

May 30, 1950

J. R. STEPHENSON
NUTATING AXIS PUMP WITH MOTOR

2,509,790

Filed Nov. 13, 1945

3 Sheets-Sheet 1

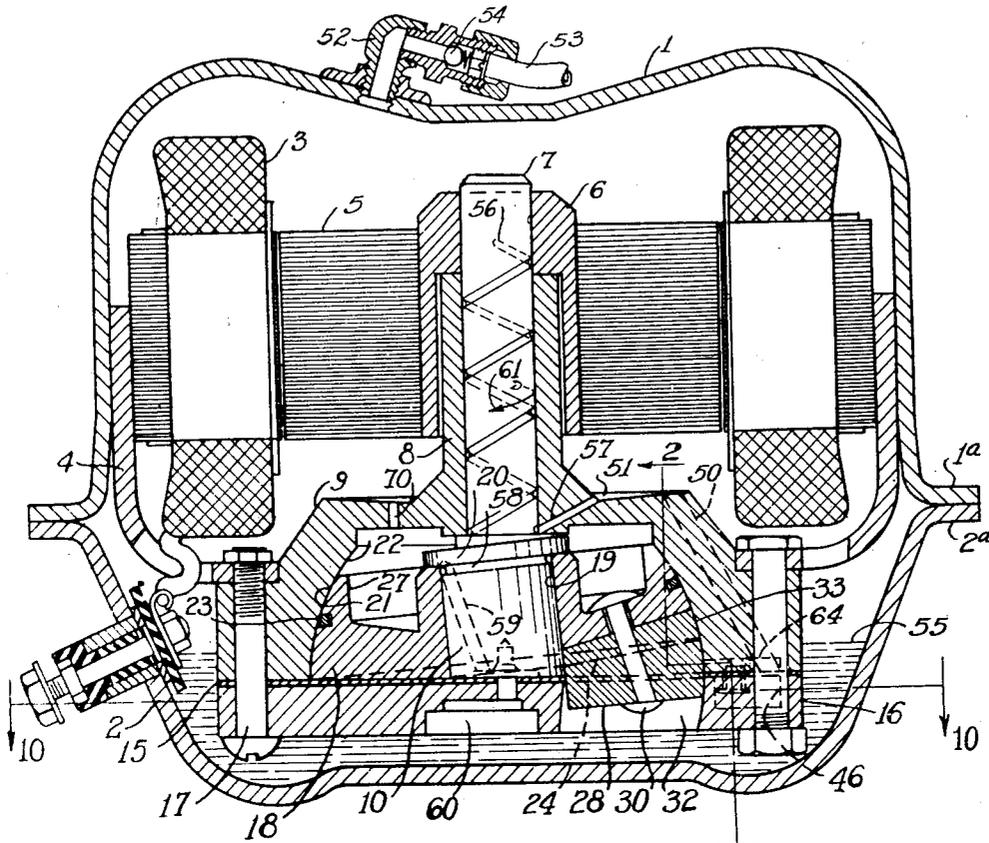


Fig. 1.

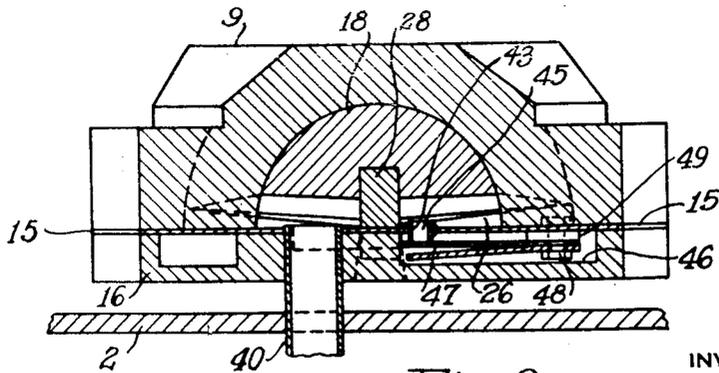


Fig. 2.

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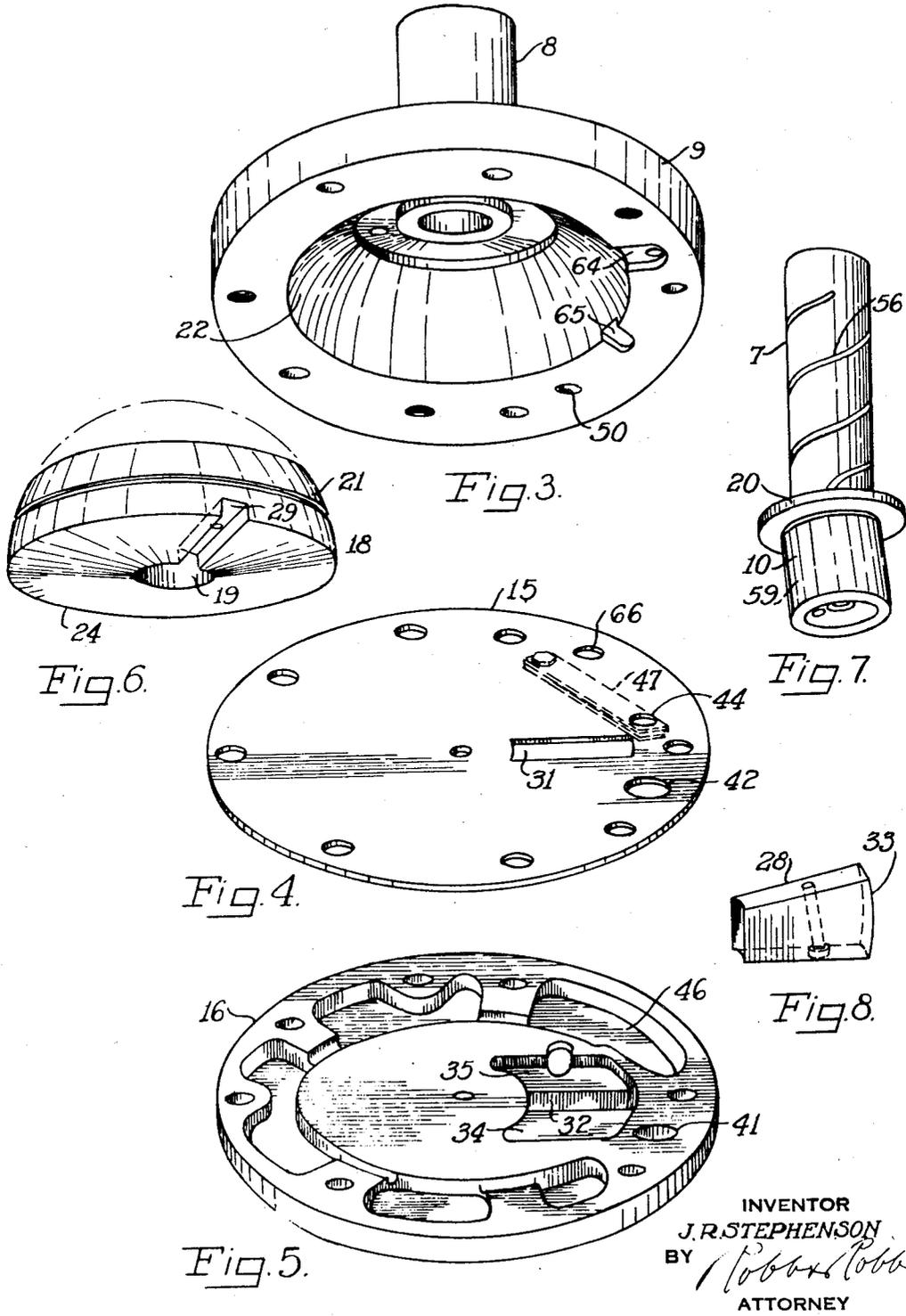
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

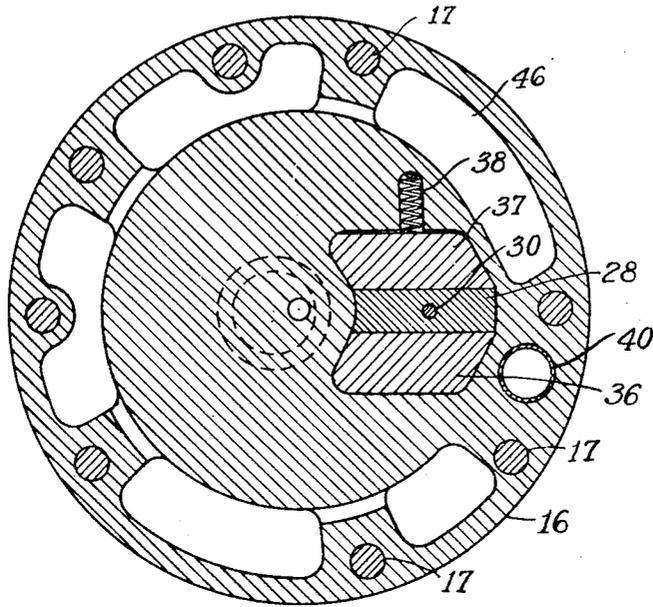


Fig. 10.

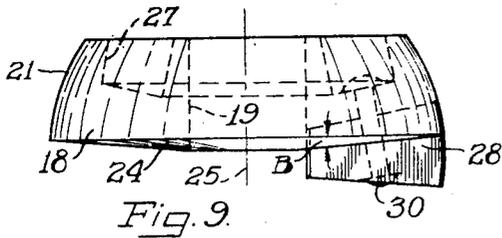


Fig. 9.

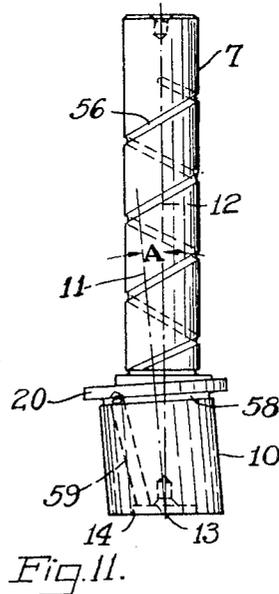


Fig. 11.

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2,509,790

NUTATING AXIS PUMP WITH MOTOR

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Application November 13, 1945, Serial No. 628,130

16 Claims. (Cl. 230—139)

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This invention relates to fluid pumps and more particularly to a fluid pump and electric motor unit designed especially for use in mechanical refrigeration.

Heretofore, pump and motor units of the type referred to have comprised a relatively large number of moving parts which are subject to wear, with consequent loss of efficiency or necessity of frequent repair or replacement, and require considerable time and care in their fabrication and assembly, thereby multiplying the cost of manufacture, as well as of operation and maintenance. Furthermore, in order to prevent substantial leakage of fluid between the impeller and its housing, prior pump constructions have necessitated laborious and expensive machining of the parts to extremely close tolerances.

One of the objects of the invention is to devise a fluid pump in which the impeller or movable pumping element and its housing are designed to have adequate sealing bearing relation to one another, whereby to prevent any substantial leakage of fluid therebetween when the pump is operating, without requiring the parts to be machined to the close tolerances heretofore necessary for this purpose.

Another object of the invention is to provide a motor and pump unit of the type referred to which comprises fewer moving parts than constructions heretofore proposed.

Another object of the invention is to provide a novel construction of sealed motor and pump unit which is easier to assemble and cheaper to manufacture than the units of this type now in use.

A further object is to provide a fluid pump in which the pressure built up at the discharge side is utilized to reduce the power required to maintain the pump operating at normal running speed.

Another object is to provide a sealed motor and pump unit of the class described which is self-lubricating.

A particular object of the invention is to provide a fluid pump in which the impeller or movable pumping element and the housing therefor are designed to have sealing bearing relation throughout a major portion of the cooperating bearing area of the pump housing at all times whereby to provide maximum sealing relation of the piston with respect to its housing, without requiring machining of the parts to the close tolerances heretofore necessary.

One feature of the invention involves the provision of a pump in which the pumping element

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and its housing have cooperating spherical bearing surfaces with the spherical surface of the pumping element arranged in bearing relation to a major portion of the area of the cooperating spherical surface of the housing.

Another feature of the invention involves the provision of a pump, capable of accomplishing the foregoing objectives, in which the pumping element has a universal bearing relation with respect to its housing and is provided with a conical working surface adapted to work against a flat surface provided in the pressure chamber within the pump housing.

Another feature of the invention involves the provision of a pump of the class described wherein the drive shaft for the pumping element is formed with an integral angular portion upon which the pumping element is mounted for rotation of the drive shaft relative thereto.

Another feature of the invention resides in the provision of a pump wherein the drive shaft for the pumping element has at one end an integral angular portion disposed so that the center line of said angular portion intersects the axis of the shaft at the end thereof.

Another feature of the invention resides in the provision of a dividing member for separating the intake from the discharge side of the pump and fixed to the pumping element for movement therewith relative to the pump housing.

Another feature of the invention involves the formation on the pump housing of an extended bearing portion which forms the sole bearing for the drive shaft carrying both the motor rotor and the impeller or pumping element.

Another feature of the invention resides in the provision of an electric motor and pump assembly construction such that the motor stator and its housing form a sub-assembly receivable within the main housing, and the pump and motor-rotor form another sub-assembly which is cooperable with the stator housing in such a manner as to insure proper spacing of the rotor and stator to provide uniformity of the air gap when the rotor is disposed within the stator.

In carrying my invention into practice I provide a pump housing, the interior wall of which has a spherical configuration. Within this housing there is provided a pumping element or impeller having a corresponding spherical bearing surface adapted to have sealing bearing relation at all times throughout a major portion of the area of the cooperating spherical inner wall of the housing.

For driving the pumping element or piston there is provided a drive shaft formed with an integral cylindrical angular portion, the axis or center line of which is disposed at an angle to, and intersects the axis of said drive shaft at the end of the latter. The pumping element or impeller is mounted on said angular portion for rotation thereof with said drive shaft relative to said pumping element whereby to impart motion to said pumping element.

According to the embodiment of the invention herein illustrated, the pumping element or impeller and the housing therefor are provided with cooperating working surfaces one of which is relatively flat and the other of which surfaces has a conical configuration. Preferably, the pumping element or piston is provided with a working surface of conical configuration adapted to work against a relatively flat surface provided on the housing. The pumping element or impeller has a cylindrical bore concentric with the cone axis of its working surface and adapted to closely receive the cylindrical angular portion of the drive shaft for mounting of the impeller element on said angular portion for rotation of the latter relative to the impeller to impart motion to the impeller as aforesaid. The mounting of the pumping element upon the angular portion of the drive shaft serves to enable the latter to impart motion to the pumping element upon the rotation of the drive shaft such that the conical working surface of said element tends to roll upon a suitably juxtaposed working surface of the pump housing. The pump housing is provided with an integral elongated bearing for journaling the impeller drive shaft.

The angular portion of the drive shaft and the pumping element or impeller are so designed and arranged that the spherical bearing surface of the impeller is in continuous sealing bearing relation with a major portion of the area of the spherical housing wall at all times. Thus there is provided a large sealing area between the spherical surfaces of the pumping element and its housing to substantially prevent leakage of fluid therebetween when the pump is operating, and in view of this fact the clearance between the cooperating spherical surfaces of the piston and its housing may be much larger than in pump constructions heretofore known, thereby reducing the cost of manufacture, since these surfaces will not have to be machined to the close tolerances required in pump constructions heretofore known.

According to the embodiment of the invention, herein illustrated, the pumping element or impeller has fixed thereto for movement therewith a dividing member working in a recess of the pump housing whereby to separate the intake and exhaust sides of the pump chamber.

Also, in the embodiment of the invention herein illustrated, the pump drive shaft has secured thereto the rotor of an electric motor rotatable in the stator of said motor. The combined electric motor and fluid pump unit is enclosed within a main housing or casing comprising upper and lower sections provided with abutting circumferential flanges adapted to be welded or otherwise secured in abutting relation one to the other whereby to provide a sealed fluid-tight electric motor and fluid pump unit.

Means is provided for discharging compressed fluid from the pump into the main housing or casing, for building up pressure therein during operation of the pump, and means is provided

for applying this pressure to the impeller so as to tend to move it in the same manner that it is moved by its primary source of power.

Other objects, advantages and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a vertical sectional view through the electric motor and pump unit of the invention;

Fig. 2 is a section taken on the line 2—2 of Fig. 1, looking in the direction of the arrows.

Fig. 3 is a perspective view of the pump housing looking toward the bottom thereof with the valve plate and its cover removed.

Fig. 4 is a perspective view of the thin metal plate constituting the bottom wall of the pump chamber.

Fig. 5 is a perspective view of the bottom plate of the pump unit.

Fig. 6 is a perspective view of the pumping element or impeller.

Fig. 7 is a view of the drive shaft.

Fig. 8 is a perspective view of the divider block adapted to be associated with the pumping element or impeller and functioning to separate the intake and exhaust sides of the pump chamber.

Fig. 9 is an elevation of the pumping element or impeller.

Fig. 10 is a section on the line 10—10 of Fig. 1.

Fig. 11 is an elevation of the drive shaft.

Now referring to the drawings and describing the invention in detail, there is illustrated in Fig. 1 an electric motor and fluid pump unit which is contained in a main housing or casing comprising upper and lower sections 1 and 2 respectively, secured together at their abutting circumferential flanges 1a and 2a respectively as by welding or in any suitable manner, preferably providing a fluidtight joint. The electric motor includes the stator 3 which is press-fitted into a housing 4 which may comprise a drawn steel cup and which, in turn, is press-fitted into the upper section 1 of the main housing. The electric motor also includes a rotor 5 carried on a bearing 6 secured to the drive shaft 7 which is journaled in an extended bearing portion 8 formed on the pump housing 9.

The drive shaft 7, as best seen in Figs. 1 and 7 is formed at one end with an integral cylindrical angular portion 10, the cylindrical axis or center line 11 of which is disposed at an angle A with respect to the axis 12 of the drive shaft 7. The axis 11 of the angular portion 10 intersects the axis 12 of the drive shaft 7 at the point 13 on the extreme end edge 14 of the drive shaft 7 which is also the extreme end edge of the angular portion 10. The edge 14 of shaft 7 has a bearing on a thin metal plate 15 which forms the bottom wall of the pump chamber 26 provided in the housing 9 and, for this purpose, the plane of the edge 14 is parallel to the plane of plate 15 and perpendicular to the axis 12 of shaft 7. Plate 15 is preferably of hardened or tempered steel similar to Swedish steel to form a suitable bearing surface for the edge 14 of drive shaft 7.

A bottom plate 16 is provided for the pump housing 9 and secured thereto by means of bolts 17 extending through the bottom plate 16, plate 15, housing 9, and stator housing 4 for securing the pump assembly to the stator housing 4.

The pumping element or impeller 18 is mounted on the angular portion 10 of the drive shaft 7 for rotation of the latter relative to impeller 18. To this end, impeller 18 is provided with a concentric bore 19 adapted to rotatively receive and

have a bearing on the angular portion 10 of the shaft 7. The drive shaft 7 is formed with an integral annular flange 20 constituting an abutment engaging the upper surface of the impeller 18 when the latter is mounted on the angular portion 10 of the shaft 7, said flange 20 being disposed at the same angle as the axis 11 with respect to the axis 12.

Impeller 18 is mounted for universal movement within the housing 9. To this end, impeller 18 has a spherical bearing surface 21 adapted to have sealing bearing relation with respect to a corresponding spherical inner wall 22 of the pump housing 9. Thus the impeller 18 has universal sealing bearing relation to the housing 9. Where the pump is intended for use with the more highly volatile fluids, pumping element or impeller 18 may be provided with a suitable expanding sealing ring or gasket 23 seated in an annular groove in the impeller 18 as shown in Fig. 1.

The pumping element or impeller 18 has a conical working surface 24, the cone angle B of which is substantially equal to the angle A between the axis 11 of angular portion 10 and the axis 12 of drive shaft 7. The bore 19, which receives angular portion 10 of drive shaft 7, is concentric with the cone axis 25 of the conical working surface 24 of the impeller 18; that is, the cone axis 25 coincides with the cylindrical axis of the bore 19 and, of course, likewise coincides with the axis 11 of the angular portion 10 of the drive shaft 7 when the impeller 18 is mounted thereon.

The conical working surface 24 of the impeller 18 works against the flat upper surface of the thin metal plate 15 constituting the lower wall of the pump or pressure chamber 26. Cavities 27 are provided in the pumping element or impeller 18 to lighten the same.

As will be seen upon reference to Fig. 1, the spherical bearing surface 21 of the impeller 18 has bearing relation with the major portion of the area of the spherical inner wall 22 of the pump housing 9. On account of the large bearing area of the impeller 18 with respect to the housing 9, the clearance between the spherical surfaces 21 and 22 may be somewhat greater than in constructions heretofore known, without producing any substantial leakage during operation of the pump. Hence, the parts are not required to be machined to the close tolerances now necessary in prior pump constructions. Thus the cost of the manufacture involved in extensive machining operations is reduced by the construction of the present invention. Nevertheless the bearing relation of the impeller with its housing is such as to prevent any substantial leakage between the spherical surfaces 21 and 22 during the operation of the pump.

A divider block or member 28 is received in a recess 29 formed in the pumping element or impeller 18, said divider block 28 being secured in association with the impeller 18 by means of a rivet 30. The divider block 28 extends through an aperture 31 in the thin metal plate 15 and into an aperture 32 in the bottom plate 16 and is provided with a spherical surface 33 flush with the spherical surface 21 of impeller 18 and likewise having bearing relation with the spherical surface 22 of the housing 9.

The bottom plate 16 is provided with recesses 34 and 35 at either side of the aperture 32. Within the recesses 34 and 35 are disposed respective slide blocks 36 and 37 working against opposite sides of divider block 28. Spring means 38 is provided acting against slide block 37 to maintain the slide

blocks in engagement with divider block 28 during movement of the pumping element or impeller 18. The slide blocks 36 and 37 are provided for the purpose of taking up wear and to prevent leakage of fluid at either side of the divider block 28, which is located intermediate the intake and discharge passages to and from the pressure chamber 26, so as to separate the intake or suction side of the pump chamber 26 from the exhaust or discharge side thereof.

As seen best in Figs. 1, 2, 4 and 5, the inlet conduit 40 extends from the exterior of the casing 1, 2 through an aperture 41 in the bottom plate 16 and through an aperture 42 in the thin metal plate 15 and thence into a recess 64 in housing 9 and so communicates with the interior of the pump housing between the plate 15 and the conical working surface 24 of the impeller 18. Valve means is provided for controlling the discharge of fluid from the pressure chamber 26, said valve means comprising a seat member 43 disposed in an aperture 44 of the thin metal plate 15 and suitably secured thereto. The seat member 43 has a passage 45 therethrough opening at its upper end into a recess 65 in housing 9 and providing communication between the pressure chamber 26 and a cavity 46 provided in the bottom plate 16. The passage 45 is normally closed by a flat metal spring or reed valve member 47 seating against the lower end of the member 43 and adapted to be opened under pressure of fluid within the pressure chamber 26. The reed valve member 47 has one end thereof secured to the thin metal plate 15 as by means of a rivet 48, a washer or other spacing member 49 being mounted thereon for spacing the member 47 from the plate 15.

By reference to Fig. 2 it will be noted that the divider block 28 is located intermediate the inlet conduit 40 and the discharge outlet 45 so as to separate the suction side of the pump chamber 26 from the discharge side of said chamber. In other words, the divider block 28 is located so that the fluid can move through the pump chamber 26 in only one direction between the inlet and outlet passages 40 and 45 for a given direction of rotation of the drive shaft 7.

A passage 50 leads through the housing 9 providing communication through an aperture 66 in plate 15 between the cavity 46 and the exterior of the housing 9, the upper end of the passage 50 opening into a tapered annular recess 51 at the top of the housing 9. Thus the fluid compressed in the pressure chamber 26 is discharged through the passage 45 into the cavity 46 and thence through the passage 50 exteriorly of the housing 9 to the interior of the main housing 1, 2, the discharged gas filling the main housing and passing around the periphery of the rotor 5 to the discharge conduit 52. The discharge conduit 52 is provided at the top of the housing 1, 2 for conducting the fluid from within the main housing 1, 2 to a supply conduit 53 for conducting the fluid to a point of use. In refrigerating apparatus the fluid will be conducted to a condenser, subsequently to an evaporator, and thence returned to the pump through intake conduit 40. A restrictor 54 is provided in the supply line 53 for restricting the flow of gas from the main housing 1, 2 so as to enable a predetermined pressure to be built up therein during the operation of the pump.

In service, a pool of lubricating oil 55 will be provided within the bottom portion of the main housing 1, 2 to about the level indicated in Figure 1 whereby to provide lubrication for the moving

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parts of the pump. To this end, the drive shaft 7 is provided with a helical groove 56 and a passage 57 is provided through the pump housing 9 leading from the annular recess 51 to the interior of the bearing portion 8 whereby to lubricate the drive shaft 7 in its bearing. The angular portion 10 is provided with an annular groove 58 communicating with a passage 59 leading through angular portion 10 and communicating through an opening in plate 15 with a counter-bored passage 60 through the bottom plate 16. When the shaft 7 is rotated, oil 55 will be forced upwardly through passage 59 in the angular portion 10 due to centrifugal force, the passage 59 extending at an angle upwardly and outwardly to its point of communication with the annular groove 58 for this purpose. Thus the passage 59 and annular groove 58 provide lubrication between the bore 19 of the impeller 18 and the periphery of angular portion 10 of the drive shaft 7.

In operation, the electric motor comprising the stator 3 and the rotor 5 is energized to rotate the shaft 7 at relatively high speed in a direction indicated by the arrow 61 in Fig. 1. The shaft 7 rotates relative to the pumping element or impeller 18 which latter does not rotate but is caused to move within the housing 9 due to the action of the angular portion 10 of the drive shaft 7 upon the impeller 18. This action is such as to cause the conical working surface 24 of the impeller 18 to roll with respect to the flat upper surface of the thin metal plate 15 about the axis 12 of the drive shaft 7. The conical working surface 24 of the impeller 18 has a radial line contact with the upper surface of the thin metal plate 15.

During rotation of the shaft 7 the rolling engagement of the conical working surface 24 with respect to the upper surface of the plate 15 causes the position of the radial line of contact between conical working surface 24 and plate 15 to progressively move in a circular orbit about the axis of the drive shaft 7; in other words, the conical working surface 24 of the impeller 18 is caused to be progressively engaged with the flat upper surface of the thin metal plate 15 so that the position of the radial line of contact between the conical working surface 24 and plate 15 progressively moves in a circular orbit about the axis of drive shaft 7. This causes the fluid entering the chamber 26 through the inlet conduit 40 to be progressively squeezed or pushed along the upper surface of plate 15 from the inlet or suction side of the chamber 26 to the discharge side thereof where the compressed fluid is discharged through the passage 45 past the valve member 47 into the cavity 46, thence through passage 50 to the interior of the main housing 1, 2 exteriorly of the pump housing 9. The pressure of fluid built up in the chamber 26 between the radial line of contact of the surfaces 24 and 15 and the passage 45 causes the valve member 47 to be opened against its normal spring bias to closed position once during each revolution of shaft 7. The valve member 47 will again immediately close the passage 45 as soon as said radial line of contact advances beyond the same in the progressive rolling of the conical working surface 24 with respect to the upper surface of the plate 15. Thus the valve member 47 will be opened once during each revolution of the drive shaft 7 and will remain open for a short period comprising a fraction of one revolution of the drive shaft 7.

The pumping element or impeller 18 moves universally within the housing 9 by reason of the

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cooperating spherical bearing surfaces 21 and 22 of the impeller 18 and housing 9 respectively, and the divider block 28 prevents the fluid from passing back to the suction side of the chamber 26.

By reference to Fig. 1 it will be noted that the area of the spherical bearing surface 21 of the impeller 18 is relatively large and is equal to a major portion of the area of the cooperating spherical surface 22 of the pump housing 9. By reason of the construction and arrangement of the drive shaft 7 with its angular portion 10 and of the impeller 18 with its spherical bearing surface and conical working surface, the spherical bearing surface 21 of the impeller 18 is enabled to be maintained in bearing relation to a major portion of the area of the cooperating spherical surface 22 of the housing 9 at all times during the operation of the pump.

Because of the large sealing bearing area between the spherical surfaces 21 and 22 of the impeller 18 and its housing 9 respectively, the clearance between said spherical surfaces may be somewhat greater than in pump constructions heretofore known and still no substantial leakage of fluid therebetween will occur during operation of the pump. This construction enables a substantial reduction in the cost of manufacture since the close tolerances now required in pump constructions heretofore known need not be maintained in reference to the spherical surfaces 21 of the impellers 18 and 22 of the pump housing 9 in the pump construction of the present invention and hence much of the machining which would otherwise be required of the bearing surfaces of these parts is eliminated.

In the operation of the pump, lubrication is effected by the forcing of oil 55 upwardly through passage 59 due to centrifugal force created by the shaft 7 to provide lubrication of the bearing surfaces of the angular portion 10 of the drive shaft 7 and the bore 19 of the impeller 18. Some of the oil 55 may leak into the pressure chamber 26 from between the angular portion 10 and the bore 19 and become entrapped with the gas or other fluid compressed by the impeller 18 so that the entrapped oil is forced upwardly through the passage 50 into the tapered annular recess 51 and then flow from the lowermost point thereof through the passage 57 to the interior of the bearing 8 where it can get into the helical groove 56 and be carried upwardly thereby in the rotation of the drive shaft 7 so as to lubricate substantially the entire length of drive shaft 7 in its bearing.

When the pump is operating, pressure is built up within the main housing 1, 2 exteriorly of the pump housing 9 due to the provision of the restrictor 54 in the discharge-supply conduit 52, 53. Means is provided for applying this pressure built up within the main housing 1, 2 to the impeller 18 in such a manner as to tend to move it in the same direction that it is moved by its primary source of power through the electric motor during the operation of the pump. The aforesaid means comprises the provision of a passage 70 through the pump housing 9 leading from the annular recess 51 to the interior of the housing 9 above impeller 18. Through this passage 70 the pressure built up within the main housing 1, 2 acts upon the upper surface of the impeller 18 in a downward direction so as to tend to assist the progressive rolling movement of the conical working surface 24 with respect to the upper surface of plate 15 in the direction in which said conical working surface 24 is moving with

respect to the plate 15 by reason of the rotation of the shaft 7. This application of pressure to the upper side of the impeller 18 will reduce the power required to maintain the pump operating at normal running speed. The pressure on the upper side of impeller 18 maintains the conical working surface 24 in contact with plate 15 along a radial line so as to insure a perfect seal between the high and low pressure sides of the pump chamber 26. Passage 70 lets oil into the pump housing 9 to lubricate the spherical bearing surfaces of the housing 9 and impeller 18.

Because of the large sealing bearing area of the spherical surface 21 of the impeller 18 with respect to the spherical surface 22 of the pump housing 9, the close tolerances usually required between the cooperating surfaces of housing and impeller are not necessary in the present construction and yet there will be no substantial leakage of fluid between said surfaces during operation of the pump so that the efficiency thereof is not substantially reduced. It will be understood, of course, that the clearance between the spherical surfaces 21 and 22 is measured in thousandths of an inch so that reference herein to relatively larger or smaller clearances between the spherical surfaces 21 and 22 means a difference of but a few thousandths of an inch. However, the lack of necessity in the construction of the invention for the maintenance of the extremely close tolerances between the impeller and its housing which are required for proper operation of other pump constructions heretofore known makes a substantial difference in the cost of manufacture in the elimination of much machining of the parts of the construction of the present invention which would otherwise be required.

It will be noted that the construction of the electric motor and pump unit of the invention is especially adapted to facilitate assembly of the parts. In this connection, attention is called to the fact that the stator 3 press-fitted into its housing 4 may comprise a sub-assembly which can be assembled as a unit within the upper section 1 of the main housing by press-fitting the stator housing 4 into said upper section 1. Subsequently with the impeller 18 assembled upon the angular portion 10 of the shaft 7 and the bolts 17 inserted through the plates 16 and 15 and into the bolt holes in the housing 9, the entire rotor and pump sub-assembly may be assembled as a unit into the position indicated in Fig. 1 with the bolts 17 passing through the bolt holes provided in the housing 4 and secured thereto. Thereafter the bottom section 2 of the main housing may be secured to the upper section 1 in the manner shown and described to complete the assembly of the electric motor and pump unit as shown in Fig. 1.

It will be noted that the extended bearing portion 8 formed on the pump housing 9 provides the sole bearing for the drive shaft 7 which latter carries both the motor rotor 5 and the pumping element or impeller 18.

It will be apparent from the foregoing, that the motor rotor 5, shaft 7, and the pump proper including housing 9, impeller 18, and plates 15 and 16 with bolts 17 inserted through plates 15 and 16 and into housing 9 constitutes a complete rotor and pump sub-assembly which may be readily secured in association with and disassociated from the stator housing 4.

Also it may be noted that the passage 59 leads from the lower end of angular portion 10 cen-

trally thereof upwardly and outwardly to the periphery of said angular portion 10.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, a drive shaft for said impeller, said drive shaft having an integral angular portion, said impeller having a bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, and a divider member secured to the impeller for movement therewith and cooperating with said housing to prevent movement of fluid between said impeller and said housing past said member.

2. A pump of the class described, comprising a housing, an impeller mounted therein for universal movement relative thereto, said impeller having a conical working surface, said housing having a working surface cooperating with said conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, said impeller having a non-spherical surface on the opposite side thereof from said working surface, means for imparting movement to said impeller to cause fluid introduced between said working surfaces to be compressed thereby, and means for applying said compressed fluid to said non-spherical surface of the impeller.

3. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, a drive shaft for said impeller, said drive shaft having an integral angular portion, said impeller having a bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, wherein said angular portion is provided with a passage therein leading from the lower end centrally thereof upwardly and outwardly to the periphery of said angular portion, and means for supplying a lubricating fluid to the lower end of said passage whereby to introduce said lubricating fluid to the mounting portions of said impeller and of said angular portion of said shaft during rotation of the latter.

4. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, and a drive shaft for said impeller, said drive shaft having at one end an integral cylindrical angular portion, the cylindrical axis of said angular portion being disposed at an angle to the axis of said shaft, the axis of said shaft intersecting the cylindrical axis of said angular portion at the extreme end edge thereof, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, the cylindrical axis of said bore coinciding with the cone axis of said working surface.

5. A pump of the class described, comprising a housing, an impeller mounted therein for universal movement relative thereto, and a drive shaft for said impeller, said drive shaft having

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at one end an integral angular cylindrical portion, the cylindrical axis of said angular portion being disposed at an angle to the axis of said shaft, the axis of said shaft intersecting the cylindrical axis of said angular portion at the extreme end edge thereof, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, the cylindrical axis of said bore coinciding with the cylindrical axis of said angular portion.

6. A pump of the class described, comprising a housing, an impeller mounted therein for universal movement relative thereto, and a drive shaft for said impeller, said drive shaft having at one end an integral angular cylindrical portion, the extreme end edge of said angular portion having a bearing on the interior wall of said housing in a plane perpendicular to the axis of said shaft, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft at said extreme end edge, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter.

7. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, and a drive shaft for said impeller, said impeller having a conical working surface, said housing having a plane working surface cooperating with said conical working surface, the plane of said working surface of the housing being perpendicular to the axis of said shaft, said housing and said impeller having cooperating spherical bearing surfaces, said drive shaft having at one end an integral cylindrical angular portion, the extreme end edge of said angular portion having a bearing on said plane working surface, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft at said extreme end edge of said angular portion, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, whereby to cause rolling of said conical working surface with respect to said plane working surface.

8. A pump of the class described, comprising a housing, an impeller mounted therein for universal movement relative thereto, said impeller having a conical working surface, and a drive shaft for said impeller, said drive shaft having at one end an integral cylindrical angular portion, the cylindrical axis of said angular portion being disposed at an angle to the axis of said shaft, the axis of said shaft intersecting the cylindrical axis of said angular portion at the extreme end edge thereof, said impeller having a cylindrical bore adapted to rotatively receive and have a bearing on said angular portion for mounting said impeller on said shaft, the cylindrical axis of said bore coinciding with the cone axis of said working surface and with the cylindrical axis of said angular portion when said impeller is mounted thereon.

9. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, a drive shaft for said impeller, said drive shaft having an integral angular portion, said impeller having a bore rotatably receiving said

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angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, and a divider member secured to the impeller for movement therewith and cooperating with said housing to prevent movement of fluid between said impeller and said housing past said member, said housing having a recess therein receiving a portion of said divider member, said housing having other recesses at either side of said divider member and communicating with said first recess, a slide member slidably mounted in each of said other recesses and engaging opposite sides of said divider member, and spring means associated with one of said slide members to maintain close contact of said latter members with said divider member during movement thereof with said impeller relative to said housing.

10. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, and a drive shaft for said impeller, the housing having a flat working surface cooperating with said conical working surface, said drive shaft having an integral cylindrical angular portion, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft in the plane of said flat working surface, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter.

11. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, and a drive shaft for said impeller, the housing having a flat working surface cooperating with said conical working surface, said drive shaft having an integral cylindrical angular portion, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft in the plane of said flat working surface, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, said flat working surface having a recess therein, and a divider member secured to the impeller and working in said recess to prevent movement of fluid between said impeller and said housing past said divider member.

12. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces and providing a pumping chamber therebetween, and a drive shaft for said impeller, the housing having a flat working surface cooperating with said conical working surface, said drive shaft having an integral cylindrical angular portion, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft in the plane of said flat working surface, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, said flat working surface having a recess therein, and a divider member secured to the impeller and working in said recess to prevent movement of fluid between said impeller and said housing past

said divider member, and inlet and outlet conduit means communicating with said chamber at opposite sides of said divider member.

13. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, and a drive shaft for said impeller, the housing having a flat working surface cooperating with said conical working surface, said drive shaft having an integral cylindrical angular portion, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft in the plane of said flat working surface, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, said conical and flat working surfaces providing a pumping chamber therebetween, the housing comprising a detachable plate containing fluid passages and recesses, the flat working surface comprising a plate overlying said detachable plate and having apertures therein arranged to communicate with certain of said recesses to provide fluid communication from said pumping chamber through the overlying plate to one of the recesses in the detachable plate and thence again through the overlying plate.

14. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, and a drive shaft for said impeller, the housing having a flat working surface cooperating with said conical working surface, said drive shaft having an integral cylindrical angular portion, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft in the plane of said flat working surface, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, said conical and flat working surfaces providing a pumping chamber therebetween, the housing comprising a detachable plate containing fluid passages and recesses, the flat working surface comprising a plate overlying said detachable plate and having apertures therein arranged to communicate with certain of said recesses to provide fluid communication from said pumping chamber through the overlying plates to one of the recesses in the

detachable plate and thence again through the overlying plate, and a reed valve member attached to the outer side of said overlying plate and arranged to coact with an outlet opening in said overlying plate communicating with one of said recesses for controlling fluid flow thereto.

15. A pump of the class described, comprising a housing, an impeller mounted therein for movement relative thereto, said impeller having a conical working surface, said housing and said impeller having cooperating spherical bearing surfaces, a vertical drive shaft for said impeller, a motor rotor carried by said shaft at the upper end thereof, the housing having a flat working surface cooperating with said conical working surface, said drive shaft having an integral cylindrical angular portion at the lower end thereof, the cylindrical axis of said angular portion being disposed at an angle to and intersecting the axis of said shaft in the plane of said flat working surface, said impeller having a cylindrical bore rotatably receiving said angular portion for rotation of said shaft relative to said impeller to impart movement to the latter, and means on said shaft cooperating with said impeller to transmit the weight of said rotor downwardly on said impeller to maintain said conical working surface in contact with said flat working surface.

16. A pump as claimed in claim 10 wherein the impeller is mounted with respect to the said angular portion for rotation of the impeller relative to said angular portion and for axial movement of the impeller relative to said angular portion.

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