Feb. 17, 1953 M. L. RHINE 2,628,568

HIGH-PRESSURE PUMP

Filed April 26, 1946 2 SHEETS—SHEET 1

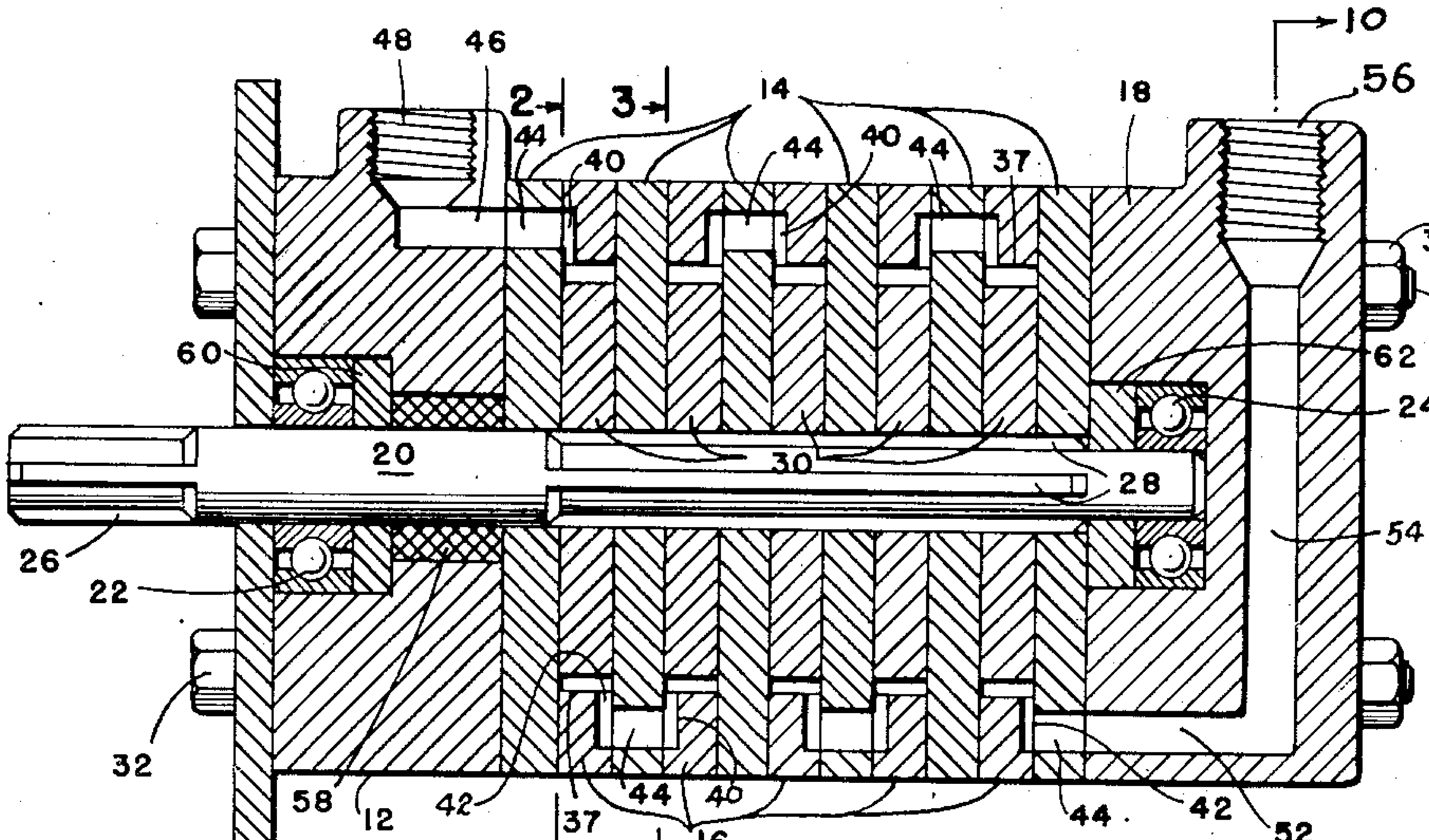


FIG. 1

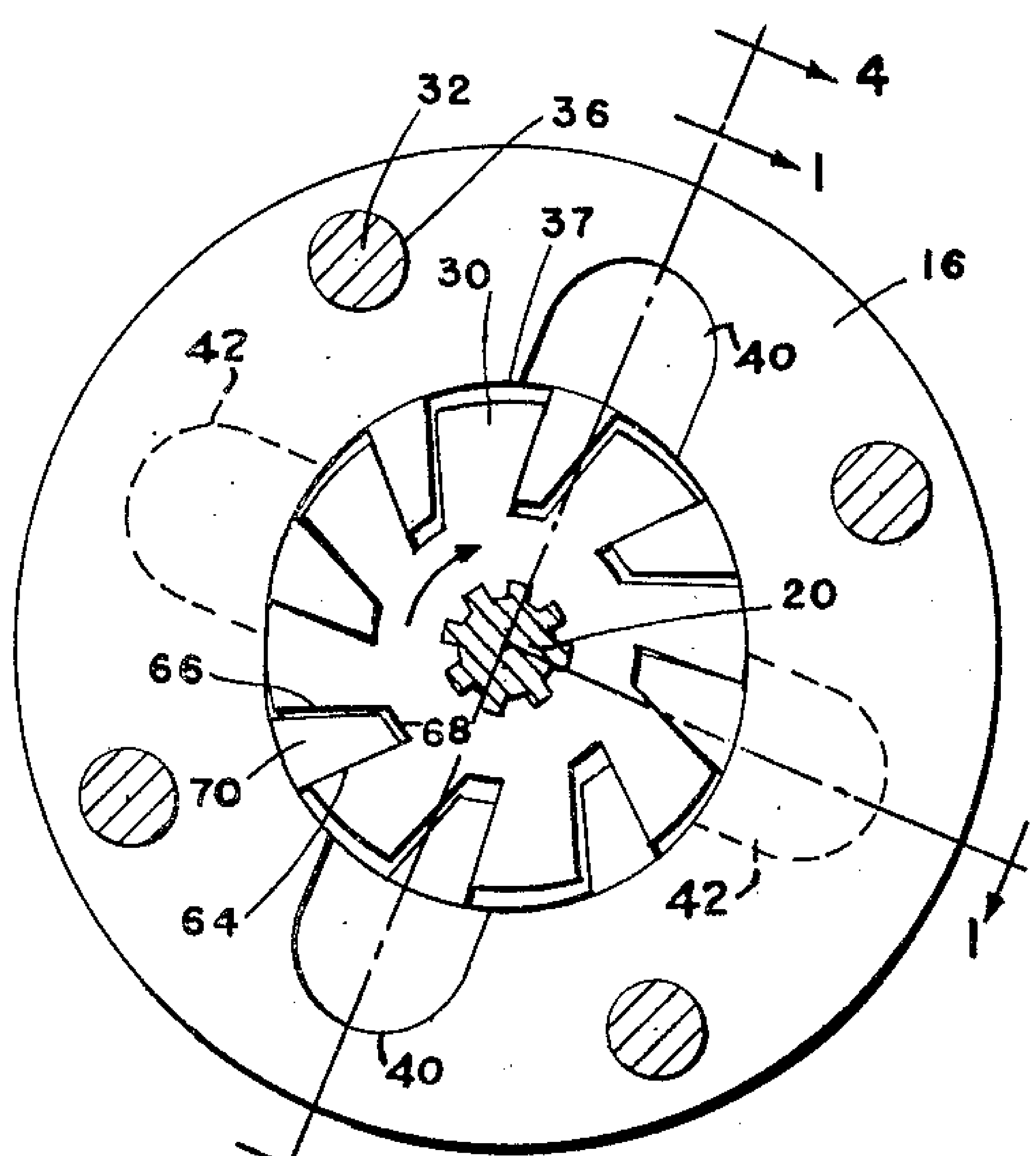


FIG. 2

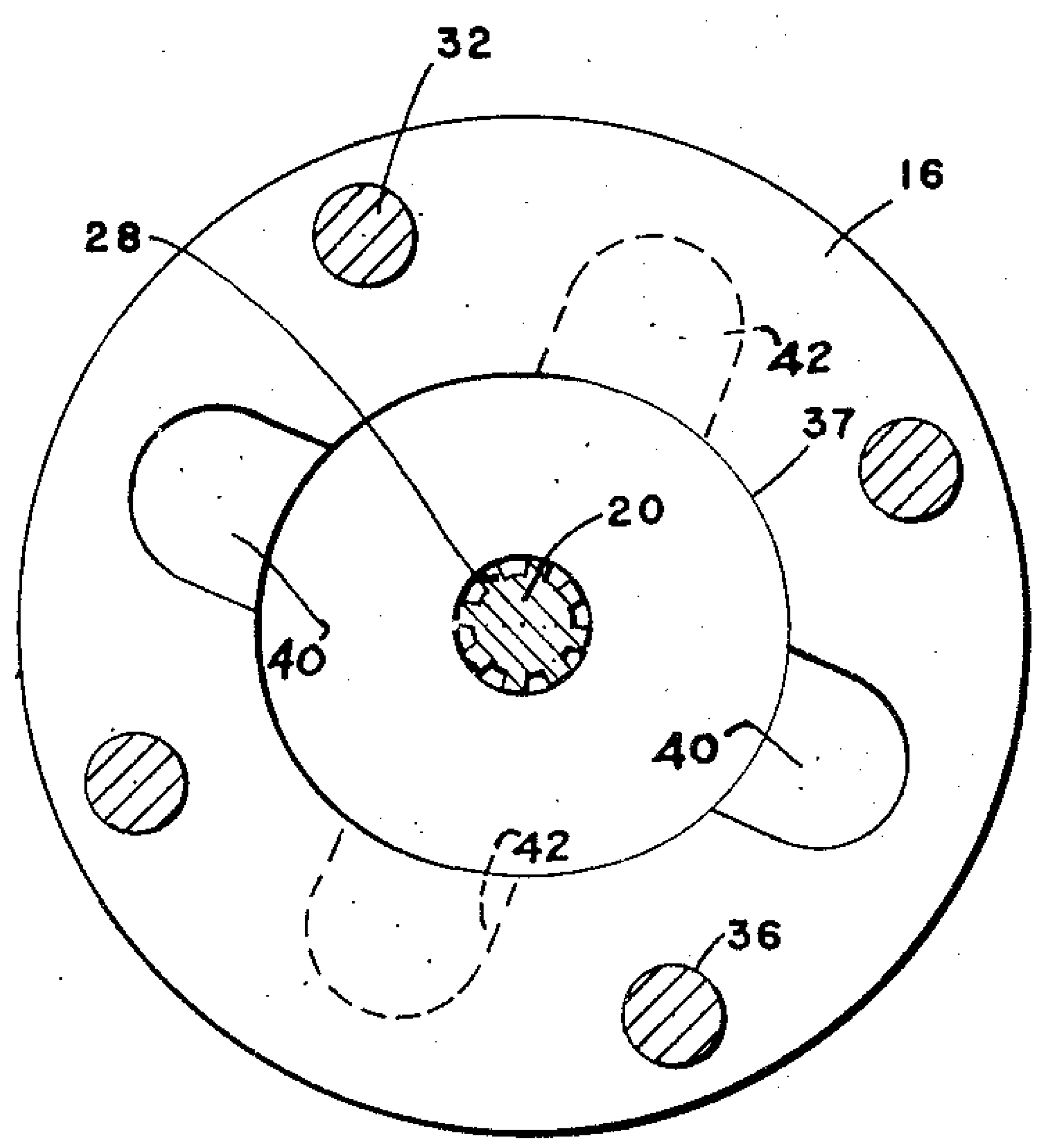


FIG. 3

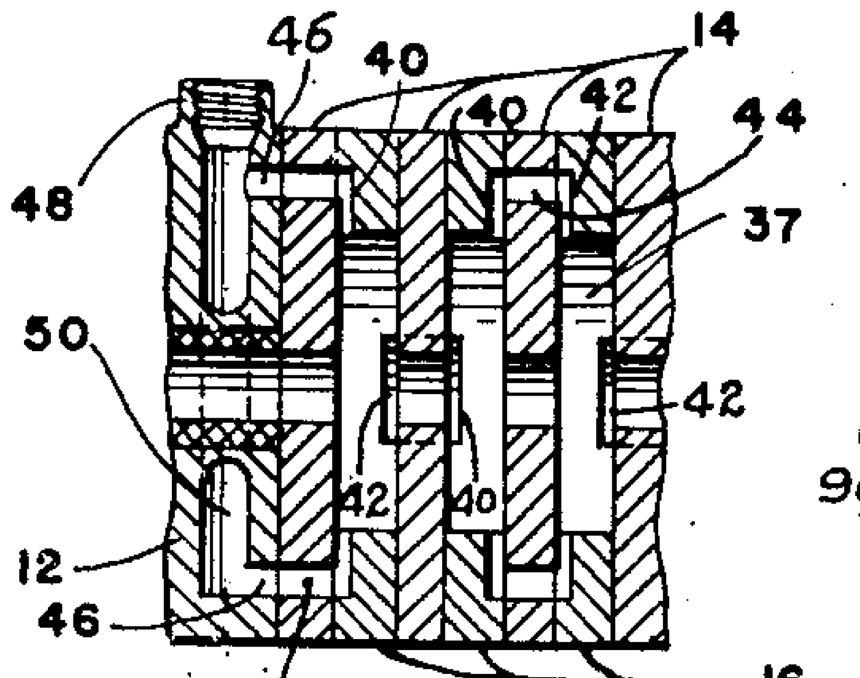
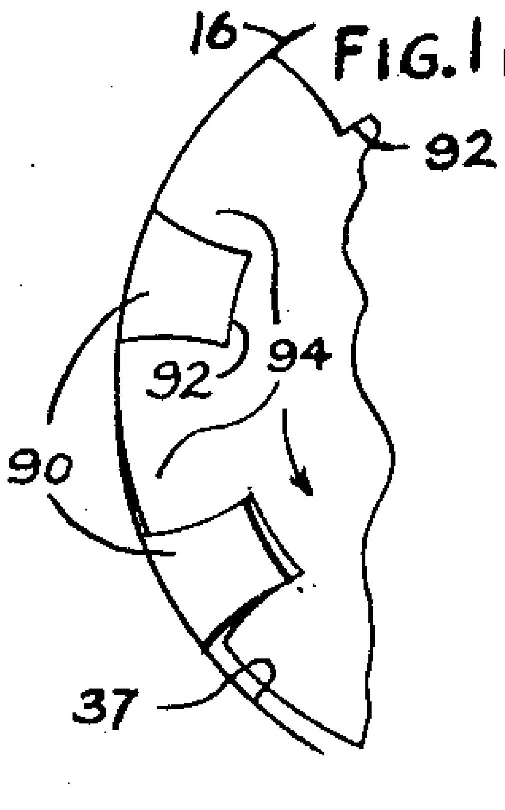


FIG. 4

FIG. 11



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2 SHEETS—SHEET 2

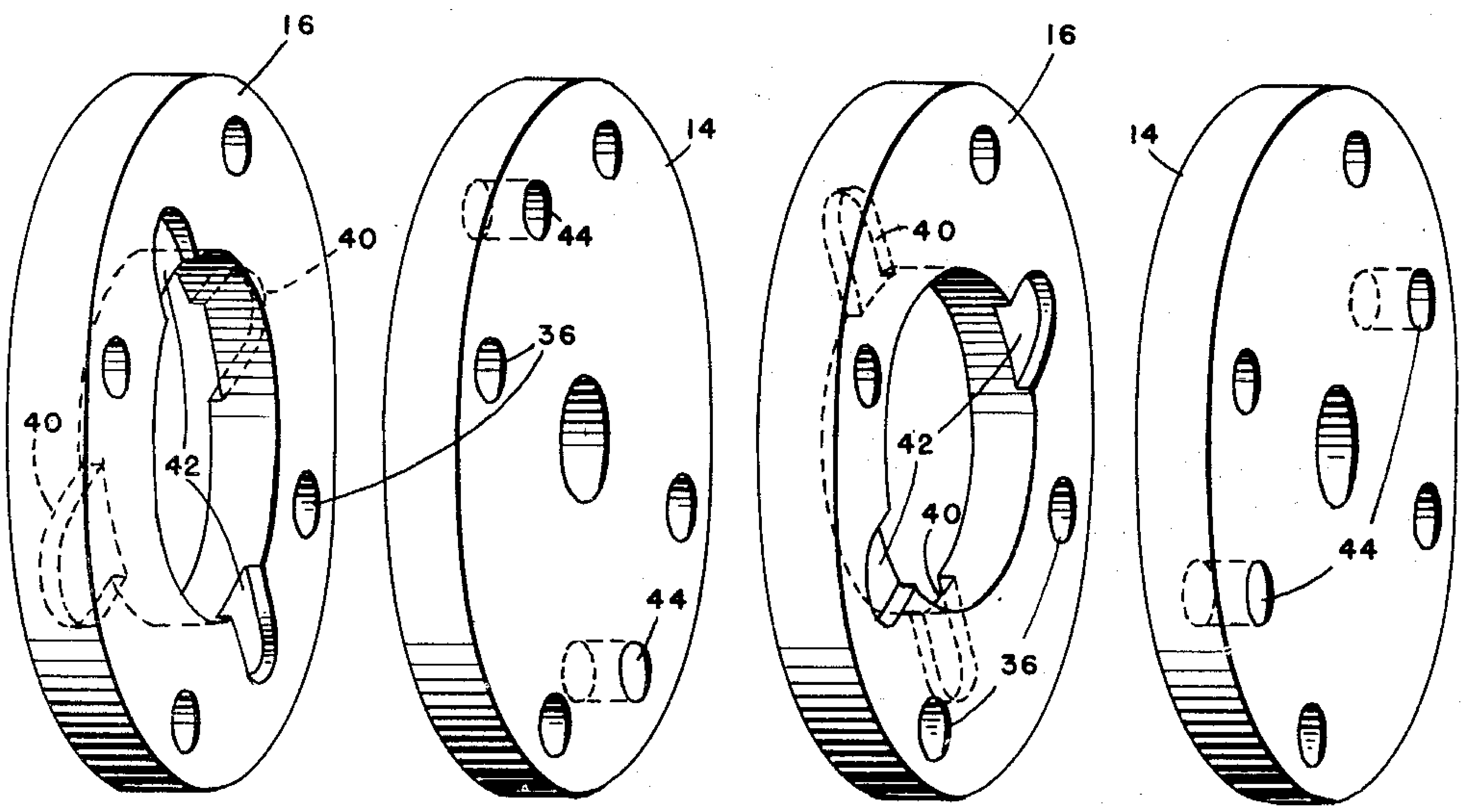

FIG. 5

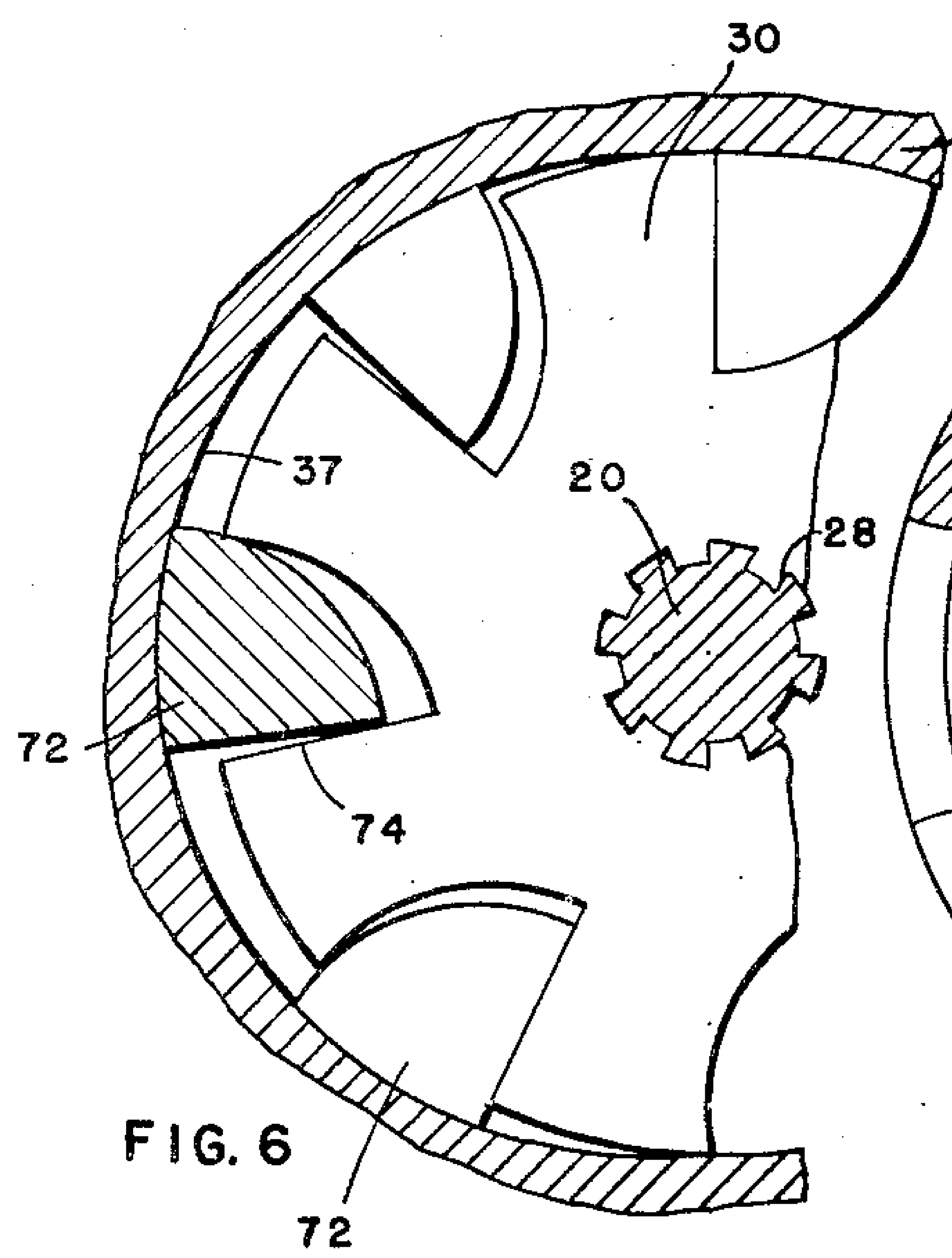

FIG. 6

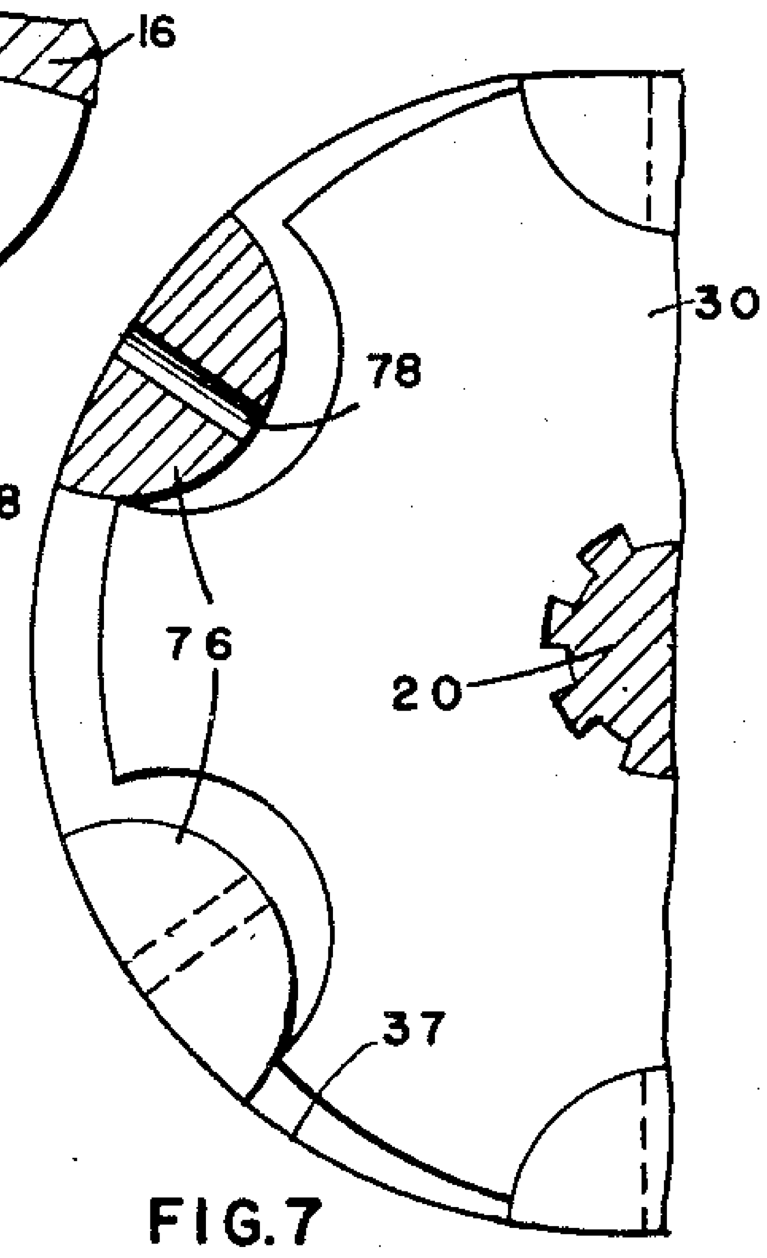

FIG. 7

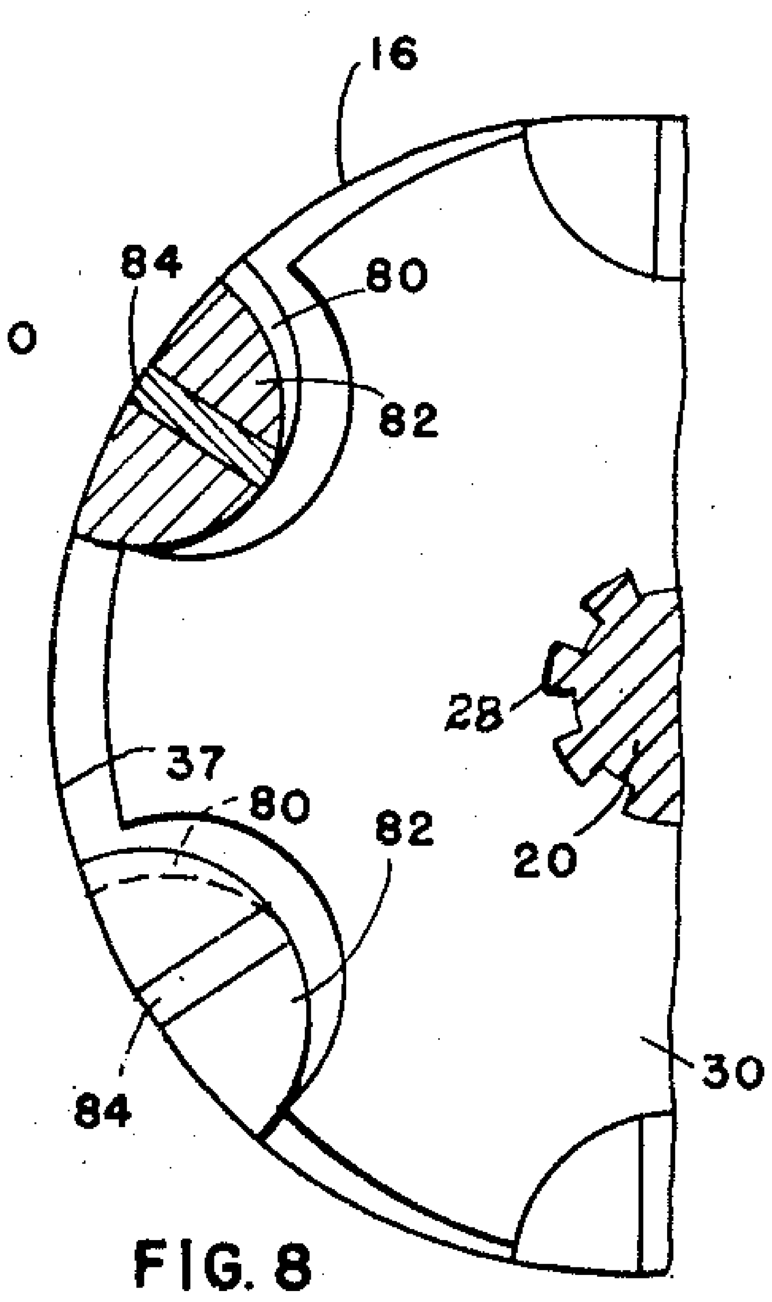

FIG. 8

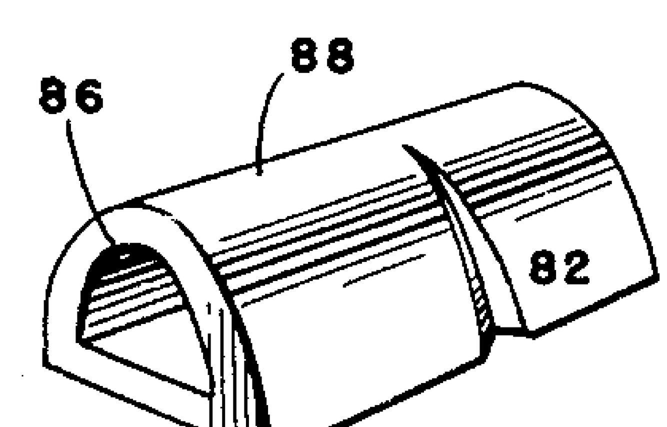

FIG. 9

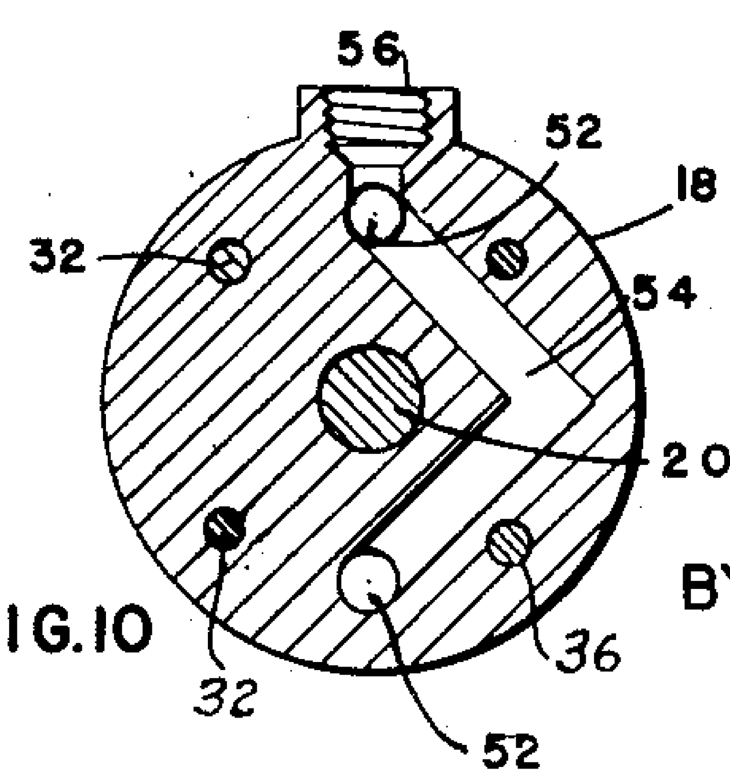

FIG. 10

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UNITED STATES PATENT OFFICE

2,628,568

HIGH-PRESSURE PUMP

Marvin L. Rhine, Chicago, Ill., assignor to Ellipse Corporation, Chicago, Ill., a corporation of Illinois

Application April 26, 1946, Serial No. 665,268

3 Claims. (Cl. 103—135)

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My present invention relates to a high pressure pump for fluids, that is, either liquid or gas.

One object of the invention is to provide a pump in which a rotor rotates in a stator, the stator cavity being elliptical in shape and the rotor having pockets in which blades reciprocate radially with their outer ends following the wall of the stator cavity.

Another object is to provide a high pressure pump including a number of rotor units in the form of disks, each surrounded by a stator unit also in the form of a disk, with separator disks between the rotor and stator disks, the stator disks being provided with inlet and outlet passageways arranged so that any number of the disks can be stacked and the resulting assembly will constitute a high pressure pump when the disks are connected together between end plates and the rotor units will be in series.

A further object is to provide rotor pockets of characteristic shape and inclination, and to provide blades mounted therein of complementary shape to reciprocate in the pockets and effect intake of fluid at opposite points in the stator and displacement of fluid at intermediate opposite points whereby rotation of the rotor disks produces pumping action, the arrangement of the units in series producing high pressures unattainable by means of single units, and a greater number of units effecting higher pressure so that the desired pressure may be secured by utilizing the proper number of units.

Still a further object is to provide modified forms of rotor blades particularly adaptable for certain types of fluids and having certain structural details which increase their efficiency and improve the pumping action.

With these and other objects in view, my invention consists in the construction, arrangement and combination of the various parts of my pump whereby the objects contemplated are attained, as hereinafter more fully set forth, pointed out in my claims and illustrated in the accompanying drawings, wherein:

Figure 1 is a sectional view through a high pressure pump embodying my present invention.

Figure 2 is a sectional view on the line **2—2** of the Figure 1, Figure 1 being a sectional view on the line **1—1** of Figure **2** to show both inlet and outlet porting arrangements for the series of pump units.

Figure 3 is a sectional view on the line **3—3** of Figure 1.

Figure 4 is a sectional view on the line **4—4** of Figure 2.

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Figure 5 is an exploded perspective view of two of the stator disks and two of the separator disks to show the relation of the passageways and ports in them.

Figures 6, 7 and 8 are views similar to Figure 2 showing modified forms of rotor blades.

Figure 9 is a perspective view of another modified form of blade.

Figure 10 is a sectional view on the line **10—10** of Figure 1 showing the connection of opposite ports with each other, and

Figure 11 is a sectional view showing a further modified form of rotor pocket and blade shape.

On the accompanying drawings I have used the reference numeral **10** to indicate a mounting plate for my high pressure pump. Stacked against the mounting plate **10** is an end plate **12**, a separator disk **14**, a stator disk **16**, five other separator disks **14** with four stator disks **16** interposed between them, and an end plate **18**.

A shaft **20** is journaled in bearings **22** and **24** which bearings are carried by the end plates **12** and **18** respectively. The shaft **20** is splined as at **26** and **28** and on the splining **28**, five rotor disks **30** are mounted. While I have illustrated fice rotor disks, this number may be varied from one to as many as desired to meet the requirements for any particular pump.

The end plates **12** and **18** and the disks **14** and **16** are held in assembled relation to each other by means of tie bolts **32** and nuts **34**. The tie bolts extend through openings **36** of the disks **14** and **16** (see Figures 4 and 5) and of course the end plates **12** and **18** are similarly drilled to receive the tie bolts.

Each stator disk has a stator cavity **37** which is elliptical in outline as shown in Figure 2, its minor diameter being substantially the same as the diameter of the rotor disk **30**. The stator disk has in one side face thereof, radial inlet passages **40** and in the opposite side face, radial outlet passages **42**. The passages **40** are circumferentially spaced 90 degrees from the passages **42** as shown in Figure 4 and alternate stator disks **16** have their inlet passages at 90 degrees, or the outlet passage of one disk aligned with the inlet passage of the next adjacent disk.

The separator disks **14** are then provided with transfer passages **44** for connecting the outlet passage **42** of one disk to the inlet passage **40** of the next adjacent disk and the transfer passages **44** are therefore rotated 90 degrees in successive disks **14** as obvious from an inspection of Figure 5.

The end plate **12** has a pair of opposite inlet ports 46 connected with an intake boss 48 and with each other by a passageway 50 (see Figure 4), the ports 46 aligning with the passages 44 of the left hand separator disk 14 in Figure 1. The end plate 18 is similar in construction having a pair of ports 52 connected together by a passageway 54 and with an outlet boss 56. The dual arrangement of the ports 46 and 52 is not illustrated in Figure 1 because the lower half of the figure is taken on a section line at right angles to the upper half as indicated by the line 1—1 in Figure 2. Figures 4 and 10 however show the true arrangements on section lines directly through the pump.

For sealing the shaft 20 against leakage, packing 58 is provided and suitable washers 60 and 62 are interposed between the packing and the bearing 22 and between the right hand separator disk 14 and the bearing 24 respectively. The bearing 24 has a sealed-in end and therefore requires no packing.

Referring to Figure 2, it will be noted that the rotor has a series of pockets each of which has a rear wall 64, a front wall 66 and an inner wall 68. A blade 70 is mounted therein and is of substantially a complementary shape with respect to pocket. These blades move substantially radially in the pockets, being thrown outward by centrifugal force and by the pressure of the fluid in front of them which tend to crowd the blades back against the back walls 64 of the rotor pockets with the blades tilting so that their outer ends fit tightly against the inner face of the elliptical stator cavity 37.

In pumping most liquids I find that centrifugal force and the pressure of the liquid holds the blades too tightly against the stator cavity wall and the back walls 64 of the rotor pockets. Therefore I incline the pockets from radial position so that there is a tendency to pull the blades inwardly to counteract this pressure. The degree of inclination determines the degree of counteraction.

In the pumping of some fluids I find that blade shapes differing from those shown in Figure 2 are more desirable. For instance, in Figure 6 quarter circle blades 72 are illustrated wherein the rotor pockets have substantially flat rear faces 74.

Where it is desirable to force the blades outwardly they may be substantially half circles as shown as 76 in Figure 7.

When the pump blades (all types disclosed) are at their inward limits they drive all fluid out of the rotor pockets and to relieve the last of this fluid the blades may be provided with relief openings 78 as shown only in Figure 7. Another method is shown in Figures 8 and 9 in which relief grooves 80 are provided.

Figure 8 illustrates a further modification in which each blade consists of two quarter circle parts 82 separated by a packing bar 84. The blades of Figures 6 and 7 instead of being solid may be hollow as indicated at 86 in Figure 9, the blade of this figure being designated 88.

In Figure 11, I show a rotor pocket and blade shape in which the blade is designated 90 and the pocket 92. The portions 94 of the rotor between the pockets 92 are somewhat the shape of gear teeth and the blades 90 have a reverse shape for fitting all the way in the pockets at the minor axis of the ellipse 37. This type rotor and blade are particularly adaptable for slow speed operation.

In all forms of the blade as shown in Figures 2, 6, 7, 8, 9 and 11 there is a pocket formed ahead of the blade from which fluid is displaced in addition to being displaced from the major axis portion of the elliptical stator cavity 37. Thus the degree of eccentricity need not be very great as between the diameter of the rotor and the major axis of the stator cavity as the stator cavity is supplemented by the spaces ahead of the blades in the rotor pockets and the bottoms of the pockets. The resulting structure is a very efficient pump with considerable capacity in spite of small radial movement of the rotor blades.

Practical operation

Referring specifically to the operation of my pump structure and considering particularly Figure 5 there would be first a separator disk 14 (in the position of the one at the left hand end of Figure 1) and this disk would be between the end plate 12 of Figure 1 and the first stator disk 16, this first stator disk being the one shown at the left in Figure 5.

Fluid would enter from the inlet 48 and flow through the passageways 50 and 46 (see Figure 4) and through the openings 44 of the first separator disk 14. These openings are in alignment with the intake passageways 40 of the left hand stator disk 16 in Figure 5 so that the fluid can flow into the stator cavity from diametrically opposite points (see particularly Figure 2). At this position the blades 70 are outward in their pockets 68 thus enlarging the effective volume of the pockets and thereby drawing the fluid into the pockets.

As the rotor disk 30 in the first stator disk 16 continues to rotate the fluid will be forced out of the pockets by reason of the blades being driven back into them which causes the fluid to be expelled into the outlet passageways 42 of the first stator disk. Since these are in alignment with the openings 44 of the second separator disk 14 (second disk from the left in Figure 5) the fluid flows through them and enters the intake passageways 40 of the second stator disk 16 (third disc from the left in Figure 5).

In the stator cavity of this stator disk a similar pumping action takes place which draws fluid in from the passageways 40 and discharges it to the passageways 42. Again these passageways are in alignment with the openings 44 of the third separator disk (right hand disc in Figure 5) which may now be considered as next to the end plate 18 so that the fluid discharges from the ports 44 of this separator disk to the passageways 52 and 54 of the end plate 18 (see Figure 10) with discharge of the fluid from the boss 56.

In order to align the ports and passageways properly alternate separator disks and alternate stator disks are rotated 90° to each other as illustrated in Figure 5 and obviously the staging in the pump can be single (two end separator disks with one stator disk between them) or two stage (the same as the single stage with the addition of one separator disk and one stator disk as just explained in connection with Figure 5 including another separator disk to the left of the four disks there shown). In Figure 1 a five stage pump is illustrated.

While I have referred to my device as being a rotary pump obviously it may be a fluid driven motor or more generically a "fluid displacement device" as the structure is adaptable to both motors and pumps which are both fluid displacing devices.

The blades are so designed in shape that wear does not affect the sealing qualities of the blades in the rotor pockets. Upon wear occurring the blades merely assume a new working range farther out in the pockets without substantially changing the relationship of the blades to the pockets.

My stacking arrangement of the pump units obviously makes it possible to assemble from a few parts a high pressure pump having any desired operating pressure within certain limits. The only modification required because of a change in size is a different length of tie rod 32.

Some changes may be made in the construction and arrangement of the parts of my device without departing from the real spirit and purpose of my invention, and it is my intention to cover by my claims any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope.

I claim as my invention:

1. A fluid displacement device comprising a stator having an out-of-round stator cavity, a rotor rotatable therein, said rotor having blade-receiving pockets, blades received therein for free movement relative to the pockets and radial movement relative to the stator cavity in order to contact the wall thereof, each of said blades being substantially a half-circle in cross-sectional shape, each of said pockets having a similar shaped bottom, said pockets being of substantially the same size as said blades to effect substantially complete displacement of fluid from said pockets in the seated positions of said blades.

2. A fluid displacement device comprising a stator having an out-of-round stator cavity, a rotor rotatable therein, said rotor having blade-receiving pockets, blades received therein for free movement relative to the pockets and radial movement relative to the stator cavity in order to contact the wall thereof, each of said blades being substantially a half-circle in cross-sectional shape, each of said pockets having a similar shaped bottom, said pockets being of substantially the same size as said blades to effect substantially complete displacement of fluid from said pockets in the seated positions of said blades, and a relief opening through each of said blades located between the front and rear faces of the blade and extending from the stator contacting face of the blade to the opposite face thereof to balance out excess pressure between said blade and said stator by conducting the fluid from the pocket, thus aiding said blade to follow the contour of said stator.

3. A rotary fluid displacement device comprising a stator having an out-of-round stator cavity, a rotor located therein, said rotor having blade-receiving pockets, a blade received in each of said pockets, each of said blades having contact at all times during operation with said stator and said rotor, in which the contact between the outer surface of the blade and the inner surface of the stator is area contact to prevent complete rotation of the blade in the pocket but permit it to rock therein with free movement in relation to said pocket, and the contact of a side of the blade with the rotor pocket being along a line which varies in position with respect to the blade and the pocket during operation and which acts as a pivot for the blade, the pivot action tending to keep the outer surface of the blade in said area contact with said stator during all positions of rotation of said rotor.

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