Dec. 17, 1957 K. Q. RICE 2,816,509

SUBMERSIBLE PUMPS

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Fig. 1

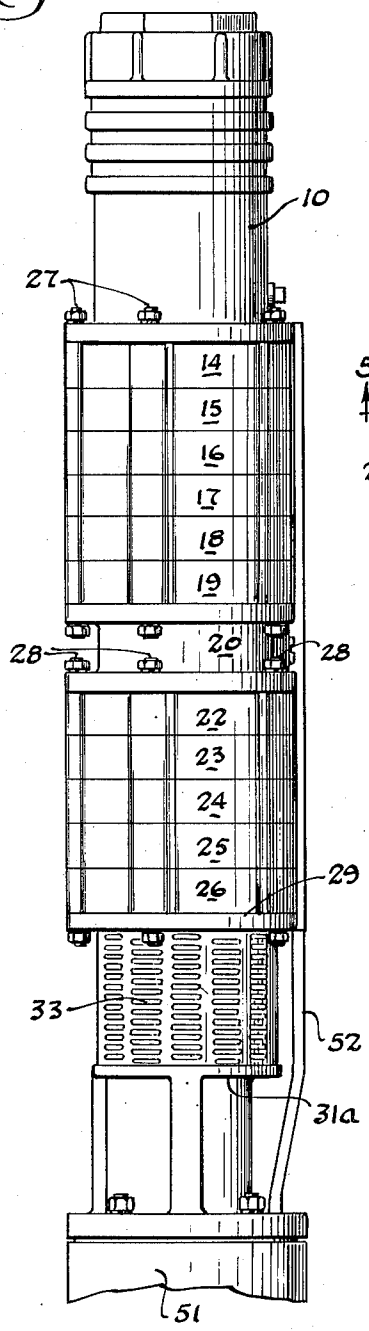


Fig. 4

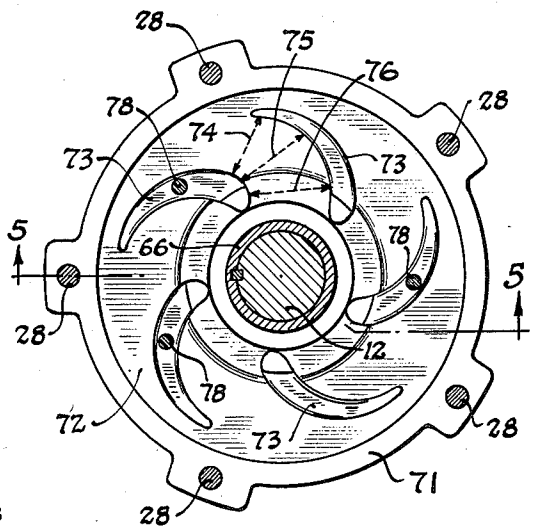
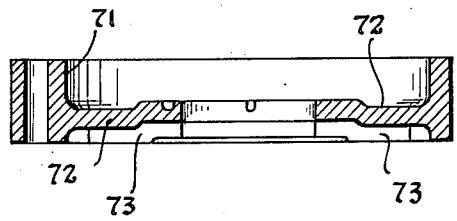


Fig. 5



Inventor
Keith Q. Rice
By Fred Bing
Attorney

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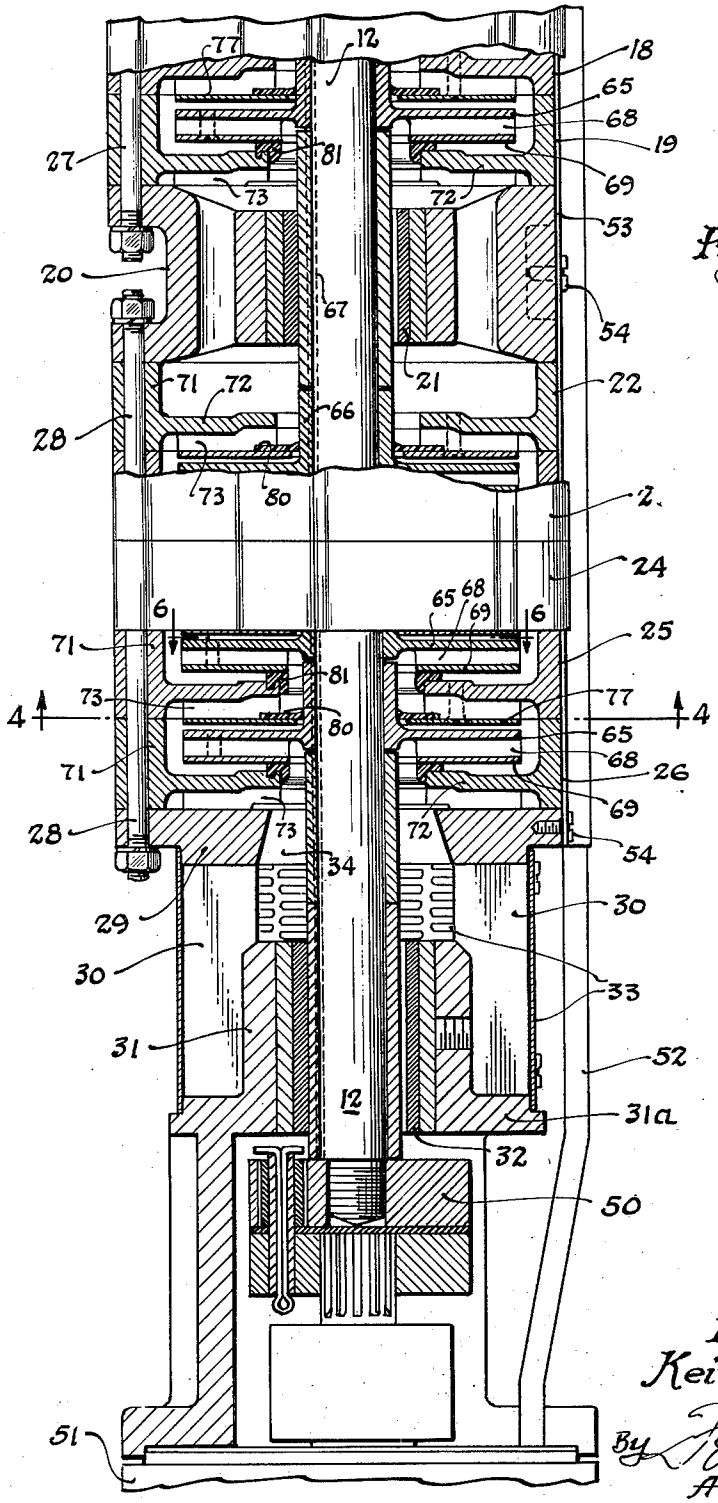


Fig. 2

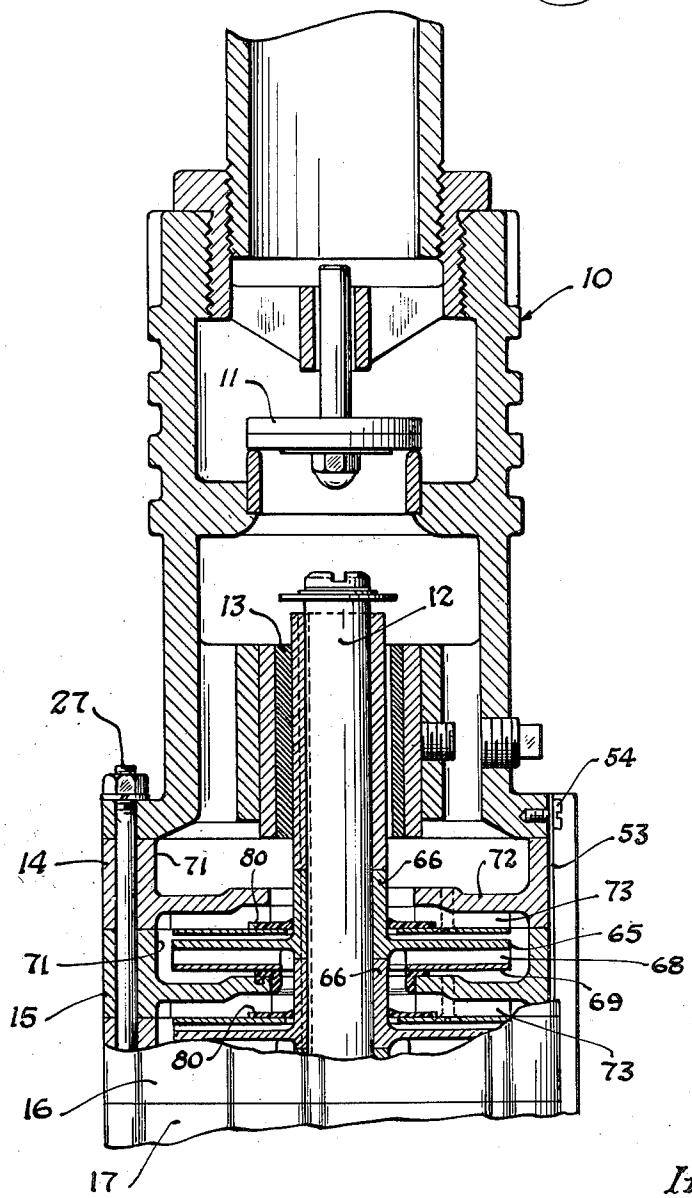
Inventor
Keith Q. Rice
By Fred Bing
Attorney

Dec. 17, 1957 K. Q. RICE 2,816,509

SUBMERSIBLE PUMPS

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Fig. 3



Inventor
Keith Q. Rice
By Jerd Bing
Attorney

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Fig. 7

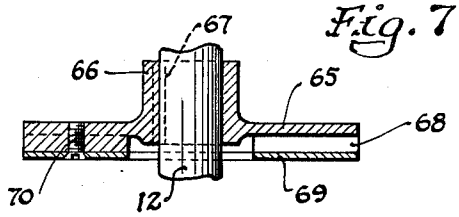


Fig. 6

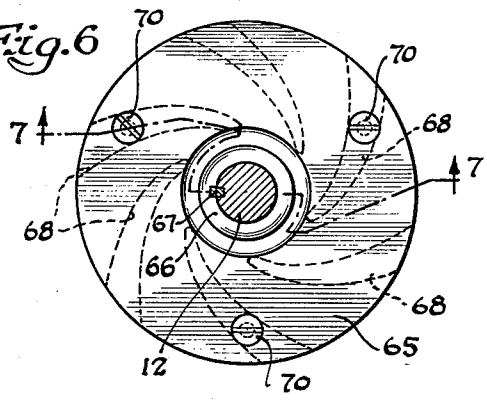


Fig. 8

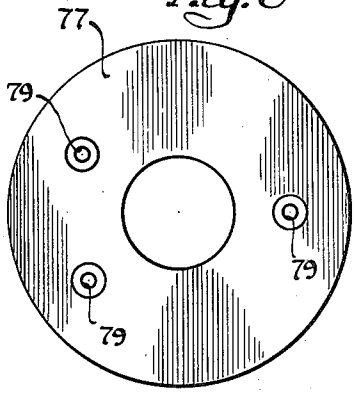
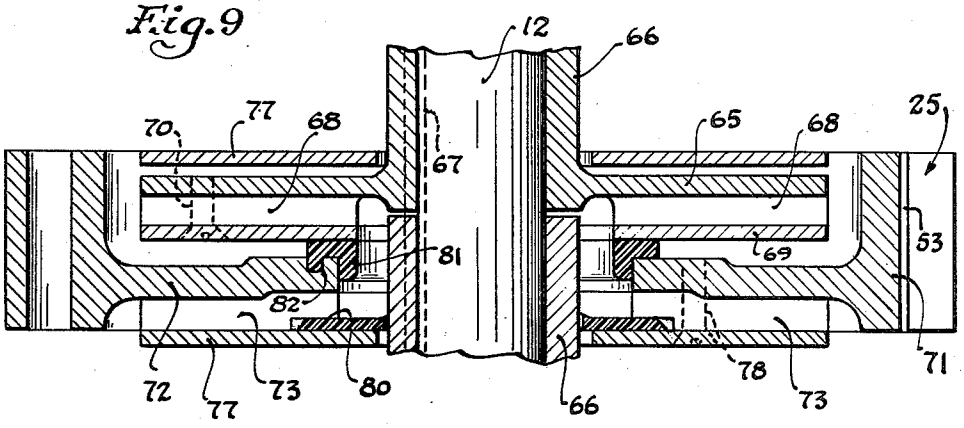


Fig. 9



Inventor
Keith Q. Rice
By Fred Bing
Attorney

United States Patent Office

2,816,509

Patented Dec. 17, 1957

2,816,509

SUBMERSIBLE PUMPS

Keith Q. Rice, Beatrice, Nebr., assignor to Dempster Mill Manufacturing Company, Beatrice, Nebr., a corporation of Nebraska

Application May 12, 1953, Serial No. 354,545

4 Claims. (Cl. 103—108)

This invention relates to multi-stage centrifugal pumps of the submersible type, and it has for its object the provision of a pump structure which shall be easy to manufacture by reason of having very few close fits between parts or other close tolerances, and by reason of the fact that there is practically no necessity for coring out small passageways in the manufacture of the pump.

It is one of the objects of the invention to provide a pump effective for handling a liquid, while at the same time avoiding excessive wear by reason of any abrasive particles carried by the liquid handled being caused to enter the bearings, and avoiding the likelihood that such abrasive particles may be caused to pile up at any point in the pump so as to interfere with the further effective operation of the mechanism.

It is one of the objects of the invention to provide in a pump of this type a structure which shall be easy to assemble and easy to repair by the replacement of worn parts, and particularly the parts upon which the heaviest wear occurs. It is still another object to provide a centrifugal pump, the normal pumping action of which tends to move out of contact with the working parts of the pump any abrasive particles carried by the liquid being pumped, in which an effective rotary sealing means is provided for preventing leakage at the impeller eye, and by which the transmission of radial load to the bearings is kept to a minimum in the various stages.

It is one of the objects of my invention to provide in a pump of this type diffuser means in the form of stationary vanes between which the liquid passes inwardly to the eye of the impeller, with such vanes of airfoil shape and with the oppositely-positioned faces of adjacent vanes diverging inwardly so as to allow for a substantial reduction in the speed of movement of the liquid as it approaches the eye of the impeller. For making this more effective, I provide quite limited clearance between the stationary guide vanes and the face of the adjacent rotary impeller. This clearance is preferably provided by the use of a cross-positioned plate mounted in fixed position on the diffuser housing and in face to face engagement with a washer readily movable edgewise with respect to said plate and adapted to be pressed toward said plate by the thrust of the liquid in the pump.

For attaining these objects, I have provided a construction in which the impeller is free to float either radially or axially with respect to the housing in which it is mounted, with the parts arranged so as effectively to block the escape of liquid between the impeller and the diffuser housing regardless of what position the parts take with respect to each other transversely of the pump. By the use of certain of the working members as parts of the housings of the structure, the requirements for the use of special plates for forming the housings are cut down, and by the use of readily movable plates as parts of the structure the necessities with respect to coring out passageways are reduced. By the arrangement of the facing portions of the bearings between the impellers and the diffuser housings so as to open outwardly in transverse

position, with little or no face portions arranged axially, the capability for the escape of abrasive particles from such bearings is greatly increased.

By arranging that the liquid shall enter the housing in its movement toward the impeller by movement axially through a rotary type sealing member, it has been possible to utilize the inherent forces of gravity and of impeller thrust for holding the sealing member in operative position so as to bring about effective sealing and for taking up wear. In my arrangement, the parts are made self-cleaning with the dangerous abrasive particles capable of removal radially out of the mechanism. With the wearing member in the form of a ring having a perfectly flat transversely positioned face, and with the ring free to move in any direction radially, abrasives are given no place to lodge, and are thus encouraged to move directly outwardly for escape from the bearing ring. With the parts most subject to wear made so as to be readily removable for replacement, the reconditioning of the pump at intervals is made readily possible. By reason of the constant pressure on the impeller toward the bearing face against which it works, the leakage of the liquid back to the impeller eye is effectively prevented.

It is another object of my invention to improve pumps of this type in sundry details hereinafter pointed out. The preferred means by which I have accomplished my several objects are illustrated in the accompanying drawings, in which

Fig. 1 is a side face view of a pump unit suitable for use in the lower end of a well casing;

Fig. 2 is a vertical sectional view on an enlarged scale through the lower end portion of the structure shown in Fig. 1;

Fig. 3 is a vertical sectional view on an enlarged scale through the upper end portion of the structure shown in Fig. 1;

Fig. 4 is a cross sectional view taken substantially at the line 4—4 in Fig. 2, but with a cross positioned washer removed from the structure;

Fig. 5 is a sectional view through a diffuser unit taken substantially at the line 5—5 in Fig. 4;

Fig. 6 is a view of the impeller assembly substantially as taken at the line 6—6 in Fig. 2;

Fig. 7 is a sectional view through the impeller assembly as shown in Fig. 6, being taken substantially at the line 7—7 in Fig. 6;

Fig. 8 is a bottom face view of a cross positioned plate immediately below the guide vanes in the diffuser unit; and

Fig. 9 is a vertical sectional view on a substantially enlarged scale through one of the impeller units in operative position in its associated diffuser unit.

Referring now to the several figures of the drawings in which corresponding parts are indicated by the same reference characters, the pump of the present invention is illustrated as embodying an upper housing 10 in the form of a heavy metal sleeve affording a final discharge opening or passage for the pump and having a check valve 11 mounted therein for preventing downward movement of water or other liquid therethrough. A shaft 12 extending downwardly from the housing 10 has a bearing 13 of any approved type in said housing, with a plurality of pump units or stages 14, 15, 16, 17, 18 and 19 mounted on the shaft above an intermediate bearing bracket 20 provided with a bearing 21 for said shaft. The arrangement is such that impeller units as hereinafter described within said units or stages are caused to rotate with the shaft while being free to move longitudinally of the shaft. Below the bearing 21 a second series of pump units or stages 22, 23, 24, 25 and 26, are mounted on said shaft 12 below the bracket 20. Impeller units as hereinafter described within said stages are keyed for rotation with the

shaft, while at the same time being free to move longitudinally of the shaft. A plurality of long, heavy bolts 27 serve to connect the housing 10, the pump stages 14, 15, 16, 17, 18, 19, and the bracket 20 strongly together in water-tight relationship with respect to each other. Similar long heavy bolts 28 connect the bracket 20, the pump stages 22, 23, 24, 25 and 26, and a heavy cross plate 29 strongly together in water-tight relationship to each other. A plurality of relatively heavy angularly spaced webs 30 integrally connect the plate 29 with a heavy bearing sleeve 31 and an integral lower cross plate or flange 31A provided with a bearing 32 in the sleeve 31 for the lower end of the shaft 12. A heavy screen 33 in the form of a piece of perforated sheet metal is secured about the webs 30 for screening the admission of water or other liquid for movement upwardly through a central opening 34 in the plate 29, from which the water or other liquid passes upwardly along the shaft 12 to the pump unit 26. The bearings 13, 21 and 32 are of the usual rubber or plastic type which are water lubricated in which the wear due to sand or like material is minimized.

At the lower end of the shaft 12, a resilient coupling 50 of any approved type serves to connect said shaft with an electric motor 51 that is suspended from the plate 29 by the webs 30, and which motor is driven by current fed thereto by an electric cable 52 extending downwardly through the well casing. A protective shield 53 of sheet-metal is secured in position by means of screws 54 so as to prevent damage of the cable by contact with other parts within the well casing.

The arrangement in connection with the several diffuser units and their cooperating impeller units is substantially uniform, as illustrated in Fig. 9, which shows the construction of the unit 25, for example. In this construction, an impeller comprising a back shroud plate 65 is mounted on the shaft 12 by means of a hub or sleeve 66 which is slidably mounted on the shaft but is held by a key 67 from rotation with respect to the shaft. On the bottom face of the shroud 65 there are mounted a plurality of impeller vanes 68, preferably formed integrally with the shroud, a front shroud plate 69 being removably secured in cross relationship below the vanes by a plurality of screws 70.

As is clearly shown in said Fig. 9, the impeller comprising the shroud 65 and the vanes 68 is positioned crosswise within a diffuser housing 71 in the form of a heavy sleeve of substantially greater diameter than the hub or sleeve 66, with a cross positioned plate 72 located in downwardly spaced relationship to the impeller, such plate 72 being provided with a central opening and with a plurality of guide vanes 73 formed integrally with the plate on its bottom face. These guide vanes 73 are of airfoil shape, as clearly shown in Fig. 4, with the space between each two adjacent vanes increasing toward the inner ends of the vanes. This inward divergence of the defining faces of the vanes is shown by the increasing lengths of the arrows 74, 75 and 76 shown in dotted lines in said Fig. 4. By reason of the increasing size of the passageway between each two adjacent vanes in the direction toward the axis, the velocity at which the water or other liquid is moved decreases toward the eye of the impeller. This is of very great importance in a pump involving a considerable number of stages, my construction being such as to insure high efficiency in the pumping operation, as well as to provide for effective removal of the abrasives.

In my improved pump, a cross positioned plate 77 is provided underneath the stationary guide vanes 73, having a central opening therethrough so as to be loose about the hub 66 of the impeller, being removably secured in position on the housing 71 by three screws 78 (see Fig. 4) extending through openings 79 in the plate, and threaded into suitable screw threaded openings in conveniently positioned guide vanes 73. In face to face engagement with the top face of this plate 77 at its inner edge portion, I provide a washer 80 which has a loose fit transversely in notches in the inner end portions of the stationary vanes 73, such washer being formed preferably of plastic of a type adapted to be lubricated by the water or other liquid being pumped. The construction and arrangement are such that the plate 77 and washer 80 cooperate effectively for preventing any substantial leakage of liquid downwardly from the guide vanes 73 along the hub 66 of the impeller, while at the same time permitting free shifting movement of the shaft and the impeller transversely so far as necessary with respect to the diffuser housing.

For preventing the liquid being pumped from leakage at the eye of the impeller, I have provided a sealing ring 81, preferably of a plastic of a type adapted to be lubricated by water or other liquid being pumped, such ring 81 comprising a short cylindrical portion with an outwardly extending flange at one end. The cylindrical portion of this sealing ring fits snugly in the central opening in the cross positioned plate 72 of the diffuser housing, with the flange portion of the ring seated squarely on the top face of said plate about the central opening therethrough. The top face of the sealing ring, in turn, seats squarely against the bottom face of the front shroud 69 of the impeller which is formed preferably flat and even at this point for insuring a close fit between the shroud and the ring. The sealing ring 81 is also provided with a downwardly extending lug 82 constituting a shoulder in position to engage the plate 72 for holding the sealing ring from rotation with respect to the housing 71 and thus insuring that the wear between the impeller and the diffuser housing shall take place on the sealing ring and the front shroud 69.

By reference to Figs. 2 and 3, it will be noted that the bottom stage 14 next to the top housing 10 and the bottom stage 22 next to the bearing bracket 20 are not provided with impellers and their cooperating parts, and that at the bottom portions of the pump stages 19 and 26 the washers 80 and cross-positioned plates 77 are omitted from the structure. With the exceptions as noted, each of the pump stages is preferably similar to that shown by Fig. 9.

In operation, the liquid being pumped enters the lowermost pump stage 26 through the opening 34 in the plate 29 and is forced outwardly by the action of the vanes 68 on the impeller in said stage, at the outer ends of which vanes 68 such liquid moves upwardly to the outer ends of the diffuser vanes 73 on the bottom face of the cross-positioned plate 72 of the diffuser housing 25, between which vanes 73 the liquid moves inwardly through passageways of increasing size for delivery to the inner ends of the impeller vanes of the next higher impeller. This action is repeated with the liquid rising from one stage to the next. At the transfer of the liquid from the pump stage 22 to the pump stage 19, the liquid passes inwardly along the diffuser vanes 73 in the stage 22, then through vertical openings through the bearing bracket 20, and then inwardly along the diffuser vanes 73 in said stage 19 for delivery upwardly through the eye of the impeller in said stage 19. By the use of my improved construction, the considerable number of pump stages are caused to cooperate for forcing the liquid upwardly.

By use of the sealing rings 81 between the plates 72 and 69, the leakage of the liquid at the eyes of the impellers is kept to a minimum, and by the use of the washers 80 and the cross-positioned plates 77, the leakage between the impellers and the diffuser housings is kept very small so as very largely to prevent re-circulation of the liquid.

In this construction, the wear of the parts is restricted very largely to the plates 69 and the sealing rings 81 and to the plates 77 and washers 80. For keeping such wear to a minimum, the plates 69 and 77 are made flat, even and smooth, and, as above specified, the rings 81 and washers 80 are made preferably of plastic, which is adapted to be lubricated effectively by the liquid being handled, such for example as nylon. With the plates 69 and 77 removable and replaceable by the removal of the

screws 70 and 78, and with the sealing rings 81 and washers 80 arranged so as to be moved readily out of position upon the movement of the plates 69 and 77 from their operative positions, a repair of the pump by the replacement of worn parts is capable of being effected quickly and easily.

In the normal operation of the pump, the impellers are free to position themselves both radially and axially, with the impellers maintained at all times in physical contact with the sealing rings by the forces of thrust and gravity. When the front shrouds 69 are kept pressed against the sealing rings 81, the probability that abrasive particles shall move outwardly between the flat contact faces is very small, and in any case, where such a thing does happen, the force of the liquid being pumped ordinarily drives such abrasive particles radially out of engagement with the sealing rings for a self-cleaning effect.

By employing the back shroud of the impeller to act as the top wall of the diffuser housing the necessity for a special plate for this purpose is avoided. By the provision of a removable plate as the bottom wall for the diffuser housing below the diffuser vanes 73, the necessity for coring out narrow passageways is avoided and a self-cleaning action is encouraged.

While I prefer to employ the form of mechanism as illustrated in the drawings and above described, it will be understood that my invention is not to be limited thereto except so far as the same may be specifically claimed, it being understood that changes might be made in the form and arrangement of the parts without departing from the spirit of the invention.

I claim:

1. In a centrifugal pump, the combination of a plurality of housing members connected together in watertight relationship to each other, a drive shaft extending through said housing members and mounted so as to rotate therein, impellers keyed on said shaft in said housing members, cross-positioned plates extending inwardly in said housing members underneath said impellers and toward said shaft but in spaced relationship to the shaft, circumferentially spaced diffuser vanes extending toward said shaft in fixed position on the bottom faces of said cross-positioned plates, other cross-positioned plates removably secured to the respective first mentioned cross-positioned plates and underneath and against said vanes for preventing the liquid being pumped from escaping downwardly from the vanes and having central openings therethrough of a size for permitting the shaft and the impellers to shift transversely with respect to said housing members, and means mounted on and cooperative with said other cross-positioned plates at the central openings therethrough for preventing such downward escape of the liquid and arranged for shifting movement transversely with respect to said last named plates.

2. In a centrifugal pump, the combination of a plurality of housing members connected together in watertight relationship to each other, a drive shaft extending through said housing members and mounted so as to rotate therein, impellers keyed on said shaft in said housing members, cross-positioned plates extending inwardly

in said housing members underneath said impellers and toward said shaft but in spaced relationship to the shaft, circumferentially spaced diffuser vanes extending toward said shaft in fixed position on the bottom faces of said cross-positioned plates, other cross-positioned plates removably secured on said first mentioned cross-positioned plates in position underneath said vanes for preventing the liquid being pumped from escaping downwardly from the vanes and having central openings therethrough of a size for permitting the shaft and the impellers to shift transversely with respect to said housing members, and washers on the top faces of said last named plates adapted to move transversely with said shaft and impellers into laterally-changed positions with respect to said last named plates.

3. A centrifugal pump as specified by claim 2 in which said washers are slidable transversely in notches in the bottom faces of said vanes.

4. In a centrifugal pump, the combination of a housing member comprising a cylindrical sleeve, a driving shaft extending through said sleeve and mounted so as to rotate therein, an impeller member comprising a much smaller sleeve keyed on said shaft with a plate extending outwardly from said smaller sleeve at right angles to the sleeve, a plurality of impeller vanes mounted in fixed position on the bottom face of said plate, a cross-positioned plate removably secured on the bottom faces of said impeller vanes, a cross-positioned plate extending inwardly in said housing member underneath said impeller but in spaced relationship to said shaft, a plurality of diffuser vanes in circumferentially spaced relationship to each other on the bottom face of the cross-positioned plate of the housing member, a cross-positioned plate removably secured on the bottom faces of said diffuser vanes, a sealing ring of plastic between the removably mounted plate of the impeller and the cross-positioned plate extending inwardly in the housing member to afford a thrust bearing and prevent leakage at the eye of the impeller, and a sealing washer of plastic between the sleeve of the impeller member and the cross-positioned plate removably mounted below the diffuser vanes for preventing re-circulaion of the liquid being pumped.

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