

April 30, 1963

L. A. DETTLOF ETAL

3,087,436

HYDRAULIC PUMP

Filed Dec. 2, 1960

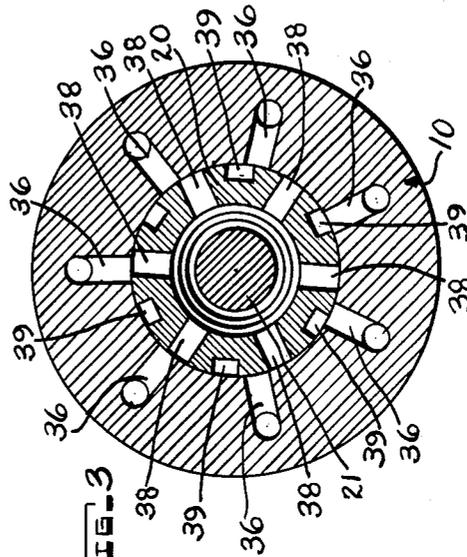
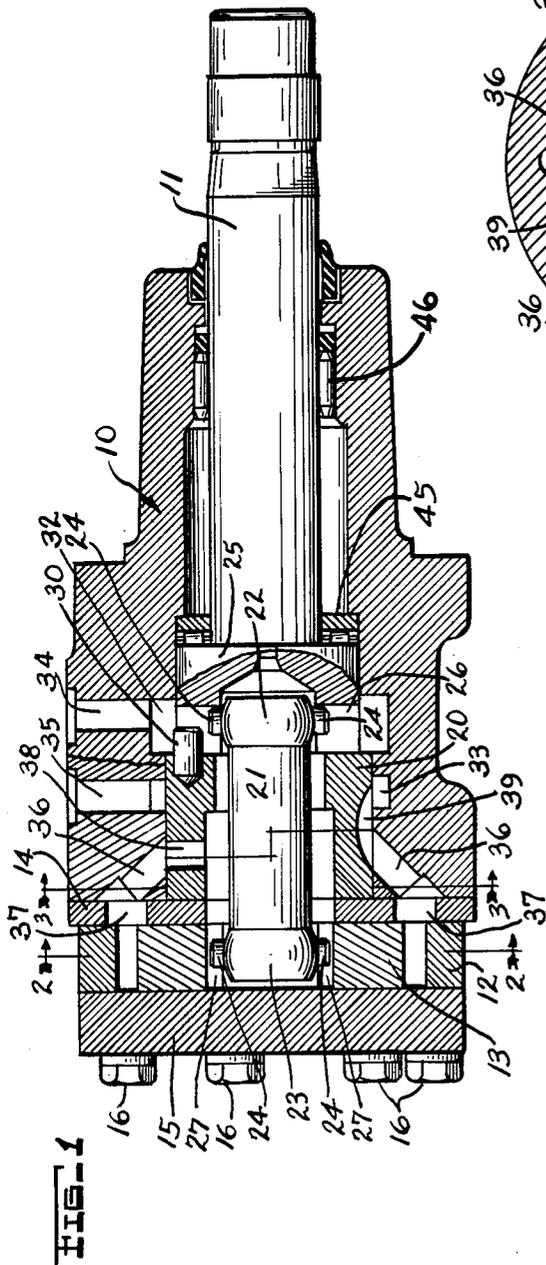
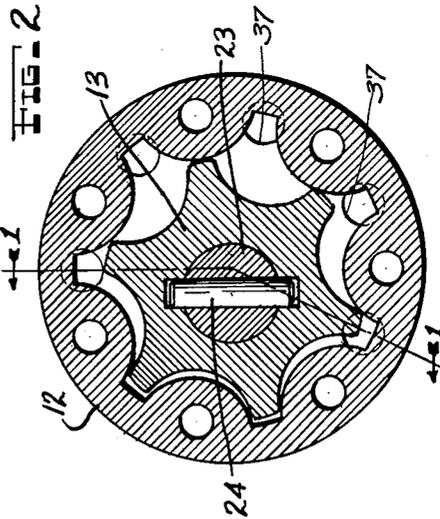


FIG. 3

FIG. 2



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3,087,436

HYDRAULIC PUMP

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Filed Dec. 2, 1960, Ser. No. 73,292

14 Claims. (Cl. 103—130)

This invention relates to gear pumps of the internal-gear type and is primarily concerned with that form of internal gear pump in which the outer pump element has one more tooth than the inner pump element.

Pumps of the internal-gear type can be and have been arranged to be driven in any of three different ways. In one arrangement, the inner and outer elements are mounted on fixed axes in the housing with the drive usually applied to the inner element. In another arrangement, the outer element is fixed and the inner element, mounted on an eccentric or crank carried by the drive shaft, orbits within the outer element. In the third arrangement, the outer element is fixed and the inner element orbits in meshing engagement with it, as in the second arrangement, but the inner element is connected to the drive shaft, as through universal joints, so that it makes one rotation on its own axis for each rotation of the drive shaft.

Each of the three arrangements just described has certain recognized characteristics of operation. In the first arrangement, the suction and pressure chambers defined by the toothed pump elements always occupy the same positions in the housing and it is therefore a simple matter to arrange for their connection to the inlet and outlet passages in the pump housing. In the second and third arrangements, where the inner element orbits within the outer element, the locations of the pump chambers continually change and it is necessary to provide some form of commutating valve mechanism to maintain the chambers properly connected to the inlet and outlet passages in the housing. The three arrangements also differ in respect to delivery rates. In the first arrangement, each complete rotation of the inner element displaces a volume of fluid corresponding to the aggregate volume of the spaces between the teeth of the inner element. In the second arrangement, each rotation of the drive shaft results in the displacement of a volume of fluid corresponding to the aggregate volume of the spaces between the teeth of the outer element. The third arrangement has a still higher delivery rate, since each rotation of the drive shaft will cause displacement of a volume of fluid corresponding to the product of the aggregate volume of the spaces between the teeth of the outer element multiplied by the number of teeth of the inner element.

In respect to possible driving arrangements and the consequences thereof on the rate of delivery, an internal-gear pump resembles the type of axial delivery pump shown in the Moineau Patents Nos. 1,892,217 and 2,028,407. In order to secure maximum delivery from a pump of that type it has been customary for many years to mount the inner element for orbiting movement and to drive it so that its speed of rotation about its own axis equals that of the drive shaft.

Our invention employs the third, or high-delivery, arrangement described above, and is principally concerned with the construction and arrangement of the valving mechanism and the manner in which it is associated with the other elements of the pump. The objects of the invention include the provision of a simple and compact pump which can be economically manufactured and which will prove durable and effective in use.

A pump embodying our invention in its preferred form comprises a housing at one end of which the internal-gear pump is mounted, with the outer element of the

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pump in fixed position and the inner element arranged to orbit in meshing engagement with the outer element. A bore in the housing and coaxial with the outer pump element provides support for a rotatable valve sleeve and drive shaft, the valve sleeve being located inwardly of the pump elements and the drive shaft projecting from the opposite end of the housing. Preferably the valve sleeve and the drive shaft are separate elements but are operately interconnected for joint rotation. Extending axially through the valve sleeve is a shaft the ends of which are connected through universal joints respectively to the drive shaft and the inner pump element. The housing is provided with a circumferential series of valving ports opening into the housing bore within the axial limits of the valve sleeve and communicating respectively with the spaces between the teeth of the outer pump element; and in the plane of such ports and valve sleeve is provided with a circumferential series of spaced radial passages corresponding in number to the teeth of the inner pump element. The bore of the housing is provided with two axially spaced annular grooves communicating respectively with supply and discharge passages formed in the housing. One of such annular grooves is in open communication with the interior of the valve sleeve for commutative connection to the valving ports through the radial passages in the valve sleeve. The second annular groove is located within the axial limits of the valve sleeve, and the latter is provided in its exterior surface with a circumferential series of grooves providing commutative connections between the valving ports and the second annular groove.

Other objects and features of the invention will appear from the following more detailed description and from the accompanying drawings in which:

FIG. 1 is an axial section through a pump on the broken line 1—1 of the FIG. 2;

FIG. 2 is a transverse section through the pumping elements on the line 2—2 of FIG. 1;

FIG. 3 is a transverse section through the valving mechanism on the broken line 3—3 of FIG. 1.

The pump shown in the drawing comprises a housing 10 provided with a bore receiving a drive shaft 11 which projects from one end of the housing for operative connection to any appropriate drive means. On the end of the housing opposite that from which the shaft 11 projects, the pump elements are mounted, such elements comprising an outer annular element 12 and an inner element 13. Preferably, a wear plate 14 is disposed between the pump element 12 and the adjacent end face of the housing 10, and such wear plate and outer pump element are clamped between the housing and a cover plate 15 by screws 16 which extend through the cover plate, outer element 12, and wear plate 14 into the housing.

Rotatably received within the bore of the housing between the inner end of the drive shaft 11 and the wear plate 14 is a valve sleeve through which extends a shaft 21 for transmitting drive from the drive shaft 11 to the inner pump element 13. Desirably, the shaft 21 is a rigid shaft and has universal-joint connections with the drive shaft 11 and the inner pump element. For this purpose, the ends of the shaft 21 are formed as frusto-spherical heads 22 and 23 and provided with a pair of radially projecting, diametrically opposite bosses 24, which may be the ends of pins extending through the heads 22 and 23. Conveniently, the drive shaft 11 has at its inner end an enlarged head 25 provided with an axial recess, which receives the head 22 of the shaft 21, and with a diametrically extending slot 26 slidably receiving the bosses 24 on the head 22. At the opposite of the shaft 21, the inner pump element 13 is provided with a central bore receiving the head 23 and with axially extending grooves 27 which slidably receive the bosses 24 on such head.

The meshing teeth of the inner and outer pump elements are formed, in known manner, so that as the inner element 13 rotates on its axis it is compelled to orbit within the outer element. In addition to compelling such orbiting movement, the teeth of the inner and outer pump elements cooperate effectively to divide the space between the elements into suction and pressure chambers, each of which alternately expands and contracts as the inner element 13 orbits. In the particular pump shown in the drawing, the inner element has six teeth and the outer element seven teeth, and for each rotation of the inner element about its axis each of the chambers referred to undergoes six complete cycles of expansion and contraction. Since the shaft 21 couples the drive shaft and the inner pump element 13 together for rotation at the same speed, the pump chambers will undergo six cycles of expansion and contraction for each revolution of the drive shaft.

To effect the connection of the expanding and contracting pump chambers respectively to inlet and discharge passages in the housing 10 the valve sleeve 20 is connected to the shaft 11 to rotate at the speed thereof. Conveniently, this connection is accomplished by providing the valve sleeve with a drive pin 30 which projects from the valve sleeve into one end of the slot 26 in the head 25 of the drive shaft. Such a connection between the drive shaft and the valve sleeve has the advantage of freeing the valve sleeve from any transverse loads that may be applied to the drive shaft as a result of the reaction thereon of the forces transmitted between the drive shaft and the shaft 21.

The bore of the housing 10 is provided with two annular grooves 32 and 33 communicating respectively with radial passages 34 and 35 opening in the side of the housing 10 and adapted for connection to conduits through which the fluid enters and leaves the pump. The annular groove 32 is located in the plane of the slot 26 and therefore is in constant communication through that slot with the interior of the valve sleeve 20, while the groove 33 is located within the axial limits of the sleeve 20. Spaced toward the pumping elements from the groove 33, the housing is provided with a circumferential series of ports 36 which open into the bore of the housing and communicate respectively, through holes 37 in the wear plate 14, with the spaces between the teeth of the outer pump element 12. For cooperation with the ports 36, the valve sleeve is provided with a series of radial passages 38 corresponding in number to the teeth of the inner pump element 13 and extending completely through the wall of the sleeve. Midway between adjacent ones of the radial passages 38, the exterior surface of the sleeve of the valve 20 is provided with grooves 39 which extend axially of the sleeve to overlap the annular groove 33 and to cooperate with the ports 36 in the housing.

The manner in which the radial passages 38 and the grooves 39 of the valve sleeve 20 cooperate with the ports 36 to establish the necessary commutative connections between the pump chambers and the housing-passages 34 and 35 will be apparent from FIGS. 2 and 3 in which the inner pump element 13 and the valve sleeve 20 are shown in positions they occupy simultaneously. The diameters of the ports 36 and of the radial passages 38 in the valve sleeve and the width of each groove 39 are all substantially equal to each other and to the width at the sleeve surface of the lands between such radial passages and grooves. The passages 38 and 39 are so oriented with respect to the teeth of the inner pump element 13 that as each of such teeth reaches the point of deepest mesh with a space between the teeth of the outer element 12 the valving port 36 connected to that space will be occluded by one of the lands of the valve sleeve. Desirably, the two pairs of bosses 24 are located in a common plane so that the orientative relation of the valve sleeve 20 and the inner pump element will remain constant as they rotate about their respective axes.

In the above described arrangement, as will be readily apparent, the valve passages 38 and the grooves 39 will cooperate commutatively with the ports 36 to connect each expanding pump chamber with one of the annular grooves 32 and 33 and each contracting pump chamber to the other of such annular grooves. Which of the annular grooves is connected to expanding pump chambers and which to contracting chambers will depend upon the direction of rotation of the drive shaft 11. In the arrangement shown, counterclockwise rotation of the drive shaft will produce clockwise orbiting of the inner pump element, connection of contracting pump chambers to the annular groove 32 through radial passages 38, and connection of expanding chambers to the annular groove 33 through the valve grooves 39. This mode of operation is preferred, because the inner end of the drive shaft is subjected to discharge pressure which imposes on the shaft an outward effort that can readily be taken care of by an anti-friction thrust bearing 45 located between the enlarged head 25 and a shoulder on the interior of the housing 10.

It was noted above that by making the drive shaft 11 and the valve sleeve 20 separate elements the valve sleeve is freed of radial loads. Other advantages possessed by such an arrangement are that the same valve sleeve 20 can be used with different drive shafts and that accurate concentricity of the cylindrical valving surfaces with the drive-shaft bearings is not required. This latter feature makes practicable the use of anti-friction radial bearings, such as the bearing 46, to support the drive shaft. The use of the interior of the valve sleeve as a fluid passage greatly simplifies the machining necessary to provide the commutative valve action. Also contributing to simple and inexpensive machining is the formation of the housing ports 36 as straight holes drilled obliquely from the end face of the housing 10 into the housing bore. The single diametrically extending slot 26 in the inner face of the drive shaft serves a triple purpose in that it provides communication between the interior of the valve sleeve 20 and the housing-groove 32 as well as receiving both the pin 30 which drives the valve sleeve and the bosses 24 which drive the shaft 21.

While our device has been described as a pump, it will be obvious that it can also be made to serve as a reversible hydraulic motor by supplying fluid under pressure to one or the other of the passages 34 and 35 and exhausting fluid from the other of such passage.

We claim as our invention:

1. In an internal-gear pump, meshing outer and inner pump elements of which the inner pump element has one less tooth than the outer element and the outer element is stationary, a housing to which said outer element is secured, said housing having a bore coaxial with the outer element, a valve sleeve rotatably supported in said bore in axially spaced relation to said elements, said housing having a circumferential series of ports opening into said bore within the axial limits of said valve sleeve and communicating respectively with the spaces between the teeth of said outer element, said housing also having inlet and outlet passages, means for commutatively connecting one of said passages to said ports, said means comprising a circumferential series of axially extending grooves formed in the outer surface of said valve sleeve, said grooves overlapping said ports axially and corresponding in number to the teeth of said inner element, the second of said passages being in open communication with the interior of said sleeve and said sleeve being provided in the plane of said ports with a circumferential series of radial passages corresponding in number to the teeth of said inner element for providing commutative connection between the interior of the valve sleeve and said ports, a drive shaft rotatably mounted in said housing coaxially with the valve sleeve and on the opposite axial side thereof from said inner and outer elements, means operatively interconnecting said drive shaft and valve sleeve for joint rotation, and means for transmitting drive from said

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drive shaft to the inner pump element to cause it to rotate on its axis at the same rate as the drive shaft, said last named means comprising a second shaft extending generally axially through said valve sleeve and having its ends drivingly connected respectively to said drive shaft and inner element.

2. A pump as set forth in claim 1 with the addition that said second shaft is a rigid shaft having universal-joint connections with said drive shaft and inner element.

3. A pump as set forth in claim 2 with the addition that the inner end of said drive shaft is provided with a central recess receiving the adjacent end of the second shaft and with a diametrically extending open slot communicating with the interior of the valve sleeve and slidably receiving diametrically opposite bosses on said second shaft, said second housing passage including an annular groove with which the ends of said slot continuously communicate, said means operatively interconnecting the drive shaft and valve sleeve comprising a pin secured in the valve sleeve and projecting axially therefrom into said slot.

4. A pump as set forth in claim 2 with the addition that the inner end of said drive shaft is provided with a central recess receiving the adjacent end of the second shaft and with a diametrically extending slot slidably receiving diametrically opposite bosses on said second shaft, said slot opening in the end face of said drive shaft, said means operatively interconnecting the drive shaft and valve sleeve comprising a pin secured in the valve sleeve and projecting axially therefrom into said slot.

5. A pump as set forth in claim 2 with the addition that the inner end of said drive shaft is provided with a central recess receiving the adjacent end of the second shaft and with a diametrically extending slot communicating with the interior of the valve sleeve and slidably receiving diametrically opposite bosses on said second shaft, said second housing passage including an internal annular groove with which the ends of said slot communicate.

6. In an internal gear pump, a stationary outer element and an inner element which orbits in meshing engagement with the outer element, a housing to which said outer element is secured, said housing having a bore coaxial with the outer element, a valve sleeve rotatable in said bore in axially spaced relation to said elements, said housing having inlet and outlet passages and a circumferential series of ports communicating respectively with the spaces between the teeth of said outer element, a drive shaft rotatably mounted in said housing substantially coaxial with said valve sleeve and on the opposite axial side thereof from said inner and outer elements, a drive connection between said drive shaft and valve sleeve, said connection including an eccentric abutment on one of said drive shaft and valve sleeve, the other of said drive shaft and valve sleeve having a generally radially extending surface which engages said abutment in torque-transmitting relation and over which said abutment is radially slidable to accommodate for any misalignment of the shaft and sleeve, means extending through the valve sleeve for operatively interconnecting the drive shaft and said inner element to cause the inner element to rotate on its own axis at the speed of the drive shaft, and means including passages in the valve sleeve for commutatively connecting said ports to said housing-passages as the valve sleeve rotates.

7. A pump as set forth in claim 6 with the addition that said drive connection includes a pin projecting axially from said valve sleeve and received in a radial slot in said drive shaft.

8. In an internal gear pump, a stationary outer element and an inner element which orbits in meshing engagement with the outer element, a housing to which said outer element is secured, said housing having inlet and outlet passages, means including a drive shaft member for rotating said inner element at the speed of the drive shaft, means including a rotatable valve member at least

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approximately coaxial with the drive shaft for commutatively connecting the spaces between the teeth of the outer element with said passages, and means capable of transmitting torque only from the drive shaft member directly to the valve member for rotating the valve member at the speed of the drive shaft, said last named means including an eccentric abutment on one of said members the other of said members having a generally radially extending surface which engages said abutment in torque-transmitting relation and over which said abutment is radially slidable.

9. In an internal gear pump, a stationary outer element and an inner element which orbits in meshing engagement with the outer element, a housing to which said outer element is secured, said housing having a bore coaxial with the outer element, a valve sleeve rotatable in said bore in axially spaced relation to said elements, said housing having inlet and outlet passages and a circumferential series of ports communicating respectively with the spaces between the teeth of said outer element, means for rotating said inner member and valve sleeve about their respective axes at the same speed, one of said housing passages being in open communication with the interior of said sleeve, said sleeve being provided with two series of fluid passages for commutatively connecting said ports with said housing passages, the fluid passages of one such series extending through the wall of the valve sleeve and those of the other series extending axially on the outer surface of the sleeve.

10. In an internal gear pump, a stationary outer element and an inner element which orbits in meshing engagement with the outer element, a housing having an end face to which said outer element is secured, said housing also having a bore coaxial with said outer element and a circumferential series of oblique holes having their outer ends opening in said end face and communicating respectively with the spaces between the teeth of said outer element, the inner ends of said holes opening into said bore, said housing being provided with inlet and outlet passages, means including a valve member rotatable in said bore for commutatively connecting said holes with said passages as said valve sleeve rotates, and drive means for rotating said inner element and said valve sleeve at the same speed about their respective axes.

11. A pump as set forth in claim 8 with the addition that said torque-transmitting means comprises a pin projecting axially from the valve sleeve and slidably received in a radially extending slot in the drive shaft.

12. A pump as set forth in claim 8 with the addition that said torque-transmitting means comprises a pin projecting from one of said valve sleeve and drive shaft and slidably received in a radially extending slot in the other.

13. A pump as set forth in claim 9 with the addition that the means for rotating the inner member and valve sleeve comprises a drive shaft rotatably supported in the housing at least approximately coaxial with the valve sleeve and in abutting relation thereto, one of said valve sleeve and shaft being provided with a radial slot and the other with a pin slidably received in said slot, said slot communicating at its inner end with the interior of the valve sleeve and at its outer end with one of said passages in the housing.

14. A pump as set forth in claim 13 with the addition that said slot is in the drive shaft.

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