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Sommer

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[54] **ROTARY PISTON PUMP**

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Nov. 2, 1972 Austria 9332/72

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[51] **Int. Cl.** **F01c 1/00;** F01c 21/00; F04c 1/00

[58] **Field of Search** 418/152, 153, 225–227, 418/260, 261, 264, 265, 233

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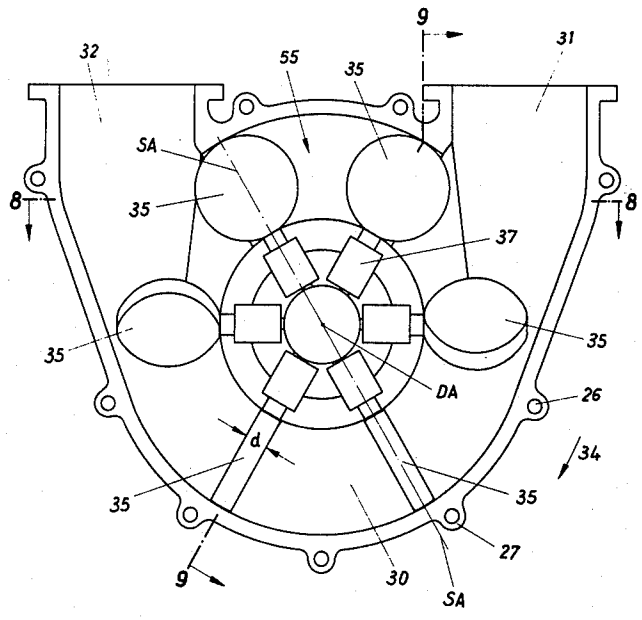
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Attorney, Agent, or Firm—Robert E. Burns; Emmanuel J. Lobato; Bruce L. Adams

[57] **ABSTRACT**

A rotary piston pump comprises vanes mounted on shafts extending radially from a hub and traveling around an annular channel having a forwarding or pumping portion of circular cross section and a restricted sealing portion corresponding in cross section to the diametrical cross section of the vanes. Control means is provided for turning the vanes about radial axes so as to position the vanes approximately perpendicular to their direction of movement while passing through the forwarding portion of the channel and to turn them approximately 90° so as to pass through the sealing portion of the channel in an edgewise position. At the ends of the forwarding portion the channel is connected respectively with inlet and outlet passageways.

21 Claims, 14 Drawing Figures



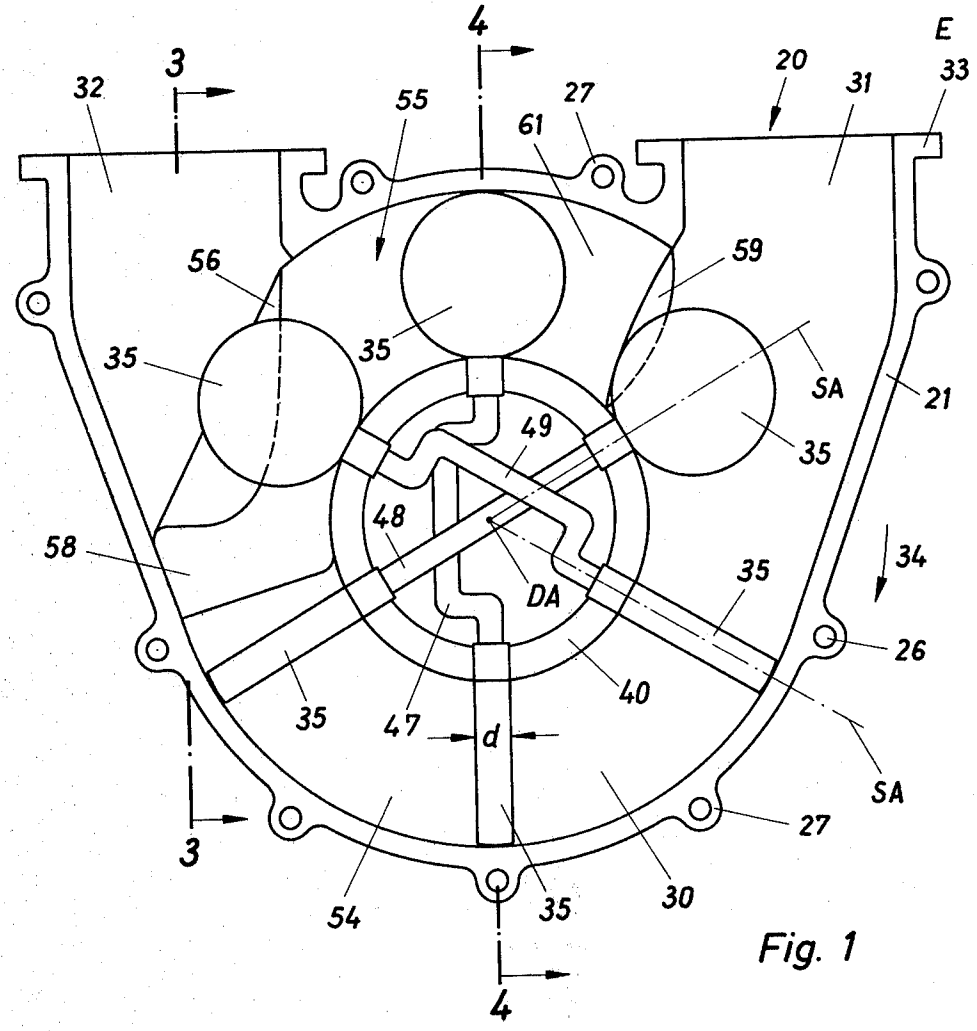

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Fig. 1

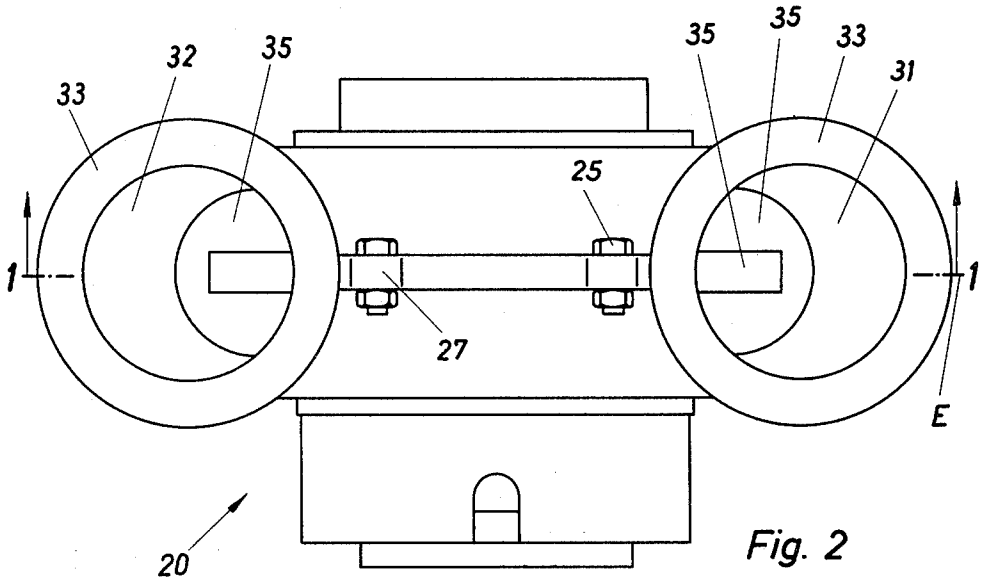


Fig. 2

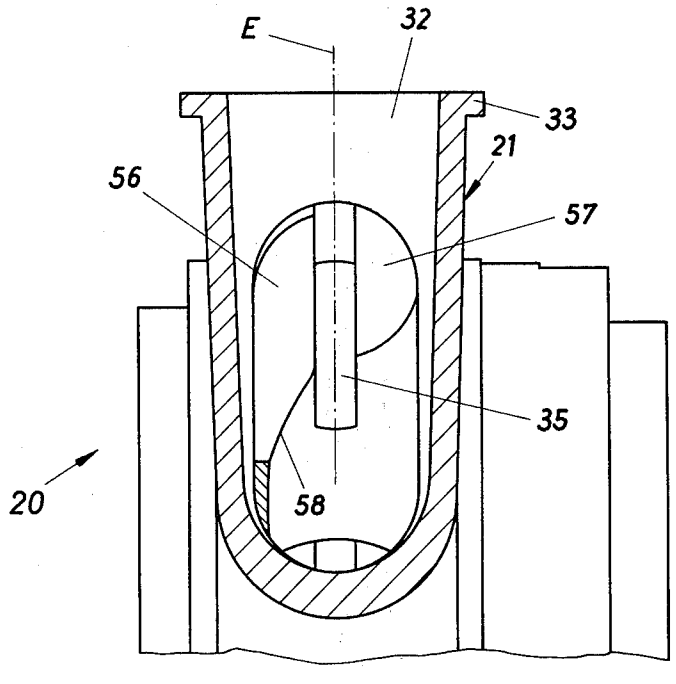


Fig. 3

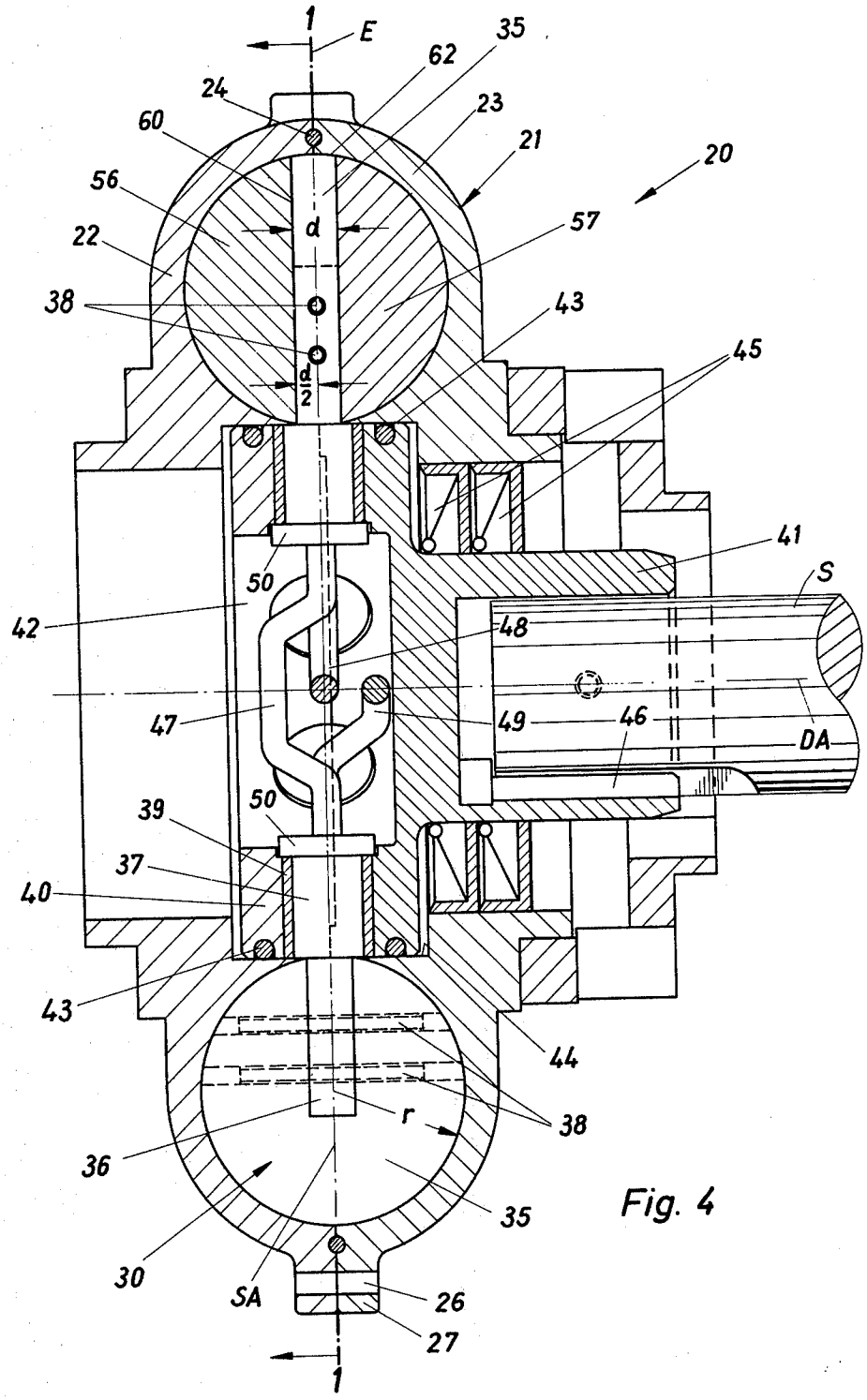

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Fig. 4

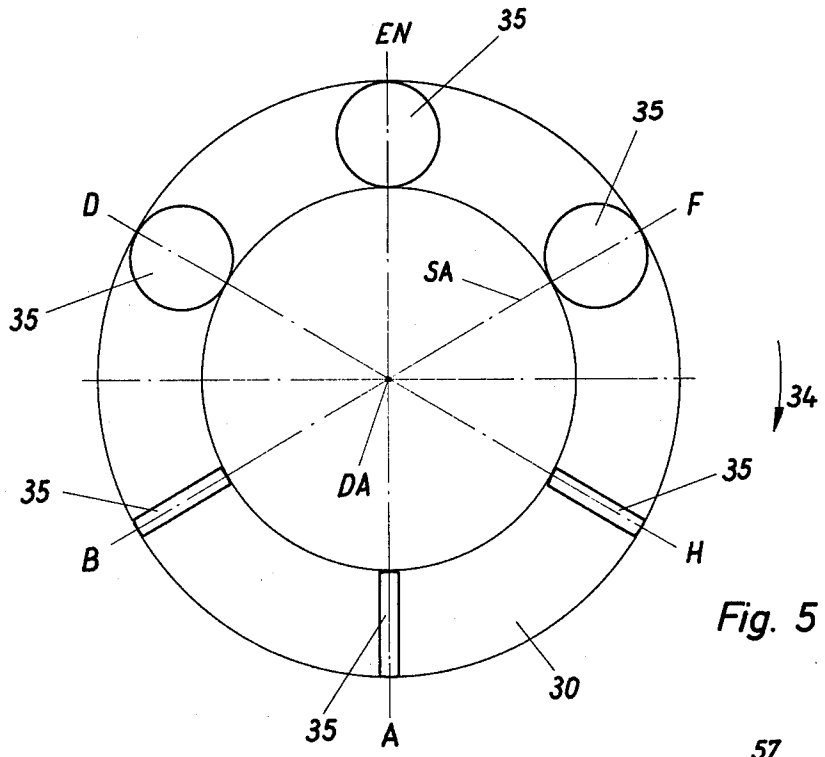


Fig. 5

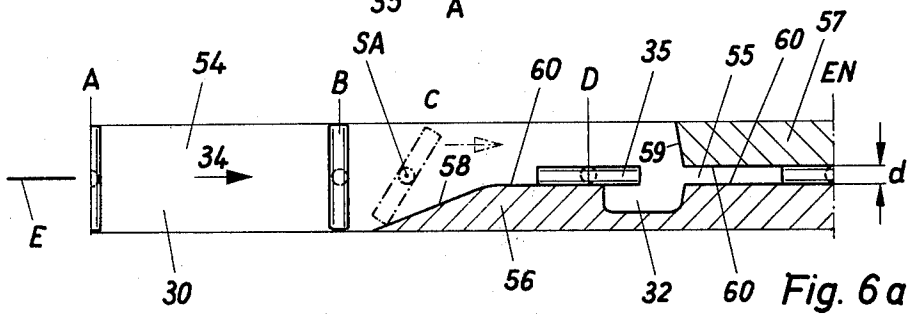


Fig. 6a

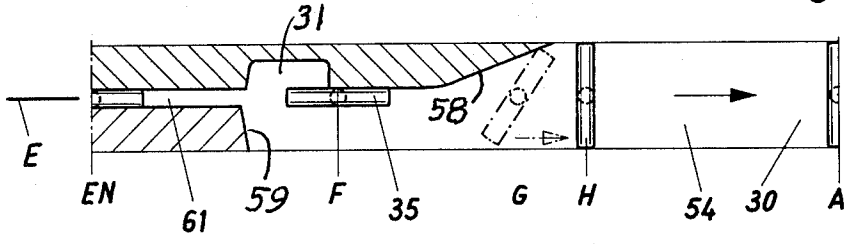


Fig. 6b

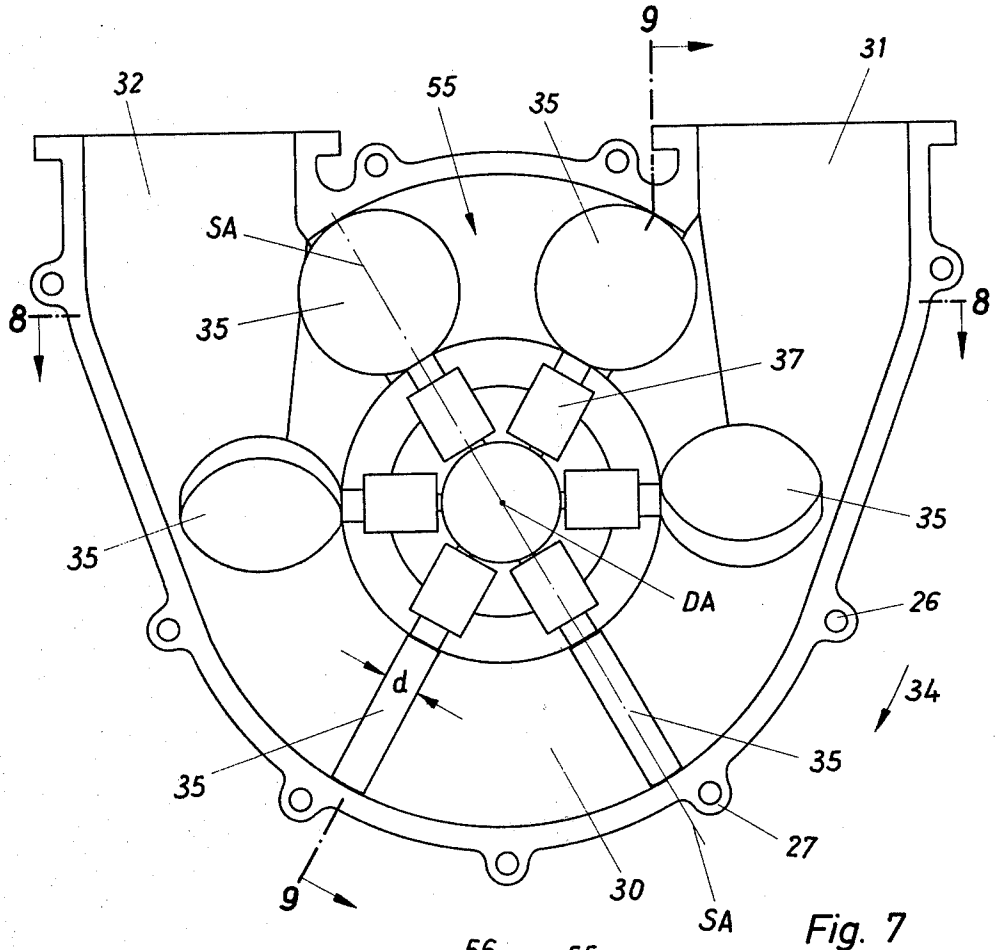

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Fig. 7

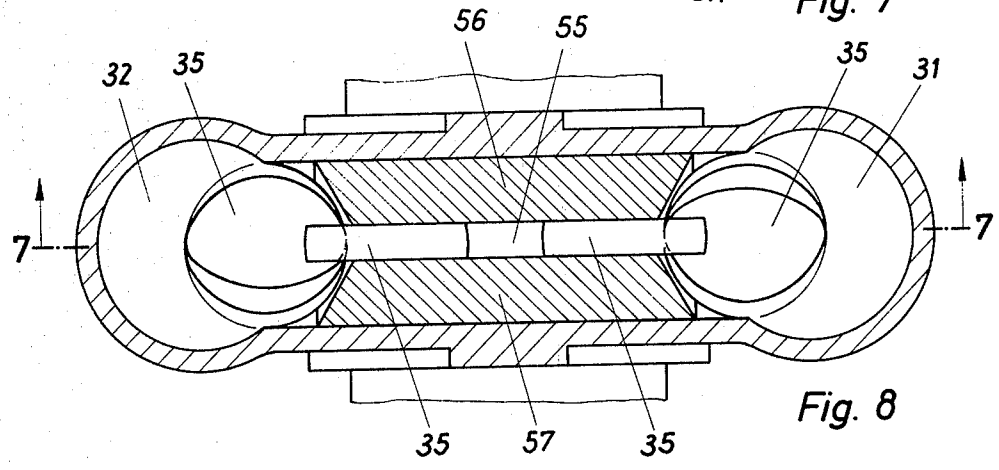

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Fig. 8

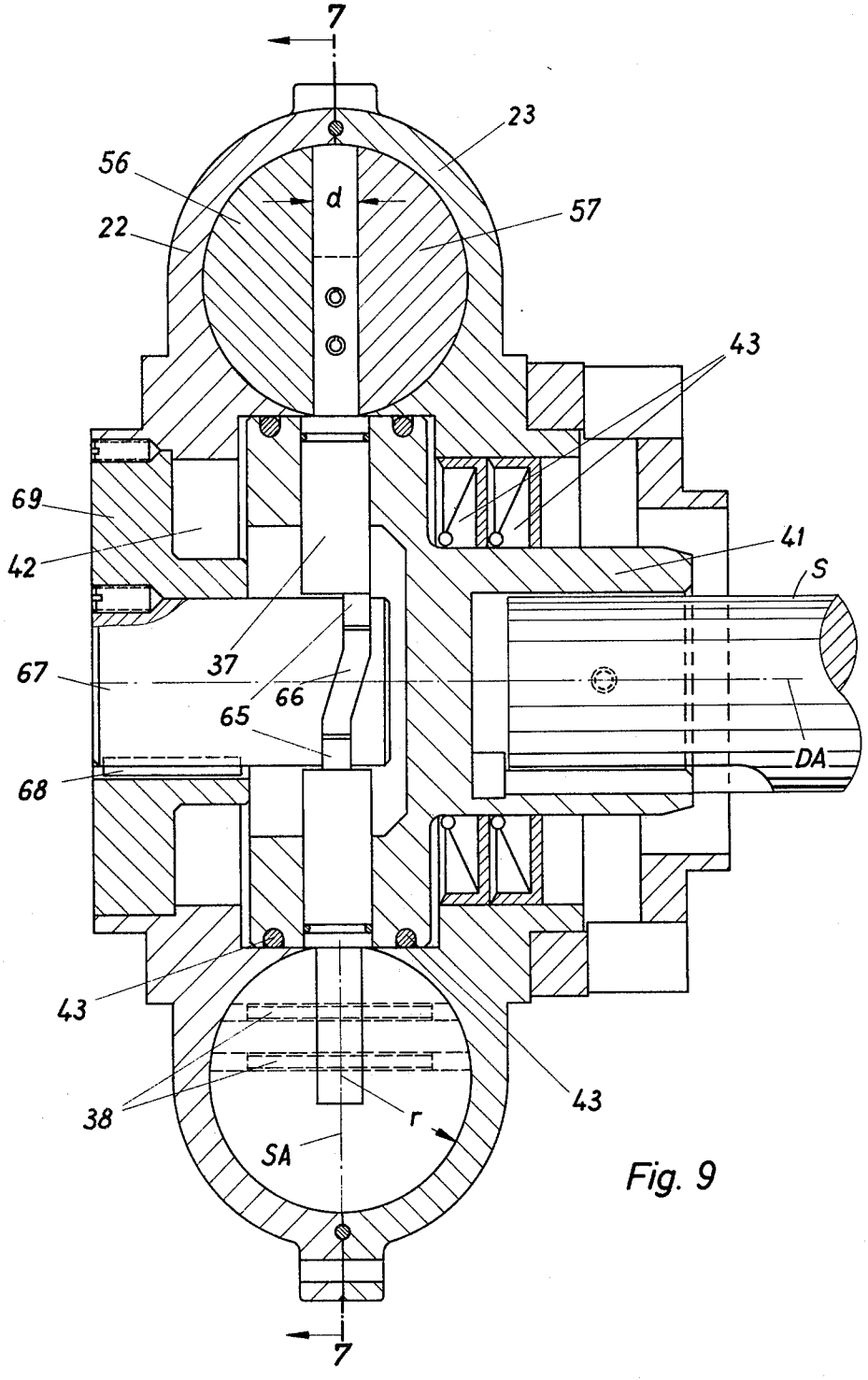


Fig. 9

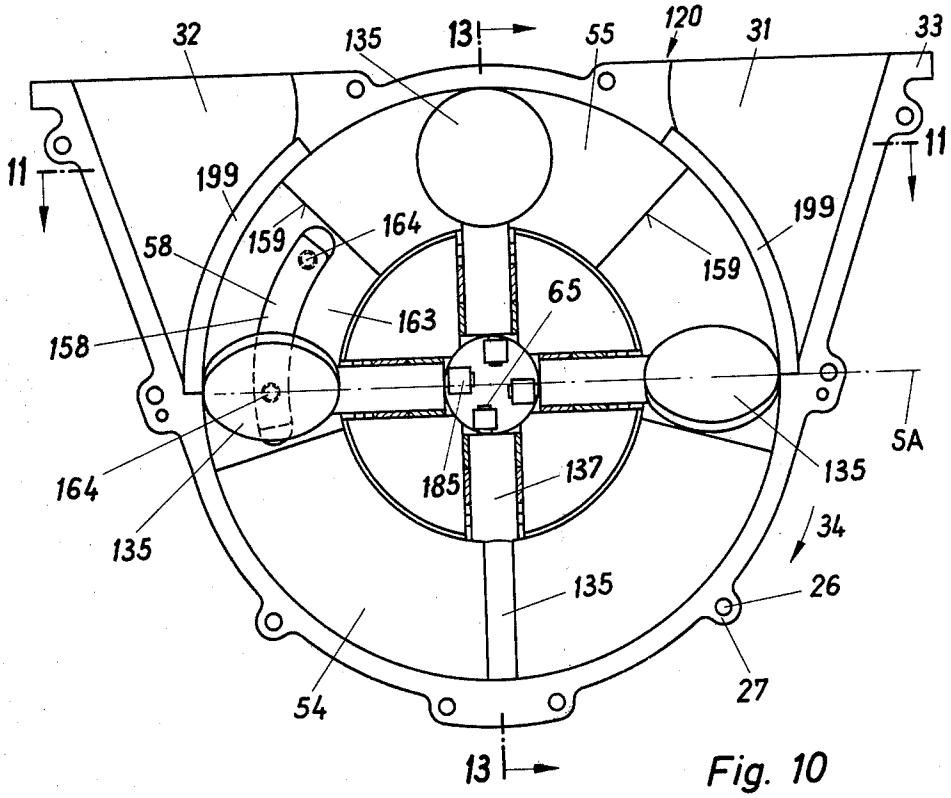


Fig. 10

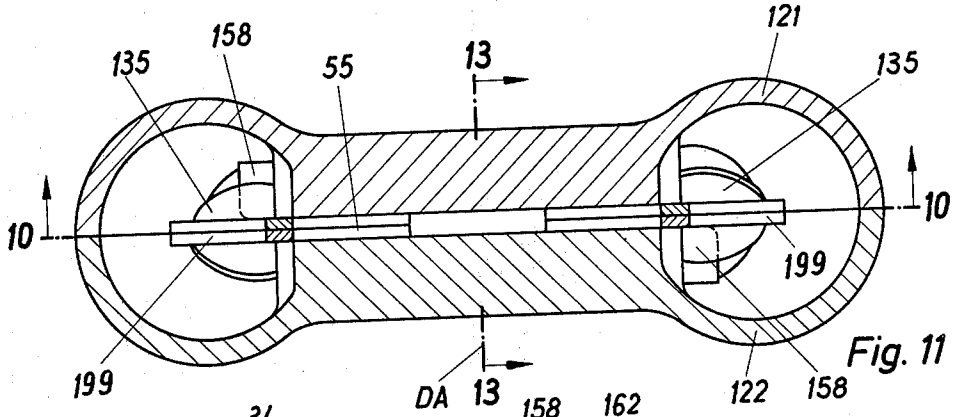


Fig. 11

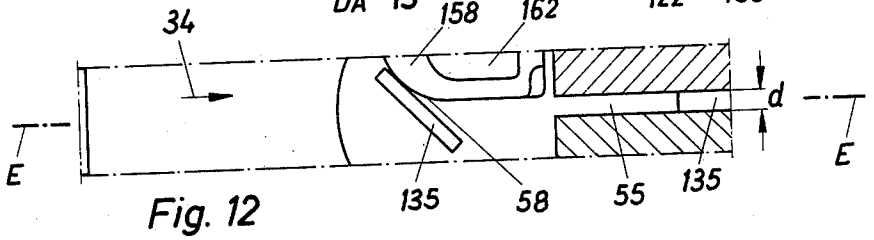


Fig. 12

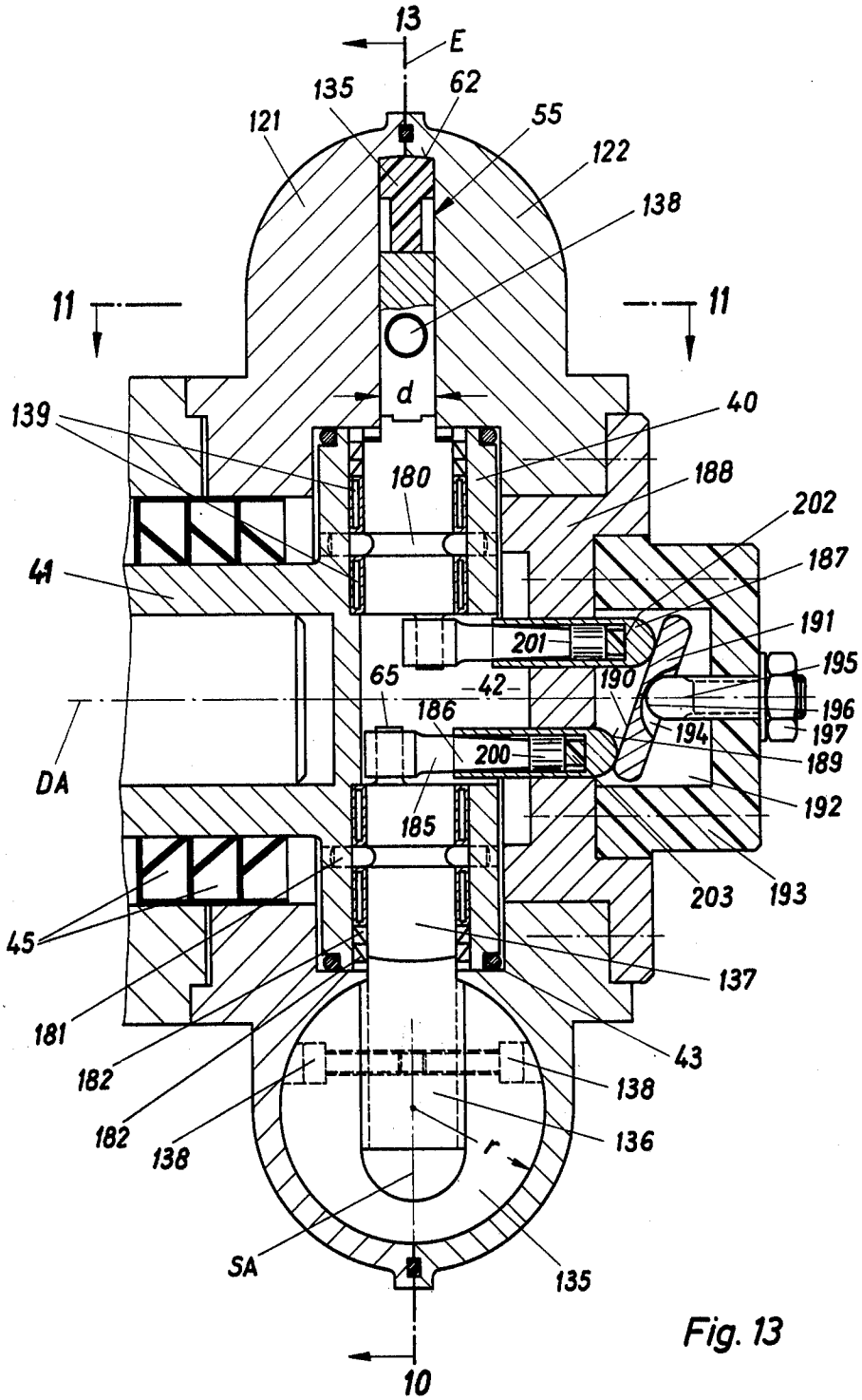

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Fig. 13

ROTARY PISTON PUMP

FIELD OF INVENTION

The invention relates to rotary piston pumps and in particular to pumps having a plurality of vanes traveling around an annular channel provided with inlet and outlet ports. The pump is suitable for pumping almost any fluid medium and especially suitable for pumping either viscous or non-viscous liquids which may or may not contain solid pieces or particles. A pump in accordance with the invention is particularly useful in handling beverages, food stuffs and chemicals.

BACKGROUND OF INVENTION

Many different pumping systems and constructions are well known. Apart from piston pumps and centrifugal pumps there are various rotary piston pumps which seek to combine the advantages of the piston pump and the centrifugal pump. However, in practice many difficulties are encountered. Such pumps are not suitable for all purposes. In particular the sealing of the pumps frequently presents difficulties. Among others there are vane cell pumps in which an eccentric rotating inner body is provided with radial slits in which vanes are slidably inserted. They extend to the outer wall and are in general rectangular. The pump chamber is sickle form so that a pumping effect is obtained as the inner body rotates and the vanes slide in and out in the slits. Vane cell pumps are not suitable for pumping all media, in particular not for such media as contain coarse or stringy particles, for example mash which is used in producing food and beverage products.

There is also known for a long time a pump of the above indicated type in which widely spaced relatively small vanes lie in openings of a rotating disc which passes through a sealing portion of a canal with the vanes in the plane of the disc so as to ensure a seal. This obviously impractical pump has no proper means for controlling the vanes and moreover serious problems through the circulating sealing discs. In addition to friction losses and difficulties, there is above all the danger of large solid objects of the medium being pumped becoming wedged between the edges of the vanes and the vane openings of the disc. Moreover, the pump is not capable of operating in either direction. It is not suitable for use in the food, drink and above all the wine producing industry.

SUMMARY OF INVENTION

It is an object of the present invention to produce a pump which is simple in construction and operation and is characterized by laminar flow of the fluid stream, high capacity with small size and high suction power. The pump in accordance with the invention makes possible smooth operation comparable to that of a centrifugal pump and moreover minimizes crushing or turbulence in the medium being pumped. It is almost wholly insensitive to foreign bodies protected against dry running and is wear resistant. Moreover, it can be operated in either direction.

In accordance with the invention there is provided a rotary piston pump having a pump chamber in the form of an annular channel having a forwarding or pumping portion of circular cross section and a sealing portion of restricted cross section. Disc-like vanes mounted on shafts extending from a hub rotatably concentrically with the annular channel are disposed in the channel

and travel circumferentially around it as the hub rotates. The vanes are rotatable about their axes radial of the hub and the turning of the vanes is cyclically controlled so that the vanes pass edgewise through the sealing portion of the channel while being turned approximately perpendicular to their direction of movement in the forwarding or pumping portion of the channel. Inlet and outlet passages are provided respectively at opposite ends of the forwarding portion of the channel. Suitable means provides fluid tight seals between the relatively moving parts of the pump.

In accordance with the invention the distance between two adjacent vanes and the length of the sealing portion of the channel are coordinated so that the next following vane has entered the sealing portion of the channel to provide a complete seal before the preceding vane has passed out of the sealing portion of the channel. Moreover, the circumferential edges of the vanes are rounded so as to permit free turning of the vanes while maintaining a close seal between the vanes and the channel walls. At the entrance of the sealing portion of the channel there is provided an inclined ramp or entrance surface which is engageable successively with the vanes as they approach the sealing channel and may be used as means for turning the vanes so as to enter the sealing channel in an edgewise position. In order to assure smooth running, the entrance surfaces and/or the vanes are formed wholly or in part of elastic material so as to avoid impact shocks.

In accordance with the invention, the advantages of a piston pump and of a centrifugal pump are combined in a single pump wherein the vanes traveling around the annular pump channel approach the piston pump system but, instead of rectilinear back and forth movement of the piston in a piston pump, the piston like vanes travel in a circular path and carry the pumped medium with them in the spaces between successive vanes. After turning to an edgewise position, the vanes pass through a restricted sealing part of the channel between pressure and suction zones and after passing through the sealing channel portion they are turned back to operating position upon entering the forwarding or pumping portion of the channel. The gradual turning of the vanes to working position is possible even if foreign bodies and coarse particles are present in the medium being pumped without the particles being crushed or the pump being damaged since the turning of the vanes occurs in a zone in which a complete sealing between the vanes and the surrounding walls of the channel has not yet been attained and because there is no possibility of clamping the circulating vanes. Because of the constant cross section of the channel in the forwarding or pumping portion of the channel, any crushing of pieces in the pumped medium, for example fruit or berries, is avoided.

The pump in accordance with the invention is particularly suitable for the beverage and food industry and above all for the wine producing industry for the transportation of the mash which is produced by a crushing mill and provides the base material for production of wine. However, the pump in accordance with the invention is also suitable for other thinner liquids and also for liquids containing coarse particles, for example in the chemical industry. No objects such as berries can become lodged in the rotatable vanes as is the case with sliding vanes of a vane cell rotary pump. Rotary vanes can be sealed essentially better than sliding vanes.

Through the rotatable arrangement of the vanes, it is possible to round the edges so as to obtain a better sealing with the walls of the conveying channel than is possible with the rectilinear contour of sliding vanes. The rounding has the further advantage that objects in the transported medium are not damaged. Through the elastic construction of the vanes and/or the entrance ramps to the sealing portions of the channel a very smooth conveyance of the pumped medium is obtained and on the other side free running of the pump is made possible.

By reason of the spacing of the vanes and the length of the sealing canal being coordinated with one another, it is unnecessary to have any additional sealing members since a seal is provided by the vanes themselves in conjunction with the sealing portion of the channel. There is, of course, passage of a small amount of the pumped medium through the sealing channel between the vanes so that there is a corresponding small loss from the pressure zone to the suction zone of the pump. However, this is insignificant in consideration of the simple construction, the easy sealing and the favorable empty running characteristics of the pump. The capability of the pump to handle media containing coarse particles is also significant. The circular form of the vanes and of the channel cross section is particularly favorable for production and sealing techniques and for the rotatable mounting of the vanes and easy working of the channel walls. Finally, the circular vanes can, if desired, be sealed with piston rings although for most purposes it is undesirable to have movable elements on the vane circumference since a good seal can be obtained with the rounded form of the vanes. The turning of the vanes about a radial axis of rotation in order to lie in a circumferentially extending plane makes possible an advantageous bearing in a driven hub portion. The elastic entrance faces avoid hard impact and guide the vanes in a noise-free manner and avoid damage through foreign bodies or hard objects in the medium being pumped. Through the elastic form of the vanes the running characteristics not only with respect to noise but also with respect to dry running is essentially improved. The resilience of these parts avoids impact. Above all foreign bodies in the medium being pumped cause no disturbance.

Two identical ramps or entrance faces, whether they engage the vanes only locally or on the entire side edge, are advantageously provided at both inlet and outlet connections of the pump so that the channel has a symmetrical profile and the pump can be run in either direction. This is particularly convenient for transferring media back and forth between two containers and represents an important advantage of these pumps.

The pressure faces of the vanes can be formed in four manners. In order to obtain a high capacity and minimize losses, the vanes are made as thin as possible. The pressure faces of the vanes may be formed curved in order to take the stresses acting in the location of the bearing or to make the profile form conform to the loading. This requires corresponding profiling of the cross section of the channel in the sealing zone. With a view to easy production and good sealing characteristics it is however desirable to select plane pressure faces for the vanes which are advantageously parallel to one another although they can, if desired, be slightly inclined with respect to one another. The formation of the pressure faces of the vanes depends on the strength and characteristics of the material of the vanes and of their bounding parts.

The guiding of the vanes can likewise be effected in various ways and indeed either in the pump chamber and/or on the bearing element. With control on the bearing element, a control system comprising a cam, levers and sliding elements acts on the bearing shafts of the vanes. This mode of control is indeed more expensive than the pure internal control but has the advantage of providing an exact and above all noiseless movement of the vanes. If it is desired to alter the delivery of the pump while keeping the same speed of rotation, this can be achieved by changing the position of the vanes in the conveying portion of the pump channel. Thus if the vanes are somewhat inclined instead of being perpendicular to the direction of movement, only a portion of the stream will be delivered to the pressure zone while another portion is bypassed.

In order to achieve a simple and easy as well as good control relationship, it is desirable to select an even number of vanes. For the internal control of the turning of the vanes it is then desirable to connect diametrically opposite vanes with one another whereby the two vanes of a pair are disposed at an angle of 90° to one another. With this arrangement when one vane engages an entrance ramp to the sealing chamber and is thereby turned 90°, the opposite and connected vane is thereby turned 90° to a position in which it is perpendicular to the direction of movement. The latter will be held in that position since the connected vane is running through the restricted sealing portion of the channel and is hence held against turning. As all of the vane axes lie in a single plane, all except the one of the connecting members between the vanes of a pair are laterally offset to opposite sides to avoid interference with one another. As the pump is particularly suitable for handling media containing coarse particles, it is desirable to make the connection between the vanes of a pair somewhat elastic so that on engagement with a hard unfavorably positioned object or foreign body, the vane can temporarily deflect and then spring back to its proper position. Moreover, through this elastic connection the impact of engagement of the vanes with the entrance curve of the sealing portion of the channel is minimized and hence the pump runs more smoothly and quietly. The elastic connection can advantageously be formed of spring steel wire.

In order to effect the turning movement of the vanes it is sufficient when the entrance face to the sealing portion of the channel locally engages only a single portion of the vanes. However, to minimize the loss and above all to avoid clamping coarse objects and foreign bodies but to propel them out of the discharge port, it is desirable for the entrance surface to conform in profile exactly to the corresponding developed profile of the vanes so that the entrance surface engages the entire side edge of the vanes. Another advantageous form is for the entrance faces to be formed of small rods which provide openings between them and the channel wall for the passage of the medium and coarse particles contained therein. A clamping of the pump parts and the medium being pumped is thereby avoided in a simple manner. The profiled parts which form the entrance face not only can be made of, or covered with elastic, plastic material but also can be made of correspondingly profiled spring steel sheet metal. The vanes can be

made of rubber or also of other elastic high strength plastic materials such as polyamides or the like.

A desirable constructive form for the bearing and guiding of the vanes is provided when the vanes are provided with inwardly projecting bearing shafts which are rotatably received in openings in a rotatable hub which is coaxial with the annular pump channel. Suitable seals are provided between the rotating parts and the housing. If the pump housing is preferably made of two parts which are joined together with a suitable sealing gasket in the central plane of the pump channel, the pump can be easily produced and can easily be assembled and disassembled, as the entire hub portion together with the vanes can be taken off with one part of the pump housing.

For a favorable form of the control of the vanes, bearing stubs can be provided eccentrically on the inner ends of the bearing shafts of the vanes. A particular reliable and very quiet running arrangement is provided when these stubs are linked to connecting rods which extend generally in the direction of the axis of rotation of the pump rotor and their ends engage an inclined face of a control member coaxial with the axis of rotation so that the vanes after leaving the sealing portion of the channel are turned to a position perpendicular to the direction of movement and upon running on to the entrance faces to the sealing portion of the channel they are turned so as to lie in the direction of their movement. Such a combination of control by the entrance faces and the linkage and cam arrangement makes it possible to vary the play between the entrance faces and the control member disposed outside of the pump chamber. This is important for the practical realization of a quiet dependable pump.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, characteristics and advantages of the invention will be more fully understood from the following description in conjunction with the accompanying drawings in which:

FIG. 1 is a central section through a first embodiment of a pump in accordance with the invention, the section being taken on the line 1—1 in FIGS. 2 and 4;

FIG. 2 is a plan view of the pump shown in FIG. 1;

FIG. 3 is a partial section taken along the line 3—3 in FIG. 1;

FIG. 4 is an enlarged cross section of the pump taken along the line 4—4 in FIG. 1;

FIG. 5 is a schematic side elevation showing a vane of the pump in successive phases of its movement;

FIGS. 6*a* and 6*b* are a developed sectional view of the path of a vane and its guiding cams;

FIG. 7 is a vertical section of a further embodiment taken on the line 7—7 in FIG. 9;

FIG. 8 is a horizontal section of the pump taken on the line 8—8 in FIG. 7;

FIG. 9 is an enlarged cross section of the pump taken on the line 9—9 in FIG. 7;

FIG. 10 is a central section through a further embodiment of the pump taken on the line 10—10 in FIGS. 11 and 13;

FIG. 11 is a section taken along the line 11—11 in FIGS. 10 and 13;

FIG. 12 shows half of a developed view of the pump channel with different vane positions; and

FIG. 13 is an enlarged and more detail cross section taken along the line 13—13 in FIGS. 10 and 11.

DESCRIPTION OF PREFERRED EMBODIMENTS

In FIGS. 1 to 6 there is shown a pump 20 in accordance with the present invention having a pump casing 21 which is formed of two casing portions 22 and 23 which are divided along the central plane E of the pump and are united by bolts 25 passing through apertures 26 in eyes 27 provided at the periphery of the pump casing parts. A fluid tight connection between the casing parts is provided by an O-ring gasket 24. In the pump casing 21 there is formed an annular channel 30 which as seen particularly in FIG. 4, is of circular cross section with a radius r. Connecting passageways 31 and 32 open tangentially into the channel 30 and are provided with flanges 33 for connection with inlet and outlet lines of the pump. Although the pump is arranged for right and left running, the connecting passage 31 will for convenience be designated as the inlet or suction connection and the connecting passage 32 as the outlet or pressure connection. They operate in this manner when the pump is rotated in a clockwise direction as indicated by the arrow 34 in FIG. 1.

A plurality of vanes 35 in the form of circular discs run around in the annular channel 30. Six such vanes 35 are shown by way of example in the drawings, the vanes being equally spaced and thus disposed 60° from one another. The vanes 35 are fixed on stub shafts 36 which extend into the vanes from bearing shafts 37 and are fixed to the vanes by pins 38. The bearing shafts 37 are rotatable in bushings 39. They are rotatable about axes SA which are disposed in the central plane E of the pump and extend radially from the axis of rotation DA of the pump. The bearing bushings 39 fit in radial holes provided in an annular hub portion 40 which is formed as a flange-like projection on a driving sleeve 41 and leaves a central space 42 free inside of the hub. The hub portion 40 is sealed with respect to the casing by means of O-ring gaskets 43 which slidably engage cylindrical sealing and bearing faces 44 of the pump casing 21. Shaft packings 45 are provided for further sealing the driving sleeve 41. The driving shaft (not shown) is rotationally connected with the sleeve 41 by means of a key fitting in an axially extending groove 46 provided in the interior of the sleeve.

The inwardly extending bearing shafts 37 of pairs of diametrically opposite vanes 35 are rotationally but elastically connected with one another by means of connecting rods 47, 48 and 49. These rods are formed, for example, of spring steel wire so as to provide torsional elasticity permitting resilient relative angular displacement of the two vanes of a pair. The rod 47 connecting the two vanes 35 appearing in FIG. 4 is offset to the right. It is thereby possible for all of the three pairs of vanes to be turned independently of one another. As seen in FIG. 1 the two vanes 35 of each pair are turned 90° relative to one another. The vanes have a thickness *d*. Stop collars 50 provided at the inner ends of the bearing shafts 37 prevent axial displacement of the shafts and hence the vanes.

The pumping or forwarding portion 54 of the annular channel 30 i.e., the lower portion between the inlet 31 and outlet 32 is completely free and is hence of circular cross section except for an annular opening at the inner periphery of the channel through which the shaft 36 enters. However, the upper sealing portion 55 of the channel is reduced to the thickness *d* of the vanes 35. For this purpose sealing pieces 56 and 57 are inserted

in the annular channel which otherwise is of circular cross section throughout its circumferential extent. The sealing piece **56** has at its left end as viewed in FIG. **1** an inclined entrance face or ramp **58,** the developed profile of which is a gradual rectilinear incline as seen in FIG. **6***a*. However, in cross section it conforms to the circular curvature of the vanes so as continually to engage one entire side edge of the vane as the vane is progressively rotated. The cross sectional contour accordingly varies progressively from approximately semicircular at the upstream end to approximately flat at the downstream end. This form can also be seen somewhat in FIGS. **1** and **3.** The sealing piece **56** extends through the entire sealing part **55** of the channel **30** to the inlet **31** and ends there in a slightly inclined end face **59.** On the outer side engaging the channel wall the sealing piece **56** has an arcuate cross section as seen in FIG. **4** while on the inner side the leading face **58** merges into a plane sealing face **60** which is spaced from the central plane E of the pump a distance equal to half the thickness *d* of the vanes **35.** A like but mirror image sealing piece **57** lies in the right hand part of the sealing portion **55** of the channel **30** as seen in FIG. **4.** The entry face **58** of the sealing piece **57** is located at the inlet **31** of the pump while the end face **59** lies at the outlet **32.** This symmetrical arrangement permits the pump to run in either direction. Between the sealing faces **60** of the two sealing pieces **56** and **57** there is formed a sealing constriction **61** which corresponds in profile to the vanes **35** turned in a direction circumferential of the channel. It is to be noted that the peripheral edges **62** of the vanes **35** are curved with the radius r so that in all positions there is obtained a free bearing and sealing arrangement between the vanes **35** and the walls of the channel **30.**

As the pump is especially suitable for beverages, fruit products and chemicals, all portions coming into contact with the medium being pumped are formed of material having corresponding resistance to attach by the medium being pumped. For example, the pump casing **21** may be made of stainless steel, bronze, gray cast iron, etc., and also of cast steel. The sealing pieces **56** and **57** may also be produced from hardenable alloy steel or also from plastic with corresponding properties. The vanes **35** can be made either from suitable resilient plastic material or advantageously from a rubber compound having corresponding physiologically uncontaminating qualities. They can moreover have a metal core covered with an appropriate rubber or plastic material. Thereby the expected wear will be concentrated almost wholly on the cheaply produced and easily replaceable vanes. To provide for an elastic engagement of the vanes on the leading faces the sealing pieces **56** and **57** can be formed as profiled sheet steel stampings which are set into the casing in such manner as to provide a fluid tight seal.

The pump works in the following manner. The successive phases of movement of the vanes are best illustrated in FIGS. **5, 6***a* and **6***b*, of which FIGS. **6***a* and **6***b* are an extension of one another. The ends A and EN Of FIG. **6***a* join respectively with the ends A and EN of FIG. **6***b* to form a continuous circuit. When the hub **40** is rotated in the direction of the arrows **34** by a motor through a shafts fitting into the sleeve **41,** all of the vanes **35** are carried around with the hub through their respective shafts **36, 37.** At the positions A, B and H the vanes are perpendicular to the circumferential direction of movement. In this position the vanes push ahead of them the fluid to be pumped until they reach the position B. Shortly thereafter the vanes reach the entry face **58** of the sealing piece **56** and, as shown in dotted lines in FIG. **6***a*, they are thereupon engaged by the face **58** so that they are slowly turned about their axes SA until shortly before the position D are disposed in the direction of movement and are thereby ready to engage the sealing faces **60.** They then pass the outlet passage **32.** The outlet **32** appears in FIG. **6***a* as a recess in the sealing face **56** because, on account of its round shape and the transistion to a flat sides passage, a lateral recessing of the sealing face **56** is necessary in order to obtain free flow of the medium being pumped. Upon further rotation of the rotor, the vanes enter the sealing part **55** of the channel which is formed between two opposite sealing pieces **56** and **57** and has a width which is only equal to the thickness *d* of the vanes from the outlet **32** to the end face **59** of the sealing piece **57** at the inlet **31.** When a vane **35** has entered the sealing part **55** of the canal sufficiently to provide a perfect seal, the preceding vane, as will be seen from the following description of FIG. **7,** is still a small distance from the exit end of the sealing canal part **55** so that a continuous seal is provided between the outlet **32** and inlet **31.** Upon exiting from the sealing channel **55,** the vanes pass the inlet **31** and continue along the exit face **58** of the sealing piece **57.** In passing from the position F through the position G to the position H the vanes are turned from a position in line with the direction of movement to a position perpendicular to the direction of movement by engagement of the diametrically opposite vanes with which they are connected by the connecting rods **47, 48** and **49** with the entrance face **58** of the sealing piece **56.** If, however, a vane encounters a hard piece in the liquid being pumped, the resilience of the connecting rod permits the vane to deflect angularly relative to the opposite vane until the obstacle is cleared. During their movement through the forwardly part **54** of the channel **30** the vanes are held in a position perpendicular to the direction of movement by the connected opposite vanes being held between the opposite sealing faces **60** of the sealing portion **55** of the channel. There is thus achieved an automatic control of proper orientation of the vanes as they circulate around the annular channel.

In this circulation of the vanes **35,** the vane which has just been turned to a position perpendicular to the direction of movement will draw the medium being pumped from the inlet **31** and when the following vane is likewise turned to a position perpendicular to the direction of movement, a constant volume of space is defined in the forwarding channel part **54** between the two vanes. The portion of medium thus confined in the forwarding portion of the canal **54** between successive vanes is carried along without any compression and when the leading vane reaches the entrance face **58** and is turned so as to lie in the direction of movement, the greater part of the medium is discharged through the outlet **32.** A small part of the medium will, however, in this embodiment be carried through the sealing part **55** between the vanes turned in the direction of movement. As the pump works in the manner of a piston pump, it is self priming. However, as it is built as a rotary pump there is a very uniform discharge practically without pulsations.

In a second embodiment illustrated in FIGS. 7 to 9 like parts are designated by the same reference numerals. The pump is basically exactly like that illustrated in FIGS. 1 to 6*b* and it also works in the same manner. However, the control of the individual vanes as they travel around the channel is effected by cams and not by coupling with opposite vanes and by entrance ramps.

For the control or orientation of the vanes, the bearing shafts **37** extend into the central hollow space **42** of the hub portion **40** and are provided at their inner ends with eccentrically arranged positioning stub shafts **65.** These engage in a cam track **66** which is provided in a control member **67** disposed concentrically with the axis of rotation of the pump. The cam track **66** is shaped to provide the desired turning of the vanes **35** as they travel around the annular channel **30.** The control member **67** is secured against rotation to a cover **69** which in turn is secured to the left casing member **22** and closes the control space **42.** This embodiment likewise has six vanes. However, as the vanes are independently controlled by engagement of the control shafts **65** in the cam track **66** the vanes can be more closely spaced so that the losses through the sealing space can be limited. The number of vanes can be increased or decreased as desired.

In FIGS. **10** to **13** there is shown a further example of a rotary piston pump which operates on the same principle as the foregoing examples and differs from these primarily only in the form of the control of the vanes. Like parts are designated by the same reference numerals as in the preceding figures.

In the pump shown in FIGS. **10** to **13** there are four vanes **135** which are likewise of circular disc form up to the part in the region of the bearing shafts **137.** The pump housing consists likewise of two essentially symmetrical housing parts **121** and **122** which, except for the slightly different form of the inlet and outlet, differ primarily in that instead of the inserted sealing pieces to limit the sealing portion **55** of the channel, two housing parts **121** and **122** are formed with corresponding thickenings to define a sealing channel portion of the thickness *d*. Also the end faces **159** are not formed in any particular manner although they can also be profiled. The entrance face **58** at the junction of the forwarding portion of the channel with the sealing portion is here formed as a separate inserted entrance piece **158** which consists, for example, of a bar or strip comprising a steel core with covering of a relatively elastic material, in particular an oil and chemical resistant elastomeric plastic material with a Shore hardness of about 80° to 85°, for example a material sold by Farbenfabriken Bayer AG under the name "VULKOLLAN." The entrance piece thus formed is resilient. Each of the entrance pieces **158** is provided with an opening **162** which permits discharge from the channel part **163** of a liquid medium containing coarser material. The members **158** are secured in place by screws **164.** This construction has the advantage that the entrance faces **58** can easily be replaced and can be varied in shape according to need. By reason of this symmetrical arrangement of the entrance surface pieces **158,** the pump is suitable for operation in either direction.

The bearing shafts **137** are, for example, rotatable in needle bearings **139** or in bushings formed of or coated with friction and corrosion resistant material. As shown by way of example in FIG. **13** each shaft is provided with two needle bearings **139** and between these bearings the shaft is provided with an annular groove **180** in which tangential pins **181** engage to secure the shaft against axial movement. A fluid tight seal is provided by shaft gaskets **182.** Flat vane-holding portions **136** extend outwardly from each of the bearing shafts **137** and, as seen in FIG. **13,** are profiled so as to fit into the vanes **135** which are secured on the shaft portions **136** by screws **138.** While the bearing shafts **137** and their holding portions **136** are formed of steel or of rust free metal, the vanes **135** are made of plastic, for example a polyamide. As in the previously described embodiments, the circumferential edges **62** of the vanes are of parti-spherical form with a radius *r*.

On the inner ends of the bearing shafts **137** which extend into the central control space **42,** there are provided control stub shafts **65** which, as in the embodiment of FIG. **9,** are eccentric to the turning axis SA of the bearing shaft. Connecting rods **185** are pivotally connected with the eccentric stub shafts **65.** The connecting rods **185** have slightly tapered conical end portions **186** and are formed of steel. They extend slidably and rotatably into pushing casings **187** and are disposed essentially in the direction of the axis of rotation DA, i.e., any deviation from this direction is due only to the eccentricity. The pushing casings **187** are slidable in the direction of the axis of rotation DA in a guiding flanged cover **188** secured to the right hand casing part as viewed in FIG. **13.** The pushing casings have rounded ends **189** which run over an inclined surface **190** of a control disc **191** which is tiltably arranged in a control disc chamber **192** formed in a cap-form cover **193.** This cover **193** is preferably formed of a high strength plastic for example polyamide. The control disc **191** has a central spherical recess **194** by means of which the disc **191** is easily tiltable on the rounded inner end of a supporting stem **195** which is received in the recess **194.** The supporting stem **195** is provided with an external threaded portion and is screwed into a threaded opening in the cover **193** so that it can be axially adjustable. It is held in adjusted position by a lock nut **197.** The guiding cover **188** and cap **193** are secured in place by means of screws of which only the center lines are indicated in the drawings. Small pistons **200** which are slidable in the push casings **187** bear on the ends **201** of the connecting rods **185.** Between these pistons **200** and the internal bearing faces **202** of the casings **187** there are spring elements **203** which are formed of an elastic plastic or rubber of very good quality and good spring characteristics, for example the above mentioned material "VULKOLLAN." These spring elements provide a not too soft elastic connection between the control stubs **65** of the shafts **137** and the inclined face **190** of the control disc **191** so as to provide very quient running and good control of the pump.

In both of the connecting passageways **31** and **32** there are provided bars **199** which lie in the central plane E of the pump and serve to guide the medium being pumped and to hold back any hard solids to prevent them from contacting and possibly damaging the vanes of the pump.

The manner of operation of the pump shown in FIGS. **10** to **13** is basically the same as that of the previously described examples. However, the control of the vanes

of the pump is somewhat different and will be described as follows.

When the four vanes **135** of the pump are driven in the direction indicated by the arrow **134,** the vane which appears at the left in FIG. **10** and in the middle of FIG. **12** is approaching the entrance surface **58** of the entrance member **158** and upon further movement is turned so as to lie in the direction of movement and in the plane E so that it can enter the sealing portion **55** of the channel. During this turning of the vane, movement of the respective pushing casing **187** toward the right is permitted by the inclined face **190** of the control disc **191** and hence the pusher **187** can move to the right to the uppermost position shown in FIG. **13.** The position of the control disc **191** is controlled by the turning of the vane upon engagement of the entry face **58** in combination with the position of the supporting stem **195** of the control disc. When the vane **135** after passing through an angle of 90°, which is the angle between the vanes, passes out of the sealing part **55** of the canal, the sliding of the rounded end **189** of the pushing casing **187** over the inclined face **190** of the control disc **191** serves to push the connecting rod **185** through the spring element **203** so as to turn the respective vane to a position generally perpendicular to its direction of movement in the pump channel. The vane then travels in this position through the forwarding portion **54** of the channel. The play between the head **189** of the pusher casing **187** and the face **190** of the control disc **191** and the elasticity of the spring element **203** take care of any necessary equalization and provie a quiet running and efficient pump. If it is desired to decrease the delivery of the pump while keeping the speed of rotation the same, the supporting stem **195** cana be adjustably screwed outwardly so as to give the control disc **191** more play. The vanes **135** are thereby positioned at a slightly inclined angle while passing through the forwarding portion **54** of the channel so that they do not provide a complete seal and thereby permit a certain backflow of the medium being pumped.

Instead of the control disc **191** being tiltably supported by the support rod **195** it can be replaced by a fixed control piece having a correspondingly inclined control face on which the rounded ends **189** of the connecting rods slide. Alternatively, in order to reduce friction, there can be provided an axial ball bearing in the nature of a swash plate between the connecting rods and the control member. Moreover, the control face instead of being flat can under proper circumstances be given a profiled form in order better to suit the geometrical structure, although with the construction shown in the drawings the necessary equalization is well taken care of through the spring elements and the play between the connecting rods and the control disc.

While preferred embodiments of the invention have been shown in the drawings, various modifications can be made particularly with respect to the control of the turning and the holding of the vanes. For example the control can be provided by any appropriate means that permits the vanes to pass through the sealing portion of the channel while being held at the desired angle of incidence through the forwarding portion of the channel.

The invention has the following advantages:

1. High capacity with small size. A pump of the illustrated construction with vane diameters of 60 mm and a speed of rotation of 1,000 rpm delivers 80,000 l/h. With a vane diameter of 90 mm the capacity is increased to 160,000 l/h. Thus with an increase of 50 percent in the diameter of the vanes the capacity of the pump is approximately doubled.

2. The pump is self-priming and has the same suction characteristics as a piston pump. It is capable of automatically removing air from the suction space.

3. The liquid flow is laminar so that the pump operates smoothly like a rotary pump without crushing the medium being pumped and without turbulence. Even at low speed the pump works uniformly and quietly.

4. The pump is insensitive to foreign bodies and large solids in the medium being pumped. It is protected against running dry. This characteristic is improved through the possibility of making the vanes elastic.

5. The pump is also suitable for viscous media and media containing solid particles.

6. The pump can be made very resistant to wear, erosion and corrosion.

7. The pump can be run in either direction.

8. The pump will work in any position.

What I claim and desire to secure by letters patent is:

1. A rotary piston pump comprising a casing having an annular channel therein, a hub rotatable in said casing concentric with said annular channel, said hub comprising a shaft portion rotatably supported in said casing and an overhanging annular flange portion at an inner end of said shaft portion and having a central space inside said shaft portion and having a central space inside said annular flange portion, said flange portion being disposed wholly radially inwardly of said annular channel of the casing, means providing a fluid tight seal between said hub and said casing, means for rotating said hub, a plurality of circumferentially spaced generally radial shafts extending through and rotatably supported by said annular flange portion of said hub, a flat circular disc-shaped vane mounted on the outer end of each of said shafts and disposed in said annular channel whereby upon rotation of said hub, said vanes are carried around in said annular channel, said channel having an arcuate pumping portion of uniform circular cross section corresponding in size to said circular vanes and a sealing portion of restricted cross section corresponding in size and shape to the diametrical cross section of said vanes, inlet and outlet openings at the opposite ends respectively of said pumping channel portion and means for cyclically controlling the rotational orientation of said vanes in said channel to hold said vanes at least approximately perpendicular to the direction of movement while passing through said pumping channel portion and to position said vanes in line with said direction of movement for passage through said sealing channel portion, said controlling means comprising portions of said shafts extending inwardly to said central space inside said annular flange portion of said hub, an eccentric portion on the inner end of each said shaft and actuating means acting cyclically on said eccentric portions to orientate said vanes, the peripheral edge of each of said vanes in cross section being of spherical curvature and being formed of resilient non-metallic material to provide an effective seal with the wall of said channel, the circumferential length of said sealing channel portion being at least slightly greater than the spacing between successive vanes whereby one vane enters the upstream end of said sealing channel portion sufficiently to form a seal

therein before the preceding vane exits from the downstream end of said sealing channel portion.

2. A rotary piston pump according to claim 1, comprising means for varying the angle of said vanes while in said pumping channel portion to provide different delivery rates of the medium being pumped while the speed of rotation of the pump is the same.

3. A rotary piston pump according to claim 1, wherein said actuating means comprises stationary cam means disposed in said central space in said hub and engaged by said eccentric portions as the hub rotates to control the rotational positioning of said shafts and the respective vanes.

4. A rotary piston pump according to claim 1, wherein said channel and said inlet and outlet openings are symmetrical about a diametrical line midway between said openings so that opposite halves are mirror images of one another, whereby said pump is reversible.

5. A rotary piston pump according to claim 1, comprising means in at least said inlet opening for guiding the medium being pumped into said channel and for holding back excessively large solid objects in said medium.

6. A rotary piston pump according to claim 1, wherein there are an even number of said vanes not less than four.

7. A rotary piston pump according to claim 1, wherein said hub comprises a cylindrical body portion rotatable in said casing and adapted to be connected to a motor for driving said hub and an annular flange portion extending axially from said body portion and rotatably supporting said shafts.

8. A rotary piston pump according to claim 1, in which said sealing means comprises packing rings providing a seal between said body portion of the hub and said casing and sealing rings providing a seal between the periphery of said flange portion and a surrounding portion of said casing on opposite sides of said channel.

9. A rotary piston pump according to claim 1, wherein at least the peripheral edge portion of said vanes is formed of a resilient non-metallic material selected from the group consisting of elastomers and resilient plastics.

10. A rotary piston pump according to claim 9, wherein at least the peripheral edge portion of said vanes is formed of a polyamide.

11. A rotary piston pump according to claim 1, further comprising ramp means disposed upstream of said sealing channel portion and engageable successively with one side of each of said vanes.

12. A rotary piston pump according to claim 11, wherein said ramp means is resilient to lessen the impact of the vanes therewith and thereby contribute to the smooth quiet running of the pump.

13. A rotary piston pump according to claim 11, wherein at least a surface portion of each of said vanes engaging said ramp means is resilient to lessen the impact of the vane with said ramp means and thereby contribute to the smooth quiet running of the pump.

14. A rotary piston pump according to claim 11, wherein said ramp means engages each of the vanes locally.

15. A rotary piston pump according to claim 11, wherein said ramp means comprises a formed sheet metal member set in said channel.

16. A rotary piston pump according to claim 11, wherein said ramp means comprises at least one bar with an opening between the bar and the wall of said channel for the passage of objects in the medium being pumped.

17. A rotary piston pump according to claim 1, wherein said actuating means comprises connecting rod means connected to each said eccentric portion and extending approximately parallel to the axis of said hub and guided for endwise movement, and a control member having an inclined face engageably by the ends of said connecting rod means.

18. A rotary piston pump according to claim 17, wherein said control member is a disc tiltably supported at its center.

19. A rotary piston pump according to claim 17, comprising means for adjustably moving said control member axially of the hub shaft axis to vary the play between said connecting rod means and said inclined face and thereby provide play of a selected amount in the connection between said vanes.

20. A rotary piston pump according to claim 17, wherein each of said connecting rod means comprises two telescopically disposed members with elastic means therebetween to provide selected longitudinal resiliency.

21. A rotary piston pump according to claim 17, wherein said inclined face of said control member is plane.

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