pedal
14 Master cylinder
18 Electric vacuum pump
22 Second check valve
32 Intake pipe
110 Motor part
116 Rotary shaft
120 Pump part
121a Inner peripheral surface
122ab Upper-end cover member
122ab End face
122bs Outer peripheral surface
123 Pump chamber
125 Vane
1. An electric vacuum pump including: a case having internal space; a motor part placed in the internal space of the case; and a pump part placed in the internal space of the case and to be driven in sync with the motor part, wherein

the pump part includes: a cylindrical pump housing; a first cover member placed in the pump housing on one end side in a center axis direction of the pump housing; a second cover member placed in the pump housing on the other end in the center axis direction; a pump chamber formed by an inner peripheral surface of the pump housing, the first cover member, and the second cover member; and a rotor housed in the pump chamber and including a plurality of vanes inserted therein,

the electric vacuum pump further includes a fastening member passed through a through hole formed in the first cover member and being fastened in a fastening hole formed in the case to fix the first cover member to the case and the pump housing,

the pump housing is provided with a positioning retainer formed on an outer periphery and the second cover member is provided with a positioning retainer formed on an outer periphery,

the case is provided with a positioning protrusion formed to protrude inward from an inner peripheral surface of the case,

the positioning retainers are in contact with the positioning protrusion to position the pump housing and the second cover member with respect to the case, and

the fastening hole is formed in the positioning protrusion.

2. The electric vacuum pump according to claim 1, wherein

the positioning retainers are formed to respectively protrude from an outer peripheral surface of the pump housing and an outer peripheral surface of the second cover member toward the inner peripheral surface of the case and include grooves engageable with the positioning protrusion.

3. The electric vacuum pump according to claim 1, wherein

the case has an end face on the one end side in the center axis direction of the pump housing, the end face being located in the same position as an end face of the first cover member on the other end side in the center axis direction of the pump housing or located in a position closer to the one end side than the end face of the first cover member on the other end side.

4. The electric vacuum pump according to claim 1, wherein

the pump part and the inner peripheral surface of the case form therebetween a space in an area excepting the positioning protrusion and the positioning retainers.

5. The electric vacuum pump according to claim 4, further including a member placed in the space to produce at least one of a silencing effect and a cooling effect.

6. The electric vacuum pump according to claim 4, wherein

the case includes a rib placed in the space and formed to protrude inward from the inner peripheral surface of the case.

7. The electric vacuum pump according to claim 1, wherein

the case is provided with a plurality of positioning protrusions and a plurality of fastening holes in two or more and odd-numbered pairs, and

one pair of the pairs of positioning protrusions and fastening holes is placed in a position 180° opposite to a center axis of the inner peripheral surface of the pump housing with respect to a rotation center axis of the rotor.

8. The electric vacuum pump according to claim 1, wherein

the first cover member includes a suction inlet for sucking gas from outside into the pump chamber and a discharge outlet for discharging gas from the pump chamber to the outside, and

the pump housing and the first cover member are integrally formed.

9. The electric vacuum pump according to claim 1, further including

a cover closing the internal space of the case from a side of the pump part, and

the cover and the first cover member form therebetween a space.

10. The electric vacuum pump according to claim 1, wherein

the pump housing has a cylindrical shape of which the outer peripheral surface has a polygonal cross section, the second cover member has a plate-like shape of which the outer peripheral surface has a polygonal cross section, and
each of the positioning retainers is a surface defined by a side of the polygonal cross section.

11. The electric vacuum pump according to claim 1, wherein the case is made of a metal material.