Oct. 21, 1969 D. K. THOMPSON ET AL 3,473,477

ROTARY PUMP

Filed Feb. 26, 1968 2 Sheets-Sheet 1

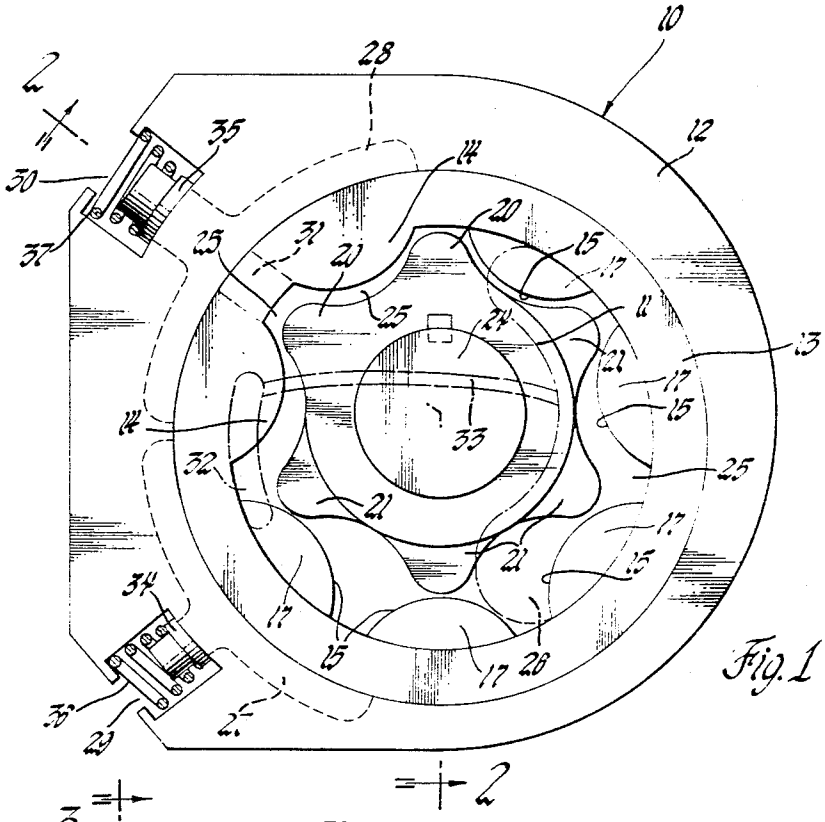


Fig. 1

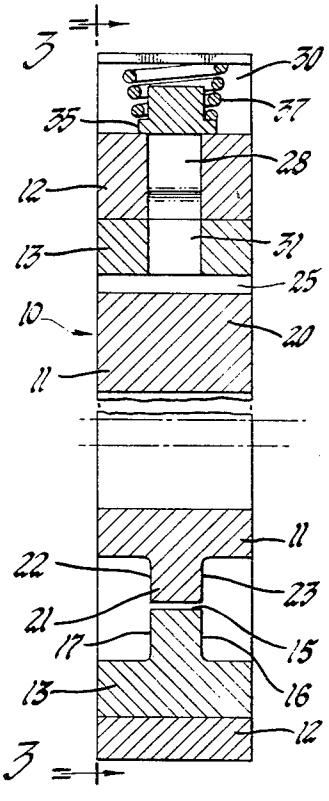


Fig. 2

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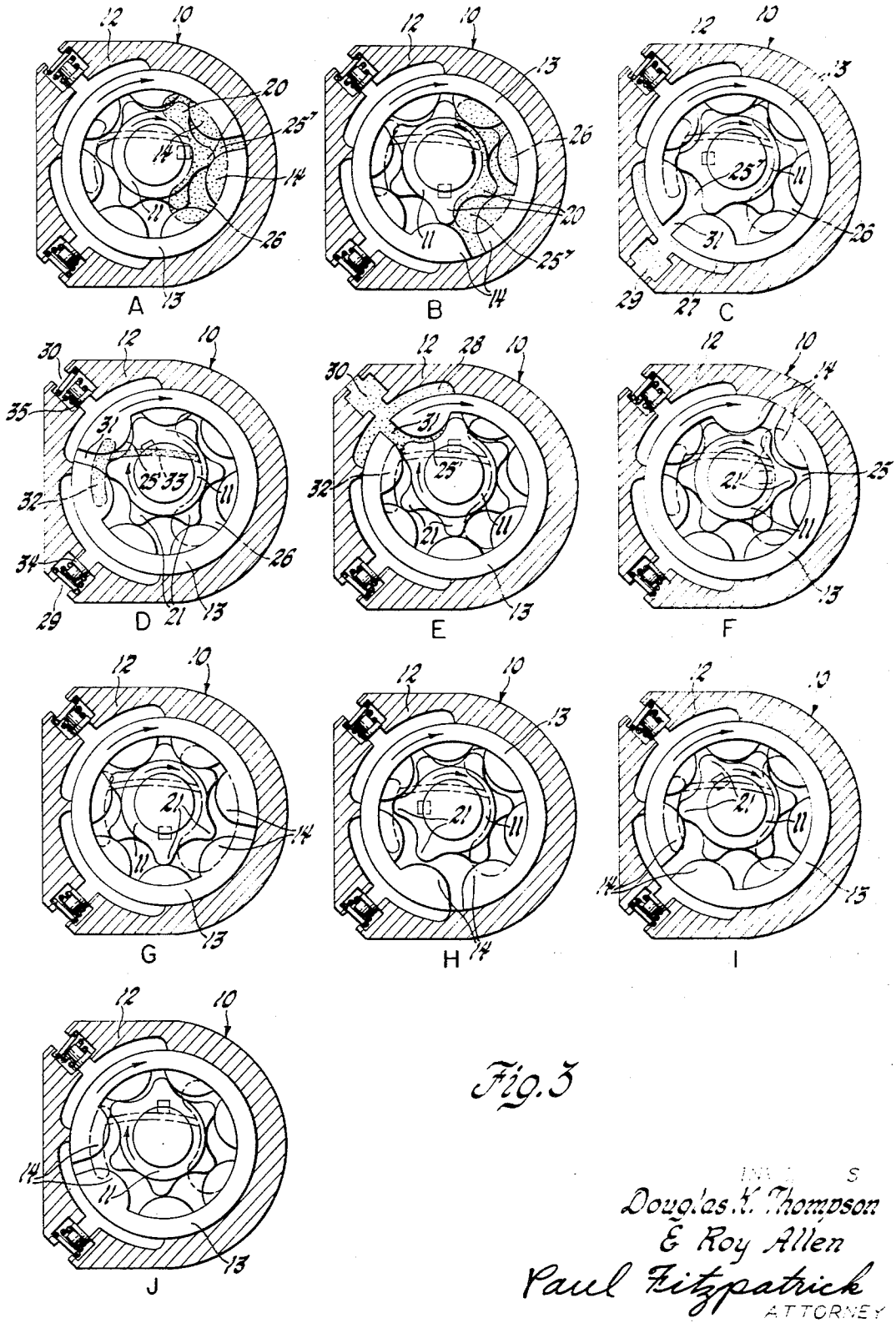


Fig. 3

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ROTARY PUMP

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Int. Cl. F04c 1/04
U.S. Cl. 103—126 6 Claims

ABSTRACT OF THE DISCLOSURE

A rotary pump of the external-internal gear type has portions of some of the teeth cut away so that fluid may flow past these teeth. As a result, fluid is discharged from the pump only when the unrelieved teeth mesh with each other to provide a closed pumping chamber. Fluid is discharged from one or more discharge ports provided with check valves. A by-pass port to the pump inlet may be provided to reduce the output of the pump.

The invention herein described was made in the course of work under a contract or subcontract thereunder with the Department of Defense.

Our invention is directed to pumps adapted to provide a very small output of the pumped fluid, particularly to rotary pumps suitable for delivering small quantities of liquids in lubrication systems. One application of such a pump is to the lubrication system of a vertical lift gas turbine engine.

The principal object of our invention is to provide a pump which may have small displacement although the parts are of reasonably large size so as to be rugged and easily manufactured. It is a further object of our invention to provide a rotary pump in which pumping is effected during only part of the rotation of the pump, and particularly a rotary pump in which pumping is effected only during part of an active rotation of the pumping members with inactive rotations occurring between the active rotations.

In the preferred embodiment of our invention, there is provided a rotary pump having inlet and outlet ports, lobed elements which are rotatably mounted eccentrically one within the other which are respectively provided with n and $n+1$ lobes, the said lobes meshing with each other and defining an annular array of spaces between the lobed elements, and means for driving one of the lobed elements to cause cyclical alterations to the volume of each said space such that, in each cycle each space successively communicates with the or with each inlet port, while increasing in volume, and then communicates with the outlet port or with each outlet port while decreasing in volume; predetermined lobes on one or both of the lobed elements being partially cut away so that, at any moment, predetermined spaces communicate with each other, whereby each space is periodically sealed and unsealed in operation so that pumping is effected thereby during a portion only of said cycle. The term "sealed" as used herein is intended to mean that the space is completely enclosed except that it may communicate with a port of one sort or another; but not with another space, except for incidental leakage.

As will be appreciated, the pump of the present invention may be so formed as to provide an accurately metered small flow while not requiring to be made of very small mechanical components, the small flow being achieved by reason of the fact that pumping is effected by only some of said spaces or during a proportion only of the said cycles, or by only some of the spaces and only during some of said cycles.

Preferably there are a plurality of outlet ports with which each space successively communicates while decreasing in volume, whereby each said outlet port receives a proportion only of the volume of the pumped fluid. As will be appreciated, if only one of the said outlet ports communicates with any particular point of use, then this will further reduce the quantity of fluid being pumped by the pump to the said point of use.

Each space may communicate successively with a first outlet port, a by-pass port which communicates with an inlet port, and a second outlet port. Each outlet port may, moreover, be provided with a check valve which ensures that fluid can flow through it only in the outlet direction, and only when the pressure of the fluid exceeds a predetermined value. The by-pass port may overlap predetermined portions only of the first and second outlet ports so that a sealed space may communicate simultaneously with the said by-pass port and with a said portion, the said check valves preventing reverse flow through the outlet port when a sealed space communicates with the said by-pass port.

Preferably, all except two adjacent lobes of one or of each lobed element are partially cut away so that, at any moment, not more than one space is sealed.

The nature of our invention and the advantages thereof will be clear to those skilled in the art from the succeeding detailed description of the preferred embodiment of the invention and the accompanying drawings thereof.

FIGURE 1 is a section through a rotary pump taken in a plane normal to the axis of rotation of the rotary members.

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

FIGURE 3 constitutes ten sectional views respectively labeled A to J, each taken on the line 3—3 of FIGURE 2, showing successive positions of moving parts of the pump as the cycle of operation proceeds.

In the drawings there is shown a rotary internal gear pump 10 for oil or other liquids having a driving gear element 11 which is mounted within and spaced from an eccentric ring, or cylinder, 12. A ring gear element 13 is mounted concentrically within and is rotatable in contact with the eccentric ring 12, the driving gear element 11 being rotatably mounted eccentrically within the ring gear element 13. The ring gear element 13 is provided internally with two adjacent lobes or teeth 14 which extend throughout the axial length of the ring gear element 13, and with a further five lobes or teeth 15 which, as shown in FIGURE 2, are cut away at both their end faces 16, 17 so as to extend in effect for only a minor, and central, poftion of the axial length of the ring gear element 13. Thus, the ring gear element 13 has seven lobes 14, 15 of which only the two adjacent lobes 14 extend throughout the full axial length of the ring gear element 13.

The driving gear element 11 is provided externally with two adjacent lobes or teeth 20, each of which extends the full axial length of the driving gear element 11, and with four lobes or teeth 21 each of which, as shown in FIGURE 2, is cut away at the end faces 22, 23, so that only a minor, and central, portion of the lobe is left. Thus, the driving gear element 11 has six lobes 20, 21 of which only the two adjacent lobes 20 extend throughout the full axial length of the driving gear element 11. The ring gear element 13 thus has one more lobe than the driving gear element 11.

The driving gear element 11 is mounted on a driving shaft 24 which may, for example, be driven by an electric motor (not shown), the lobes 20, 21 on the driving gear element 11 meshing with the lobes 14, 15 of the ring gear element 13 which is thus rotated within the eccentric ring 12. The lobes 14, 15, 20, 21 define an annular array

of six spaces 25 between the elements 11, 13 undergoing cyclical alteration in operation.

At one end of the eccentric ring 12 there is provided a substantially kidney-shaped inlet port 26. The internal wall of the eccentric ring 12 is provided with outlet grooves 27, 28 which respectively communicate with an outlet port 29 and with an outlet port 30. The curved wall of the ring gear element 13 has a radially extending opening 31 therein which is disposed between the two lobes 14 and which communicates, as shown in FIGURE 1, with the outlet port 30. The outlet port 30 and the opening 31 are brought into and out of communication with each other as the ring gear element 13 is rotated.

The said end of the eccentric ring 12 is also provided with a by-pass port 32 which communicates, by way of a passage 33, with the inlet port 26, each space 25 in operation communicating successively with the outlet port 29, the by-pass port 32, and the outlet port 30. The outlet ports 29, 30 are respectively provided with check valves 34, 35 which are urged by springs 36, 37 respectively in a closing direction. Thus liquid can flow past the check valves 34, 35 only in the outlet direction and only when its pressure exceeds a predetermined value.

The by-pass port 32 overlaps certain portions of the outlet grooves 27, 28, so that a space 25 may communicate simultaneously with the by-pass port 32 and with a said portion.

The operation of the pump 10 is illustrated in FIGURE 3 in which the views A to J show the relative positions of the parts as the driving gear element 11 moves through successive angular increments.

When the parts are as shown in FIGURE 3A, the two lobes 20 of the driving gear element 11 are in engagement with the two lobes 14 of the ring gear element 13 so as to define a sealed space 25' which is completely enclosed except that it communicates with the inlet port 26.

As the driving gear element 11, however, rotates clockwise from the position shown in FIGURE 3A and through the position shown in FIGURE 3B, the space 25' steadily increases in volume and an increasing volume of liquid is therefore drawn into it. In moving, however, from the position shown in FIGURE 3B to the position shown in FIGURE 3C, the space 25' when it has reached its maximum volume, ceases to communicate with the inlet port 26 and starts to communicate with the outlet port 29 through the opening 31 and outlet groove 27. As the driving gear element 11 continues to rotate the space 25' is gradually reduced, so forcing the liquid out through the outlet port 29.

When, however, as shown in FIGURE 3D, the space 25' communicates with the by-pass port 32, the liquid flows through the passage 33 to the inlet port 26. Although at this time the space 25' will also communicate successively with the outlet ports 29, 30 by way of the opening 31, the check valves 34, 35 will prevent flow through the outlet ports 29, 30.

Further rotation of the driving gear element 11 will, as shown in FIGURE 3E, bring the sealed space 25' out of communication with the by-pass port 32 and, through the opening 31 and outlet groove 28, into communication with the outlet port 30 so that the latter receives the final fraction of the liquid being pumped out of the said space 25'.

There is therefore a cyclical alteration of the volume of the sealed space 25' and this cyclical alteration of volume also, of course, occurs in relation to all the other spaces 25 between the lobes of the elements 11, 13. Since, however, the lobes 15, 21 are partially cut away, these other spaces 25 will not be sealed, and liquid can therefore flow freely out of a reducing space and into a succeeding space.

Once, however, the driving gear element 11 has moved past the position shown in FIGURE 3E, to the position shown in FIGURE 3F, all the various spaces 25, between the lobes on the elements 11, 13, are unsealed, as indicated in FIGURE 3F to FIGURE 3J. This is because a space 25 will only be sealed when each of the lobes 14 simultaneously contacts a lobe 20. Until, however, the driving gear element 11 has turned through six complete revolutions, each of the lobes 14 will not simultaneously contact a lobe 20, and no further pumping therefore occurs until the driving gear element 11 has turned through the said six complete revolutions, after which a further pumping cycle does occur.

Thus, during a pumping cycle, only one space 25 is sealed while all the other spaces 25 communicate with each other, whereas during a non-pumping cycle every space 25 is unsealed.

Since each of the spaces 25 is thus periodically sealed and unsealed in operation, and effects a pumping action only when it is sealed, not merely (in the specific embodiment being described) will pumping occur only once in each seven cycles, but even during a pumping cycle only one of the six spaces 25 will effect pumping. The output of the pump is therefore only $\frac{1}{42}$ of what it would be if the lobes 15, 21 were not partially cut away, while by reason of the provision of the by-pass port 32 and of the outlet port 30, much of this reduced output does not pass through the outlet port 29. Thus the pump 10 will have an accurately metered small flow while not requiring to be made of very small mechanical components.

It will be apparent that many modifications of structure may be made within the principles of the invention. As previously stated, one or more outlet ports may be provided, and the by-pass port may be provided or omitted as desired.

Various means may be adopted to provide communication between the spaces 26 other than cutting away the ends of the teeth. Communication between the spaces may be provided by alteration in only one of the relatively rotatable pumping members.

Since, in the form of the device shown the teeth of lobes 17 and 21 perform no pumping function, they can be omitted altogether if some external means for effecting driving connection between the two rotary pumping members is provided.

The detailed description of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be considered as limiting or restricting the invention, since many modifications may be made by the exercise of skill in the art.

We claim:

1. A rotary pump having an inlet port and one or more outlet ports, lobed elements which are rotatably mounted eccentrically one within the other and which are respectively provided with n and $n+1$ lobes, the said lobes meshing with each other and defiining an annular array of spaces between the lobed elements, and means for driving one of the lobed elements to cause cyclical alteration of the volume of each said space such that, in each cycle, each space successively communicates with an inlet port while increasing in volume and then communicates with an outlet port while decreasing in volume, predetermined lobes on the lobed elements being partially cut away so that, at any moment, predetermined spaces communicate with each other, whereby each space is periodically sealed and unsealed in operation so that pumping is effected thereby during a proportion only of said cycles.

2. A rotary pump as claimed in claim 1 in which each outlet port is provided with a check valve which ensures that fluid can flow through it only in the outlet direction.

3. A rotary pump as claimed in claim 1 in which there are a plurality of outlet ports with which each space successively communicates while decreasing in volume, whereby each said outlet port receives a proportion only of the volume of pumped fluid.

4. A rotary pump as claimed in claim 3 including a by-pass port and in which, in operation, each space communicates successively with a first outlet port, a by-pass port which communicates with an inlet port, and a second outlet port.

5. A rotary pump as claimed in claim 3 in which the by-pass port overlaps predetermined portions only of the first and second outlet ports so that a sealed space may communicate simultaneously with the said by-pass port and with a said portion, the said check valves preventing flow therepast when a sealed space communicates with the said by-pass port.

6. A rotary pump as claimed in claim 1 in which all except two adjacent lobes of each lobed element are partially cut away so that, at any moment, not more than one space is sealed.

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