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(54) **Combinational molecular pump capable of readily being cleaned.**

(57) In a molecular pump comprising a pump vessel (11) having inlet and outlet ports (13 and 14), an axial-flow type molecular pump member (20) disposed near the inlet port, and an additional pump member (30) of a helical groove type disposed near the outlet port, the additional pump member comprises an inside cylindrical member (31) rotatable around a center axis of the pump vessel and an outside cylindrical member (32) held on an inner surface of the pump vessel. An additional cylindrical member (32a) is situated near the outlet port and brought into contact with the outside cylindrical member. The additional cylindrical member is separable into a plurality of separate pieces each of which is radially detachable from another. The additional cylindrical member is independent of the outside cylindrical member. Alternatively, the additional cylindrical member may be integral with the outside cylindrical member cut into separate pieces.

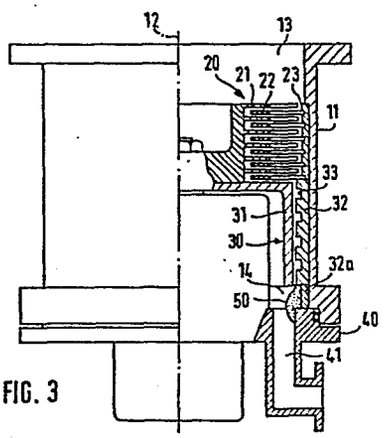

FIG. 3

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COMBINATIONAL MOLECULAR PUMP CAPABLE OF READILY BEING CLEANED

Background of the Invention:

This invention relates to a molecular pump for use in evacuating a space to be exhausted to an ultra-high vacuum. It is to be noted here throughout the instant specification that the molecular pump comprises a combination of a molecular pump member of an axial-flow type with an additional molecular pump member having a helical groove.

In Japanese Patent Publication No. 33446/1972, such a molecular pump is disclosed. The molecular pump comprises a pump vessel of a cylindrical shape which has a center axis, an inner surface defining a hollow space along the center axis, an inlet port, and an outlet port. The molecular pump further comprises a first pump member operable as the molecular pump member of an axial-flow type within the hollow space. The first pump member is disposed nearer to the inlet port than the outlet port. A second pump member is operable as the additional molecular pump member and has a helical groove in communication with the hollow space. The second pump member is positioned nearer to the outlet port than

the inlet port. The first pump member comprises a plurality of rotor blade members rotatable around the center axis and a plurality of stator blade members held on the inner surface with the rotor blade members alternately interposed. The second pump member comprises an inside cylindrical member and an outside cylindrical member held on the inner surface and having an inner peripheral surface parallel to the center axis. The inner peripheral surface faces the hollow space. The inside cylindrical member has an outer peripheral surface rotatable around the center axis with a predetermined distance left in the hollow space from the inner peripheral surface. It is possible to form the helical groove into either of the inner and the outer peripheral surfaces. The stator blade members and the outside cylindrical member are fixed to the inner surface of the pump vessel by pressing the pump vessel onto a pump base member which is for use in supporting the molecular pump.

It is general that the gas to be evacuated includes dust and/or a substance which changes into a solid. Such dust and solids adhere as a deposit onto the inner peripheral surface of the outside cylindrical member at a location nearer to the outlet port. The deposit reduces the ultimate degree of vacuum and the speed of exhaust. It is therefore necessary to often clean the molecular pump. More particularly, the deposit should be removed by taking the molecular pump to pieces after the molecular pump is operated for a long time. The molecular pump is taken to pieces by upwardly pulling out the pump vessel from the pump base member at first, next removing the stator blade members away from the rotor blade members, and then upwardly pulling out the outside cylindrical member. However, it is difficult to pull out the outside cylindrical member when the

deposit has grown bulky. It is necessary in such a case to detach the inside cylindrical member before pulling out the outside cylindrical member. However, it needs much time and great expense to again install the inside cylindrical member in position. This is because precise control is necessary so as to balance the inside cylindrical member, which is rotated at high speed. Thus, the conventional molecular pump can not be readily swept or cleaned.

Summary of the Invention:

It is therefore an object of this invention to provide a molecular pump which can be readily swept or cleaned.

It is another object of this invention to provide a molecular pump which can save time and labor on cleaning.

A molecular pump to which this invention is applicable comprises a pump vessel which has a center axis and an inner surface defining a hollow space along the center axis and which has an inlet port and an outlet port in communication with the hollow space, a first pump member comprising a plurality of rotor blade members rotatable around the center axis in the hollow space near the inlet port and a plurality of stator blade members held on the inner surface with the rotor blade members alternately interposed, and a second pump member comprising an inside cylindrical member near the outlet port and an outside cylindrical member held on said inner surface and having an inner peripheral surface parallel to the center axis and in a face to face relationship relative to the hollow space. The inside cylindrical member has an outer peripheral surface rotatable around the center axis with a predetermined distance left in the hollow space from the inner peripheral surface. Either of the inner and the outer peripheral surfaces is provided with a helical groove.

According to this invention, the outside cylindrical member is brought into contact with an additional cylindrical member situated nearer to the outlet port than the inside cylindrical member and cut into a plurality of separate pieces each of which is radially detachable from another.

Brief Description of the Drawing:

Fig. 1 is a partial vertical sectional view of a conventional molecular pump;

Fig. 2 is a partial vertical sectional view of a modified molecular pump;

Fig. 3 is a partial vertical sectional view of a molecular pump according to a first embodiment of the instant invention;

Fig. 4 is a perspective view of an additional cylindrical member for use in the molecular pump depicted in Fig. 3;

Fig. 5 is a partial vertical sectional view of a molecular pump according to a second embodiment of this invention; and

Fig. 6 is a perspective view of an outside cylindrical member used in the molecular pump illustrated in Fig. 5.

Description of the Preferred Embodiments:

Referring to Fig. 1, a conventional molecular pump will be described at first for a better understanding of this invention. The molecular pump comprises a pump vessel 11 of a cylindrical shape. The pump vessel 11 has a center axis 12, an inner surface defining a hollow space along the center axis 12, an inlet port 13, and an outlet port 14.

A first pump member 20 is operable as a molecular pump member of an axial-flow type within the hollow space. The first pump member 20 comprises a plurality of rotor blade members 21

rotatable around the center axis 12 in the hollow space nearer to the inlet port 13 than the outlet port 14. The rotor blade members 21 are stacked from one another with a gap left between two adjacent ones of the rotor blade members 21. Each of the rotor blade members 21 has a plurality of rotor blades in the manner known in the art. The first pump member 20 further comprises a plurality of stator blade member 22 held on the inner surface by a plurality of spacers 23, respectively, with the stator blade members 22 interposed between each gap left between two adjacent rotor blade members 21. Each of the stator blade members 22 also has a plurality of stator blades in the manner known in the art.

An additional molecular pump member of a helical groove type cooperates with the first pump member 20 and may be referred to as a second pump member 30. Thus, the illustrated pump may be called a combinational molecular pump. The second pump member 30 comprises an inside cylindrical member 31 nearer to the outlet port 14 than the inlet port 13 and an outside cylindrical member 32 held on or snugly received by the inner surface of the pump vessel 11. The outside cylindrical member 32 has an inner peripheral surface parallel to the center axis 12. The inner peripheral surface is in a face to face relationship relative to the hollow space. The inside cylindrical member 31 has an outer peripheral surface rotatable around the center axis 12 with a predetermined distance left in the hollow space from the inner peripheral surface of the outside cylindrical member 32. The inner peripheral surface of the outside cylindrical member 32 is provided with a helical groove 33 having predetermined depth, width and pitch.

Let this pump be seen from a top thereof in Fig. 1 and the helical groove 33 form a right-handed screw. Under the circumstances, the inside cylindrical member 31 is rotated clockwise around the center axis 12. On the contrary, the inside cylindrical member 31 is rotated counterclockwise around the center axis 12 when the helical groove 33 may form a left-handed screw.

The stator blade members 22 and the outside cylindrical member 32 are fixed to the inner surface of the pump vessel 11 by pressing the pump vessel 11 onto a pump base member 40. The pump base member 40 is for use in supporting the molecular pump. The pump base member 40 has an exhaust pipe 41 which communicates with the outlet port 14 of the pump vessel 11.

The molecular pump is attached at the inlet port 13 to a device which is to be evacuated. A forepump is coupled with the exhaust port 41 in order to evacuate to a fore-vacuum. A gas is evacuated from the device through the exhaust port 41 during operation of the first and the second pump members 20 and 30.

As a rule, the gas to be evacuated includes dust and/or a substance readily solidified. Such dust and solidified substance adhere as a deposit 50 onto the inner peripheral surface of the outside cylindrical member 32 at a location nearer to the outlet port 14. The deposit 50 reduces the ultimate degree of vacuum and the speed of exhaust. Therefore, the molecular pump should often be cleaned or swept so as to remove the deposit 50. Such cleaning is very cumbersome. More particularly, the molecular pump must be disassembled into pieces on cleaning in the following manner. At first, the pump vessel 11 is detached from the pump base member 40 by upwardly pulling out the pump vessel 11. Subsequently, the

spacers 23 and the stator blade members 22 are removed from the rotor blade members 21. Then, the outside cylindrical member 32 is upwardly pulled out to be detached from the pump base member 40. However, it is difficult to pull out the outside cylindrical member 32 when the deposit 50 has grown bulky. In such a case, it is necessary to detach the inside cylindrical member 31 from the pump base member 40 before the outside cylindrical member 32 is pulled out. After cleaning, the detached elements should be assembled in position. Among others, the inside cylindrical member 31 must be precisely positioned because the inside cylindrical member 31 is rotated at a high speed and is therefore accurately balanced. Anyway, much labor and time are consumed on cleaning.

Referring to Fig. 2, let a modified molecular pump be tentatively considered to remove the defect. According to the modification, the inner peripheral surface of the outside cylindrical member 32 is given a greater diameter at a portion of the deposit 50 than the remaining inner peripheral surface. We expected that the outside cylindrical member 32 can be pulled out without detaching the inside cylindrical member 31 even if the deposit 50 may protrude towards the center axis. However, it has been found according to our experiment that the deposit 50 adheres onto the inner peripheral surface of the outside cylindrical member 32 so as to protrude inwardly over the outer peripheral surface of the inside cylindrical member 31 at a location nearer to the bottom end of the inside cylindrical member 31, as illustrated in Fig. 2. In addition, it has been confirmed that the deposit 50 tenaciously adheres also to the pump base member 40. It is therefore impossible with the modified molecular pump to pull out the outside cylindrical member 32 without detaching

the inside cylindrical member 31.

Referring to Fig. 3, a molecular pump according to a first embodiment of this invention comprises similar parts designated by like reference numerals. The outside cylindrical member 11 is brought into contact with an additional cylindrical member 32a situated nearer to the outlet port 14 than the inside cylindrical member 31. As will presently be described, the additional cylindrical member 32a is cut into a plurality of separate pieces each of which is detachable from another away from the center axis 12. The additional cylindrical member 32a is separable from the outside cylindrical member 32.

Referring to Fig. 4, the additional cylindrical member 32a is cut into separate pieces along at least two lines. The line may have an angle with the center axis 12. At any rate, the lines are parallel in effect to the center axis 12 so that the semicircular separate pieces are radially detachable from each other away from the center axis 12.

When the molecular pump of Fig. 3 is to be cleaned or swept, the molecular pump is disassembled by upwardly pulling out the pump vessel 11 from the pump base member 40 at first, by removing the spacers 23 and the stator blade members 22 away from the rotor blade members 21, by pulling out the outside cylindrical member 32, and then by detaching the additional cylindrical member 32a. Inasmuch as the outside cylindrical member 32 and the additional cylindrical member 32a are disassembled without detaching the inside cylindrical member 31 from the center axis 12 even when the deposit 50 is highly piled up in the additional cylindrical member 32a, the molecular pump of Fig. 3 can be readily cleaned or swept to

remove the deposit 50. Thus, it is possible to save time and labor on cleaning the molecular pump. Furthermore, it is easy to again install the additional cylindrical member 32a, the outside cylindrical member 32, the stator blade members 22, the spacers 23 and the pump vessel 11 in position, as the inside cylindrical member 31 is not detached.

Referring to Fig. 5, a molecular pump according to a second embodiment of this invention comprises similar parts designated by like reference numerals. The helical groove 33' is formed on the outer peripheral surface of the inside cylindrical member 31'.

Let the helical groove 33' form a left-handed screw when seen from top of this figure. In this event, the inside cylindrical member 31' is rotated clockwise around the center axis 12. On the contrary, the inside cylindrical member 31' is rotated counterclockwise around the center axis 12 when the helical groove 33' forms a right-handed screw.

The outside cylindrical member 32' is integral with the additional cylindrical member 32a situated nearer to the outlet port 14 than the inside cylindrical member 31'. Consequently, the additional cylindrical member 32a is brought into contact with the outside cylindrical member 32', like in Fig. 3. As will presently be described, the illustrated outside cylindrical member 32' is cut into a plurality of separate pieces, as is the case with the additional cylindrical member 32a illustrated in Fig. 3. Each of the separate pieces is radially detachable from another.

Referring to Fig. 6, the outside cylindrical member 32' made integral with the additional cylindrical member 32a comprises

two pieces each of which is separable from another and which is of a semicircle. Each piece has a pair of ends brought into contact with those of the other piece. As mentioned in conjunction with Fig. 4, the separate pieces can be manufactured by cutting a cylindrical member serving as the outside cylindrical member 32' and the additional cylindrical member 32a.

According to the molecular pump of Fig. 5, it is also possible to clean the molecular pump in order to remove the deposit 50 by separating the outside cylindrical member 32' made integral with the additional cylindrical member 32a. Thus, the molecular pump of Fig. 5 can be readily cleaned or swept to remove the deposit 50. Thus, it is possible to save time and labor on cleaning of the molecular pump.

While the present invention has thus far been described in conjunction with a few preferred embodiments thereof, it will now be readily possible for those skilled in the art to practice this invention in various other manners. For example, it is possible to form the helical groove 33 or 33' into either of the inner and the outer peripheral surfaces. The additional cylindrical member 32a or the outside cylindrical member 32' may be divided into separate pieces more than two.

WHAT IS CLAIMED IS:

1. In a molecular pump comprising a pump vessel which has a center axis and an inner surface defining a hollow space along said center axis and which has an inlet port and an outlet port in communication with said hollow space, a first pump member comprising a plurality of rotor blade members rotatable around said center axis in said hollow space near said inlet port and a plurality of stator blade members held on said inner surface with said rotor blade members alternately interposed, and a second pump member comprising an inside cylindrical member near said outlet port and an outside cylindrical member held on said inner surface and having an inner peripheral surface parallel to said center axis and in a face to face relationship relative to said hollow space, said inside cylindrical member having an outer peripheral surface rotatable around said center axis with a predetermined distance left in said hollow space from said inner peripheral surface, either of said inner and said outer peripheral surfaces being provided with a helical groove, the improvement wherein:

said outside cylindrical member is brought into contact with an additional cylindrical member situated nearer to said outlet port than said inside cylindrical member and cut into a plurality of separate pieces each of which is radially detachable from another.

2. A molecular pump as claimed in Claim 1, wherein said additional cylindrical member is separable from said outside cylindrical member.

3. A molecular pump as claimed in Claim 1, whrein said additional cylindrical member is integral with said outside cylindrical member, said outside cylindrical member being also cut into said separate pieces.

4. A molecular pump as claimed in Claims 1, 2, or 3, wherein said helical groove is formed on said inner peripheral surface.

5. A molecular pump as claimed in Claims 1, 2, or 3, wherein said helical groove is formed on said outer peripheral surface.

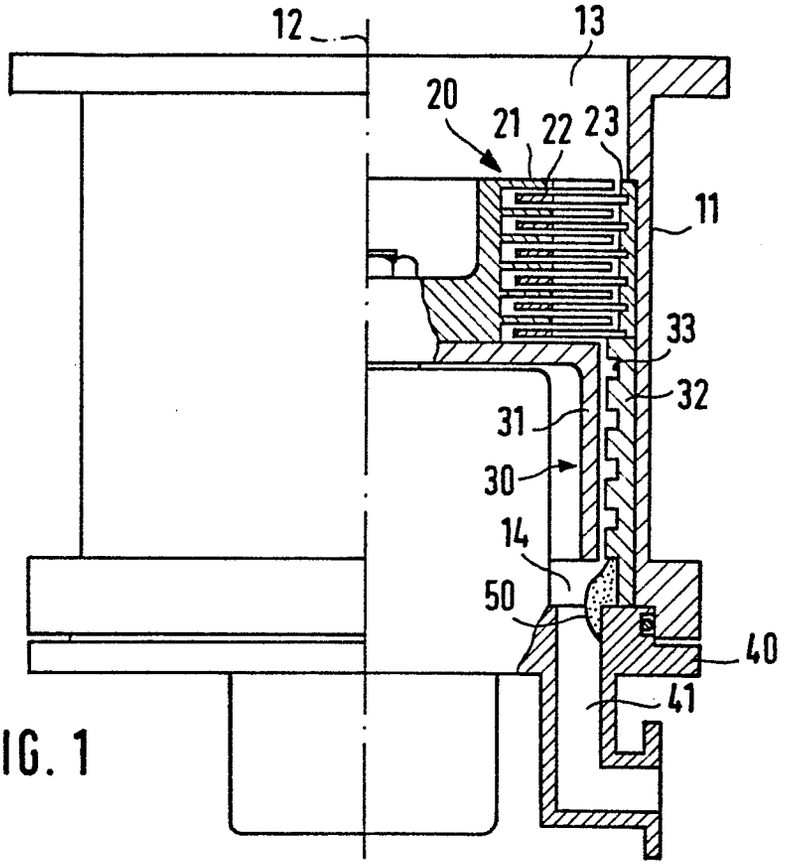
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FIG. 1

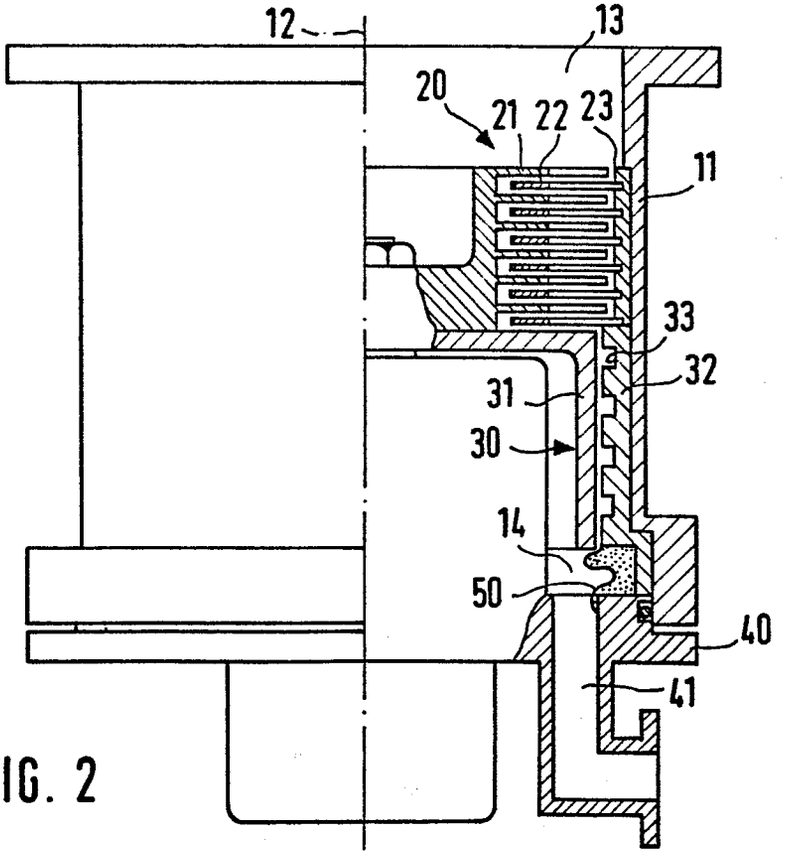
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FIG. 2

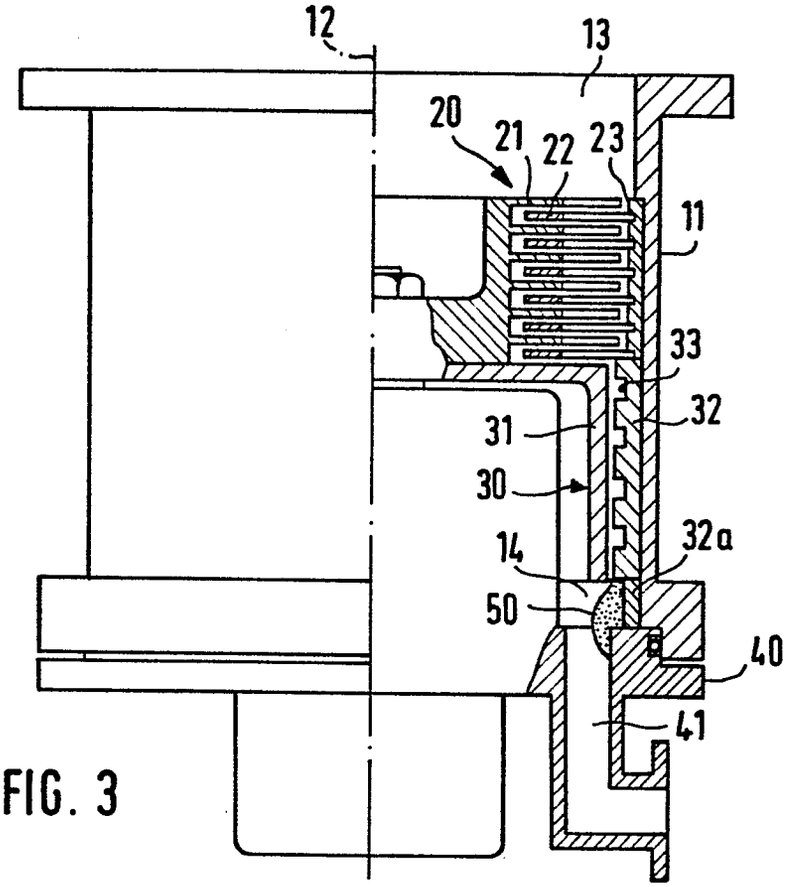
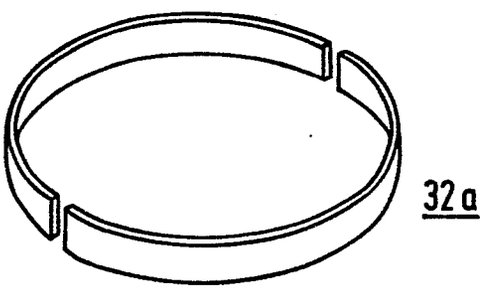


FIG. 3

FIG. 4



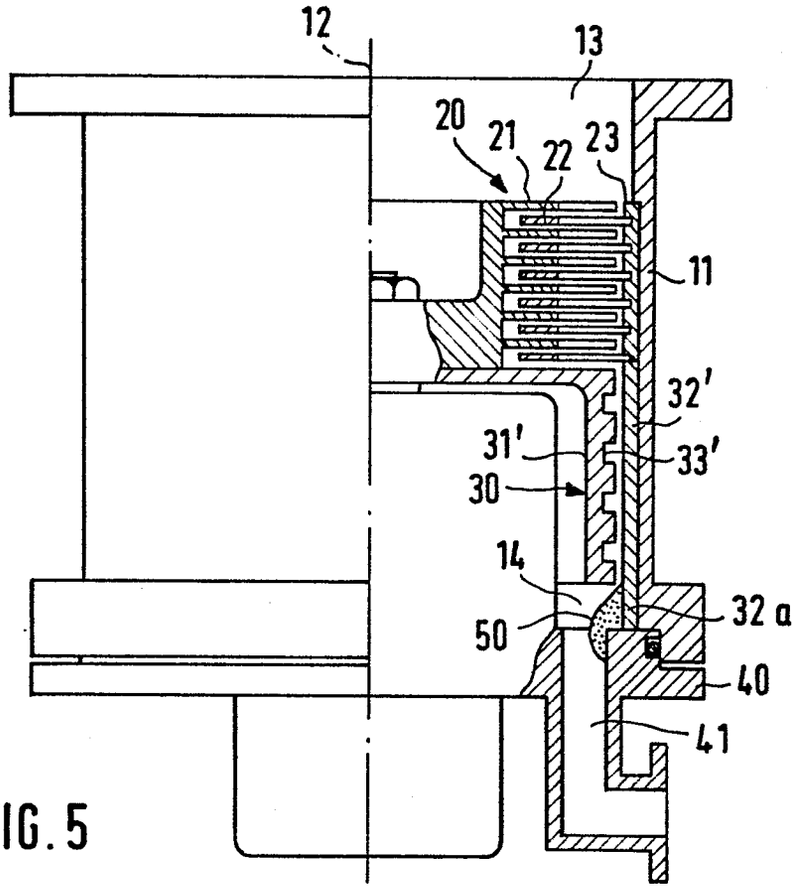


FIG. 5

FIG. 6