Jan. 17, 1961 J. C. HENNING ET AL 2,968,252

ENGINE

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Fig.1

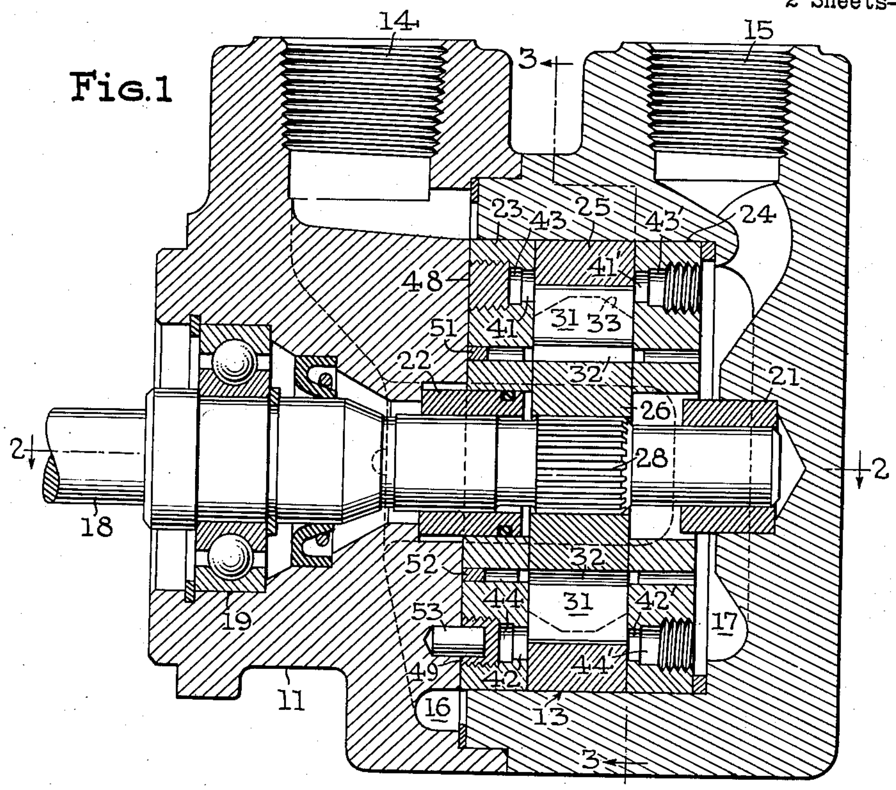

Fig.2

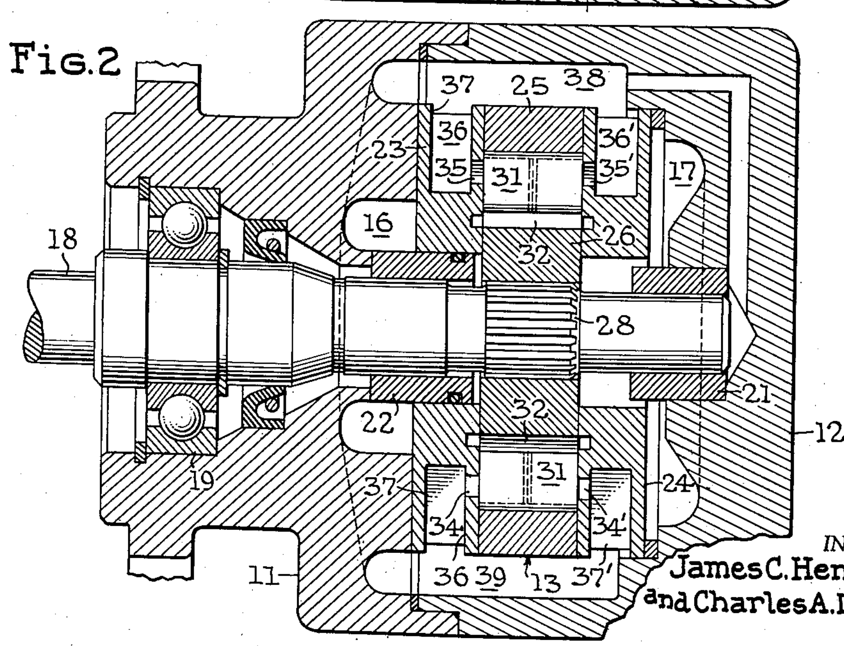

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Fig.4

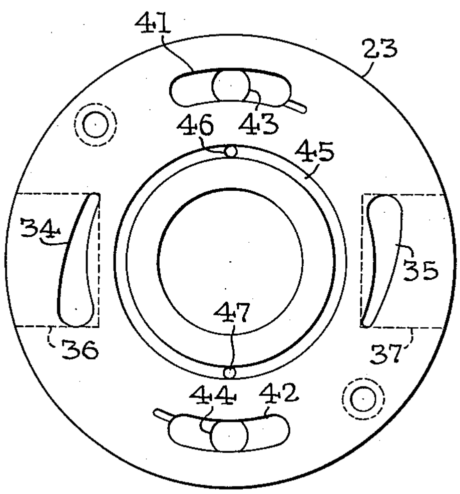


Fig.5

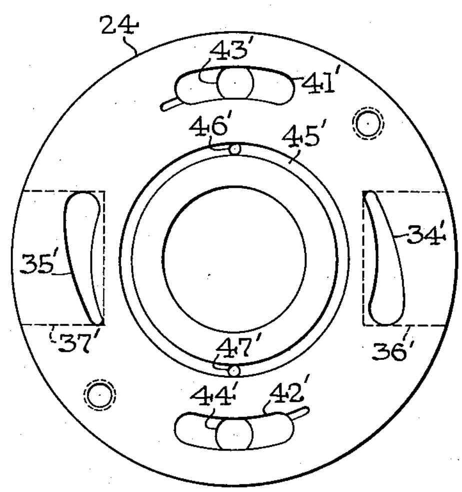
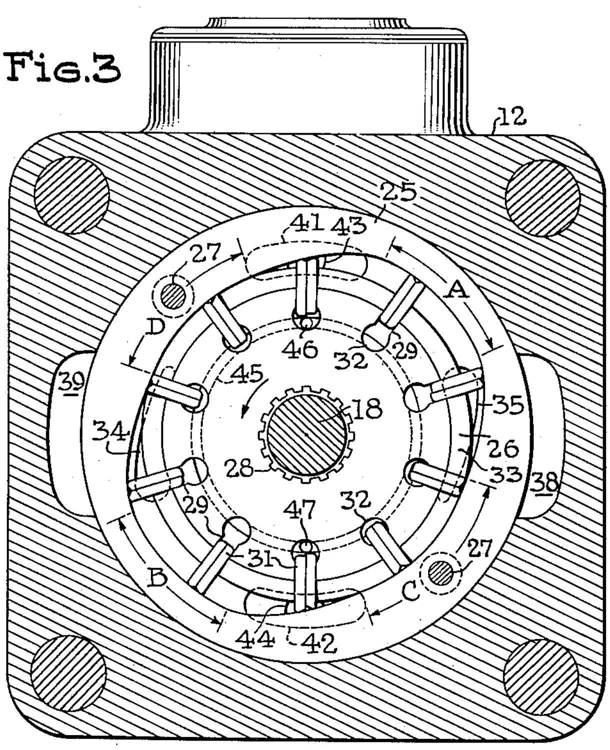


Fig.3



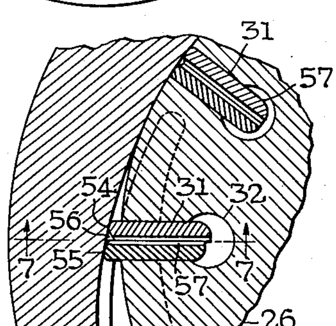
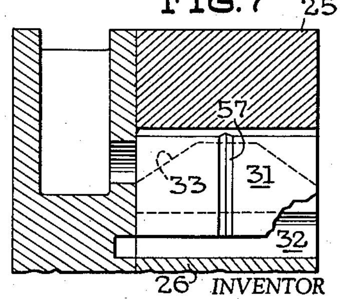


Fig.6

Fig.7



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ENGINE

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2 Claims. (Cl. 103—136)

This invention relates to rotary engines of the vane type, and particularly to engines of this type employing semi-balanced vanes which are biased outward into sealing engagement with the cam ring by fluid pressure. The term engine is used herein in its generic sense and it will be understood that it includes pumps as well as motors.

In these engines, of which the one described in Rosen Patent 2,393,223, granted January 15, 1946, is typical, the outer end of each vane is in engagement with the cam ring along two spaced lines of contact which extend between the port plates disposed on opposite sides of the rotor. Formed in the outer end of each vane between these lines of contact is a balance chamber whose opposite ends open through the side faces of the vane and communicate with the high and low pressure ports in the port plates as the vane passes by those ports. Each of these chambers is in continuous communication with the space in the vane slot beneath the inner end of its vane by passages formed in the side faces of the vane. The port plates are also provided with vane ports which are in communication with the high and low pressure manifolds of the engine and which are arranged to transmit high pressure fluid to the inner end of each vane slot when that vane is crossing the high pressure port, and to vent each slot when that vane is crossing the low pressure port. The high and low pressure ports are in more restricted communication with the manifolds than the vane ports and, as a result, the balance chamber and the inner end of each vane develop net forces on the vane that urge it outward against the cam ring in the region of the high pressure port and urge it inward in the region of the low pressure port.

In general, this method of controlling the vanes is satisfactory because it provides a large sealing force in the region where leakage or blow-by across the outer ends of the vanes is most apt to occur, and reduces the sealing force and thus decreases wear on the cam ring in that region where the leakage problem is not as acute. However, in low speed engines, i.e., those operating at about 700 r.p.m., the centrifugal forces acting on the vanes are so small that the pressure bias forcing the vanes inward in the region of the low pressure port tends to cause the vanes and the cam ring to separate. Vanes which separate from the cam ring in the low pressure region will return to it with a sudden impact when their slots are again connected with the high pressure manifold. This hammering causes objectionable noise and greatly reduces the life of the cam ring.

The object of this invention is to provide an improved engine of the type mentioned which is capable of operating at low speeds without risk of causing separation between the vanes and the cam ring. According to the invention, the spaces in the vane slots beneath the vanes are in continuous communication with the high pressure manifold, and the balance chambers and the connecting passages between these chambers and the vane slots are so located that they are never in free communication with the low pressure port in the port plate. Because of this arrangement, the pressures acting in the vane slots and in the balance chambers are always equal and are always high. The area of each balance chamber, projected on plane normal to the longitudinal axis of the vane, is less than the effective area of the inner end of the vane and is so selected that the high pressure fluid acting on these areas produces a net biasing force on the vane sufficient to maintain it in sealing contact with the cam ring without causing undue wear of this ring. Since the bias on the vanes is always in an outward direction, low speed operation, with its attendant small centrifugal forces, will not cause hammering of the vanes on the cam ring.

The preferred embodiment of the invention will now be described in detail with reference to the accompanying drawing, in which:

Fig. 1 is an axial sectional view of a vane pump incorporating the invention.

Fig. 2 is a sectional view taken on line 2—2 of Fig. 1.

Fig. 3 is a sectional view taken on line 3—3 of Fig. 1 showing the relationship between the surface of the cam ring and the inlet and discharge ports.

Fig. 4 is a view of the front face of one of the port plates.

Fig. 5 is a view of the front face of the other port plate.

Fig. 6 is an enlarged view of a portion of Fig. 3 showing the spatial relationship between one of the balance chambers and one of the inlet ports.

Fig. 7 is a sectional view taken on line 7—7 of Fig. 6.

As shown in the drawings, the pump comprises a housing having separable sections **11** and **12** which are joined by four bolts and which are bored to receive and hold a pumping cartridge **13**. Inlet and discharge ports **14** and **15** are formed in housing sections **11** and **12**, respectively, and communicate with cored inlet and discharge manifolds **16** and **17** which encircle drive shaft **18**. The shaft is supported in housing sections **11** and **12** by bearings **19** and **21**, respectively, and in one of the port plates by bearing **22**.

The cartridge **13** comprises two substantially identical port plates **23** and **24**, cam ring **25**, and rotor **26**. The unit is held together by two bolts **27** whose heads are received in counterbores formed in port plate **23** and which are threaded into tapped holes formed in port plate **24**. The rotor **26** is connected in driven relation with shaft **18** by splines **28** and is formed with a plurality of uniformly spaced radial slots **29** which receive the laminated sliding vanes **31**. The inner ends of these slots are enlarged, as shown, to provide vane-biasing chambers **32** adjacent the inner ends of the vanes. The outer peripheral edges of the rotor are beveled at **33** to provide access between the ports in port plates **23** and **24** and the inter-vane working chambers.

As shown in Figs. 2 and 4, port plate **23** is formed with two diametrically opposed teardrop-shaped inlet ports **34** and **35** which open through the front face of the plate and communicate with the radial slots **36** and **37**, respectively. When the pump is assembled, these slots open into the longitudinal extensions **38** and **39** of inlet manifold **16** that are formed in housing section **12**. Port plate **23** also contains two diametrically opposed arcuate discharge ports **41** and **42** which are located 90° from the inlet ports and connect with tapped bores **43** and **44**, respectively. An annular groove **45**, coaxial with the plate **23**, is formed in the front face and communicates with two through bores **46** and **47**. The radial position of this groove is so selected that it is overtravelled by the vane-biasing chambers **32** (see Fig. 3). As shown in Fig. 1, the tapped bores **43** and **44** and the through bores **46** and **47** are closed and sealed by plugs

48, 49, 51 and 52; the plug 49 also serving as a socket for locating pin 53. These plugs are required in order to prevent communication between the inlet and discharge manifolds through the inter-vane working chambers. Port plate 24 is provided with the same ports and passages as port plate 23 but in this plate the bores 43′, 44′, 46′ and 47′ are not plugged but communicate with discharge manifold 17.

The cam ring 25 is conventional, employing four constant radius sections A, B, C and D separated by transition zones, as shown in Fig. 3; the radius of sections A and B being equal, and the radius of sections C and D being equal. Fig. 3 also shows the annular relationship between the surface of the cam ring and the ports in plate 23 when the cartridge is assembled.

The vanes 31 are of the laminated type disclosed in the Rosen patent mentioned previously. The two laminae are free to move relatively to each other so that the outer end of each vane is always in engagement with the cam ring along two spaced lines of contact (see Fig. 6 in which the points 54 and 55 represent end views of these lines). The outer edges of the two laminae of each vane are chamfered, as shown in Figs. 3 and 6, to define a balance chamber 56 which is located between the lines of contact with cam ring 25 and whose cross-sectional area, projected on a plane normal to the longitudinal axis of the vane, is less than the cross-sectional area of the inner end of the vane. When the pumping cartridge is assembled, the inner margins of chambers 56 are located radially outward of the outer margins of inlet ports 34, 34′, 35 and 35′. Each of these balance chambers communicates with the vane-biasing chamber 32 beneath its vane via a passage 57 that is defined by grooves formed in the mating faces of the laminae.

When drive shaft 18 is rotated in the direction of the arrow in Fig. 3, fluid is drawn into the inter-vane working chambers through inlet port 14, inlet manifold 16, manifold extensions 38 and 39, radial passages 36, 36′, 37 and 37′ and inlet ports 34, 34′, 35 and 35′, and is discharged under high pressure through discharge ports 41′ and 42′, bores 43′ and 44′, discharge manifold 17, and discharge port 15. The high pressure prevailing in discharge manifold 17 is transmitted continuously to the vane-biasing chambers 32 through bores 46′ and 47′ and annular groove 45′ where it acts upon the inner ends of vanes 31 and urges them outward into sealing engagement with cam ring 25. Since the passages 57 define closed high pressure conduits between chambers 32 and 56, and since the running seals between the side faces of the vanes and the front faces of the port plates and between the outer ends of the vanes and the cam ring (along lines 54 and 55) isolate the chambers 56 from the inlet ports 34, 34′, 35 and 35′ and from the inter-vane working chambers, the high pressure in manifold 17 and biasing chambers 32 will also exist in balance chambers 56. The fluid pressure in the balance chambers produces forces which urge the vanes in an inward direction, but since the cross-sectional area of these chambers is less than the cross-sectional area of the biasing chambers, the net force exerted on each vane acts in an outward direction. The ratio of the area of chamber 32 to the area of chamber 56 is so selected that the net biasing force is large enough to hold the vanes 31 in contact with cam ring 25 at the operating speed of the pump, but not so large as to cause undue wear of the cam ring.

As stated previously, the drawings and descrpition relate only to a preferred embodiment of the invention. Since many changes can be made in the structure of this embodiment without departing from the inventive concept, the following claims should provide the sole measure of the scope of the invention.

What is claimed is:

1. In a rotary engine of the vane type including a rotor having a plurality of vane slots spaced around its periphery, a vane reciprocable in each slot, the opposite side faces of each vane being in sliding and sealing engagement with two spaced parallel walls and the outer end of each vane being in sliding contact with a cam ring along two spaced lines which extend between the said two parallel walls, and at least one high and one low pressure port formed in one of said walls, the improvement which comprises a balance chamber formed in the outer end of each vane between the spaced lines of contact, the chambers and the low pressure port being so located relatively to each other that they are isolated from one another at all times by the lines of contact and by the running seals between the walls and the opposite side faces of the vanes; means forming a continuously open flow path between the high pressure port and the spaces in the vane slots beneath the vanes; and means defining a closed conduit connecting the space beneath each vane with the balance chamber at the outer end of that vane.

2. In a rotary engine of the vane type including a rotor having a plurality of vane slots spaced around its periphery, a vane reciprocable in each slot, the opposite side faces of each vane being in sliding and sealing engagement with two spaced parallel walls and the outer end of each vane being in sliding contact with a cam ring along two spaced lines which extend between the said two parallel walls, and at least one high and low pressure port formed in one of said walls, the improvement which comprises a balance chamber formed in the outer end of each vane between the spaced lines of contact and opening through the side faces of the vane, the inner margin of each chamber being located radially outward of the outer margin of the low pressure port; a closed passage connecting each balance chamber with the space in the vane slot beneath its vane; and means forming a continuously open flow path between the high pressure port and the spaces in the vane slots beneath the vanes.

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