

[54] **SUBMERSIBLE PUMP**

[75] Inventor: **Francis Maginnis**, Norman, Okla.

[73] Assignee: **Little Giant Corporation**, Oklahoma City, Okla.

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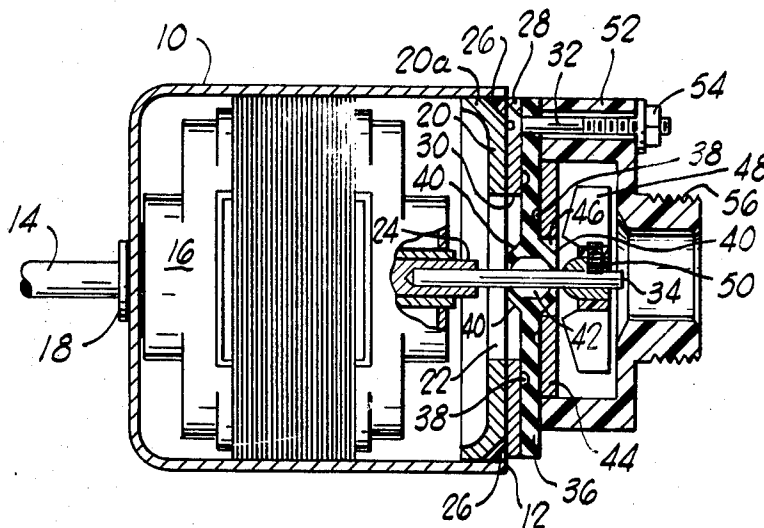
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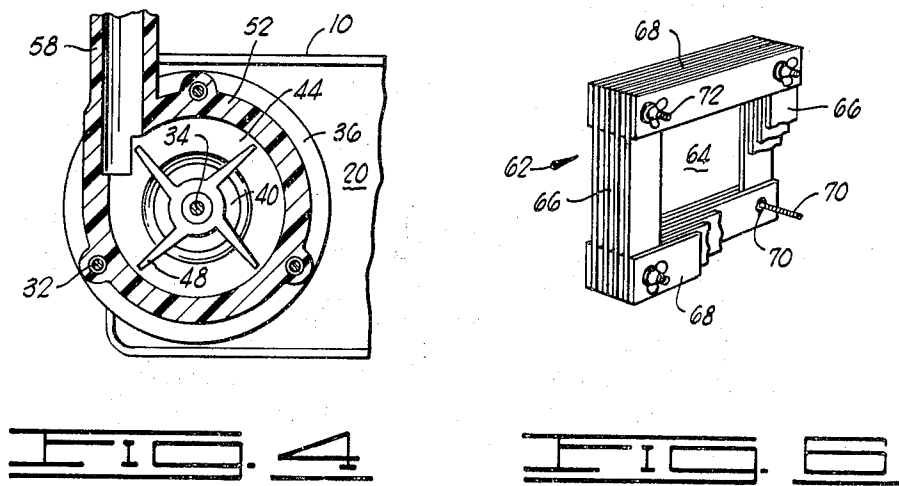
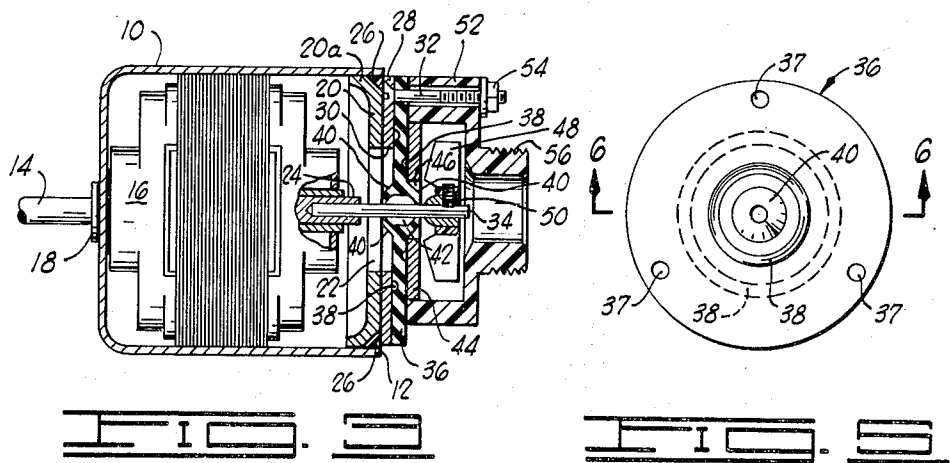
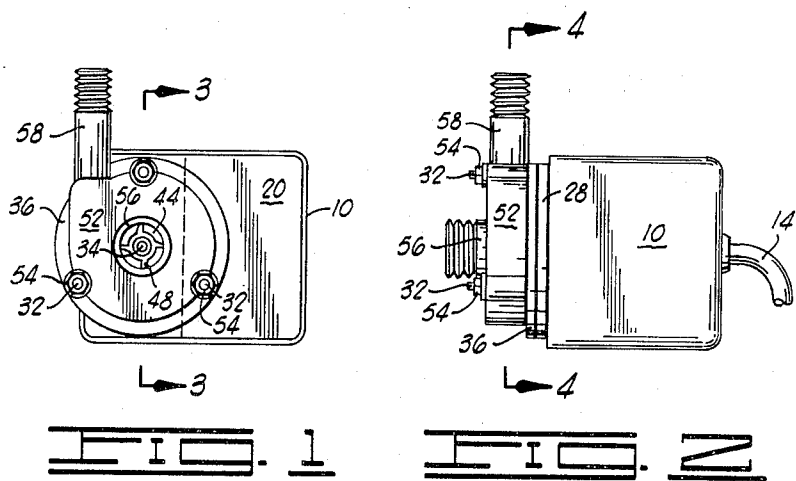
Attorney, Agent, or Firm—Dunlap, Laney, Hessin & Dougherty

[57] **ABSTRACT**

The disclosure relates to an improved resin encapsulated submersible electrically driven pump of the centrifugal type. The pump unit utilizes a novel sealing gasket arrangement for establishing a seal between the impeller housing and the back support plate, and for establishing a high integrity seal around the shaft extension element.

11 Claims, 6 Drawing Figures





SUBMERSIBLE PUMP

This application relates to submersible electric pumps. More specifically, but not by way of limitation, the present invention relates to resin encapsulated submersible electric pumps of the centrifugal type.

During recent years, a number of companies have endeavored to develop a sub-fractional horsepower, relatively small capacity submersible electric pump which is reliable in operation, and which will perform satisfactorily over extended periods of time while submerged in a variety of liquid materials to be pumped. The problems confronting the manufacturer of a pump of this type are manifold and, as a result of these problems, small capacity submersible pumps as presently marketed are, in each instance, limited in their usefulness to one or two media, and are, in most instances, incapable of operation in a submerged state in both acid and basic solutions, as well as in an open air operation.

Among the difficulties which have plagued previous efforts to provide a small, relatively low capacity fractional horsepower submersible pump have been the problem of preventing overheating of the pump, or of preventing dissipation of the heat developed by the motor of the pump to the surrounding media; ability of the pump to operate efficiently in any position in which it may be oriented, and whether submerged, partially submerged, or completely exposed to the atmosphere; maintaining integrity of the seal structure around the motor drive shaft so that the pumped media is not drawn into the motor upon cooling of the pump, nor is lubricant lost from the motor housing to the pumped media; and finally, while attempting to overcome these problems, retaining the cost of manufacture of the pump at a reasonably economical level.

The present invention provides an improved submersible electric pump which, relatively broadly, comprises, in one embodiment, a motor housing which is open at one side and is provided with a power lead line opening therein which is spaced from the open side of the motor housing. An electric motor is positioned inside the motor housing and has a shaft extending toward the open side of this housing, and a power lead line extending through the power lead line opening in the housing. Means is provided for securing the motor in a fixed location within the housing. A rigid, dished closure member is frictionally pressed into the motor housing to close the open side thereof, and this closure member defines with the motor housing, a continuous groove adjacent the free edge of the motor housing which is at and bounds the open side thereof. The dished closure member has a shaft opening formed therethrough, and a shaft extension element extends through the shaft opening in the closure member and is connected at one of its ends to the motor shaft.

An apertured back support plate is bonded to the dished closure member and encircles the shaft extension element which extends through the aperture in this plate. Fastening elements are secured to this plate and extend from the plate in a direction away from the motor housing. An impeller is keyed to the shaft extension element and is positioned on the opposite side of the back support plate from the rigid, dished closure member. An impeller housing is connected to the fastening elements which extend from the back support plate, and the impeller housing encloses the impeller. The impeller housing has a fluid inlet opening and also

a fluid discharge opening formed therein. A resilient sealing gasket is positioned between the back support plate and the impeller housing and establishes a seal therebetween. The sealing gasket has an aperture formed therethrough which receives the shaft extension element, and this aperture is dimensioned to provide sealing engagement between the shaft extension element and the sealing gasket. Finally, a rigid apertured impeller backup plate is positioned in the impeller housing and around the shaft extension element at a location between the impeller and the sealing gasket.

In a preferred construction of the pump, several important features are incorporated in the structure as broadly described in the preceding paragraph. Once the motor is placed in its housing with a power lead line extending through a suitable sealed opening in the motor housing, the motor is then preferably partially encapsulated and rigidly secured in position in its housing by pouring a settable resinous material, such as one of the epoxy resins, into the housing until the housing is partially filled to a level just below the bearing housing of the motor shaft. In another feature of preferred construction, a highly polished aluminum oxide ceramic shaft extension element is employed, and I find that this material effectively resists shaft wear and pitting at the point of contact with the sealing gasket, regardless of the type of liquid in which the pump is used.

Finally, in the preferred construction of the pump, a novel sealing gasket is employed for establishing a seal between the impeller housing and the back support plate, and for establishing a high integrity seal around the shaft extension element. The sealing gasket is made of an elastomeric material and is a flat or substantially monoplanar element having a central aperture therethrough for receiving the shaft extension element, and further having a pair of radially spaced annular grooves concentrically surrounding the shaft extension element and functioning to impart greater flexibility and sealing efficiency to the gasket. The edge portion of the gasket which defines the central aperture is bifurcated to provide a pair of divergent, annular sealing lips which bear against the shaft extension element.

From the foregoing description of the invention, it will have become apparent that a major object of the invention is to provide a relatively inexpensive, easily manufactured submersible electric pump which is reliable in operation over extended periods of time in a variety of different media having widely differing chemical properties.

A more specific object of the invention is to provide a low cost submersible electric pump which can be operated for extended periods of time in acidic, basic or neutral solutions without malfunction.

An additional object of the invention is to provide an improved shaft seal in a submersible electric pump.

An additional object of the invention is to provide a submersible electric pump construction which eliminates the need for precision machining operations in the manufacture of the pump.

Another object of the invention is to eliminate the necessity of precise shaft alignment in the construction of a submersible electric pump.

Another object of the invention is to provide a submersible electric pump which can also be used without malfunction for in-line, open air pumping.

Another object of the invention is to provide a submersible electric pump which can operate over ex-

tended periods of time without becoming damaged due to overheating.

An additional object of the invention is to provide a submersible electric pump which includes an improved heat dissipating element.

In addition to the described objects and advantages, additional objects and advantages will become apparent as the following detailed description of the invention is read in conjunction with the accompanying drawings which illustrate a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a view in elevation of one embodiment of the submersible pump of the invention as it appears when viewed from one end.

FIG. 2 is a side elevation view of the pump.

FIG. 3 is a sectional view of the pump taken along the line 3—3 of FIG. 1, but illustrating the motor and its shaft extension element in elevation.

FIG. 4 is a sectional view taken along line 4—4 of FIG. 2.

FIG. 5 is a view in elevation of the sealing gasket utilized in a preferred embodiment of the invention.

FIG. 6 is a perspective view of an adjustable heat sink attachment which can be used in conjunction with the pump shown in FIGS. 1—5, with a portion of the stacked plates used in the construction of the heat sink broken away for clarity of illustration.

Referring now to the drawings in detail, and particularly to FIG. 1, a motor housing 10 is preferably formed as a zero draft, one piece structure, and can be suitably constructed of aluminum, yellow brass, monel or other rigid and ductile material. In the illustrated embodiment of the invention, the motor housing 10 is shaped as a right parallelepiped which is open at one of its sides. This open side is shown in FIG. 3 as being bounded or defined by the free edges 12 of the motor housing 10. Spaced from the open side of the motor housing 10 is a small aperture for the accommodation of a power lead line 14 extending from an electric motor 16 positioned within the motor housing 10. The electric motor 16 is preferably a shaded pole motor which is equipped with a thermal cutout switch (not shown) with such cutout switch being typically set to operate at a temperature of about 105°C. Alternatively, the motor may be impedance protected. A sealing grommet 18 is positioned around the power lead line 14 in the aperture through the motor housing 10 to form a suitable seal at this point.

The motor housing 10 is sized to permit the motor 16 to be easily slid into the housing through the open side thereof without permitting excessive play or movement of the motor inside the housing. It will be noted from the following description, however, that precise positioning of the motor 16 within the motor housing 10 is not of critical importance, and that the problem of shaft alignment which is of major significance in the construction of many types of submersible motors now on the market is of no significant concern in the construction of the present invention. It is only necessary that the shaft of the motor 16 be directed toward the open side of the motor housing 10.

After the motor has been placed within the motor housing 10 and the power lead line 14 extended through the aperture in the motor housing, the motor housing is next closed by pressing a rigid, dished closure member 20 into the open side of the housing. The

dished closure member 20 is provided with a peripheral flange 20a which frictionally engages the sides of the motor housing 10 when the dished cover member is pressed into place and occupies the closing position depicted in FIGS. 1 and 3 of the drawings. It will be noted in referring to this figure of the drawings that the radius of curvature of the peripheral flange 20a of the dished closure member 20 at the point where it is attached to the main body of this member is such that a moat or groove is formed or defined between the dished closure member and the motor housing 10 at a location which is adjacent the free edge 12 of the motor housing which defines or bounds the open side thereof. In its construction, the dished closure member 20 is a blanked and formed member having a relatively large aperture 22 formed therethrough, and when the closure member is pressed into the open side of the motor housing 10, the large aperture 22 is aligned with the shaft 24 of the motor which has been oriented to face toward the open side of the motor housing.

When the dished closure member 20 has been pressed into the open side of the motor housing 10 to form the groove extending around the edge 12 of the housing, the closure member is secured in the housing preferably by filling the groove with an epoxy material 26 which sets up to a hardened state either at room temperature, or more preferably, at an elevated temperature. A suitable epoxy resin can be applied in the liquid state, and then allowed to set up to establish a tenacious bond between the closure member 20 and the housing 10.

With the closure member 20 secured in place in the open side of the housing 10 in the manner described, the housing is rested on its side so that the motor shaft 24 is most nearly adjacent the upper wall of the motor housing. The lower portion of the housing 10 which will, in this position of the housing, contain the windings of the shaded pole motor, is then filled with liquid epoxy resin by pouring the liquid resin through the large aperture 22 formed in the closure member. The epoxy resin utilized should have a high thermal conductivity characteristic, and is preferably filled with appropriate thermally conductive powders. The approximate level to which the epoxy resin is poured within the motor housing 10 is indicated by a dashed line in FIG. 1. Thus, the upper level of the resin is approximately the midline of the motor housing 10, the main consideration in the establishment of this level being that the shaft 24 of the motor 16 and its bearings remain above the level of the epoxy. Upon curing, the resin sets up to a hardened state to secure the motor in a fixed position within the motor housing 10.

After the epoxy resin within the motor housing 10 and surrounding the lower portion of the motor has cured to a hardened state, the next step in the assembly of the pump is the securement of a flat or substantially monoplane back support plate 28 to the dished closure member 20. The back support plate 28 has a large aperture 30 formed therein which is aligned with the aperture 22 through the dished closure member 20 and, in the illustrated embodiment, is further provided with a plurality of small holes which accommodate a plurality of elongated threaded fastening members or bolts 32. The heads of the countersunk fastening members 32 are flush with the surface of the back support plate 28 which abuts the dished closure member 20 so that the fastening members extend away from the

motor housing 10. When the back support plate 28 is positioned on the dished closure member 20 in the manner described, it is bonded to the dished closure member with a sheet epoxy resin of high bonding strength. It should be pointed out that this bonding operation can be performed prior to the fitting and securing of the dished closure member 20 in the motor housing 10 if desired.

The next step in the assembly of the submersible pump is to secure to the motor shaft 24 a suitable shaft extension element 34. The motor shaft 24 is initially drilled to provide an axially extending bore in the end thereof. A retaining collar (not shown) may be positioned around the motor shaft during such drilling to prevent bellling and departure from the desired bore diameter. Upon completion of the drilling of the motor shaft 24 to provide a bore in the end thereof, one end of the shaft extension element is pressed into the bore drilled in the motor shaft 24 and the shaft extension element is secured in this bore by the use of a suitable cementing material. The shaft extension element 34 can be constructed of suitable metallic materials of the type conventionally used in submersible pumps. In a preferred construction of the invention, however, the shaft extension element 34 is made of an aluminum oxide ceramic material which is highly polished and preferably is characterized in having a polished surface which is not greater than 1 micro-inch surface finish in roughness around the external periphery of the shaft. I have found that a highly polished aluminum oxide shaft of the type described successfully resists erosion, corrosion, and pitting of the shaft at the point where it is contacted by an elastomeric sealing gasket. This has been a major point of wear and a source of pump malfunction in the types of comparable submersible pumps previously manufactured.

Once the shaft extension element 34 has been secured in the bore at the end of the motor shaft 24, and is extended through the apertures 22 and 30 in the dished closure member 20, and in the back support plate 28, respectively, a sealing gasket 36 is then placed in position in abutting contact with the back support plate 28 as illustrated in FIG. 3. The preferred sealing gasket 36 which is employed in the manufacture of the submersible pump of the present invention is an elastomeric disc which is provided at points near its outer peripheral edge with apertures 37 for the accommodation of the fastening members 32, and at approximately its center with an aperture for the accommodation of the shaft extension element 34. All apertures which are provided for permitting passage of the fastening members 32 and the shaft extension element 34 through the sealing gasket are, of course, undersized to provide sealing engagement with the structural elements which are extended through these apertures. The elastomeric disc constituting the sealing gasket 36 is further provided with a plurality of annular grooves 38 which concentrically surround the central aperture through the sealing gasket, and include at least one groove 38 provided in each of the opposed faces of the sealing gasket. The grooves 38 impart enhanced flexibility to the elastomeric disc which is preferably constructed of a synthetic rubber such as Buna N or Viton.

The radially inwardly positioned edge portion of the sealing gasket 36 which defines the central aperture therethrough is preferably bifurcated so as to provide a pair of divergent annular sealing lips 40 which bear

against the shaft extension element 34, and which form a grease cavity 42 surrounding the shaft extension element 34. It will be noted in referring to FIG. 3 that the divergent character of the sealing lips 40 assures that pressure exerted by fluids on opposite sides of the sealing gasket 36 and acting in opposite directions along the shaft extension element 34 will effectively bias the sealing lips into a more tenacious sealing engagement with the shaft extension element 34.

A centrally apertured, rigid, and preferably metallic impeller backup plate 44 is positioned around the shaft extension element 34, and is placed in flat abutting contact with the outwardly facing side of the sealing gasket 36. The central aperture 46 formed through the impeller backup plate 44 is preferably diametrically dimensioned so that no distorting force is exerted by this plate upon the sealing lips 40 of the sealing gasket 36 which are on the same side of the gasket as is contacted by the impeller backup plate 44.

A suitable impeller 48 is keyed to the free outer end of the shaft extension element 34 by a set screw 50 or other suitable keying means, and the assembly of the pump is then completed by placing over the impeller 48, a hollow impeller housing 52 which is preferably constructed of a chemically inert, high mechanical strength resinous material. The impeller housing 52 is provided with a plurality of elongated bores formed through the housing adjacent the periphery thereof for the accommodation of the fastening members 32. The impeller housing is then drawn against the sealing gasket 36 by threading nuts 54 on the fastening members 32. The sealing gasket 36 is thus placed in compression and a tight seal is formed by the sealing gasket between the impeller housing 52 and the back support plate 28. The impeller housing 52 is preferably dimensioned so that the impeller backup plate 44 frictionally engages the internal wall of the impeller housing and is retained in the position shown in FIG. 3 by such frictional engagement. If desired, however, a small shoulder can be formed in the impeller housing 52 by a counterboring process so that the impeller backup plate 38 will bear against such shoulder when the impeller housing 52 is secured in position.

The impeller housing 52 is provided with an externally threaded fluid intake opening 56 which is coaxially aligned with the shaft extension element 34 and the openings 22 and 30 through the dished rigid closure member 20 and the back support plate 26, respectively. The impeller housing 52 is further characterized in having a fluid discharge opening 54 which extends into the impeller housing in a tangential direction with respect to the circular path swept out by the free, radially outer ends of the impeller 48.

At a time prior to the placement of the sealing gasket 36 in a position adjacent the back support plate 28, it is preferable to paint or coat the motor housing 10 and the dished closure member 20 secured therein with a suitable paint or resinous material having a high degree of chemical inertness and forming a protective coating over the entire motor housing 10 and any exposed surfaces of the dished closure member 20 and the back support plate 26.

In some uses of the submersible pump of the invention, it is highly desirable that the heat developed by running of the motor 16 over extended periods of time be dissipated in an efficient manner. For the purpose of accomplishing such heat dissipation, an adjustable and

detachable heat sink 62 is provided and is constructed in the manner illustrated in FIG. 6. The heat sink 62 comprises a plurality of superimposed or stacked fin plates which collectively form a rectangularly shaped fin frame having a variable size rectangular aperture 64 in the center thereof. The adjustable heat sink 62 thus includes a plurality of spaced parallel sheets or plates 66 which are alternately stacked with, or interposed between, a plurality of parallel sheets or plates 68 which extend normal to the first mentioned sheets or plates. The superimposed plates 66 and 68 in each case have apertures 70 extending therethrough for the accommodation of a plurality of elongated fastening elements 72. The apertures 70 through the plates are of substantially larger diameter than the fastening elements 72 and thus permit the parallel plates to be moved toward or away from each other so as to vary the size of the internal rectangular aperture 64. The adjustable heat sink 62 can thus be adjusted to accommodate submersible pumps having motor housings 10 of varying sizes, with the motor housing of the pump being positioned in the rectangular aperture 64 through the center of the adjustable heat sink with the several plates 66 and 68 in contact with the housing. It will also be noted that the number of plates 66 and 68 included in the adjustable heat sink can be selectively varied to provide varying heat transfer characteristics as may be required.

The submersible pump of the present invention, constructed in the manner described, is a highly versatile pump having an extended service life and high reliability in operation. The pump can be used effectively in acidic, basic or neutral solutions and it will work well whether in the submerged condition or in open air, in-line operation. The preferred embodiment which includes in the assembly the aluminum oxide ceramic shaft extension element may be particularly effectively used in the pumping of strong electrolyte solutions since the ceramic shaft resists deleterious wear of the type which normally occurs at the point where the shaft is contacted by the sealing gasket.

The novel sealing gasket which is employed in the pump assembly is itself a highly desirable feature of the invention providing several advantages. First, the dual lip seal provided by the bifurcation of this element at its radially inner periphery which defines the aperture receiving the shaft extension element permits a grease cavity in which a lubricant can be confined to exist at this point. Moreover, the divergent sealing lips of the sealing gasket provide a high assurance against loss of lubricant from inside the motor housing 10 as the environment of the motor becomes heated over extended periods of operation, and also assures that cooling of the interior of the motor housing 10 after extended periods of operation will not effectively draw the pumped solution into the motor housing past the sealing gasket. Because of the relatively few parts which are used in the fabrication of the pump, and the ease with which they may be manufactured without the requirement of high precision machining operations, the pump can be assembled quickly and economically by personnel having a relatively low degree of skill in machining and assembly operations.

Although certain preferred embodiments of the invention have been herein described and a preferred embodiment of the pump has been shown in the drawings, it will be understood that various changes and modifications can be effected in the steps of assembly,

and in the several structural elements employed without departure from the basic principles underlying the invention. All such changes and innovations which yet continue to rely upon these basic principles are therefore deemed to be circumscribed by the spirit and scope of the invention except as the same may be necessarily limited by the appended claims or reasonable equivalents thereof.

What is claimed is:

1. A submersible pump comprising:

- a unitary, one piece motor housing having an opening therein;
- a motor positioned in the motor housing;
- an apertured closure member positioned across and closing the opening in the unitary housing;
- shaft means drivingly connected to the motor and extending through the aperture in the closure member;
- an apertured, back support plate bonded to said closure member and surrounding said shaft means;
- an impeller keyed to said shaft means and positioned on the opposite side of said back support plate from said closure member;
- an impeller housing around said impeller and having an inlet opening and a discharge opening therein;
- a sealing gasket positioned between said impeller housing and said back support plate and sealingly engaging said shaft means;
- an impeller backup plate positioned in said housing between said impeller and said sealing gasket and surrounding said shaft means; and
- fastening means interconnecting said back support plate and said impeller housing and drawing the impeller housing toward said back support plate to compress the sealing gasket therebetween.

2. An electric pump comprising:

- a motor housing open at one side and having a power lead line opening therein spaced from the open side of the housing;
- an electric motor positioned inside the housing and having a shaft extending toward the open side of the housing and a power lead line extending through the power lead line opening;
- means securing the motor in a fixed location in the housing;
- a rigid dished closure member frictionally pressed into the motor housing to close the open side thereof and defining with the motor housing a continuous groove adjacent the edge of the motor housing at the open side thereof, said dished closure member having a shaft opening therethrough;
- a shaft extension element extending through the shaft opening in the dished closure member and connected at one end to the motor shaft;
- a bonding and sealing material in the continuous groove bonding the dished closure member to the motor housing and forming a seal therebetween;
- an apertured, back support plate bonded to the dished closure member and encircling the shaft extension element;
- fastening elements secured to the back support plate and extending therefrom in a direction away from the motor housing;
- an impeller keyed to said shaft extension element and positioned on the opposite side of said back support plate from said rigid dished closure member;

an impeller housing connected to said fastening elements and enclosing said impeller, said impeller housing having an inlet opening axially aligned with the shaft extension element, and a discharge opening extending tangentially with respect to the circular path of the outer ends of the blades of the impeller;

a resilient sealing gasket positioned between the back support plate and said impeller housing and establishing a seal therebetween, said sealing gasket having an aperture therethrough receiving said shaft extension element and dimensioned for sealing engagement between the shaft extension element and sealing gasket; and

an impeller backup plate in said impeller housing and positioned between said sealing gasket and said impeller to abut said sealing gasket, said impeller backup plate having an aperture therethrough receiving said shaft extension element.

3. A pump as defined in claim 2 wherein said sealing gasket comprises an elastomeric material having a bifurcated edge portion adjacent the aperture through the sealing gasket with the bifurcation in the edge portion forming a pair of annular, diverging sealing lips sealingly engaging the periphery of said shaft extension element.

4. A pump as defined in claim 3 wherein said shaft extension element is an aluminum oxide ceramic material.

5. A pump as defined in claim 3 wherein said sealing gasket further includes at least one annular groove formed therein and surrounding the aperture therethrough which receives said shaft extension element.

6. A pump as defined in claim 2 wherein said motor

housing is of one piece unitary construction, and said means securing the motor in a fixed location in the motor housing is a settable resinous material surrounding a portion of the motor and positioned between the motor and the motor housing.

7. A pump as defined in claim 2 wherein said back support plate is bonded to said dished closure member by an epoxy resin.

8. A pump as defined in claim 2 wherein the apertures in said closure member, said back support plate and said impeller backup plate are all substantially larger in diameter than the cross-sectional dimension of the shaft extension element extended therethrough so that clearance around the shaft extension element is provided, and the necessity of precise alignment of the motor in the motor housing is obviated.

9. A pump as defined in claim 4 wherein said shaft extension element is an aluminum oxide ceramic material and is dimensioned to pass with substantial clearance through the apertures in said closure member, back support plate and impeller backup plate so that the necessity of precise alignment of the motor in said housing is obviated.

10. A pump as defined in claim 9 wherein said motor housing is of one piece unitary construction, and said means securing the motor in a fixed location in said motor housing is a settable resinous material surrounding a portion of the motor and positioned between the motor and the motor housing.

11. A pump as defined in claim 10 wherein said back support plate is bonded to said dished closure member by an epoxy resin.

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