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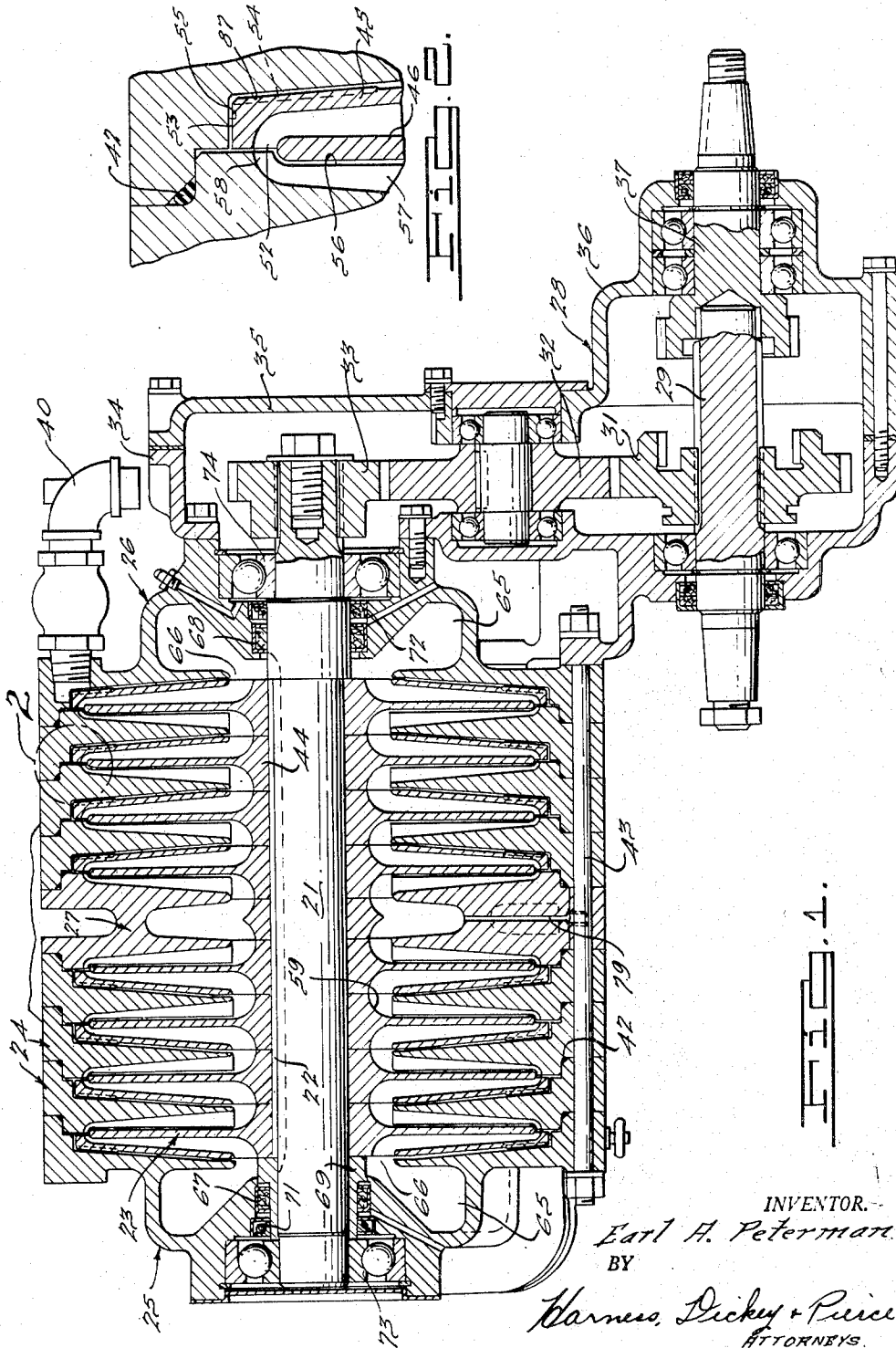
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HIGH PRESSURE CENTRIFUGAL PUMP

Filed March 24, 1952

4 Sheets-Sheet 1



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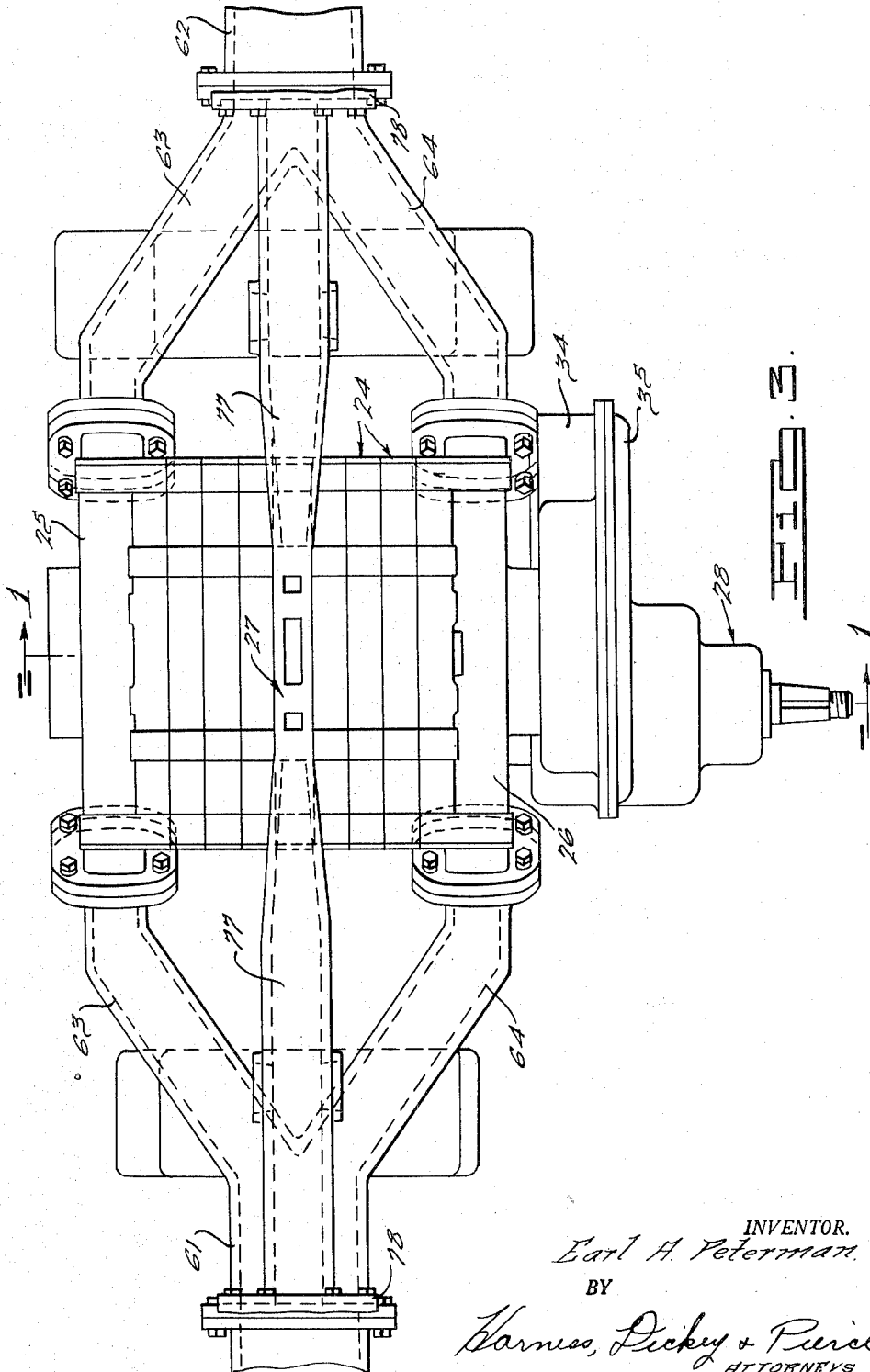
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4 Sheets-Sheet 2



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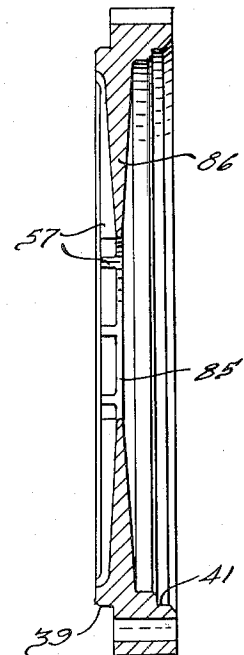
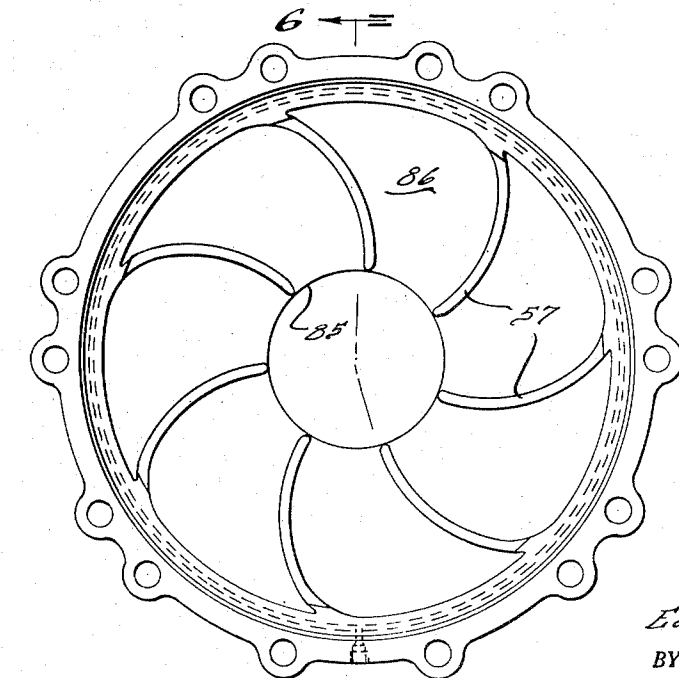
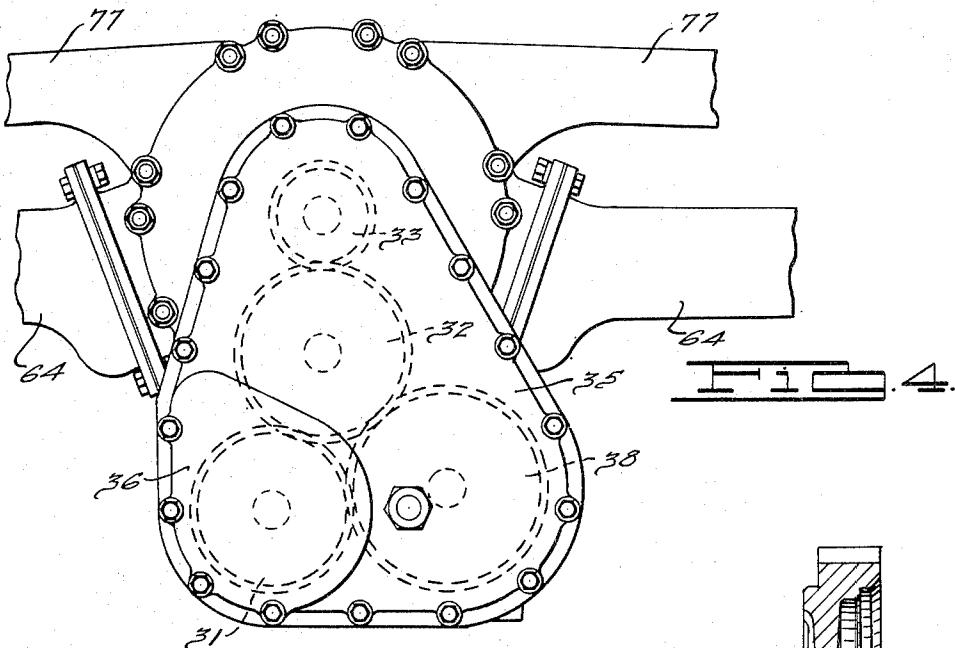
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4 Sheets-Sheet 3



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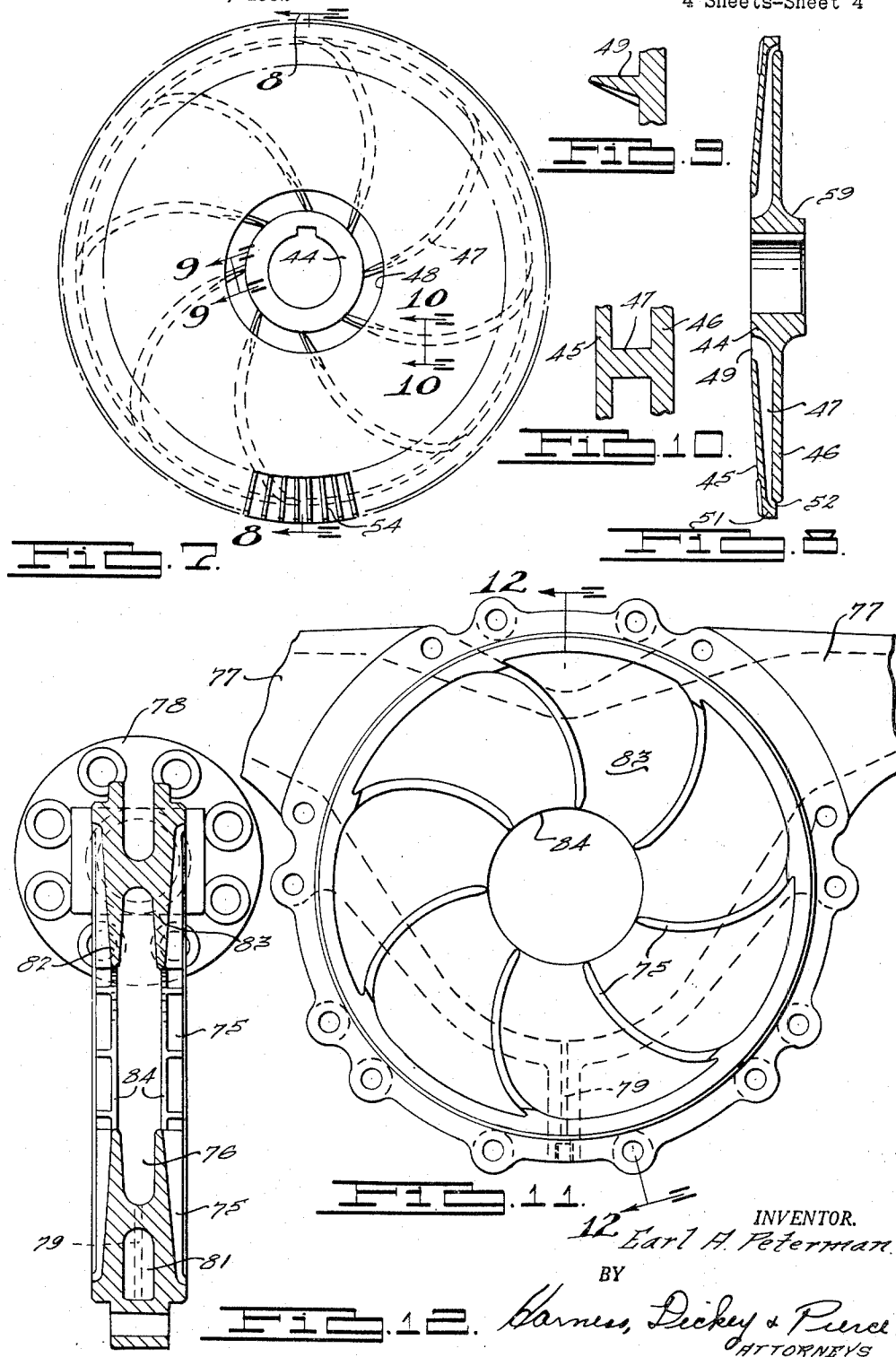
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4 Sheets-Sheet 4



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1

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HIGH PRESSURE CENTRIFUGAL PUMP

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8 Claims. (Cl. 103—109)

This invention relates to fluid pumps, and more particularly to multi-stage centrifugal pumps for delivering water to high pressure fog fire fighting equipment or other apparatus requiring high pressures.

The primary difficulty with previously known centrifugal pumps for use with fire fighting apparatus has been the relative low maximum pressure which such pumps can produce. It is well known that the most efficient fog for fire fighting is produced by a nozzle pressure of 600 p. s. i., or higher. Nozzle pressures less than 600 p. s. i. produce a larger particle fog which is markedly less efficient in absorbing poisonous gases and smoke. The fine particle high pressure fog is more efficient in displacing air around the fire and also presents a greatly increased water surface area thereby absorbing the heat more rapidly. The amount of water necessary to extinguish a given fire is greatly reduced with high pressure fog, and a small mobile truck can carry its own water supply sufficient to extinguish a fire of considerable size.

Multi-stage pumps have been proposed and are being used to some extent for the purpose of increasing the pressure, but such pumps have consisted merely of a plurality of conventional single stage pumps, connected in series, thus requiring greater expense and installation space, as well as adding greatly to the overall weight. These features make it impractical, if not impossible, to use previously known multi-stage pumps on the smaller fire trucks for the production of high pressure fog.

It is an object of the present invention to overcome these disadvantages of previously known pumps and to provide a novel and improved multi-stage centrifugal pump which is capable of producing a high delivery pressure, and at the same time is extremely compact and efficient in design and is constructed as a single unit.

It is another object to provide a multi-stage centrifugal pump of this type having alternate rotors and stators each of identical shape, so that the pump may be built up in stacked fashion to provide any desired number of stages, without the necessity of manufacturing differently shaped parts for each stage.

It is also an object to provide an improved pump of the above nature which has two sets of stages and a double ended intake with the pressure being built up from both ends toward the center, so that thrust unbalance is avoided and all seals are in low pressure areas without any size or pressure limitations resulting.

It is a further object to provide an improved centrifugal pump of this nature in which the impellers or rotors are of a radial nature but have axial discharge passages at their outer ends, with the rotor bodies extending radially beyond these axial passages and bearing slots or corrugations on their outer portions, so that a pressure seal is developed outwardly of the rotors to prevent leakage between stages.

It is another object to provide an improved high pressure multi-stage centrifugal pump with no wearing parts such as are found in pumps of other design, except the necessary bearings and low pressure static seals at either end of the shaft.

2

Other objects, features, and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 is a general cross-sectional view through the entire pump showing the pump driving means;

Figure 2 is an enlarged detail view within the circle 2 of Figure 1 and showing the construction of the pressure seal;

Figure 3 is a plan view of the pump showing the arrangement of the inlet and discharge conduits;

Figure 4 is an end view of the pump showing the transmission arrangement and the intake and discharge conduits;

Figure 5 is a front elevational view of one of the pump stators;

Figure 6 is a side cross-sectional view taken along the line 6—6 of Figure 5 and showing the stator wall contour;

Figure 7 is a front elevational view of one of the pump rotors, showing the shape of the rotor vanes and the pressure seal slots at the outer rim;

Figure 8 is a cross-sectional view taken along the line 8—8 of Figure 7 and showing the contour of the rotor passageways;

Figure 9 is a fragmentary cross-sectional view taken along the line 9—9 of Figure 7 and showing the shape of the inner vane end;

Figure 10 is a fragmentary cross-sectional view taken along the line 10—10 of Figure 7 and showing the double wall construction of the rotor;

Figure 11 is a front elevational view of the discharge stator showing the contour of its vanes and the outlet conduits; and

Figure 12 is a cross-sectional view taken along the line 12—12 of Figure 11 and showing the symmetrical construction of the discharge stator.

The pump comprises a rotor shaft 21 to which is secured by key 22 a plurality of rotors or impellers generally indicated at 23, these rotors being alternately disposed within a plurality of stator elements generally indicated at 24. The rotors, which are all duplicates, take the fluid from intake ring housings generally indicated at 25 and 26 which are disposed at opposite ends of the pump. The rotors and stators alternately guide the fluid toward the pump center which comprises a discharge stator generally indicated at 27 receiving the pressurized fluid from both sides and discharging it from the pump. Although four stages are shown on each side of the pump in the illustrated embodiment, it will be understood that any practical number of stages could be used.

The shaft 21 is shown as being driven by a conventional transmission generally indicated at 28 which may comprise an input shaft 29 connected to the prime mover, for example the vehicle engine (not shown), and moving shaft 21 through driving gear 31, idler gear 32 and driven gear 33. These gears may be mounted as shown in a separate housing 34 secured to intake ring 26, and having a cover plate 35 and a casing portion 36 supporting a spindle 37 which is connected to the drive shaft of the vehicle. Gear 31 may be shiftable on shaft 29 to engage the spindle 37 for driving the vehicle, and additional gearing 38 may be provided for driving a priming pump (not shown) from gear 31 when the latter is in an intermediate axial position, to prime the pump through connection 40. It will be understood that the drive mechanism for the rotors is conventional and in itself forms no part of the present invention.

The stators 24 are so shaped that when secured together in stacked fashion they form in themselves the main casing of the pump, and completely enclose the ro-

tors 23. For this purpose the stators are of generally circular shape as shown in Figures 5 and 6 and are provided with outwardly facing annular shoulders 39 on one side and inwardly facing shoulders 41 interfitting with adjacent stators. Ring seals 42 are preferably disposed between the contacting shoulders of adjacent stators, and a plurality of assembly bolts 43 extend through the outer portions of the stators, securely holding them together. These bolts also secure the intake housings 25 and 26 to the outer stators of the assembly, the intake stators being provided with appropriate annular shoulders for this purpose.

The duplicate rotors 23 are each provided with a hub portion 44 keyed to the shaft 21; these hub portions being in flush relation on the shaft. The rotors are constructed as shown in Figures 7 and 8, and in particular have double walls 45 and 46 between which are disposed a plurality of curved vanes 47. Although the curvature of these vanes is not critical, they are preferably of such contour as to provide the maximum and most efficient impelling force during operation. The wall 45 terminates at an inner angular edge 48 which is outwardly spaced from the hub 44, and the vanes 47 are provided at their inner ends with axial extensions 49 of tapered shape as shown in Figure 9. The edges of these axial extensions are preferably flush with the hub 44 and wall 45 so that each rotor has an inner annular intake area defined by hub 44 and wall 45 and separated into sections by vanes 47.

The outer edge of wall 46, which is preferably thicker than wall 45, terminates inwardly of the latter wall, which has a thickened outer flange portion 51 extending partially into the plane of wall 46. The vanes 47 are provided with axial outlet extensions 52 between the outer edge of wall 46 and the thickened flange portion 51, these extensions being in the opposite direction from inner extensions 49. It will be noted that the distance between walls 45 and 46 narrows in an outward direction, so that the outlet passages between extensions 52 have substantially the same cross-sectional area as the intake passages between extensions 49. It will also be observed, particularly in Figure 2, that the outer annular surface 53 of the rotor is a substantial radial distance outwardly from the rotor discharge passages. This feature is important in producing the pressure seal effect, later described. The outer external portion of wall 45 is also provided with a plurality of radially extending vanes forming slots 54 which extend radially beyond the rotor discharge passages, the pumping effect of these slots as later described contributing to the pressure seal operation.

The stators are so shaped as to accommodate the rotors and to receive the fluid therefrom to be re-directed radially inwardly toward the intake end of the next rotor. The stators are provided with inwardly facing surfaces 55 slightly outwardly spaced from the rotor surfaces 53, and are also provided with recessed portions 56 for accommodating the rotor walls 46. The vanes 57 of the stator are of a curved nature, having axial outer portions 58 for receiving the axial flow from the rotors, and a gradually flaring cross-sectional area progressing inwardly. The hub portions 44 of the rotor are provided with convex annular surfaces 59 which are adapted to receive the inwardly directed fluid from the stators and re-direct them axially toward the next rotor.

The intake housings 25 and 26 are basically similar in function, these members serving to support the shaft 21 as well as to deliver fluid to the first stage on each side of the pump. The connections to the intake housings are best seen in Figure 3, wherein two intake conduits 61 and 62 are shown. Each of these conduits branches into two sections 63 and 64, the section 63 of each conduit leading to intake housing 25, and the section 64 leading to intake housing 26. This intake arrangement is merely illustrative and would be used in such installations as fire apparatus where it is desired to have alter-

nate sources of fluid. The pump will operate with either one or both of conduits 61 and 62 in operation. Housings 25 and 26 have annular intake chambers 65 which receive the fluid from the intake conduits and deliver it to the first or low pressure stages through the annular passages 66 leading to the outermost rotors 23. The intake housings are provided with water seals 67 and 68 which engage the journal portions of shaft 21, the shaft portion within seal 67 being provided with a bushing 69. The stators also support oil seals 71 and 72 which are disposed outwardly of the seals 67 and 68. These oil seals are adjacent a pair of antifriction bearings 73 and 74 which are supported by the intake housings and which rotatably support the pump shaft.

It will be observed that due to the symmetrical nature of the pump the thrust loads on shaft 21 will be evenly balanced since the outward forces on the rotors of each side of the pump will oppose each other. For this reason there will be only negligible thrust loads to be taken by bearings 73 and 74. Furthermore, since the water seals 67 and 68 are at the first or low pressure stages, there will be relatively little leakage pressure, the high pressure fluid being in the vicinity of the center of the pump.

The central discharge housing 27 is best seen in Figures 11 and 12 and receives the high pressure fluid from the rotors on both sides, guiding this fluid by curved vanes 75 toward the open central chamber 76 of the housing. Leading from chamber 76 are one or more discharge conduits 77 which are adapted to guide the high pressure fluid from the pump. It will be understood that while the illustrated embodiment shows a central chamber for receiving the fluid, it would be possible to have other types of discharge arrangements, and in particular the discharge could be in either a radial or a tangential direction. The ends of conduit 77 are provided with flanges 78 for attachment to the remainder of the system. A drain passage 79 may also be provided in the discharge housing, this passage being disposed in a web 81 between the side walls 82 and 83. It will be observed that the inner edges 84 of these side walls are spaced a substantial radial distance from the axis of rotation, this distance being approximately equal to the distance of the edges 85 of stator walls 86.

In operation, the pump will receive fluid through intake housings 25 and 26 and this fluid will pass through the outermost rotors 23 to receive its first pressure increase. From the outer ends 52 of the rotor vanes, the fluid will pass between the stator vanes 57 to be guided back toward the axis of rotation. From the first stators the fluid will be guided axially along the back surfaces 59 of the first rotors into the second rotor stage, to be subjected to another increase of pressure. The increments of pressure in each stage will be approximately equal, and after leaving the final rotor stage the fluid will pass into the discharge housing 27 to be delivered through conduits 77.

Although the actual proportions of the pump elements are not critical, it may be stated for illustrative purposes that tests have found a typical 12" diameter rotor to produce 150 pounds of pressure per stage at 3000 R. P. M., giving a total delivery pressure of 600 pounds if four stages are used. This delivery pressure may of course be varied by changing the R. P. M. of the pump, and the delivery rate could be varied by changing the size of the outlet. Changes in the required delivery would of course be made by variations in the horsepower applied to the pump shaft.

It will be seen that due to the required clearances between the rotors and stators there would normally be a tendency for leakage to occur between the stages, that is, for fluid passing from rotor vane ends 52 to leak back through the space 87 between the rotor and the preceding stator, since this space would normally be connected to a point of lower pressure. The present invention

5

avoids the possibility of such leakage by a pressure seal which is inherent in the pump operation. This pressure seal depends for its effect on the fact that the flow at the outlet ends of rotors 23 is in an axial direction and also upon the presence of the plurality of slots or corrugations 54 along the outer portion of each rotor. These slots acting as vanes have a pumping effect on the fluid within space 87, creating a sealing pressure between walls 53 and 55. The axial flow at the rotor exit portions coacts with these vanes to provide a pressure seal to prevent leakage from the rotor exit into the clearance space 87. If desired the rotor exit portions may be of venturi shape to further reduce the pressure in this area.

While it will be apparent that the preferred embodiment of the invention herein disclosed is well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. In a centrifugal pump, a rotatable shaft having a plurality of rotors thereon, said rotors being of substantially identical shape, a plurality of passageways in each of said rotors extending in a generally radial direction, each passageway having an axially facing intake section at its inner end and an axially facing discharge section at its outer end, a plurality of stators interposed between said rotors and having vanes adjacent said rotors to form passageways for directing the fluid from the discharge of one rotor to the intake of the next adjacent rotor, said stators being separable and of substantially identical shape, and a plurality of vanes on the back surfaces of said rotors, said vanes extending radially outwardly at least to the outermost portions of said rotor discharge sections.

2. In a centrifugal fluid pump, a rotary shaft, a plurality of rotors on said shaft, each rotor having a plurality of passageways extending in a generally radial direction, an axially facing discharge portion at the outer end of each passageway, the outer peripheral surface of the rotor being spaced radially outwardly from said discharge portion, a plurality of stators interposed between said rotors, each stator having a recess on one side within which a rotor is disposed, said recess having an annular wall facing the peripheral surface of the rotor and a generally radial wall facing the back of the rotor, and a plurality of radial passages at the peripheral portion of the rotor back surface, said passages leading to the space between the peripheral rotor surface and the annular stator surface.

3. In a centrifugal fluid pump, a rotary shaft, two sets of rotors in symmetrical relation on said shaft, each set of rotors having intakes facing the adjacent shaft end and discharges facing the shaft center, a plurality of stators interposed between said rotors and having passageways for directing fluid from the discharge of one rotor to the intake of the next adjacent rotor, annular intake housings at the outer ends of said shaft, the intakes of the outermost rotors facing said intake housing, an annular discharge housing at the shaft center, the discharges of the innermost rotors leading to said discharge housing, and a plurality of vanes on the back surfaces of said rotors, said vanes extending radially outwardly at least to the outermost portions of said rotor discharge sections.

6

4. The combination according to claim 3, said intake housings being further provided with bearing means for supporting said shaft.

5. In a centrifugal pump, a rotatable shaft, a plurality of rotors on said shaft, each of said rotors having a plurality of passageways, an axial discharge section at the outer end of each of said passageways, said discharge sections being spaced radially inwardly from the periphery of the rotor, a plurality of stators interposed between said rotors, said stators having passageways for re-directing the fluid from one rotor to the next adjacent rotor, and a plurality of radially extending vanes on the back surfaces of said rotors, said vanes extending radially beyond said rotor discharge sections.

6. In a centrifugal pump, a rotatable shaft, intake means at opposite ends of said shaft, two sets of rotors secured to said shaft in symmetrical relation, each set having an intake portion connected to one of said intake means, passageways in said rotors having discharge sections directing fluid toward the central portion of said shaft, stators interposed between adjacent rotors, said stators having passageways for directing fluid from the discharge of one rotor to the intake of the inwardly adjacent rotor, and a plurality of radially extending vanes on the peripheral portions of the back surfaces of said rotors.

7. In a centrifugal pump, a rotatable shaft, a plurality of rotors on said shaft, each of said rotors having a plurality of passageways, an axial discharge section at the outer end of each of said passageways, said discharge sections being spaced radially inwardly from the periphery of the rotor, a plurality of stators interposed between said rotors, said stators having passageways for re-directing the fluid from one rotor to the next adjacent rotor, and a plurality of vanes on the back surfaces of said rotors, said vanes extending radially beyond said rotor discharge sections.

8. In a centrifugal pump, a rotatable shaft, a plurality of rotors on said shaft, each of said rotors having a plurality of passageways, an axial discharge section at the outer end of each of said passageways, said discharge sections being spaced radially inwardly from the periphery of the rotor, a plurality of stators interposed between said rotors, said stators having passageways for re-directing the fluid from one rotor to the next adjacent rotor, and a plurality of radially extending vanes on the back surfaces of said rotors, said vanes extending radially outwardly at least to the outermost portions of said rotor discharge sections.

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