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(54) **Dry rotary vane compressor.**

(57) A rotary vane compressor in which the lubricating oil is kept separate from the pressurized fluid. The compressor comprises a stator (10) defining a chamber (14) delimited by a cylindrical wall in which a hollow rotor (15) eccentrically rotates; the rotor (15) is provided with vanes (19) sliding in corresponding longitudinal slots (18). Cam means (29) are provided within the hollow rotor (15) to cause the vanes (19) to slide radially and to hold their edge in very close proximity to the internal wall of the stator chamber (14).

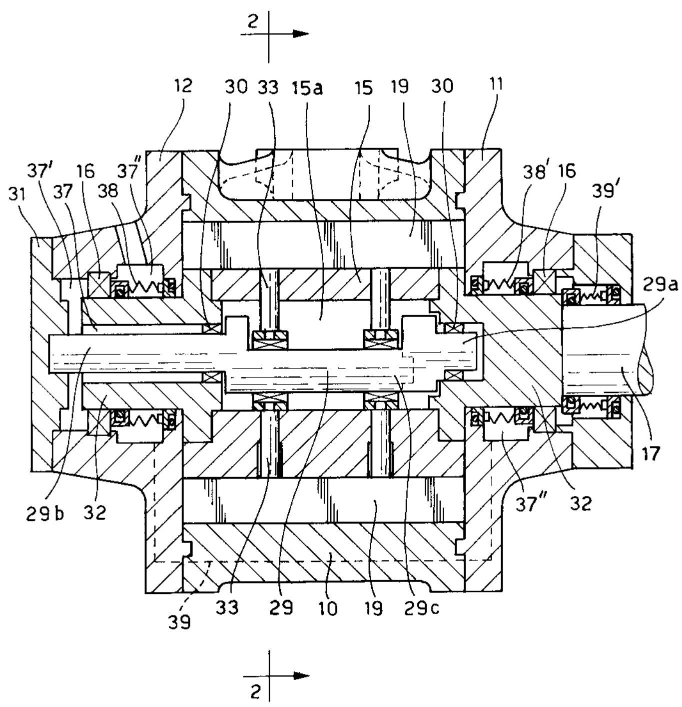

Fig. 1

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This invention relates to rotary vane compressors of the type comprising a stator defining a cylindrical chamber in which a rotor eccentrically rotates, the rotor being provided with radially sliding vanes which are reciprocable in corresponding slots longitudinally extending to the rotor. More specifically, the invention is intended for a vane compressor of the kind stated above, also referred to as a "dry type compressor", in which, inside the compressor, the fluid to be compressed is constantly kept separate from the lubricating oil.

For many applications, for example in the refrigerating sector or the food manufacturing field, there is a need for dry rotating compressors especially of low or medium power type, to deliver a pressurized fluid that is uncontaminated by lubricating oil. In the food-manufacturing industry, for example, it is extremely important to dispose of dry air, uncontaminated by other fluids, this reason being self-evident given that this air may come into contact with food substances during a given production cycle. Furthermore, the use of dry air uncontaminated by lubricating oil, results in significantly simplified pneumatic distribution plants as, too, the compressor design.

The need for an uncontaminated pressurized fluid is acutely important, for example, in the refrigeration field. This is because the lubricating oil entrained in circulation with the freezing fluid creates notable separation problems, especially when operating at low temperatures. Moreover, in the refrigerating cycle multi-phase conditions are established for freezing fluid that are difficult to control and negatively affect efficiency.

Accordingly, there is a need in general for machines to compress air and gas that do not contaminate the compressed fluid but which, at the same time, are able to operate to high rotational speed in order to reduce the compressor size and cost.

At present, apart from traditional piston and screw type compressor equipment, there is no known rotary vane compressor able to satisfy the needs stated above.

Therefore, the main object of this invention is to provide a dry rotary vane compressor by means of which it is possible to produce a pressurized fluid uncontaminated by oil or by other lubricating fluid.

A further object of this invention is to provide a dry rotary vane compressor, as previously specified, particularly adapted for low and medium power, which is able to operate at high rotational speed without generating excessive heat and yet of limited size and power consumption.

Another object of this invention is to provide a rotary vane compressor as described above that has no mechanical parts in sliding contact between rotor and stator, with the purpose of considerably lessening the difficulties of maintenance work on the compressor and of inspection and checking operations, while nevertheless enabling high compression efficiency that is equal or close to that of traditional compressors.

The above objects can be otained by means of a dry rotary vane compressor comprising the characteristics of the main claim. The essential principle of this invention resides in providing a hollow rotor comprising fixed control cam means to constantly control the position of the vanes both with respect to the stator and to the rotor as the latter rotates, while holding the vanes in very close proximity to and though without any contact with the internal wall of said chamber. Through the use of vanes provided with a special profile it is possible to form a sort of hydraulic seal between the internal wall of the stator chamber and the vanes, so avoiding leakage of the fluid being compressed.

Details of these and other characteristics of the rotary compressor according to the invention are more fully presented in the description below with reference to the appended drawings, in which:

Fig. 1 is a longitudinal cross-sectional view of the compressor along the line 1-1 in fig. 2;

Fig. 2 is a cross-sectional view along the line 2-2 in fig. 1;

Fig. 3 is an enlarged detail of a vane, showing the formation of a hydraulic seal;

Fig. 4 is another enlarged detail of the lubrication system;

Fig. 5 is a view along the line 5-5 in fig. 2.

As shown in figures 1 and 2, the rotary compressor according to the invention comprises a stator 10 which, together with the two end walls 11 and 12, defines a cylindrical chamber 14 in which eccentrically rotates a hollow rotor 15 supported, by hubs 32 and rolling bearings 16, by the two end walls 11 and 12, one of said hubs being connected to a control shaft 17.

The rotor 15 is provided with radial slots 18 that are longitudinally arranged to the rotor. In each of the slots there is a vane 19 which moves between a completely retracted position inside the rotor and a completely advanced position out of the rotor 15 during rotation of the latter inside the chamber 14. This chamber 14 has two separate areas and more precisely a first intake area 14b connected with an inlet 20 for the fluid to be compressed through fluid-admission openings 21 in the stator wall which lead to an intake chamber 25, as well as a second compression area 14a, connected to a delivery output 22 through openings 23 in the stator 10, located in a position that is angularly spaced from the inlet opening 20.

As shown in fig. 5 the fluid-admission openings 21 extend in directions that are inclined with respect to the stator axis, preferably according to cylindrical helices, in order to provide a broad fluid-admission section along the intake area, said openings being inclined, for example, in one direction in one half of the chamber and in the opposite direction in the other half.

The stator 10 of the compressor is partially surrounded by an external wall 24, which in addition to defining the intake chamber 25, also defines a refrigeration chamber 26 along the fluid compression area, peripherally along area 14a in the aforesaid chamber 14. This refrigeration chamber 26 comprises an inlet 27 for the refrigerating fluid positioned at the beginning of the compression area and an outlet 28 for the refrigerating fluid positioned at the end of the compression area 14a.

As previously stated, the radial vanes 19 of the rotor are mechanically controlled in such a way that they can be made to emerge from the slots and to return inside them as the rotor 15 rotates, while at the same time their outside edge is kept in constant and very close proximity to, or at a narrow distance from the surface of the internal wall of the stator chamber, without there being any frictional contact.

For this purpose the hollow rotor 15 contains suitable control cam means to control the vanes 19 and to which said vanes are rotatably connected in such a way that they rotate with the rotor and, at the same time, slide radially with respect to it. In particular, inside the hollow rotor 15 there is a fixed crankshaft 29, also referred to as a camshaft, comprising a central part 29c offset with respect to the lateral extensions 29a and 29b, in which the longitudinal axis of said central part 29c coincides with the longitudinal axis, that is the centre of the stator chamber 14. The central part 29c of the crankshaft 29 is connected to the rotor vanes 19 in the way shown so as to allow the vanes to rotate freely with the rotor. The central portion 29c of the camshaft is therefore eccentrically positioned inside the rotor and its eccentricity is opposed to that of the rotor with respect to the stator. The camshaft 29 is supported inside the rotor by means of the extensions 29a and 29b coaxially arranged to the rotor, and by ball bearings 30 so that the rotor can rotate while said crankshaft is fixedly held to a cover 31 of the end wall 12 by, for example, the shaft end 29b that extends axially through and beyond the hollow hub 32 of the rotor 15.

This arrangement of the camshaft 29 inside the hollow body of the rotor 15 allows the position of the vanes 19 to be mechanically controlled during the entire rotation of the rotor 15 so that they can slide radially with respect to the rotor as they are being driven around by the latter, and so that the vanes can follow the profile of the stator's chamber 14 while always remaining at a narrow distance from and in very close proximity to said internal wall of the chamber. Accordingly, as diagrammatically shown in figures 1 and 2, each vane 19 is connected to a pair of rods 33 that extend into radial guide holes 34 in the rotor to connect with a ring 35 rotatably supported, for example by rollers 36, concentrically to the central part 29c of the crankshaft 29. By virtue, therefore, of the coinciding positions of said central part 29c of the crankshaft and the stator centre, it is possible to control the radial position of the vanes 19 with extreme accuracy for the entire rotation through while holding the edge of the vanes in close proximity to, and free of sliding contact with the internal surface of the stator chamber. The stator, because of its eccentric position, will also draw the vanes 19 around with it when it is rotating and cause in them a relative forward and rearward radial movements with respect to the rotor. At the same time the vanes are in no way subject to the effects of centrifugal force since they are held by the controlling camshaft.

Another characteristics and innovative aspect of the compressor in this invention consists in the separation between the circuit for the pressurized fluid and that for the lubricating oil, with the aim of preventing the latter from contaminating the pressurized fluid. To accomplish this, the hollow rotor 15 defines a sort of oil chamber 15a in which is immersed the fixed camshaft 29, which permits splash lubrication. In particular, the oil chamber 15a communicates through an annular passage 37 between the hollow hub 32 of the rotor and the camshaft extension 29b, with a first chamber 37' in the end wall 12, said chamber 37' in its turn communicating through the bearing 16, with an annular chamber 37'' containing a rotating seal 38 between the oil circuit and the compressed air circuit. A second seal 38' is provided between the oil circuit and the outside about the compressor shaft 17. The annular chamber 37'' on the left in fig. 1 communicates in its turn, through a duct 39, with a corresponding annular chamber 37'' in the other end wall 11 of the compressor in which there a second seal 38'' is provided. By contrast, as shown in the detail of figure 4, lubrication of the rotor rods 33 occurs through special channels 40 as an effect of their repeated reciprocating movement.

Figure 3 is a detailed drawing of the hydraulic seal which is formed between the radially most outward edge of each vane 19 and the internal wall delimiting the stator chamber 14.

As is known, when air is compressed, the moisture it contains is condensed and this leads to the formation of a thin film of water 41 on the internal surface of the chamber 14 along the compression area 14b.

According to this invention this phenomena and the film of condensed water is exploited to form a hydraulic seal along the edges of the vanes 19. For this purpose, as shown in fig. 3, the radially most outward edge of the vane 19 is provided with a step contour, that is, with a rounded saw-tooth profile, which gradually diverges from the internal surface 14b of the stator chamber starting from the step 19a of the vane towards the rear side of the same as defined by the rotational sense of the rotor. As a result of this step contour on the vane edge and because of the effect of the water film 41 on the internal wall of the stator chamber, a sort of water cushion 42 is formed in the concave surface of the step 19a, which prevents any leakage of the fluid under compression, so that in this way an effective seal is formed between moving parts. The arched and diverging form of the rear part of the edge of the vane 19 also facilitates the discharge of the water film into the next compression space, so preventing the phenomenon of water hammering.

If the fluid to be compressed is a gas or fluid which in the liquid state has a high density or viscosity, the problem associated with the seal along the edges of the vanes is less acute; this is because the compressed fluid that partially condenses along the cooled surface of the chamber 14, in the compression area, contributes to form the hydraulic seal referred to above.

The rotary compressor according to his invention operates as briefly outlined below. The vanes 19, while being drawn around by the rotating rotor 5, are kept centred with respect to the stator by the shaft 29. This enables them to faithfully follow the internal cylindrical profile of the chamber 14, remaining at a narrow distance from its wall, without giving rise either to fictional effect or, accordingly, to consequent overheating or wear. At the same time, the hydraulic seal between the vanes 19 and the internal surface of the stator chamber 14 is broadly effective in preventing a loss of pressure between one space and the next, defined by the vanes.

Considering the eccentric position of the rotor 15 with respect to the stator chamber 14, as well as the eccentric position of part 29c of shaft 29 with respect to the rotor, said shaft 29 performs precisely the function of a cam or of a crankshaft which causes a progressive radial reciprocating movement outwards and backwards of the vanes 19 with respect to the rotor 15. Accordingly, starting from the position in which a vane is totally recessed, as shown in the upper part of fig. 2, and viewing the rotation of the rotor as indicated by the arrow in the figure, the vane will gradually move from the totally recessed position to that in which it fully emerges as rotates through the intake arc 14b of the chamber 14. It will then gradually return to the recessed position as rotate through the right-hand or compression arc 14a, as diagrammatically shown.

A rotary vane compressor for air or gas is thus provided in which all frictional effects between the vanes 19 and the surface of the internal chamber of the stator are eliminated, so obviating any need for lubrication that releases lubricating oil into the compressed fluid and thereby removing any cause of further overheating of the gas. Lubrication of the rotating parts can, therefore, be effected separately and independently from the gas compression circuit, which remains uncontaminated by the lubricating oil. The result is a considerable simplification in the design and operation of the compressor which makes it particularly suitable and advantageous for medium and low power compressors. It follows that it may be employed and utilised in any sector where the rotary vane compressor used to be excluded both because of the high costs of a traditional machine and the need to undertake complex operations to separate the compressed fluid from the lubricating oil.

It is intended that what has been stated and shown with reference to the appended drawings has been presented purely to exemplify, the innovative and operative principles of the dry rotary compressor according to the invention, and that other modifications and variants may be provided without thereby departing from the principles claimed.

Claims

1. A rotary vane compressor comprising a stator (10) defining a chamber (14) delimited by a cylindrical wall in which a rotor (15) eccentrically rotates, said rotor (15) being provided with vanes (19) sliding radially in corresponding slots (18) which extend longitudinally to the rotor (15), said chamber (14) comprising along its periphery a first intake area (14b) connected to an inlet (20) for the fluid to be compressed and a second compression area (14a) connected to an outlet (22) for the compressed fluid, characterised by the fact that said varies (19) extend to within a short distance from the internal wall of the stator chamber (14); by the fact that said rotor (15) is hollow and comprises fixed cam means (29) for controlling the vanes (19), and by the fact that said vanes (19) are rotatably connected to said cam means (29) inside the above-mentioned hollow rotor (15).

2. A rotary compressor according to claim 1, characterised by the fact that said cam means

(29) are positioned eccentrically with respect to the rotor (15) and coaxially to the chamber (14) of the stator (10).

3. A rotary compressor according to claim 1, characterised by the fact that said cam means (29) are in the form of a shaft (29), said shaft (29) being eccentrically positioned with respect to the rotor (15) and coaxially arranged to the stator chamber (14), and by the fact that said vanes (19) are connected by sliding rods (33) to rings rotatingly supported by the above-mentioned shaft (29).

4. A rotary compressor according to claim 3, characterised by the fact that said shaft (29) is rotatingly supported by hollow hubs (32) of the rotor (15) and is fixedly connected to an end wall (12) of the stator (10).

5. A rotary compressor according to claim 1, characterised by the fact that it comprises means (26) for refrigerating the stator (10) along the compression zone (14a) of said chamber (14).

6. A rotary compressor according to claim 5, characterised by the fact that said refrigeration means comprise a semi-cylindrical refrigeration chamber (26) for the circulation of a refrigerating fluid, said refrigeration chamber (26) externally surrounding the stator chamber (14).

7. A rotary compressor according to claim 1, characterised by the fact that said intake area (14b) of the stator chamber (14) communicates with the inlet (20) for the fluid through an intake chamber (25).

8. A rotary compressor according to claim 7, characterised by the fact that the stator wall in coincidence of the intake chamber (25), comprises fluid-admission openings (21) that extend in inclined directions with respect to the stator axis.

9. A rotary compressor according to claim 8, characterised by the fact that said fluid-admission openings (21) are oriented according to cylindrical helices.

10. A rotary compressor according to claims 8 or 9, characterised by the fact that the openings (21) in one half of the intake chamber (25) are inclined in one direction, and the openings (21) in the other half of said chamber (25) are inclind in the opposite direction.

11. A rotary compressor according to claim 1, comprising a circuit (39) for lubricating oil, characterised by the fact that said lubricating-oil circuit (39) is separated and distinct from the circuit for the fluid to be compressed inside the stator (10).

12. A rotary compressor according to claim 11, characterised by the fact that sealing means (38, 38') are provided between the path (39) of the lubricating oil in the compressor and the path of the fluid to be compressed, and also between the path of the lubricating oil and the outside of the compressor.

13. A rotary compressor according to claim 12, in which the rotor (15) is rotatably supported in the stator (10) by bearing means (16) located at the rotor hubs (32), characterised by the fact that on one side of each bearing (16) the stator (10) comprises an annular lubricating-oil feed chamber (37''), said annular feed chamber (37'') being positioned concentrically to the stator hubs (32), and by the fact that at least one of said oil chambers (37'') is in communication with the inner cavity of rotor.

14. A rotary compressor according to claim 3, characterised by the fact that said vane rods (33) comprise internal lubricating-oil circulation ducts (40) that open to the cavity inside the rotor (35).

15. A rotary compressor according to claim 1, characterised by the fact that it comprises hydraulic seal means (42) between the radially outermost edge of each vane (19) and the internal wall of the stator chamber (14).

16. A rotary compressor according to claim 15, characterised by the fact that said hydraulic seal means comprise a step contour (19a) on the external edge of the vane (19) and a liquid cushion (42) in the step cavity of a condensed liquid film on the inner surface of the stator chamber (14).

17. A rotary compressor according to claim 15, characterised by the fact that the rear portion of external edge of the vane (19) comprises a profile diverging with respect to the cylindrical surface inside the chamber (14) of the stator (10).

18. A rotary compressor according to claim 17, characterised by the fact that said vane edge comprises an arched profile.

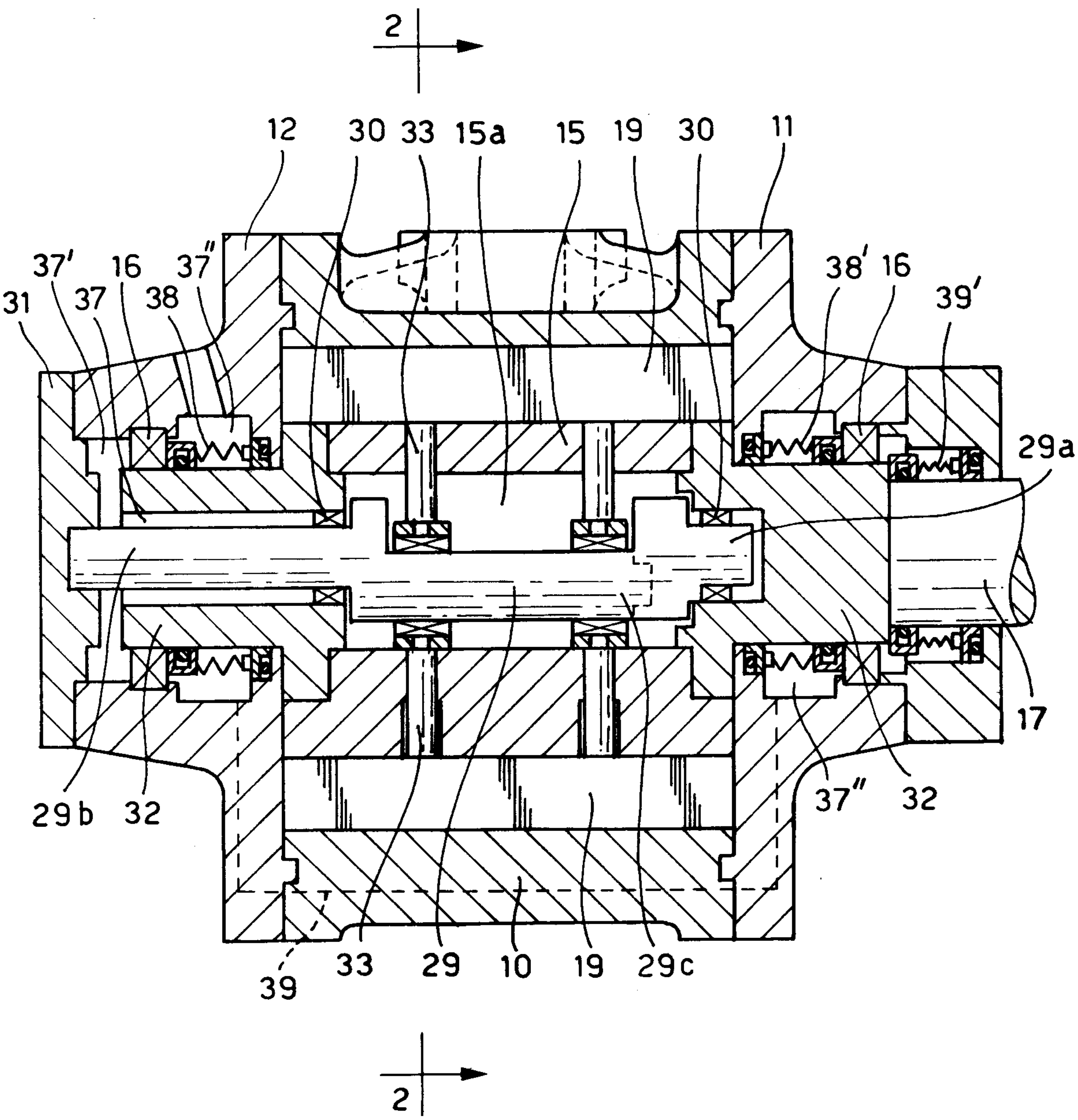
2
12
30
33
15a
15
19
30
11
37'
16
37''
38' 16
31
37
38
39'
29a
17
29b
32
37''
32
33
29
10
19
29c
39
2

Fig. 1

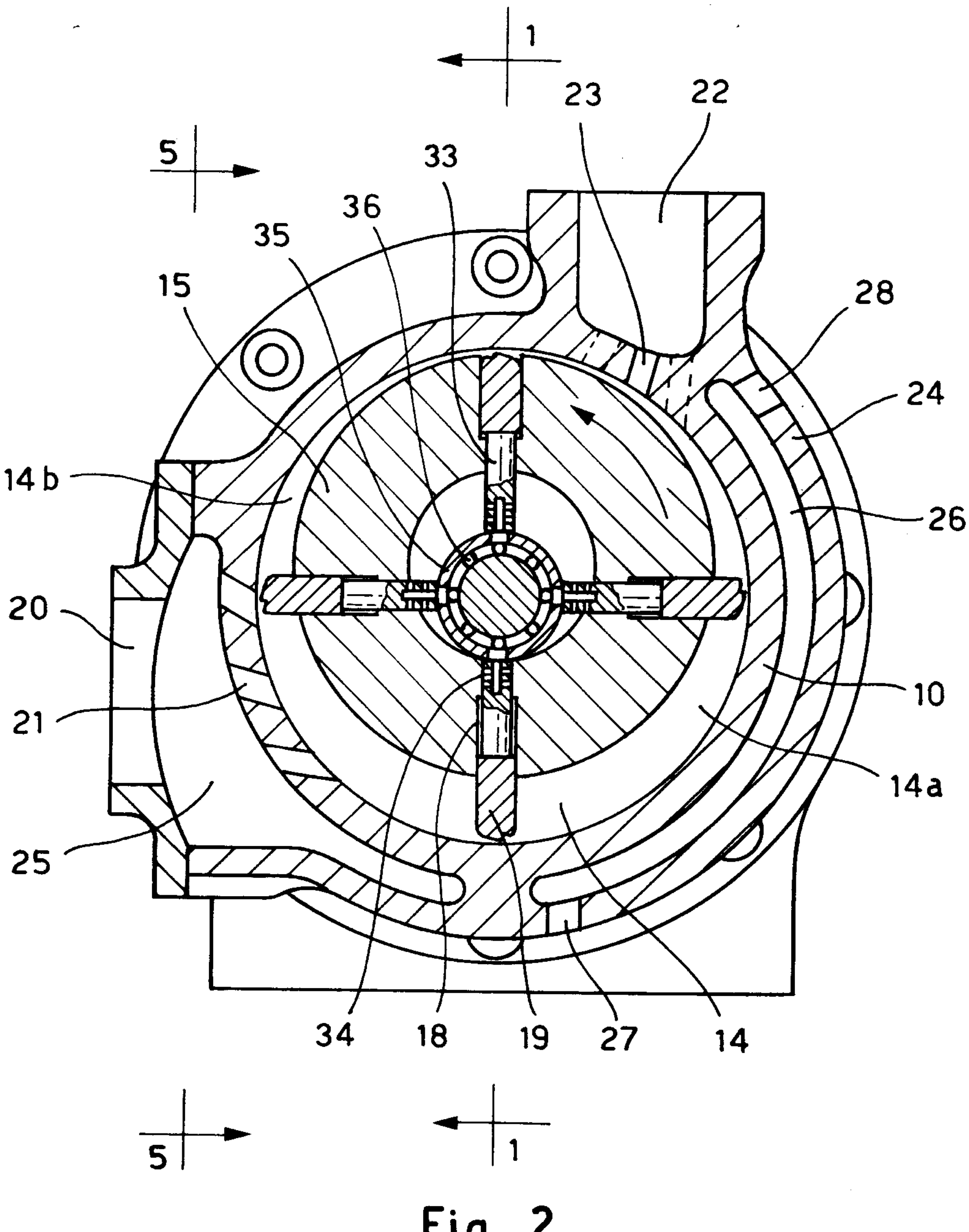

Fig. 2

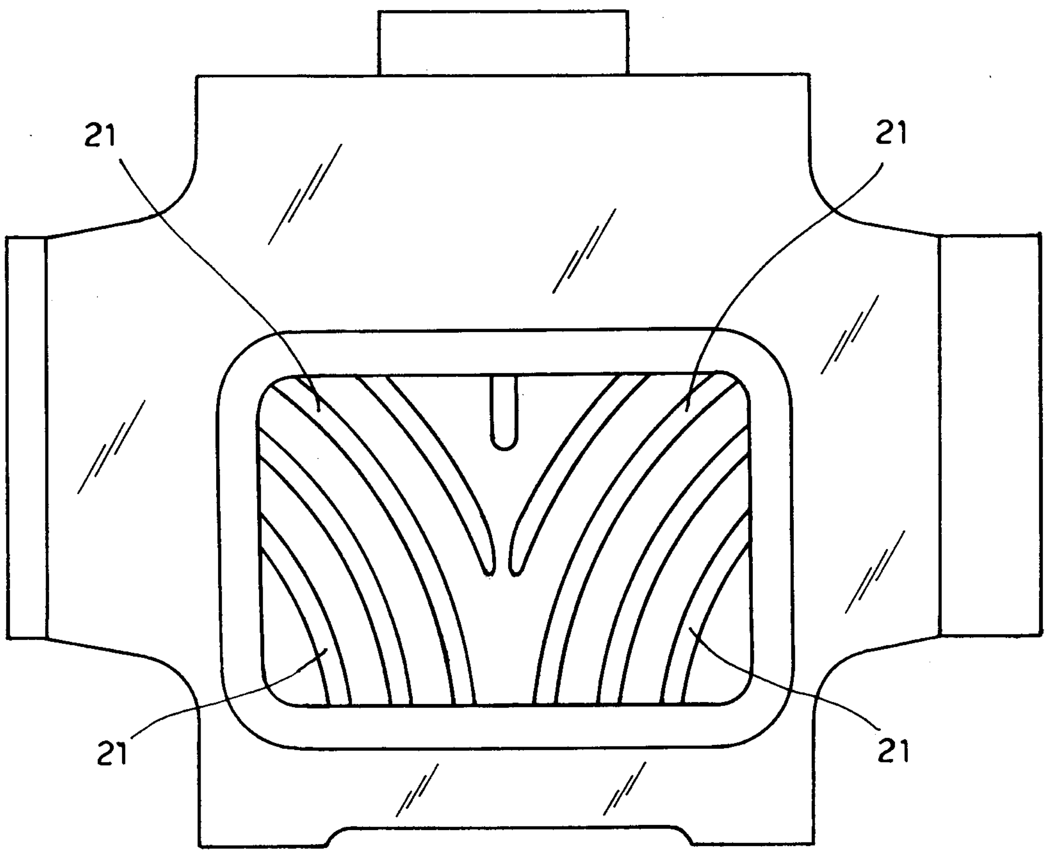

Fig. 5

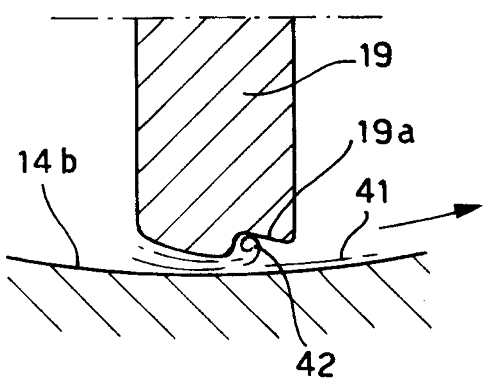

Fig. 3

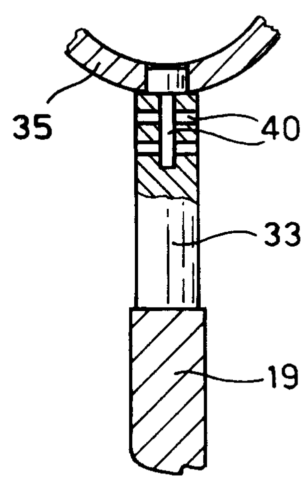

Fig. 4