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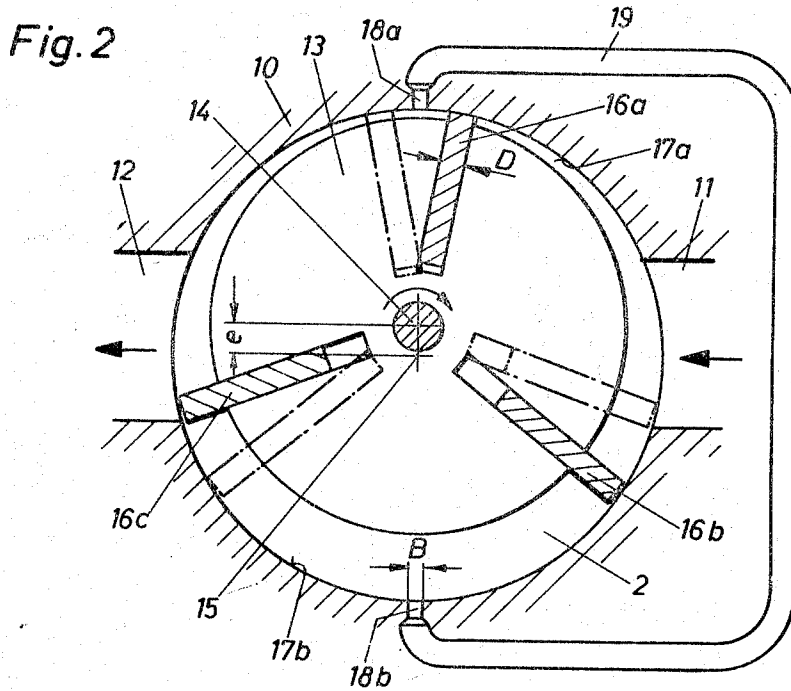
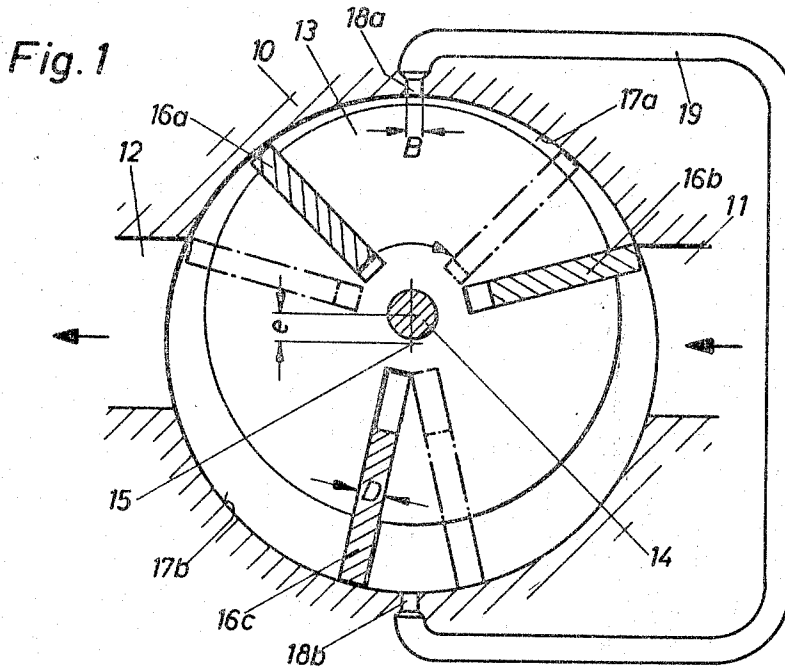
H. F. VON THUENGEN ET AL

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VANE PUMPS AND MOTORS

Filed Aug. 10, 1965

2 Sheets-Sheet 1



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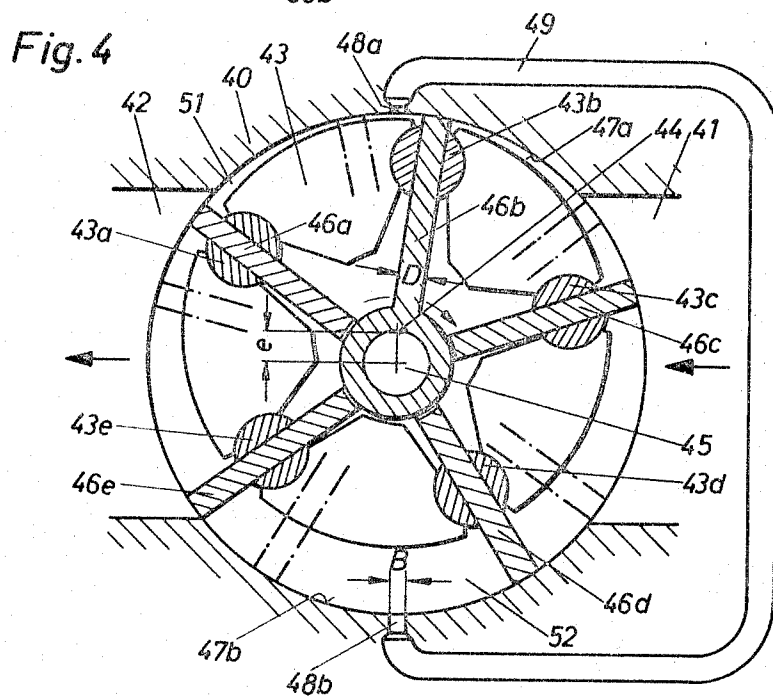
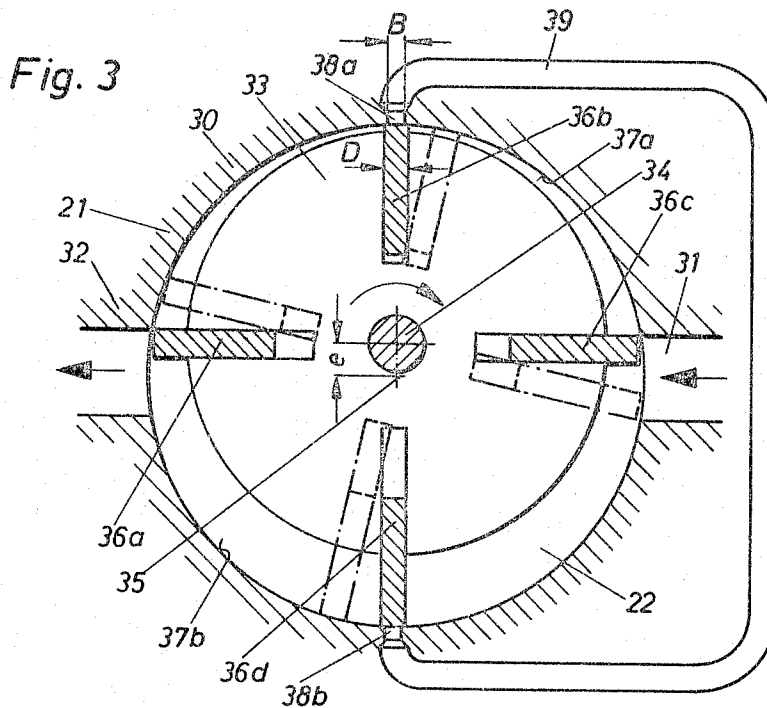
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2 Sheets-Sheet 2



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VANE PUMPS AND MOTORS

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The invention relates to vane type hydraulic pumps and, more particularly, to pumps having radially slidable or radially and pivotally movable vanes.

One of the difficulties in connection with vane type pumps is the pressures which develop at opposite sides of the rotor in which one clearance space of the pump chamber may have a pressure in excess of maximum permissible pressure while in the opposite clearance space a considerably reduced pressure is effected. Such clearance spaces are generally diametrically opposite to each other and in a plane normal to the suction pressure ports of the pump. As a result of this differential pressure developing on opposite sides of the rotor, there is an unbalance of force on the rotor which results in pressure oscillation and shock pressures causing premature wear on the casing and the pump parts. This is, of course, a very undesirable effect.

The present invention has for its object the elimination of such pressure unbalance and the consequent pressure shock forces and oscillations. Another object of the invention is to provide for the elimination of the above drawback in a very simple, economical, and rugged construction.

Briefly, the invention comprises the provision of small bypass ports in the clearance spaces of the casing at opposite sides thereof to permit flow therebetween for pressure balancing. Thus, the ports are connected with a bypass tube. Accordingly, high pressures are equalized diametrically across the pump chamber. However, in order to prevent loss of efficiency due to fluid passage from the suction to the pressure sides of the pump, the pump vanes are made of a thickness larger than the diameter of the aforementioned small ports so as to close these ports in sweeping past them.

The arrangement is such that the regions of maximum and minimum pressures in the clearance spaces are diametrically opposed to each other on a diameter perpendicular to the common diametrical axis of the inlet and outlet ducts. The pressures are equalized without sacrificing loss of outlet pressure or pumping efficiency.

The bypass tube is of relatively large diameter compared to the bypass ports so that the flow rate in the tube is small, in fact, very slight. Accordingly, since the pressures in the clearance spaces alternate from high to low relative to each other, flow in the bypass tube is reversible, but of such low velocity that the bypass arrangement can respond rapidly to the repetitive pressure variations in the clearance spaces.

A detailed description of the invention now follows in conjunction with the drawing in which:

FIG. 1 is an elevation in cross-section through a hydraulic pump having three radially slidable vanes;

FIG. 2 illustrates a position of the vanes occurring shortly after the vane position of FIG. 1;

FIG. 3 illustrates a four-vane pump in elevational cross-section, the vanes being of the radially sliding type; and

FIG. 4 illustrates in elevational cross-section a five-vane pump wherein the vanes are radially slidable and pivotal.

FIG. 1 illustrates a pump housing 10 having an inlet duct 11 and an outlet duct 12 with a rotor 13 rotative clockwise in the pump chamber. The axis 14 of the ro-

tor is eccentrically disposed relative to the housing axis 15 by eccentricity "e."

The rotor 13 carries radially slidable vanes 16a, 16b, 16c, spaced 120° apart and rotating in a clockwise direction. The construction thus far is conventional, the vane edges having a sealing sliding movement against the annular wall of the chamber. The invention comprises the addition of a bypass tube 19 leading from a port 18a in the upper chamber clearance space 1 to a port 18b in the lower chamber clearance space 2. It will be noted that the vanes have a thickness D greater than the port openings B.

Attention is called to the phantom line positions of the vanes 16a and 16b which mark off a cell of the pump. It will be noted that the clearance space 1 initially decreases in volume as these vanes move clockwise to the full line position. However, with continued movement, the clearance space 1 increases in volume. This decrease and increase in volume corresponds to an increase and decrease in pressure within that space. In a similar manner, as the cell effected by the vanes 16b and 16c rotates, the reversed condition is realized in clearance space 2. In other words, the volume of that space first increases and then decreases. Accordingly, there is initially a decrease in pressure in clearance space 2 followed by an increase in pressure. It is these opposing increases and decreases in pressure between the two clearance spaces which cause the shock effects on the rotor and housing. However, by providing the bypass tube 19, the differential pressures are equalized or balanced in order to avoid the pressure differential stresses.

As seen in FIG. 1, the following events occur:

(a) The casing portion 17a of the upper clearance space 1 forms a cell between vanes 16a and 16b.

(b) As vane 16a moves from the phantom to full line positions, the volume of clearance space 1 decreases.

(c) Flow occurs through port 18a, tube 19, port 18b to outlet duct 12 (vane 16c is in phantom line position).

(d) Vane 16c closes port 18b to cut off flow to duct 12.

(e) Vane 16c (full line position) opens port 18b to afford communication to inlet duct 11.

(f) Clearance space 1 now begins to increase in volume.

(g) Continued movement of vane 16b beyond the full line position causes flow from duct 11 through port 18a, tube 19, port 18b into clearance space 2 of casing portion 17b, in the cell between vanes 16b and 16c.

(h) Vane 16a closes port 18a to cut off clearance space 1 from communication with tube 19 (in FIG. 2, this vane in solid lines has just passed port 18a).

(i) Vane 16b at the same time cuts off flow from duct 11 to clearance space 2 (in FIG. 2) this vane in solid lines has just passed the lower edge of duct 11, the closing instant being illustrated by the phantom line position.

(j) The volume of the cell between vanes 16b and 16c (clearance space 2) is now decreasing, the pressure rising above that in the cell between vanes 16c and 16a (clearance space 1).

(k) Flow moves from port 18b, through tube 19 to port 18a, to effect balance, and the cycle of communication and cut-off between the clearance spaces and ducts is repeated.

Referring to FIG. 3, a four-vane pump with eccentric rotor is illustrated, the vanes being radially slidable wherein rotor 33 is mounted eccentrically with eccentricity "e" in pump housing 30 which has an axis 35 and upper and lower portions 37a and 37b. The rotor carries the four radially slidable vanes spaced 90° apart, 36a, 36b, 36c, and 36d. In the full line position, vane 36a has just closed outlet port 32, and in continuing its movement, it reduces the volume of clearance space 21, measured off at this time between vanes 36a and 36b. In the sub-

sequent vane positions shown in dash-dot lines, vane 36c cuts off lower clearance space 22, measured off between vanes 36c and 36d from inlet opening 31. As the rotor continues beyond the phantom line position, the volume of clearance space 22 will increase initially. When, however, the rotor has moved to a position such that the respective vanes are about 90° from their full line position shown, the clearance space 21 communicates through tube 39 with clearance space 22 which is still measured off between vanes 36c and 36d. This bypassing communication occurs for almost 90° of movement of the rotor and effects a pressure balance across the rotor from top to bottom by virtue of delivery of fluid through tube 39 as was the case in FIG. 1 for delivery through tube 19. The cycle of communication and cut-off of the ports, clearance spaces and ducts follows the principles set forth in the description of FIGS. 1 and 2, as will be understood by persons skilled in the art.

FIG. 4 shows a five-vane rotor in which the rotor 43 is carried on a shaft 44. The housing has the usual ducts for inlet and outlet, 41 and 42, respectively. The vanes 46a, 46b, 46c, 46d and 46e are radially fixed and rotatably disposed on a bearing shaft 45 which is provided in the center of the pump chamber. Said vanes are slidably extending through slide pivot inserts 43a, 43b, 43c, 43d and 43e which are rotatably arranged in said rotor 43 in angularly fixed relation to each other. In this instance, the rotor shaft 44 has eccentricity *e* with relation to the casing axis 45. The construction thus far described is conventional and the invention is applied thereto by means of port 48a in the clearance space 51 at upper casing portion 47a and of the port 48b at the lower casing portion 47b in the clearance space 52, with tube 49 connecting the ports.

As in the previous modifications, the vane thickness *D* is larger than the port openings *B*, and such ports are located in a plane midway between the inlet and outlet ducts 41 and 42.

In operation, as the vanes 46d and 46e rotate from the phantom line position to the full line position, the volume of clearance space 52 is first increased and subsequently reduced. Accordingly, suction effects movement of fluid from the inlet duct 41 through port 48a, tube 49 to port 48b. After vane 46b moves past port 48a, communication for pressure fluid takes place through port 48b, line 49, and port 48a into outlet duct 42. This continues until vane 46a cuts off communication between duct 42 and port 48a. At that time, the same process is reversed for clearance space 51 which is then a cell between vanes 46c and 46d, all in accordance with the principles hereinabove described.

For all forms of the invention, the bypass tube is made of sufficiently large diameter so that balancing flow between the ports occurs at a very low discharge rate and therefore equalization of forces on the rotor and casing can occur very rapidly, such balancing flow being relatively slight in comparison with the pump capacity, as has been hereinabove mentioned. The bypass ports are quite short in length so that no serious resistance to flow with rapid reversal is experienced. The invention is readily adaptable to any conventional vane pump construction, due care being taken to make the bypass port diameters less than the vane thickness.

We claim:

1. In a rotary vane type pump comprising a casing having an inlet and an outlet duct, a rotor in said casing comprising angularly spaced vanes effecting cells for pumping fluid from said inlet duct to said outlet duct, wherein the disposition of said rotor and said vanes in said casing effects clearance spaces in said casing at generally opposite sides of said casing, said clearance spaces being intermediate said inlet and outlet ducts and being subjected to oppositely varying pressures as said rotor rotates, the improvement which comprises a flow bypass means between said clearance spaces for effecting communications of fluid therebetween to equalize pressures in said clearance spaces,

said bypass means comprising ports in said casing opening into respective clearance spaces, and a bypass tube means connecting the ports,

said vanes having a thickness larger than the dimension of said ports so as to cut off flow therethrough in sweeping therepast whereby pressure is maintained at said outlet duct without bypass flow loss,

wherein said bypass tube means comprises a tube exteriorally of said casing and of a diameter sufficiently large relative said ports to effect relatively low velocity of fluid intermediate said clearance spaces.

2. In a rotary pump as set forth in claim 1, including means for mounting said vanes whereby said vanes are individually slidable and pivotal in said rotor.

References Cited by the Examiner

UNITED STATES PATENTS

985,091	2/1911	Wittig	230—152
2,711,698	6/1955	Bozek et al.	103—136
3,252,284	5/1966	Von Thuengen	103—144

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