June 23, 1964 R. A. BIELEFELD 3,138,321

ROTARY VANE PUMP

Filed March 22, 1962 2 Sheets-Sheet 1

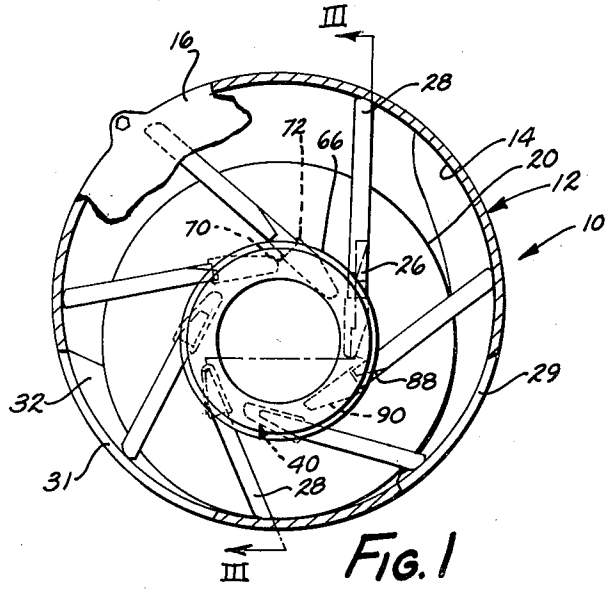


FIG. 1

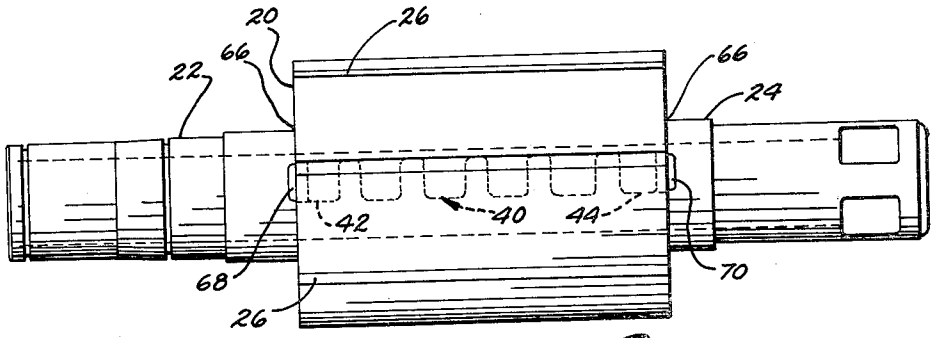


FIG. 2

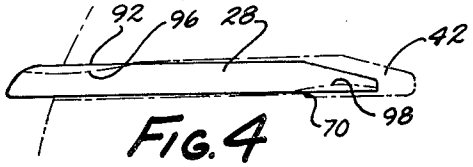
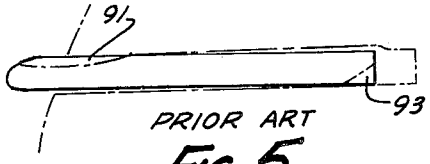


FIG. 4



PRIOR ART

FIG. 5

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ROTARY VANE PUMP

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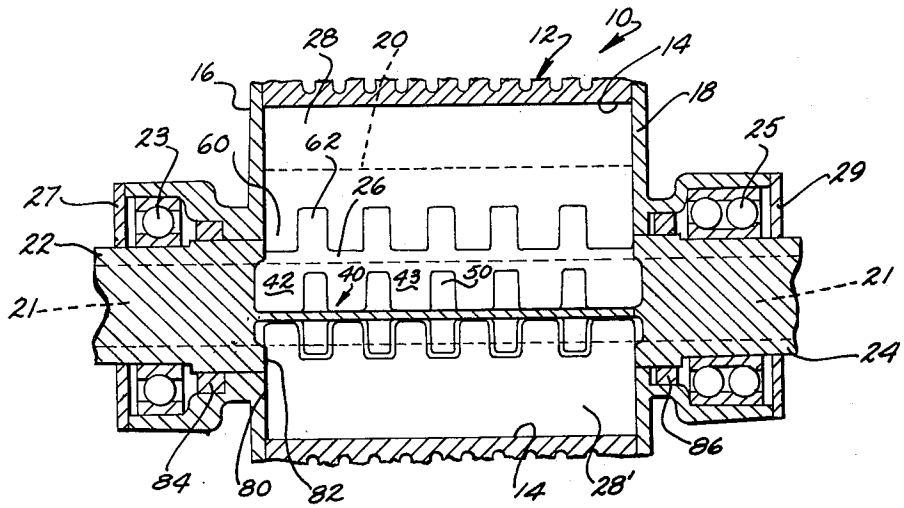


FIG. 3

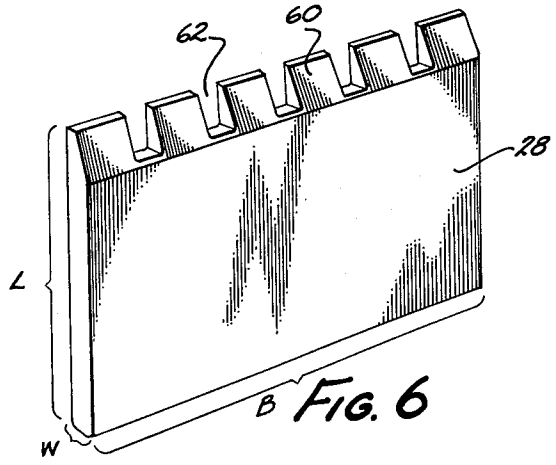


FIG. 6

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ROTARY VANE PUMP

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This invention relates to pumps, and more particularly to rotary vane-type compressors, and vacuum pumps.

The output and efficiency of a rotary vane-type pump per overall size increases as the rotor hub size decreases, as the number of vanes increases, and as the length of vanes increases. Long wear and life characteristics are obtained by radially longer vanes. Ordinarily, one or more of these characteristics is sacrificed in favor of the others due to their obviously inconsistent natures. For example, long vanes ordinarily require a large rotor hub since the slots, when extended to accommodate the long vanes, create structural weakness in the hub, especially if a hollow hub is used for maximum cooling as disclosed in applicant's copending application Serial No. 196,267, filed May 21, 1962, and entitled Cooled Rotary Pump. Further, long vanes extending through a small hub require arranging the slots and vanes at a greater angle to the radius with the slots thus extending substantially past the central hub axis. This causes the center of gravity of each vane to be substantially closer to the hub axis, thereby hindering the centrifugal outward thrust of the vanes and creating inadequate radial acceleration characteristics of the vane. As another example, a large number of vanes ordinarily requires short vanes or a large rotor hub since the greater the number of slots to accommodate the vanes, the weaker the hub structure unless it is made substantially larger or the slots are made shallower. Even when slots are made deeper to accommodate longer vanes, delicate and expensive finishing operations must be performed at the bottom of the slots, thus adding to the expense of the unit.

Another factor ordinarily detracting from top efficiency involves the insufficient end sealing of vanes on the housing end walls. Much of the blow-by or leakage occurs along the end walls between the bottom edge of the vane and the rotor shaft since the vanes do not extend radially inwardly far enough to seal off all of the end wall area.

It is an object of this invention to provide a novel vane-type rotary pump of greatly increased wear life, efficiency and potential output per size of the unit since the structure is inherently capable of employing extra long vanes in a relatively small rotor, and yet in spite of the long vanes and slots, can accommodate a relatively large number of vanes for the small rotor size and the greater vane length.

Another object of this invention is to provide a rotary vane-type pump wherein extra long vanes are accommodated in extended slots where the extension or slot base requires no finishing operations. Further, the extensions, by their configuration or size create a longer life for the vane due the creation of a distributed wear on the vane sides. Also, the vanes themselves possess a unique configuration providing extra length without substantially weakening the hub structure, and with a center of gravity allowing proper centrifugal acceleration to provide uninterrupted sealing on the housing periphery.

Another object of this invention is to provide a novel rotor and vane construction which substantially eliminates the usual blow-by at the ends of the housing between the lower edge of the vane and the end shaft.

These and several other objects will be apparent upon studying the following specification in conjunction with the drawings in which:

FIG. 1 is an end view of the novel vane-type pump;

FIG. 2 is an elevational view of the novel rotor hub and end shafts of the pump illustrated in FIG. 1;

FIG. 3 is an elevational sectional view of the novel pump taken on plane III—III of FIG. 1;

FIG. 4 is an enlarged side view of a vane in the novel rotor slots showing the balanced wear pattern formed thereby;

FIG. 5 is an enlarged view of a vane in a conventional rotor slot showing the unbalanced wear pattern thereof; and

FIG. 6 is a perspective view of the novel vane used with this pump.

Referring now to the drawings, the novel pump **10** includes a housing **12** defining an inner peripheral cylindrical housing wall **14** enclosed by a pair of end plates **16** and **18** (FIG. 3). Although the invention is described with respect to a cylindrical housing, it may be generally cylindrical or of some other suitable configuration such as oval shaped. These end plates may be of the simple construction shown or may comprise the novel construction set forth in my copending application Serial No. 196,267, filed May 21, 1962, and entitled Cooled Rotary Pump. Eccentrically mounted within the housing on an axis parallel to that of the housing is a rotor hub **20** having integral end shafts **22** and **24** at least one of which extends through the end plate to permit attachment of a pulley or coupling (not shown) for driving the pump. The end shafts are rotatably mounted on bearings **23** and **25** in the end plates. Caps **27** and **29** may be used to close the bearings off as desired.

The end shafts and rotor are preferably hollow to define an elongated passageway **21** enabling cooling of the apparatus as set forth specifically in my above identified copending application. Rotor hub **20** includes a plurality of generally radially oriented slots **26** extending the length of the rotor hub and adapted to receive slidable vanes **28** therein. The housing is provided with a conventional inlet port **29** and adjacent end plate **32**. The location of the inlet and exhaust ports is not critical, and may be in the end plates and/or in the housing.

According to the invention, slots **26** are provided with a radially inward extension or cavity well means **40** at the base of each slot **26**. Each cavity well means includes at least cavities **42** and **44** adjacent the end walls **16** and **18**, and preferably includes a plurality of spaced cavities over the breadth of the hub slot **26** from end to end of the rotor hub as illustrated at **42**, **43** and **44** in FIG. 3. Intermediate the cavities are strengthening ribs or webs **50** which provide the necessary structural rigidity and strength to the hub even though the slots are extended a considerable amount, and even though a hollow hub and end shafts are used. The slot extensions protrude radially within the cylindrical periphery of the end shafts and thus within the circular conjunction **66** of the end shafts with the rotor hub as seen in FIG. 1. Preferably,

the end cavities extend a small amount into the end shaft itself as at **68** and **70**.

In forming the novel rotor, the entire hub and end shafts are cast as one integral unit with the slots and slot extensions or cavity means being cored out according to conventional casting processes. The extensions or cavity means are formed with a width substantially greater than the adjacent portions of the slots. Thus, the side walls and bottom surface of the added cavities need not be finished by machining since the vanes do not contact these surfaces. Shoulders **70** and **72** are formed between the narrower and wider slot portions. The shoulder is in sliding contact along a substantial portion of the side surface adjacent the inner edge of the vane during operation (as described hereinafter) to produce a balanced wear pattern on both ends of the vane.

Extra long vanes **20** are used in combination with the special rotor hub the length L of each vane (FIG. 6) is the dimension from the inner edge to the outer edge. The breadth B (FIG. 6) is the dimension from one lateral edge to the opposite lateral edge. The width W is the smallest dimension from face to face across the thickness of the vane. The same terminology applies to corresponding slot dimensions. Each vane includes a plurality of spaced projecting fingers **60** interfitting with the hub slot extension cavities, and a plurality of intermediate recesses **62** interfitting with the hub strengthening ribs **50**. In splite of the extra length of the vanes, the center of gravity is close enough to the outer edge to effect proper centrifugal vane acceleration and thereby forestall hanging up of the vanes in the depressed position. This is achieved both by the cut-away recesses **62** in the vanes and the diagonal beveled portions at **88**. The cavities may also be shaped with a taper **90** to match the diagonal inner vane edge, thereby further strengthening the hub structure.

Operation

During operation of the pump, acting either as a compressor or a vacuum pump, air is introduced through inlet port **29** and is compressed by the rotating hub and vanes as the space between the hub and the housing inner peripheral wall becomes smaller. The vanes are thus depressed gradually into the slots. When the vane becomes completely depressed like vane **28'** in FIG. 1, the inner edge thereof with its projections extend into the cavities within the imaginary cylindrical extension of the end shafts into the rotor hub. Thus, the side edges **80** (FIG. 3) of the vanes contact the inner walls **82** of the end plates over the entire distance between the outer peripheral housing wall **14** and the cylindrical periphery of the shafts **22** and **24**. Thus, this entire area is substantially sealed against blow-by.

The extra length of the vane provides longer life since the notched inner edge is capable of supporting the worn vanes to supply much more wearing surface at the outer edge.

Also, long effective life is achieved by a novel balanced wear pattern (FIG. 4) caused by the extra wide extension or cavity means. As each vane rotates, it tends to bear against one outer edge of the slot **92** and against the novel shoulder **70**. As the vane slides backwardly and forwardly over these edges, wear occurs over a large area of the vane on each end like that indicated in phantom at **96** and **98**. Thus, the wear on each end is spread over an area of the vane rather than being concentrated. According to the prior art as illustrated in FIG. 5, edge wear on the outer end **91** is over an area but wear on the inner end of the vane is along the very edge **93** rather than on a large side area of the vanes, thereby resulting in localized wear which creates greater sloppiness and faster deterioration of the vane.

may occur to those in the art upon studying the principles of the invention taught, without departing from the inventive concept. Such modifications are deemed

Various other advantages and slightly modifications to be part of this invention which is to be limited only by the scope of the appended claims and the reasonably equivalent structures thereto.

I claim:

1. In a rotary vane pump, the combination of a housing; a rotor hub eccentrically located in said housing; said housing including end plates; end shafts extending from both ends of said rotor hub into said end plates; at least more than four elongated slots in said rotor hub for receiving slidable vanes; said slots extending perpendicular to a diameter of said hub and extending beyond said diameter; the innermost portions of said slots including a plurality of longitudinally spaced recesses separated by a plurality of strengthening ribs formed integral with the central portion of said rotor hub; and a plurality of vanes in said slots having cooperating projections to fit into said recesses and cooperating cut outs to receive said ribs to enable vanes with said cut outs to be accommodated in said slots without detrimentally weakening said hub.

2. In a rotary vane pump, the combination of: a housing, a rotor hub eccentrically mounted in said housing; said housing including end plates having faces closely adjacent the ends of said rotor to form a seal against excessive gaseous flow around the ends of revolving vanes; integral end shafts extending from both ends of said rotor hub into said end plates and through at least one end plate; a plurality of elongated slots in said rotor hub for receiving elongated slidable vanes; cavity well means at the base of each of said slots extending radially inwardly past the end shaft peripheries and extending the breadth of said hub from one end plate to the other end plate; said cavity well means including a plurality of wells separated by strengthening webs formed integrally with the central portion of said rotor hub; and sliding vanes in said slots extending from one end plate to the other end plate to form a seal on the end plates against excessive gaseous leakage by contacting said end plates; said sliding vanes including cut out portions for receiving said strengthening webs; at least the longitudinal end portions of each of said vanes being longer than the respective slot to extend into said well means when depressed into said slots during operation and thereby seal off the end wall area between the end shafts and the bottom end portions of said vanes to substantially lessen leakage of gases thereby under high compression conditions.

3. A rotary pump comprising: a housing including a peripheral inner wall and two end walls; a rotor hub eccentrically and rotatably mounted in said housing and having its end surfaces closely adjacent said housing end walls; circular end shafts extending from said rotor through at least one of said end walls; a plurality of elongated vane-receiving slots in said hub extending the breadth of said hub from one housing end wall to the other housing end wall; each of said slots having a plurality of longitudinally spaced recesses extending radially inwardly into said hub past the periphery of said shafts and separated by strengthening ribs formed integral with the central portion of said hub; and a vane in each of said slots contacting and forming a seal against said housing end walls by extending the breadth of said slots from one housing end wall to the other housing end wall and said sliding vanes including cut out portions for receiving said strengthening webs, portions of said vanes adjacent said end plates extending into certain of said recesses when depressed during operation thereby to seal an area on the end walls to a radial depth to substantially eliminate gaseous leakage beneath the ends of the vanes and adjacent the end shafts under high compression conditions; and spaced portions of the inner edges of said vanes being removed in a manner to leave intermediate portions of ordinary vane width to shift the center of gravity thereof radially outwardly for proper centrifugal sealing action between said vanes and said peripheral inner wall.

4. In a rotary vane pump, the combination of a housing; a rotor hub eccentrically located in said housing; said housing including end plates; end shafts extending from both ends of said rotor hub into said end plates; at least more than four elongated slots in said rotor hub for receiving slidable vanes; said slots extending perpendicular to a diameter of said hub and extending beyond said diameter; the innermost portions of said slots including a plurality of longitudinally spaced recesses including at least recesses at the ends of said rotor, and intermediate strengthening ribs; said recesses having a width greater than that of adjacent slot portions to remove the necessity of surface finishing operations in said recesses; and a plurality of vanes in said slots having cooperating projections to fit into said recesses and cooperating cut-outs to receive said ribs to enable vanes with said cut-outs to be accommodated in said slots and contacting said end plates to obtain optimum end sealing between the vanes and the end plates without detrimentally weakening said hub and without shifting the center of gravity of said vanes an excessive amount to hamper radial acceleration of the vanes.

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