

June 21, 1955

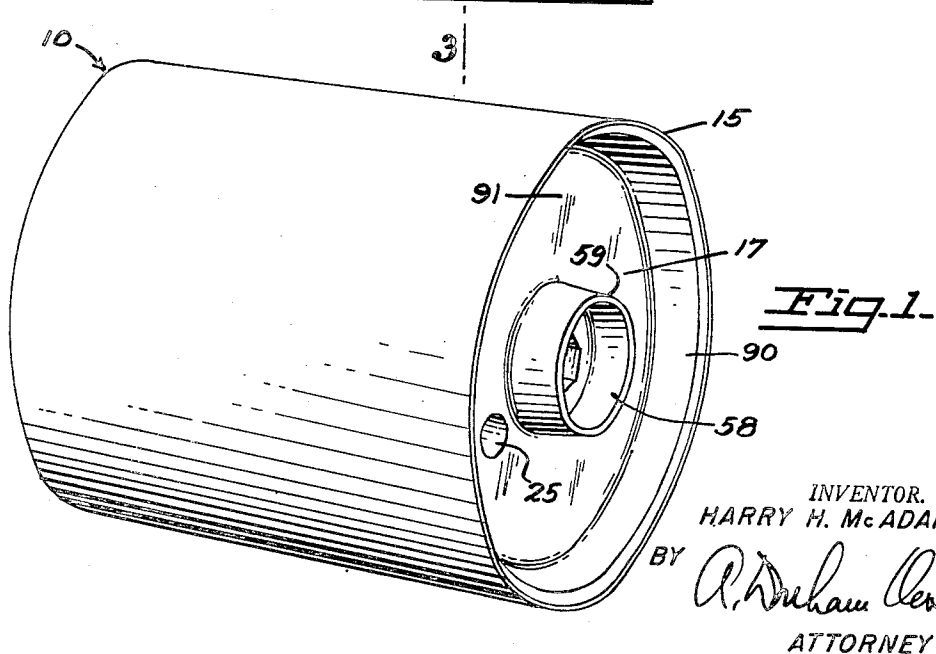
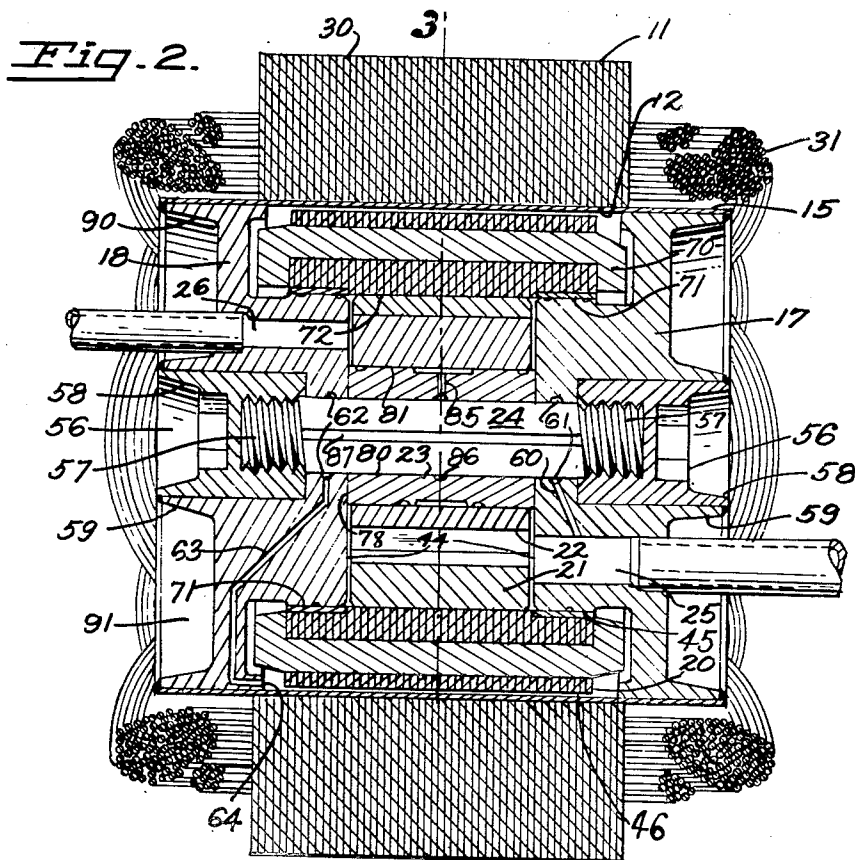
H. H. McADAM

2,711,286

MOTOR-PUMP OR COMPRESSOR

Filed Aug. 1, 1952

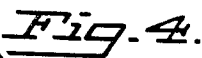
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Filed Aug. 1, 1952

MOTOR-PUMP OR COMPRESSOR

3 Sheets-Sheet 2



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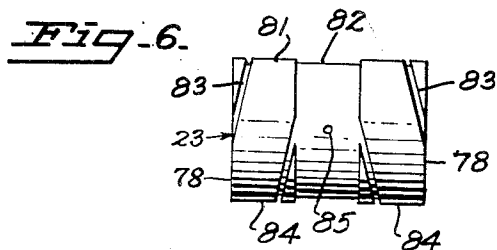
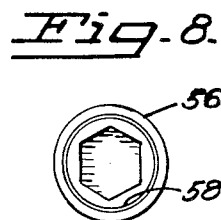
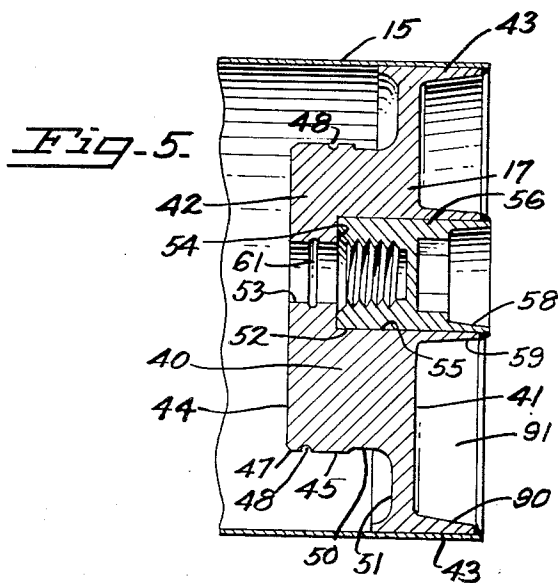
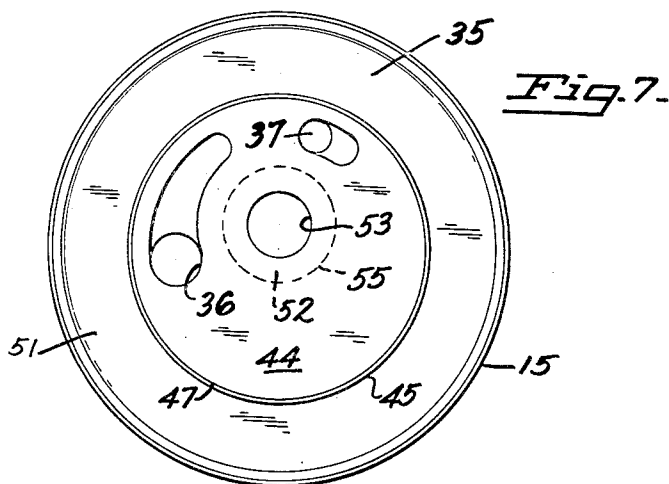
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3 Sheets-Sheet 3



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2,711,286

MOTOR-PUMP OR COMPRESSOR

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Application August 1, 1952, Serial No. 362,099

15 Claims. (Cl. 230—139)

This invention relates to an improved motor-pump or compressor of the positive displacement type. It also relates to a sealed pump package which needs only to be slipped into an electric motor stator of the proper dimensions to make a complete, leak-tight pump or compressor unit.

This invention solves many problems which have long confronted the pump and compressor industry, particularly in relation to such applications as compressors for domestic refrigerators, home freezers, and home air conditioners, water coolers, and other refrigerated devices.

Three interrelated problems have been particularly troublesome, and the present invention solves them: (1) how to make small enough, light enough, and inexpensive enough motor-compressors having the requisite capacity, (2) how to improve the dissipation of the heat which the motor and compressor build up, and (3) how to provide a pressure-tight motor-compressor, without having to encase the whole within an all-enclosing, pressure-retaining shell. A brief discussion of these three important problems will aid in understanding the present invention and its importance.

Small powerful motor-compressors have long been sought after, because space is always at a premium. Every cubic inch of space taken up by the power unit subtracts from the cabinet space that can be made available to the consumer. Moreover, large, heavy compressors have been expensive to build, ship, and store.

Their large size was one objection to the old style of compressors, which used belts and in which the motor and the compressor were separately housed. Another objection to this two-unit style of compressor was that it required shaft seals for retaining the charge of refrigerant. These shaft seals were subject to leaks, squeaks and chattering noises, which could not be tolerated. Also, these seals wore out rather rapidly and had to be replaced often.

Confronted by this problem, the refrigeration industry eliminated the shaft seals by enclosing both the motor and the compressor in a single pressure-tight housing, which was usually an outer shell surrounding the whole motor-pump unit.

This brings us to the problem of heat-dissipation. An outer shell around a motor retards the passage of the heat off into the air. The more the motor is exposed to the air, where a cooling current can be passed directly over the hot parts, the cooler the motor can be kept. Enclosure of the motor-compressor in an outer shell interferes with and seriously retards the heat flow, thereby tending to keep the heat in and resulting in undesirably high operating temperatures.

The above factors caused the dissipation of heat to be a more serious problem than is usually realized. Since electrical conductivity is a function of the temperature of the conductor, with electrical resistance increasing with temperature rise, it becomes evident that a cool motor can and will deliver more power than a hot motor. About the only thing that could be done with a shell-

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enclosed motor-compressor was to increase the size of motor and the shell to compensate for the power lost through overheating, or to add cooling fins to the casing for the same reason. These solutions, however, conflicted directly with the problem of the keeping the size, cost, and weight of the compressor small.

The present invention has solved these three important related problems—how to keep the unit small in size, light in weight, and low in cost; how to dissipate the heat built up inside it; and how to do these and still have a satisfactory pressure vessel—by a novel structure in which a pressure vessel is made from a thin imperforate sleeve that is secured around the motor rotor between two end plates. This forms a compact sealed pump-package which can be placed inside a hollow motor stator. All the moving parts are inside this novel pressure vessel.

The problem of how to reduce the size, weight, and cost of compressors without penalizing their output or performance has thus been solved by placing the compressor completely inside an electric motor. The invention should therefore be distinguished from attempted solutions by the prior art where the compressor was placed outside the motor, often on one end of it, and in which a common drive shaft connected the compressor to the motor. In the present invention there is no drive shaft or similar connection. As stated above, the entire compressor is inside the motor stator.

Another problem with prior art positive-displacement motor-compressors was that they required either an inlet valve, a discharge valve, or both. Being moving parts, the valves were subject to many types of trouble. The present invention has made it possible to do away with inlet and discharge valves and to replace them with simple ports. Nor are any other valves needed in the remainder of its closed system. The motor-pump or motor-compressor of this invention has operated successfully in a refrigeration system that had no valve of any kind anywhere in the system.

Two problems, related in their effects and solved by the present invention, were the effects in prior art compressors of torque reactions and of eccentric rotating masses. Torque reactions due to rapid momentary changes in load caused difficulties, for example, in piston-type compressors where large changes in load take place at the end of one compression stroke of the piston and the beginning of the next suction stroke. Eccentric masses caused problems in reciprocating and single-vane rotary pumps. Wherever there was reciprocating motion and its resultant torque reaction and wherever eccentric masses rotated, there was considerable vibration, so that counter-balances had to be applied to effect some reduction of this disastrous vibration. Vibration dampeners or some other means for absorbing some of those shocks also had to be applied in order to reduce oscillation, noise, and wear. Heretofore all positive displacement compressors had either eccentric motion or reciprocating motion, or some other motion in which there were rapid changes in angular velocity or load, and all of these types of motion resulted in either heavy torque reaction, rotational unbalance, oscillation or vibration, all highly objectionable.

The pump of the present invention has no eccentric rotating masses and is free from torque reaction, rapid load changes and oscillation. It has only two rotating parts, and they rotate about their respective centers at a constant rate, so that there is no change in angular velocity. All the problems mentioned in the preceding paragraph, have therefore been solved.

Another problem in motor-pumps was that the lubrication systems of these units would not operate if the units were placed on their sides or upside down, or in angular positions. This inadaptability has been one cause for other design problems involving undesirable compromises

in cabinet structure, piping systems, and the arrangement of related parts. The pump of the present invention can operate in any attitude, because it has a novel type of lubrication system.

In addition to solving all the problems discussed above, the present invention also has brought many other unusual advantages. It is a remarkably simple apparatus, having only two moving parts. It can operate in any attitude with the same performance characteristics. It has none of the problems that occur where a common rotating drive shaft connects the motor to the pump, because there is no drive shaft of any kind. The pump is driven solely by electromagnetic force; there is no mechanical driving means. Having no drive shaft in any of its applications, no shaft seals are needed.

An outstanding feature of the present invention is that the entire pump unit is a sealed package that may be inserted into a stator bore and will operate there as a pressure vessel without the need for any external shell of any kind. It is a unitary device, or pump package, that may be removed from one stator and placed in another stator. The heat from the rotor passes through the thin sleeve to the stator, and the stator is free to dissipate its heat, because there is no external shell around the stator. It can therefore be made relatively small in size, as compared with prior art pumps and compressors.

In the present invention all the pumping elements are mounted inside the rotor of an electric motor in accordance with the invention disclosed in my co-pending application, Serial No. 286,880, filed May 9, 1952, which matured into Patent No. 2,693,313 on November 2, 1954. The rotor itself is mounted rotatably on a pair of end plates that are imperforate except for the provision of intake and discharge ports, no valves being required. An external tubular metal sleeve encircles the rotor and end plates and is sealed to the end plates, providing a self-contained, sealed pump package inside the sleeve between the end plates. This package, when inserted in a motor stator, becomes a complete operative pump.

The end plates provide stationary bearings that support the rotor for free rotation. Also the engagement of the end plates in the stator bore assures uniform clearance between the stator and the rotor, a factor that makes it possible to place the encircling sleeve between the rotor and the stator without unduly increasing the size of the air gap, as prior art attempts in this field had done.

Since the pump and compressor elements are completely contained inside the rotor and are driven by the rotor, the only two moving pump elements are: (1) an outer annular gear with interior teeth, which is secured to and driven by the rotor, and (2) an inner pinion gear driven by the outer gear. Both gears are perfectly symmetrical and are in natural dynamic balance. This structure solved the eccentric rotating mass problem, because the only two elements that rotate, do so in paths which are truly concentric to their individual centers: the pinion gear rotates about its true center, and the outer gear rotates about its own true center.

As in application Serial No. 286,880 (Patent No. 2,693,313), there is no rotating shaft, another feature that, so far as is known, is novel in this type of apparatus. Obviously, the absence of a rotating shaft eliminates the need for connecting rods, fluid seals, outboard bearings, overhung bearings, and so on.

The novel type of positive lubrication system claimed in application Serial No. 286,880 (Patent No. 2,693,313), is employed in this pump. It operates without a sump and without the type of splash lubrication utilized in reciprocating pumps. The operation of this new lubrication system remains the same, whatever the attitude in which the unit is placed.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment thereof which will be described in detail in

order to comply with the requirements of 35 U. S. C. 112. It should be understood that the details are illustrative and are given as examples and are not intended to narrowly limit the scope of the invention.

In the drawings:

Fig. 1 is a view in perspective of the pump package of this invention.

Fig. 2 is a view in section of a motor pump incorporating the pump-package of Fig. 1. The view is taken along the line 2—2 in Fig. 3.

Fig. 3 is a view in section taken along the line 3—3 of Fig. 2.

Fig. 4 is a view in section similar to Fig. 3, showing the rotor and its contained parts. This view is also taken along the line 3—3 in Fig. 2 but looks in the opposite direction, and the pump gears are shown rotated through a relatively small angle.

Fig. 5 is a view in section of a portion of the pump package, showing how the sleeve and nuts may be fused to the end plates.

Fig. 6 is a view in elevation of the cylindrical stationary bearing member around which the pinion gear rotates. Fig. 7 is a view of a modified form of end plate.

Fig. 8 is an end view of one of the nuts which secure the bolt and is itself fused to the end plates.

The pump package 10 shown in Fig. 1 is adapted to fit inside an electric motor stator; e. g., the stator 11 shown in Figs. 2 and 3. The pump package 10 may be inserted in the bore 12 of any stator 11 and will convert it to a complete pump.

The package 10 is generally similar to that disclosed in my co-pending application, Serial No. 286,880, filed May 9, 1952 (Patent 2,693,313, issued November 2, 1954), with some important differences, the principal new feature being the tubular sleeve 15 that encircles the package 10 and seals the entire pump package, so that no external sealing member is needed.

The sleeve 15, which may be made of thin metal such as non-magnetic stainless steel, non-magnetic Monel metal, or other non-magnetic material is sealed at each end to one of a pair of end plates 17, 18. Inside the sleeve 15, between the end plates 17, 18, and radially-inwardly spaced from the sleeve 15 is a hollow rotor 20. An outer gear or pump element 21 is secured to the inside of the rotor 20. An inner gear 22 is inside the outer gear 21 and rotates around an axis C_2 eccentric to the axis C_1 of the rotor 20 and the outer gear 21. The inner gear pump element 22 is supported by a stationary bearing member 23, which encircles the single stationary bolt 24. When the rotor 20 rotates, the outer gear 21 drives the inner gear 22 and causes fluid to flow from the intake opening 25 to the discharge opening 26.

The stator 11

Any suitably sized motor stator 11 may be used. Most stators are made up of a plurality of thin iron laminations 30 and wire windings 31 which pass through the slots 33.

The end plates 17, 18

The end plates 17 and 18 perform many functions in this device: In combination with the sleeve 15 and the nuts 56, they constitute the means for hermetically sealing, by fusion, the pump-package 10; they provide the means to close both ends of the gear elements 21 and 22; they fix the meshing relationship between the gears, as shown by the centers C_1 and C_2 ; they hold the air-gap 46 between the rotor 20 and the stator 11 uniform and parallel; they provide intake and discharge ports 25, 26; they provide suitable means for connecting conduits to the ports. The end plates 17 and 18 are also recessed and drilled in certain places to provide grooves and passages that are part of the lubrication system of the motor-compressor.

In the forms of the invention shown in Figs. 1 and 2, the intake port 25 is in one end plate 17 while the discharge port 26 is in the other end plate 18. This is not necessary, as may be seen from Fig. 7, where a single end plate 35 has both an intake port 36 and a discharge port 37. Similarly, there may be more such ports.

In their general shape, the end plates 17, 18, and 35 are substantially identical, consisting basically of a stepped disc 40 having a wider diameter outer portion 41, and a narrow diameter inner portion 42. The outer portion 41 may have a generally smooth outer rim 43. The inner disc portion 42 preferably terminates in a flat wall 44, which is preferably ground to insure that it has a perfectly plane surface. The periphery 45 of the portion 42 is concentric with the rim 43 and forms a bearing surface for rotatably supporting the motor rotor 20. The proportioning, spacing, and concentricity of the two peripheries 43 and 45 insure perfectly accurate alignment and spacing of the pump package 10 in the stator 11, so that the rotor 20 is perfectly aligned and spaced, enabling the clearance area or air gap 46 between the rotor 20 and the stator 11 to be very small, even though the sleeve 15 is between them. This assures uniform rotor-to-stator clearance and uniform rotor-to-stator parallelism. The inner edge of the bearing 45 may be chamfered at 47 to facilitate assembly of the parts and a helical oil groove 48 may be provided around the bearing 45.

The outer periphery of the disc portion 42 may be relieved at 50, and there may be an annular inset recess 51 to accommodate the portions of the rotor 20 which extend beyond the rotor bearings 45 and to give adequate clearance between the end plates 17, 18 and the rotor 20.

The end plates 17, 18 may also be provided with an eccentrically located, preferably stepped, circular opening 52 whose center C₂ is radially offset with respect to the center C₁ of the rim 43 and the bearing surface 45. The amount of offset depends on the diametral difference of the ratio circles of elements 21, 22 and all other related features of construction. The inner smaller diameter portion 53 of the opening engages the cylindrical body of the through-bolt 24, which extends beyond the shoulder 54 into the wider diameter portion 55 of the opening 52. Blind nuts 56 may be threaded on the outer ends 57 of the bolt 24 so that the nuts 56 abut the shoulders 54 and thereby urge the end plates 17, 18 inwardly against the cylindrical bearing member 23.

The nuts 56 and the end plates 17 and 18 are shaped to provide respective thin tapering flanges or fins 58, 59 extending outwardly so that the nuts 56 may be fused to the end plates 17, 18 by induction brazing, by silver soldering, or by automatic arc welding without disastrously over-heating the main body of the nuts or end plates or other adjacent parts of the pump-package.

The end plate 17, which is provided with the intake opening 25 through which fluid is drawn into the pump, has, as part of the lubrication system, a bore 60 connecting the intake port with an annular groove 61 in the opening 53. The other end plate 18, which is provided with the discharge opening 26, also has an annular groove 62 in its opening 53, which is connected by a passageway 63 with an orifice 64 adjacent its outer periphery 43. The effect of these lubrication passageways on the operation of the device will be discussed later.

The end plate 35 shown in Fig. 7 is like the end plates 17, 18 except that it has both an intake port 36 and a discharge port 37. The opposite end plate may have no ports in it or it may also have an intake port or a discharge port or both. All of the intake and discharge ports 25, 26, 36, 37, may be threaded or otherwise adapted to receive the ends of suitable conduits therein.

The motor rotor 20

The motor rotor 20 may be of the usual squirrel cage induction design having generally-annular projecting por-

tions 70 at each end. Annular bearings 71 may be provided on the inner surface of the central rotor bore 72. The bearings 71 ride on the bearings 45 of the end plates 17, 18 and are lubricated by oil which passes along the helical grooves 48.

The bearings 45 and 71 serve to locate the rotor 20 in relation to the stator 11 and thereby govern the air gap or clearance 46 between the parts. They also serve to position the rotor 20 along its proper axis so that it rotates truly about the center C₁.

The pump elements 21, 22 and the bearing 23

The outer pump element 21 may be press fitted or otherwise secured to the rotor 20 in the bore 72 so that it becomes essentially integral with the rotor 20. The drawings show a hollow gear type of a pump element 21 with a toothed inner surface 73.

The inner gear element 22 comprises a hollow cylindrical member having a toothed outer surface 74 driven by the toothed inner surface 73 of the outer element 21.

It will be obvious that the two pump elements 21, 22 rotate around different centers. The inner element 22 rotates around the center C₂, and is made perfectly true and cylindrical so far as itself is concerned, its bore 75 and its teeth 74 being perfectly concentric. Similarly, the outer periphery 76 of the outer element 21 and its teeth 73 are perfectly concentric, but the outer element 21 rotates around the center C₁ because it is fastened to the rotor 20 and rotates therewith.

Preferably the inner and the outer gear elements 22 and 21 are of the so-called "Rotoid" type, that is, they preferably have an odd number of teeth, with the outer element 21 having two more teeth than the inner element 22. The teeth are preferably further constructed so that there is a sliding contact between the inner and outer elements 22, 21 which is not broken over a considerable arc as the gears rotate. In the form of pump shown in the drawings, this arc will be about 240°, with the open space 77 shown in Figs. 3 and 4 being about 120°. No claim is made herein to the use of Rotoid gears per se, but only when they are in combination with the other elements shown. The "Rotoid" elements themselves are described and claimed in Patent #2,547,392 issued April 3, 1951, to Myron F. Hill and Francis A. Hill, 2nd.

Between the inner gear element 22 and the bolt 24, is the cylindrical stationary bearing 23 which also acts as a stop and accurately spaces apart the end plates 17, 18. The nuts 56 are tightened on the bolt 24 until the flat surfaces 44 of both end plates 17, 18 are in tight contact with the radial faces 78 of the bearing 23, thereby placing the bearing 23 under compression. The radial end faces of the gears are spaced apart from the end plate surfaces 44 enough to provide a running clearance. For this purpose they are made almost, but not quite, as long as the bearing 23. A clearance of 0.0003 inch at each end has been used successfully.

The bearing 23 is preferably cylindrical and its inner surface 80 and outer surface 81 are concentric. The central portion 82 of the outer surface 81 is relieved, and a pair of helical grooves 83 are provided around the outer bearing surfaces 84 which engage the bore 75 of the inner gear element 22. These grooves 83 provide a path for the oil in the lubrication system which will be discussed later. Another part of the lubrication system is a radial bore 85 provided between the relieved portion 82 and an annular groove 86 provided in the interior surface 80 of the stationary bearing member 23.

The bolt 24 may be provided on its outer surface with one or more axial grooves 87 which serve to connect the two annular grooves 61 and 62 in the end plates 17 and 18 and also communicate with the annular groove 86 in the bearing 23. Preferably the bolt 24 is provided with two such grooves 87 spaced diametrically apart.

As has been stated earlier, the bolt 24 and the bearing 23 are stationary, as are the end plates 17, 18 and the stator 11. The rotor 20 and the outer gear element 21, being fixed together, form one rotating element, and the inner gear element 22 is the only other rotating member. The position of the bolt 24 determines the center of rotation C₂ of the inner gear element 22, and the positioning of the bolt 24 is determined by the construction of the end plates 17, 18. Thus the end plates 17, 18 must be made carefully in order to provide exactly the right eccentricity between the centers C₁ and C₂. When the end plates 17, 18 are properly constructed, the motor pump is readily assembled. To prevent tampering by unskilled mechanics, the pump package 10 may be permanently fused together by induction brazing or resistance welding, and it will continue to operate without the need for taking it apart.

Assembly of the motor pump package 10

A preferred way of assembling the pump package 10 is to first thread one blind nut 56 to one end 57 of the through-bolt 24 and then to pass the through-bolt 24 through the opening 52 in one end plate 17. Then the hollow cylindrical bearing 23 may be placed around the through-bolt 24, and the inner gear 22 may be placed around the bearing 23. The rotor 20, with the outer gear 21 secured to it, may then be placed over the inner gear 22, the motor rotor bearings 71 being set to fully engage the bearing surface 45 on the end plate 17. The other end plate 18 may then be placed over the projecting bolt 24 and guided by the bolt 24 until its bearing 45 is in full engagement with the motor rotor bearing 71. The other blind nut 56 may then be threaded on its bolt end 57 and drawn up with sufficient tension to achieve slight compression of the hollow cylindrical spacer bearing 23 between the end plates' inner faces 44.

The sleeve 15, preferably of non-magnetic metal such as non-magnetic stainless steel or Monel metal, and about 0.005 to 0.010 inch thick, may then be slipped over the package unit that has been assembled thus far. The fit with the end plates 17 and 18 is snug, with about a 0.008 inch clearance between the sleeve 15 and the rotor 20. As the drawings show, the end plates 17 and 18 may have thin, tapered flanges or fins at 59, 90 separated by a generally annular recess 91. The larger diameter fin 90 is in contact with the sleeve 15, whereas the smaller diameter fin 59 is in contact with a similar fin 58 provided on the nuts 56. The purpose of the thin, tapered flange or fin 90, is to enable the paper-thin sleeve 15 to be circumferentially fused to each end plate 17, 18 without overheating the end plate as a whole or overheating adjacent parts. As stated, high frequency induction heating for silver soldering the sleeve to the end plate fin is one method of joining the parts. Another method, automatic arc welding, could be employed. In either method the fused joint is completed in a very brief time period. The thin sections of metal at the apex of the fins act to retard heat flow into the relatively massive end plate during fusion. In general the same process may be employed for fusing the fins 58 of the nuts 56 to the end plate fins 59. Here, as with the sleeve joint, fusion would occur circumferentially at the apex of the adjacent fins 58 and 59.

The pump package 10 is complete when the sleeve 15 and the two nuts 56 are fused to end plates 17, 18 by either of the above methods or by some other suitable method. The package 10 may then be pressed into the stator 11. It fits snugly in the stator bore 12, so that any force exerted by fluid pressure inside the pump package 10 is actually retained by the massive walls of the stator 11 rather than by the thin sleeve wall 15. The thin wall 15 does not substantially widen the air gap or clearance 46 between the stator 11 and rotor 20. This pump package, being fused together, achieves a truly hermetic pump-

ing mechanism that is permanently pressure-sealed of itself. It is therefore readily interchangeable between any standard motor stators of proper size.

Operation and lubrication

When an electric current is applied to the windings of the stator 11, the rotor 20 will rotate on its bearings 71, 45. The outer pump element 21, being rigidly mounted to the rotor 20, will then drive the inner pump element 22, and fluid will be drawn in through the intake opening 25 and expelled through the discharge opening 26. The reason the fluid will be moved is fully explained in the Hill patent mentioned above and can be seen from Figs. 3 and 4 of the drawings. The present invention is an improvement over the Hill patents in that its Rotoid gears do not require any rotating shaft. In fact, other gears than Rotoid gears may be used, provided they make a seal when in mesh.

The lubrication system of pump 10 is composed of three circuits. The first circuit includes the other components of a closed system, the pump 10 forming only a part of this closed system. In operation, some oil is discharged from the port 26 along with the pumped fluid. This oil circulates along with the pumped fluid throughout other parts of the system and finally reenters the pump through the intake opening 25.

The other two lubrication circuits are within the pump 10. Due to the positive displacement pumping action created when the gear elements rotate, a pressure difference exists between the pump intake and the pump discharge. This pressure difference is a positive force that acts to drive oil and fluid from the higher-pressure discharge portions of the pump toward the lower-pressure intake portions. This force is utilized and controlled for forcing predetermined quantities of oil and fluid through the extremely small running clearances maintained between the end faces of the rotating gear elements 21 and 22 where they nearly abut the stationary plane surfaces 44 of the end plates 17 and 18. Since this running clearance is adjustable, the quantity of oil recirculated within the pump 10 is controllable.

Of the two recirculation lubrication circuits inside the pump 10, one is caused by the pressure that forces oil outwardly across both ends of the outer gear 21. After being forced through the running clearance at each end, the oil enters the helical grooves 48, in both end plates 17 and 18, and lubricates the bearing surfaces 45, 71. On leaving the helical groove 48 of the end plate 17, the oil is driven along the clearance area 46 between the rotor 20 and the inside of the sleeve 15, where it flows toward the other end plate 18. Here it joins with oil leaving the groove 48 of the end plate 18, and enters the orifice 64. The oil is forced through the passage 63 in the end plate 18 and into the annular groove 62. From there it is driven along the axial grooves 87 in the bolt 24 to the annular groove 61 in the end plate 17. Then it flows through the passage 60 in the end plate 17 into the intake port 25. From there the oil reenters the rotating gears 21, 22 to lubricate the meshing teeth and then is forced outwardly across the gear ends, to repeat the cycle.

The third of the three lubrication circuits includes the two streams of oil that are forced inwardly across both ends of the inner gear 22. These two streams of oil are forced under pressure through the running clearances between each end of the inner gear and the surfaces 44 of the end plates 17 and 18 until they reach the bearing 23. Each stream then enters the helical groove 83 at its end of the bearing 23 and lubricates its bearing surfaces 84 and 75. The two streams meet at the recessed area 82 of the bearing 23. The oil then goes through the passage 85 from the recess 82 into the annular groove 86 in the bore of the bearing 23. Here the oil of this third circuit joins with oil of the second circuit and

flows along the axial grooves 87 to the groove 61 and through the passage 60 to the suction or intake port 25. Here the combined streams are joined with oil of the first lubrication circuit returning from the portions of the system outside the pump 10. The three joined oil streams then enter the rotating gears and the three cycles are repeated indefinitely.

The three circuits are all positive-pressure systems, so that recirculation is assured. It will be evident that the lubrication system in no way depends upon the attitude of the pump so that the pump may be placed in any attitude without impairing any of its operations.

The simplicity of the pump, the novel pressure vessel, its freedom from masses rotating off-center, its freedom from torque reaction, its positive lubrication system, its relatively small number of parts, the elimination of rotating shafts and of valves, make the pump one that can be made inexpensively and in a variety of sizes. Its performance is remarkably fine, and a pump a fraction of the size of prior art pumps may have a larger capacity. Finally, in view of the facts that there is no mechanical driving connection between the pump package and the stator, and that the stainless steel sleeve 15 provides the pressure vessel, the pump package is interchangeable with other stators of the right size and will hold its charge with any such stator.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. A motor-pump, including in combination a hollow stator; a hollow motor rotor within said stator; a pair of end plates in said stator at each end of the opening therethrough, at least one of said end plates being ported so that said motor-pump has intake and discharge means, and at least one said end plate being slidable through said stator opening; a tubular sleeve secured to said end plates around said rotor so that said rotor is rotatable inside said sleeve, said sleeve fitting snugly but slidably against the wall of the stator; and pump means inside said rotor and driven thereby for moving fluid between said intake and discharge means, whereby said end plates and sleeve form a pressure vessel, containing said rotor and said pump means, that can be slid into and out from said stator.

2. A motor-compressor including in combination a hollow stator; a hollow motor rotor within said stator; a pair of end plates adjacent each end of said hollow stator, at least one of said end plates being ported so that said motor-compressor has intake and discharge means, and at least one of said end plates being slidable through said stator; a tubular metal sleeve sealed to said end plates to provide a pressure vessel around said rotor, said rotor being rotatable inside said sleeve, said sleeve fitting snugly but slidably against the wall of the stator; and compressor means inside said rotor and driven thereby for moving fluid between said intake and discharge means.

3. A motor-pump, including in combination a hollow stator; a hollow motor rotor within said stator; a pair of end plates at each end of the opening through said stator, at least one of said end plates being ported so that said motor-pump has intake and discharge means, and at least one of said end plates being slidable through said stator opening; a tubular sleeve in the air gap between said rotor and said stator and secured to said end plates around said rotor so that said rotor is rotatable inside said sleeve, said sleeve fitting slidably in but snugly against the wall of the stator; and pump means inside said rotor and driven thereby for moving fluid between said intake and discharge means.

4. A motor-compressor, including in combination a

hollow motor stator; a hollow motor rotor within said stator; a pair of end plates at each end of said stator, at least one of said end plates being ported so that said motor-compressor has intake and discharge means, and at least one said end plate being slidable through said stator; a tubular sleeve of thin stainless steel secured by a pressure-tight fit to said end plates so as to enclose said rotor in a pressure vessel formed thereby, said rotor being rotatable inside said sleeve, said sleeve fitting slidably in but snugly against the wall of the stator; and compressor means inside said rotor and driven thereby for moving fluid between said intake and discharge means.

5. An electric motor-pump, including in combination a hollow stator; a pair of end closure plates at each end of the stator cavity, having annular bearing surfaces projecting into said stator cavity, at least one of said plates being ported so that said motor-pump has intake and discharge means, and at least one said plate being slidable through said stator cavity; a hollow motor rotor inside said stator rotatably mounted on said end plate bearing surfaces; a tubular thin metal sleeve fused to said end plates to provide a pressure vessel around said rotor, said rotor being rotatable inside said sleeve, said sleeve fitting snugly against but slidably in the interior wall of the stator; and a pumping mechanism inside said rotor and driven hereby, whereby said end plates and sleeve constitute said pressure vessel and provide a pump package containing said rotor and pumping mechanism, said package being insertable within or withdrawable from said stator cavity.

6. An electric motor-compressor, including in combination a stator having a cavity; a pair of end plates at opposite ends of said cavity, said plates having coaxial inner bearing surfaces spaced radially away from the walls of the stator; a hollow motor rotor inside said stator cavity between said end plates and rotatably mounted on said bearing surfaces; a tubular imperforate metal sleeve surrounding said rotor and said end plates and secured at its outer ends to the outer ends of said end plates to provide a pressure vessel around said rotor, said rotor being rotatable inside said sleeve, said sleeve fitting snugly against the wall of said stator cavity; an outer compressor element secured inside said rotor concentric therewith and driven thereby; a stationary bearing means extending between said end plates along an axis located parallel to the axis of said coaxial bearing surfaces; an inner compressor element rotatably mounted on said stationary bearing means and concentric therewith and in engagement with said outer compressor element for moving and raising a fluid from a lower to a higher pressure; and intake and discharge ports in the walls of said motor-compressor.

7. In an electric motor-pump, the combination of a stator having a cylindrical cavity; a pair of end plates at opposite ends of said cavity, said plates having thin annular outer rims and inner bearing surfaces spaced radially away from and concentric with the walls of the stator cavity; a hollow motor rotor inside said stator cavity between said end plates and rotatably mounted on said bearing surfaces; a tubular stainless metal sleeve having a wall thickness of about 0.008 inch, surrounding said end plates and said rotor and fused at its outer ends to the thin rims of said end plates to provide a pressure vessel around said rotor, said rotor being freely rotatable inside said sleeve, said sleeve fitting snugly against the wall of the stator; an outer pumping element secured inside said rotor concentric therewith and driven thereby; a stationary bearing means extending between said end plates along an axis located parallel to the axis of said inner bearing surfaces; an inner pumping element rotatably mounted on said stationary bearing means and concentric therewith and in engagement with said outer pumping element for moving a fluid and raising it from a lower to a higher pressure; and intake and discharge ports in the walls of said motor-pump.

8. An electric motor-compressor, including in combination a stator having a cavity; a pair of end plates at opposite ends of said cavity, said plates having coaxial inner bearing surfaces spaced radially away from the walls of the stator and having aligned off-center openings therethrough, each said plate having an annular depression in its outer face near its outer periphery to provide thereat a thin rim portion; a hollow motor rotor inside said stator cavity between said end plates and rotatably mounted on said coaxial bearing surfaces; a rigid metal shell surrounding said end plates and said rotor and bonded to said thin rim portion of each said plate, to provide a pressure vessel around said rotor, said rotor being free to rotate inside said shell, said shell fitting snugly against the wall of said stator cavity; an outer compressor element secured inside said rotor and driven thereby; a stationary cylindrical bolt-bearing means extending between said end plates and through their respective aligned off-center openings and secured to said end plates for holding them at a predetermined spaced-apart interval; an inner compressor element rotatably mounted on said stationary bolt-bearing means and in engagement with said outer compressor element for moving a fluid and raising it from a lower to a higher pressure; and intake and discharge ports in the walls of said motor-compressor.

9. A motor pump-package for an electric motor-pump, including in combination a pair of end plates each having a stepped rim with an annular bearing surface, at least one of said plates being ported, to provide intake and discharge means; a hollow motor rotor between said end plates rotatably mounted on said bearing surfaces; a tubular seamless sleeve secured to said end plates to form a pressure vessel around said rotor so that said rotor is rotatable inside said sleeve; and a pumping mechanism inside said rotor and driven thereby for moving a fluid therethrough.

10. A motor-compressor-package for an electric motor-compressor, including in combination a pair of end plates each having a stepped rim with an annular bearing surface, at least one of said plates being ported, to provide intake and discharge means; a hollow motor rotor between said end plates rotatably mounted on said bearing surfaces; a tubular thin metal sleeve sealed to said end plates to form therewith a pressure vessel around said rotor in which said rotor is freely rotatable, whereby said compressor-package may be inserted in any suitable stator to form a motor-compressor having a pressure vessel; and a pumping mechanism inside said rotor and driven thereby for moving a fluid therethrough.

11. A pump package for a motor-pump, including in combination a pair of end plates, at least one of which is ported so that said motor-pump has fluid intake and discharge means, said end plates each having cylindrical bearing surfaces radially instepped from their rims; a hollow motor rotor rotatably mounted on said bearing surfaces; a hollow cylindrical metal sleeve around said end plates and said rotor and sealed to said end plates to form a pressure vessel in which said rotor is rotatable; an outer annular gear element secured inside said hollow rotor and connected therewith; a cylindrical bearing member held stationary between said end plates on a different center from said rotor; and an inner annular gear element mounted on said bearing member and concentric therewith and driven by said outer gear element for moving fluid between said intake and discharge means.

12. A compressor package for a motor-compressor, including in combination a pair of end plates, at least one of which is ported so that said motor-compressor has fluid intake and discharge means, said end plates each having a cylindrical bearing surface radially instepped from its rim; a hollow motor rotor rotatably mounted on said bearing surfaces; a cylindrical shell of paper-thin rigid strong metal surrounding said end

plates and said rotor and secured pressure-tight to said end plates to provide a pressure vessel in which said rotor is free to rotate; an outer annular gear element secured inside said hollow rotor and concentric therewith; a cylindrical bearing member held stationary between said end plates on a different center from said rotor; and an inner annular gear element mounted on said bearing member and concentric therewith and driven by said outer gear element for moving fluid between said intake and discharge means.

13. A motor-pump-package including in combination a pair of end plates having a cylindrical bearing surface axially inset from its outer periphery and having a fluid intake opening and a through-bolt opening through one plate and a fluid discharge opening and a through-bolt opening through the other plate, said through-bolt openings being off center with respect to said bearing surfaces, each said end plate also having a tapered annular depression around its outer face close by its outer periphery to provide a thin outer peripheral rim portion; a hollow motor rotor rotatably supported on said bearing surfaces and spaced between said end plates; a tubular sleeve of stainless steel of the order of about 0.005 to 0.01 inch thick fused to the outer edge of said rim portion to provide a pressure-tight fit, whereby said end plates and said sleeve cooperate to form a pressure vessel around said rotor in which said rotor is freely rotatable; an outer pumping element rigidly secured inside said rotor and driven by said rotor; a through-bolt passing between said through-bolt openings and holding said pump-package together; bearing means concentric with said through-bolt between said end plates; and an inner pumping element mounted concentrically on said bearing means and in engagement with said outer pumping element for moving fluid from said intake opening to said discharge opening.

14. A pump-package for insertion in a motor stator including in combination a pair of end plates each having a cylindrical bearing surface axially inset from its outer periphery, said plates having a fluid intake opening and a fluid discharge opening; a hollow motor rotor rotatably supported on said bearing surfaces and spaced between said end plates; a thin tubular metal imperforate sleeve secured to said end plates to provide therewith a sealed pressure vessel around said rotor, said rotor being freely rotatable inside said sleeve, so that said pump package may be inserted in any stator of suitable size to form a leak-tight motor pump; an outer pumping element rigidly secured inside said rotor and driven by said rotor; means located off center with respect to said bearing surfaces for holding said end plates together at a spaced interval; and an inner pumping element mounted concentrically on said last-named means and in engagement with said outer pumping element for moving fluid from said intake opening to said discharge opening.

15. A motor-pump-package including in combination a pair of end plates having a cylindrical bearing surface axially inset from its outer periphery and having a fluid intake opening and a through-bolt opening through one plate and a fluid discharge opening and a through-bolt opening through the other plate, said through-bolt openings being off center with respect to said bearing surfaces, each said end plate also having a tapered annular depression around its outer face to provide a thin outer peripheral rim portion and a thin inner peripheral rim portion around said through-bolt opening; a hollow motor rotor rotatably supported on said bearing surfaces and spaced between said end plates; a tubular sleeve of non-magnetic metal of the order of about 0.005 to 0.01 inch thick fused to the outer edge of said outer rim portion to provide a pressure-tight fit, whereby said end plates and said sleeve cooperate to form a pressure vessel around said rotor in which said rotor is freely rotatable; an outer pumping element rigidly secured

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inside said rotor and driven by said rotor; a through-bolt passing between said through-bolt openings and holding said pump-package together; nuts secured to the outer ends of said through-bolt and fused to said inner rim portion; bearing means concentric with said through-bolt between said end plates; and an inner pumping element mounted concentrically on said bearing means and in engagement with said outer pumping element for moving fluid from said intake opening to said discharge opening.

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