

Feb. 7, 1939.

H. H. LOGAN

2,146,123

DIAPHRAGM PUMP

Filed May 25, 1936

3 Sheets-Sheet 1

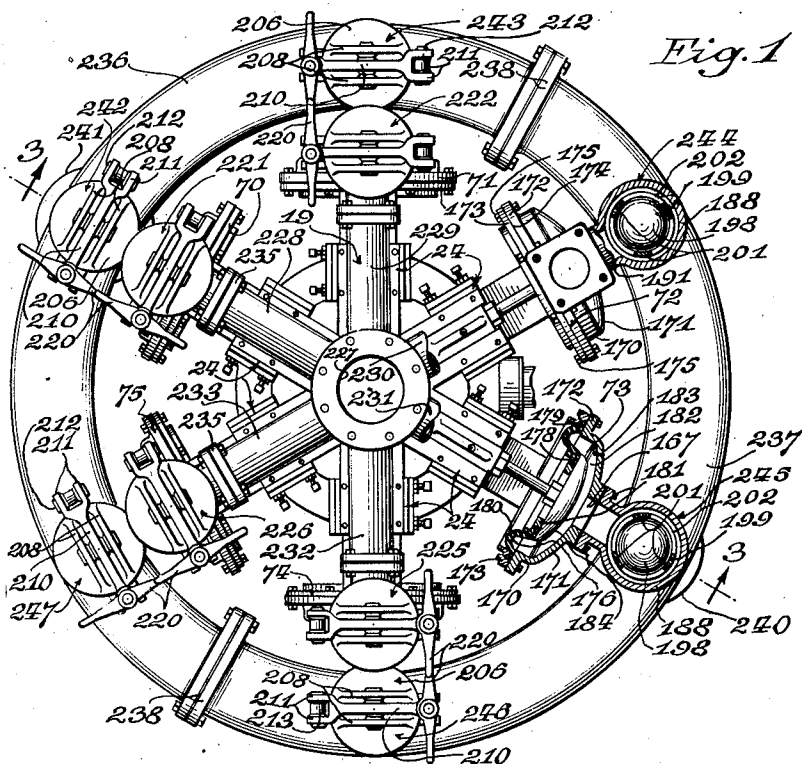


Fig. 1

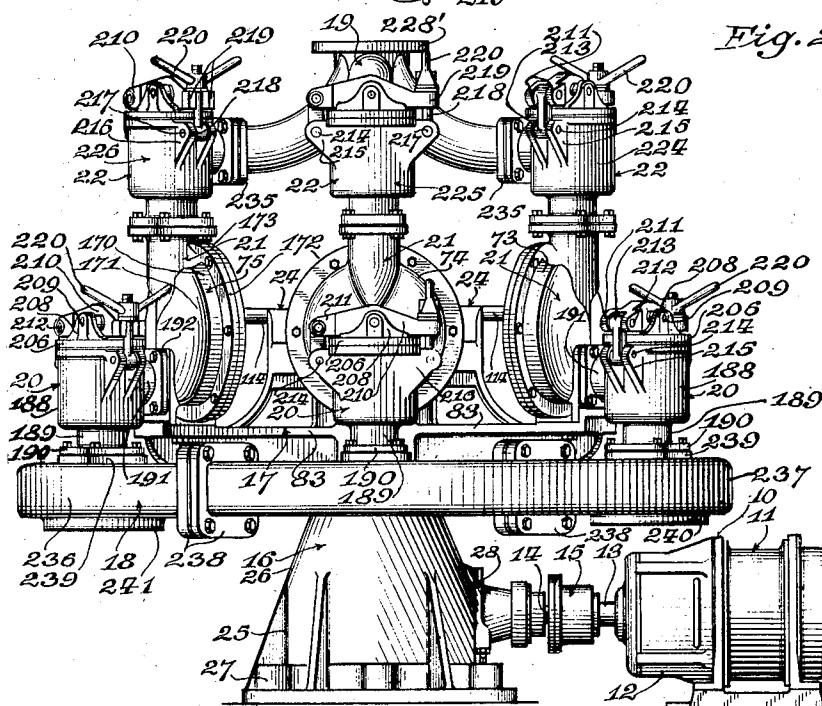


Fig. 2

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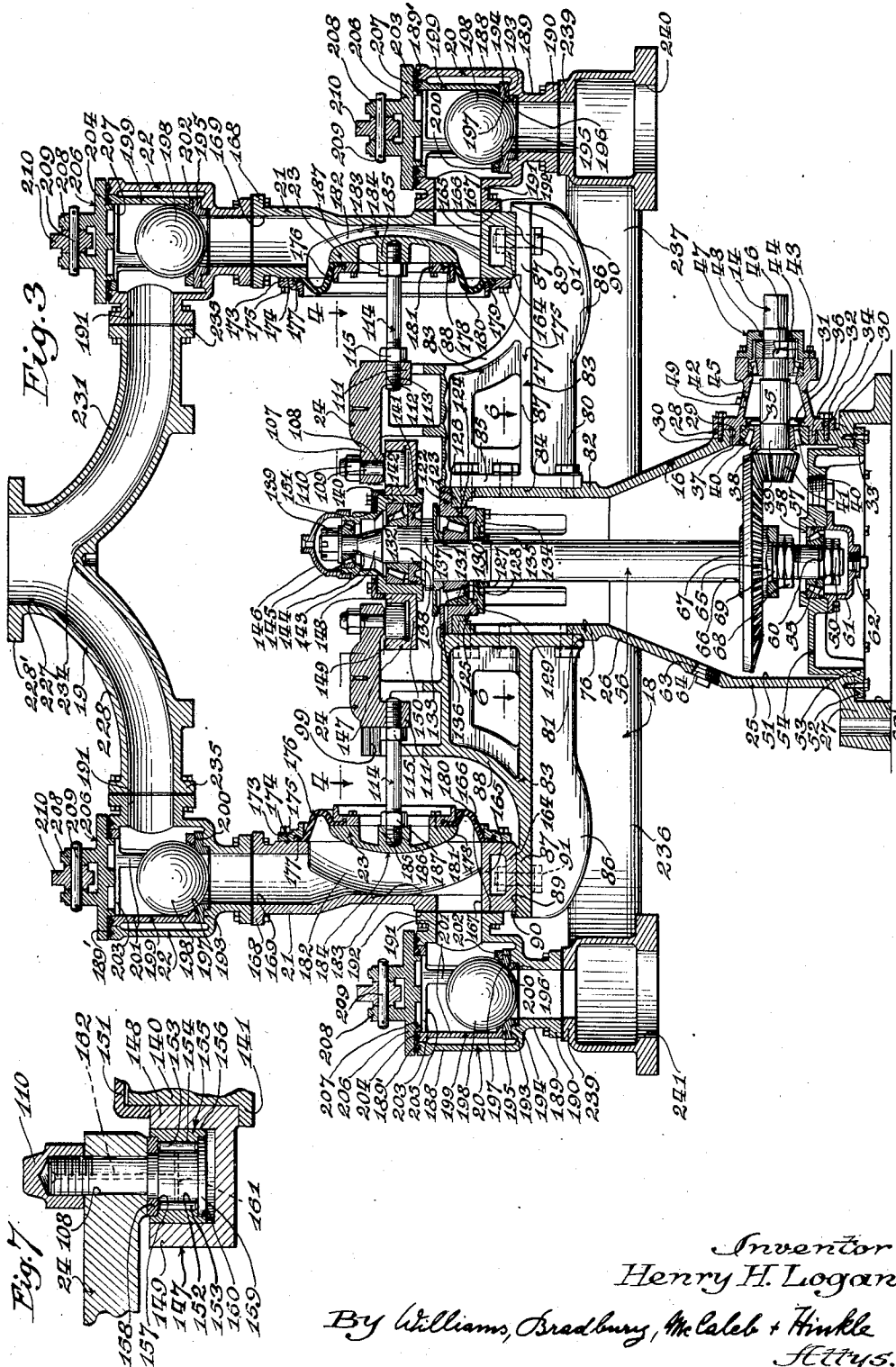
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

Fig. 4

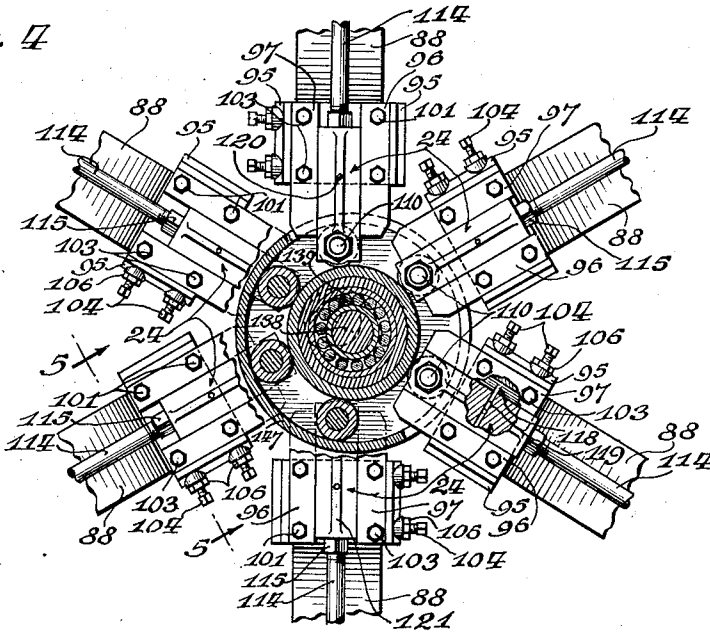
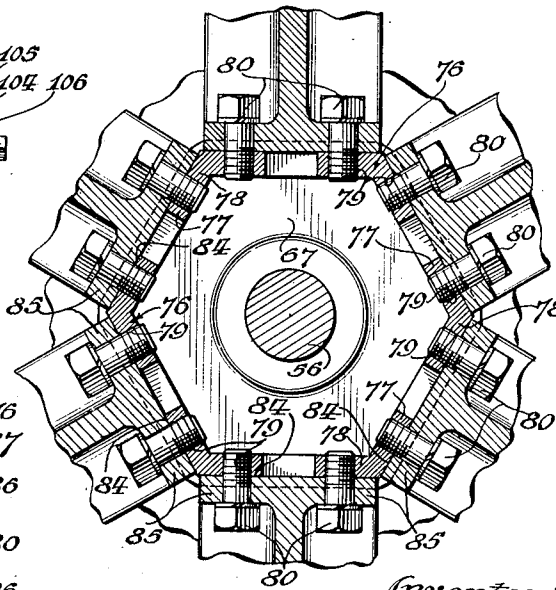
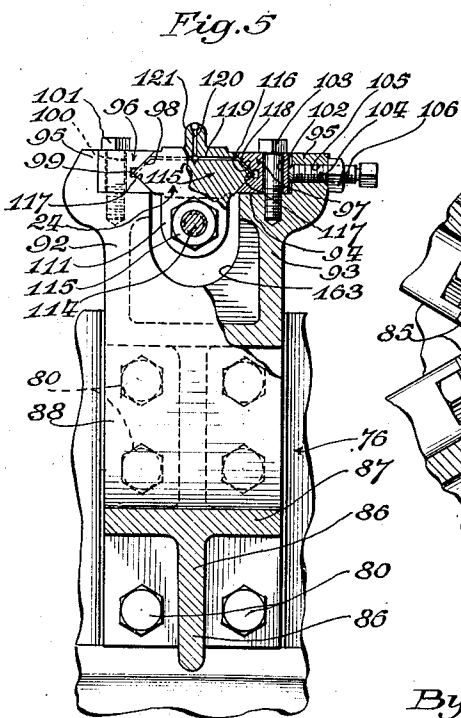


Fig. 6



UNITED STATES PATENT OFFICE

2,146,123

DIAPHRAGM PUMP

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Application May 25, 1936, Serial No. 81,668

9 Claims. (Cl. 103—150)

This invention relates to diaphragm pumps, and is particularly concerned with the provision of an improved diaphragm pump which is adapted to be used for pumping under the most difficult conditions. It should be understood, however, that the present pump is capable of general application and may be used for any type of service where its characteristics may seem desirable.

One of the objects of the invention is the provision of an improved pump particularly adapted to the pumping of gritty materials or dirty water or for chemicals which would be damaged by contact with lubricants or packings in other types of pumps.

Another object of the invention is the provision of an improved pump which is adapted to pump water carrying a considerable amount of foreign matter, such as might be the case in pumping water out of sumps and in which the pump is particularly adapted to be cleaned with the greatest of ease.

Another object of the invention is the provision of an improved pump which is adapted for the pumping of foodstuffs, medicines, or any fluids or flowable material intended for human consumption, in which contact with foreign materials would be detrimental to the material being pumped.

Another object is the provision of an improved pump of the diaphragm type, which is so constructed as to eliminate high and low torque values, excessive vibration, and which produces a substantially steady flow from the discharge.

Another object is the provision of an improved pump of the diaphragm type which is economical in the amount of floor space occupied and which requires but a relatively small foundation.

Another object is the provision of an improved pump of the diaphragm type so arranged that the action of the pump causes a constant flow of liquid through the manifolds, thereby tending to carry sediment along with the liquid and to keep it in suspension in the water, and eliminating the clogging of the manifold and other chambers.

Another object is the provision of an improved pump construction of the diaphragm type, in which all of the parts are accessible for repair or replacement, and in which the valves are capable of easy removal for cleaning or other service.

Another object is the provision of an improved pump of the diaphragm type, having a substantially constant flow, thereby eliminating the uneven load on the drive shaft which is present in the devices of the prior art, and eliminating the necessity for air chambers which are usually

necessary on reciprocating pumps on account of the intermittent action of the pumps of the prior art.

Another object is the provision of an improved drive mechanism for diaphragm pumps, by means of which a multiplicity of diaphragms may be directly operated from a single crank pin, producing a substantially even torque for the driving motor by distributing the work evenly throughout the entire cycle of revolution of the crank.

Another object is the provision of an improved valve arrangement for pumps, by means of which the seats for ball valves are quickly and firmly secured in place and the ball valves are adapted to be removed with the valve seat with a minimum amount of difficulty.

Another object is the provision of an improved drive mechanism for reciprocating pumps by means of which the expensive and complicated connecting rod devices of the prior art, usually necessary to drive a multiplicity of independent pumping members from a single crank pin, have been eliminated. This has been accomplished by the use of what I prefer to call a "floating eccentric", which permits satisfactory operation even if the parts should be slightly out of alignment through inaccuracy of manufacture, and also permits the removal of any of the driven members in a very simple manner.

Another object is the provision of an improved drive mechanism, including such a "floating eccentric" so arranged that the wear on the rollers carried by the cross-heads, which actuate each separate pumping element, is greatly reduced and the rotation takes place between the "floating eccentric" and the crank pin upon which the "floating eccentric" is mounted, by means of suitable antifriction bearings at that point.

Another object is the provision of an improved diaphragm pump construction which is sturdy, efficient, and which is characterized by economy in the manufacture and machining of the various parts by virtue of the fact that many of the elements are exact duplicates so that they may be constructed in production on a volume basis at a comparatively low cost.

Other objects and advantages of the invention will be apparent from the following description and the accompanying drawings, in which similar characters of reference indicate similar parts throughout the several views.

Referring to the three sheets of drawings accompanying the specification:

Fig. 1 is a top plan view of a pump constructed according to the present invention;

Fig. 2 is a side elevational view of the pump;

Fig. 3 is a vertical sectional view, taken on the plane of the line 3—3 of Fig. 1, looking in the direction of the arrows, showing the details of construction of the mechanism;

Fig. 4 is a fragmentary sectional view, taken on the plane of the line 4—4 of Fig. 3, in partial section, showing the details of construction of the cross heads, floating eccentric and associated parts;

Fig. 5 is a vertical sectional view, taken through one of the cross heads on the plane of the line 5—5 of Fig. 4, showing the details of construction of the cross head and its supporting guides;

Fig. 6 is a fragmentary sectional view, taken on the plane of the line 6—6 of Fig. 3, looking in the direction of the arrows;

Fig. 7 is an enlarged detail view of one of the stub shafts 109 which is used to connect each cross head 24 to the floating member 147.

The present pump is adapted to be driven by means of a belt and pulleys, since the drive shaft is arranged for a convenient and suitable drive speed, or it may be driven by means of a gear motor, as shown in Fig. 2.

The gear motor 10 comprises an electric motor 11 of suitable characteristics, having an auxiliary gear housing 12 containing reducing gears and adapted to deliver power at the shaft 13 at a relatively slow speed and relatively high torque. The gear motor drive shaft 13 is connected to the horizontal pump drive shaft 14 by a suitable form of universal joint 15. The supporting and housing structure of the pump is preferably constructed of cast metal and comprises a plurality of cast metal parts, as follows:

The base 16, supporting spider 17, intake manifold 18, discharge manifold 19, intake valve housings 20, pump housings 21, discharge valve housings 22, diaphragm heads 23, cross heads 24.

Of these, the intake valve housings and the discharge valve housings may be identical in structure, differing only in their location with respect to the pump elements of the complete pump, and they are given a separate indicating numeral only because of their different function in the operation of the pump. Of course, the valves operate in the same way whether they are used as intake valves or output valves, but they operate at different times, as will be apparent from the following description of the structure and operation.

The base 16 comprises a cast metal member having a substantially cylindrical side wall portion 25, supporting a frusto-conical side wall portion 26 for the purpose of reducing the size of the base at the point where it supports the spider 17. The cylindrical base part 25 is carried by a foot flange 27 suitably reinforced and provided with apertures so that the base may be bolted to a concrete foundation.

At one side the cylindrical portion 25 is provided with a flattened seat or surface 28 bordering a cylindrical bore 29 and provided with threaded bores 30. The bore 29 is adapted to receive the bearing casting 31 for the horizontal drive shaft 14. This bearing casting has a cylindrical flange 32 bordered by a radially projecting attaching flange 33 through which the screw bolts 34 pass into the threaded bores 30 to secure the fitting on the base.

The cylindrical flange 32 is provided with a counterbore 35 having an inwardly extending radial flange 36, against which the outer race

37 is seated. The outer race 37 may be a close frictional fit in the bore 35. An inner race 38 has a close frictional fit on the portion 39 on the horizontal drive shaft 14, and the tapered frusto-conical anti-friction rollers 40 are disposed between the races 37, 38. The raceways in the races 37, 38 are disposed diagonally to the axis of shaft 14 so that the anti-friction bearings 37, 38, 40 also constitute a thrust bearing for taking the thrust from the bevel pinion 41 carried by the end of drive shaft 14.

The drive shaft bearing casting 31 has a tapered frusto-conical portion 42, and it terminates in a cylindrical flange 43 having a counterbore 44, which is adapted to receive an anti-friction bearing similar in structure and installation to the anti-friction bearings 37, 38, 40, and indicated in its entirety by the numeral 45.

The race 38 rests against the shoulder at the right end of the bevel pinion 41, while the race of the bearing 45 is forced on the shaft 14 by a pair of nuts 46 threaded on a threaded part of the shaft at that point.

The bearing 45 need not be as large as the bearing 37, 38, 40, as it does not take the direct thrust from the bevel pinion 41. The bearing 45 and nuts 46 are covered by a cast metal cap 47, which has a groove surrounding the shaft 14, filled with a packing 48 to prevent egress of lubricant from the casting 31. A threaded filling aperture at the top of the casting may be closed by a filling plug 49 so that lubricant may be applied to the bearings from this filling aperture.

The base 25 is hollow and formed with a bore 50 and counterbore 51 separated by an annular shoulder 52. The annular shoulder 52 is engaged by the attaching flange 53 of a bearing plate 54, which carries the lower bearing 55 for the main or drive shaft 56.

The bearing plate 54 is bolted to the base as shown, and has a counterbore 57 and an annular flange 58 for receiving and supporting the anti-friction bearing 55, which is mounted in its socket and on the lower end of shaft 56 in a manner similar to the anti-friction bearings just described, by means of nuts 59 on threaded portion 60.

A cast metal cap 61 is bolted to the plate 54 covering the end of main drive shaft 56, and it is provided with a clean-out opening and plug 62. The base casting may also have an aperture 63 closed by threaded plug 64 for observation of the gears and for filling the lower part of the base with lubricant within which the gears may run.

The main drive shaft 56 is provided with a reduced portion 65 and an annular shoulder 66 for seating the bevel gear 67, which is secured in place by a plurality of nuts 68 on the threaded portion 69. Bevel gear 67 meshes with bevel pinion 41 so that shaft 56 is driven at a reduced speed.

The present pump may include any number of pumping elements, but preferably includes four, five, six or more of such pumping elements. In the preferred embodiment of the invention there are six separate pumping elements, which may be indicated in Fig. 1 by the numerals 70-75. In any event, the pumping elements are arranged radially at equally spaced distances about the axis of the drive shaft 56, and they are adapted to be actuated in succession in the direction in which the shaft rotates. The drive shaft may be rotated in either direction to operate the pumping elements with equal facility.

Each of the pumping elements is identical in structure to each of the other pumping elements, thereby greatly reducing the cost of manufacture, since only one type of pumping element need be made, and it can be made in large quantities by volume production machining methods. It is to be understood that the present embodiment, which has six pumping elements, is exemplary of one of the preferred forms of the invention and that other embodiments may be made embodying a multiplicity of pumping elements, certainly more than two, and numbers of elements which are easily divisible are preferred to make the construction more simple.

The base 16 has above the frusto-conical portion 26 a box-like portion 76, which is hexagonal in plan, as shown in Fig. 6. The six sides of this hexagonal portion 76 are formed by upwardly projecting flanges 77, 78 at each corner of the figure, the flanges being joined together at an angle of 120 degrees and provided with threaded bores 79 for receiving the screw bolts 80.

The hexagonal portion has a supporting shoulder 81 formed on a radially outwardly extending flange 82 at the bottom to give additional support to the spider 17, which may be formed of a multiplicity of separate arms 83. Each of these arms has a flat end surface 84 located on attaching flanges 85, through which a multiplicity of the fastening bolts 80 pass, the bolts being threaded into the flanges 77, 78 on base 16. The spider arms 83 are all secured to the base 16 in such manner that they extend radially therefrom at the top, and they are provided with suitable reinforcing flanges such as the vertical flange 86, the horizontal flange 87, and the curved border flange 88, joined by various webs to make a light and strong structure. These spider arms 83 are shown in elevation at the right of Fig. 3, and in section at the left of Fig. 3. Near the outer end of each arm 83 the arm is provided with a horizontal machined seating surface 89, which is bordered by a flange 90 to assist in aligning the pump element on the spider, and to support the pump chamber against the thrust of the working parts. The horizontal flanges 87 have apertures for receiving the securing bolts 91, which pass through the spider arm flanges, and are secured by nuts which nestle in recesses at opposite sides of pump chamber 21.

The spider arms 83 also have upwardly extending guide-supporting flanges 92, 93 (Fig. 5) at the top, the guide flanges being formed with the upper flat seating surfaces 94, and the flange extensions 95 for housing and supporting the cross-head guides 96, 97.

Each cross-head guide comprises a substantially rectangular block of metal having a V-shaped groove 98 formed on the side toward the cross-head. For convenience in machining these V-shaped grooves, I provide a rectangular section groove 99, formed at the apex of the V. This is a clearance groove machined in the guides to relieve pressure at the apex of the V and to concentrate it on the flat sides only.

The block 96 has bores 100 for passing the screw bolts 101 which secure that block fixedly to the spider arm 83. The other guide block 97 is preferably provided with an enlarged or laterally elongated aperture or slot 102 for receiving the screw bolt 103, which secures it in place.

This guide block is also engaged by the ends of a plurality of set screws 104 located in the threaded bores 105 and secured by lock nuts 106.

The use of the V-shaped guides enables the use of the adjustment screws 104, which can take up any wear on the guides or cross-heads in a vertical or horizontal direction, thereby eliminating any unnecessary play between the cross-heads and guides after a period of use or in the initial assembly of the machine.

The sliding cross-heads 24, which are six in number in the present embodiment, are identical in construction and are shown in plan in Fig. 4, vertical section in Fig. 5, and longitudinal vertical section in Fig. 3. Each cross-head member comprises a cast metal member having at the inner end a horizontally projecting securing flange 107 provided with a vertical bore 108 for receiving the stub shaft 109, which has a threaded end provided with a nut 110. The opposite end of each cross-head 24 has a vertically extending attaching flange 111, which is provided with a threaded bore 112 for receiving the threaded end 113 of a connecting rod 114, which is locked in place by lock nut 115.

The intermediate body 115' of each cross-head 24 may be of any convenient shape, provided its lateral edges are provided with flat surfaces 116, 117 forming a V-shaped angular edge which is complementary to the shape of the V-shaped groove in the blocks or guides 96, 97. These edges are accurately machined to fit the guides, and each of the upper guide surfaces 116 is provided with an oil groove 118, which extends diagonally downward across the guide surface 116, toward each end, from the middle.

The groove 118 communicates with a drilled aperture 119 extending across the body 115', and a drilled aperture 120 in an upwardly projecting lug 121 communicates with the aperture 119. The vertical aperture 120 may be used for conducting oil to the oil groove 118 on the cross-head guide surface 116. The lower surface 117 will be lubricated by the gravity flow of lubricant from the upper surface.

The base 16 has in its upper hexagonal portion 76 a bearing plate 122. For this purpose the base portion 76 is provided with an inwardly extending annular flange 123 at the top, having a circular bore 124 for receiving a complementary cylindrical formation 125 on bearing plate 122.

The bearing plate 122 has a radially extending flange 126, which may be hexagonal in plan, fitting in the space between the ends of the spider arms 83, where they project above the base portion 76. The bearing plate 122 has a cylindrical bore 127, which receives the outer race of an anti-friction bearing 128. It also has an inwardly extending radial flange 129 to support the race, the main drive shaft 56, and enlarged portion 130, on which the outer race of the bearing 128 has a close frictional fit. An oil seal plate 131 is mounted on this portion 130 against the annular shoulder 132. The oil seal plate extends over the flange 126, and has grooves filled with packing 133 to retain the oil in the cup or bore 127.

The anti-friction bearing 128 may be identical in construction to that described in detail at 37, 48, 40, except that it is a main supporting bearing for the drive shaft 56, and is necessarily larger for this duty.

The bearing plate 122 has an oil seal plate 134 bolted to its lower flange 129, the oil seal plate being provided with grooves filled with packing 135 in the aperture or bore which receives the shaft 56.

Horizontal and vertical grooves 136 are drilled in the flange 126 at the left to provide for oiling

the bearing 128. It will be understood that in drilling such oil apertures the end of the horizontal aperture 136 is plugged up at the left. This practice is followed in other places where it is necessary to drill oil apertures through parts.

The crank shaft 56 is provided at its upper end with the crank or eccentric portion 137 which supports the vertically extending eccentric or crank pin 138. This crank pin carries a similar anti-friction bearing 139 installed in the same way, and the bearing housing 140 is cylindrical in shape and has a horizontally extending supporting flange 141 at its lower edge. The bearing is sealed at the bottom by an oil seal 142, and the eccentric pin 138 has a tapered portion 143 and a reduced cylindrical portion 144.

The bearing housing 140 is likewise extended upwardly, having an integral reduced cylindrical portion which supports in a similar way a second anti-friction bearing 145, which engages the reduced cylindrical portion 144 on the eccentric pin 138. A screw cap 146 encloses the upper end of the bearing housing 140 and is provided with an oiling aperture. A nut on the end of eccentric pin 138 secures the inner race on the cylindrical end of the eccentric pin.

The bearing housing 140 supports an annular floating member 147 which is rotatably mounted on the eccentric pin 138 by means of the bearing 139. Floating member 147 has a pair of substantially cylindrical walls 148, 149 joined by an annular yoke 150. The inner and outer surfaces of these walls are machined to cylindrical form, and the walls are concentric and substantially equal in height.

The inner surface of wall 148 comprises the cylindrical surface of a bore which fits on the cylindrical outer surface of the bearing housing 140. It rests upon the flange 141, and it may be secured in place by means of a cap plate 151, comprising a cup-shaped member having a bore for passing the upper part of the bearing housing 140 and having a depending annular flange for engaging the upper edge of wall 148. This cap plate 151 may be secured in place by a plurality of screw bolts threaded into the housing 140.

The eccentric pin 138 is thus provided with an annular track which is rotatably mounted upon the pin 138 and is adapted to provide means for actuating a multiplicity of different pump units.

The stub shaft has at its lower end a cylindrical portion 152, which engages a plurality of rollers 153 that are contained in the cylindrical bore 154 of a roller 155. Roller 155 has an outer cylindrical surface 156 that fits between the machined cylindrical surfaces on the walls 148, 149 to accommodate the connection to the side sway of the crank action.

As previously described, each stub shaft 109 is fixedly secured in the cross-head 24 by a nut 110. Each stub shaft preferably has an annular shoulder 157 and a roller-retaining ring 158 is seated against this shoulder and clamped between the cross-head and the annular shoulder 157. The roller 155 may be rabbeted to receive the ring 158.

Stub shaft 109 has a head 159 rotating in a counterbore 160 in the bottom of the roller 155. The stub shaft 109 preferably has a transverse bore 161, and an axial bore 162 communicating with it, drilled in the shaft for the purpose of permitting the oiling of the anti-friction rollers 153 which fill the annular space between the cylindrical surfaces 152, 154.

It will thus be apparent that the actual rota-

tion takes place at the anti-friction rollers 153, and the only motion occurring between the surface 156 of roller 155 and the surfaces of the walls 148, 149 of the floating member 147 is a minimum. This small amount of motion permits the parts to be made by volume production methods at a relatively low cost.

Referring to Fig. 5, it will be noted that each cross-head 24 is slidably mounted in its guides 96, 97 located between the upwardly extending legs 93, 94 of a spider arm 83. The cut-out or slot 163 between the legs of the spider arm 83 at the top provides space for the cross-heads and their connecting rods.

The various pumping units 70-75 are all identical in structure, and this also serves to reduce the cost of the complete device. Each pump unit comprises a housing 21 of cast metal, which is adapted to be connected to the intake valves and output valves and supported by the spider arms 83. Thus each housing has a flat base flange 164 which is spaced from the inner bottom wall 165 of the pump housing so as to eliminate any possibility of leakage.

The screw bolts 91 pass through the flanges 87 on the spider arm 83, and are threaded into threaded bores in the pump housing flange 164. The pump housing has a flat flange surface 166 located in a vertical plane at its outer side with respect to the axis of shaft 56, and this surface surrounds an intake bore 167.

At its upper end the pump housing 21 has an attaching flange 168 surrounding an output conduit 169, and the end of the flange 168 is provided with a seating surface in a horizontal plane for attachment to the output valve.

The main body of the pump housing 21 between the inlet 167 and outlet 169 comprises a substantially cylindrical wall 170, which merges into a curved or tapered wall 171 communicating with the intake conduit 167 (Fig. 1). The cylindrical wall 170 has an attaching flange 172 projecting radially outwardly from the cylindrical wall for the attachment of a diaphragm retaining ring 173.

The diaphragm retaining ring is provided with a flat seating surface 174 engaging a complementary surface on the flange 172, and a plurality of screw bolts 175 secure the ring to the housing 21 and clamp the edge of a diaphragm 176. The ring 173 is provided with a groove 177, which is complementary in shape to the outer edge and head of the diaphragm 176, but of slightly less depth than the diaphragm, so that when the ring 173 is fixedly clamped to the housing 21 the rubber diaphragm wall is firmly clamped in fluid-tight relation to the housing 21.

The diaphragm 176 comprises a flexible rubber member which is suitably reinforced with fabric and which is premolded to the shape shown in Figs. 1 and 3. It has a pair of substantially parallel attaching flanges 178, 179 located in different planes, and each provided with a laterally projecting bead adjacent the edge thereof for engaging in a complementary groove in the pump head ring and diaphragm retaining ring.

It also has a curved intermediate wall portion 180, the inner leg of which, as shown in section in Fig. 3, is considerably longer so that the premolded shape of the diaphragm is that of the pump in its collapsed position, as shown in Fig. 3.

The diaphragm is annular in form and has its inner edge secured to the pump head 23 by a

The discharge manifold 19 comprises a cast metal member having a centrally located discharge port 227 surrounded by an attaching flange 228'. This discharge port is large enough to take care of the discharge from all of the discharge conduits 191 of the outlet valves. In this case six discharge conduits are used.

The discharge port 227 communicates with a multiplicity, in this case six, radially projecting conduit arms 228-233. Each arm comprises a downwardly and outwardly curved tube, all of the tubes joining at the point 234, and each tube being provided with the radially projecting securing flange 235.

It should be understood that in every case the pipe flanges on the manifolds, housings, pump units, etc., are provided with flat end surfaces to engage complementary flanges and provided with apertures for the bolts which secure these flanges to adjacent flanges. The aperture in one flange is threaded, and the other one is usually left smooth to pass the bolt, or both apertures may be smooth bores and the bolt may pass through both and be secured by a nut. A suitable gasket may be provided between the flanges, or the flanges may be machined to a liquid-tight fit, or the joint may be made water-tight by the use of any suitable compound.

The intake manifold 18 may be made of a single cast metal annular tube in the case of small pumps, but in the present embodiment I prefer to make the intake manifold 18 of two semi-circular sections 236, 237. Each of these sections comprises a cast metal tube provided with flanges 238 at each end of the tube, the tube being circular in section and semi-circular in plan, so that when the flanges 238 are bolted together in the usual manner a circular manifold 18 is provided.

The manifold has in its upper wall a plurality of outlet conduits bordered by the flanges 239, which have flat seating surfaces for engaging the lower flanges 190 on the intake valve units. In this case the bolts pass through the flanges 190 and are threaded into the flanges 239.

The intake manifold may be provided with one, two, or more intake ports. In the present embodiment I have provided two intake ports 240, 241, each bordered by an attaching flange of the usual type for securement to pipes leading to the source of supply of the liquid being pumped. Where the intake manifold 18 is made of two sections, it may be more conveniently applied and removed after the complete machine has been set up, since otherwise it would be impossible to get it over the top of the machine without removing other parts.

It will be observed that the intake valve units lead from the intake manifold to the pump units, and for convenience the intake valve units are designated (Fig. 1) by the numerals 242-247.

The operation of the diaphragm pump is as follows: When the shaft 14 is driven, either by a belt or by a gear motor unit, the vertical drive shaft 56 is rotated at a reduced speed, and the eccentric pin 138 moves in an orbit, but also makes one rotation each time the shaft 56 rotates. As the pin 138 moves in its orbit, it causes the floating member 147 to move eccentrically, but the floating member 147 need not rotate, as the rotation takes place at the anti-friction bearings 139, 145. Rotation is permissible, however, as the cross-head pins 109 have a roller 155, which has a rolling contact against the walls 148 and 149 of the floating member 147. There is a very small amount of clearance allowed in the diameter of

the roller and therefore its rotary movement alternates, rolling in turn against the inner surface 148 during the pressure stroke and against the outer surface 149 during the suction stroke.

The eccentric movement of the floating member 147 causes the cross-heads 24 to be reciprocated in succession, and the pump units 21 are therefore actuated in succession. The cycle of this diaphragm pump does not have all of its resistance occurring at one or two points in the cycle, but there is a constant load on the drive shaft of the pump which is similar to that of a four cycle, twelve cylinder internal combustion engine. When one of the pump units is in the midst of its stroke, at least two other pump units are being actuated and are part way along their strokes.

The reciprocation of the pump unit heads 23 causes an alternate collapse and expansion of the pump unit walls, including the diaphragms 176. As the pump head 23 moves outwardly, expanding the pump chamber, the output valves 22 stay closed, but the intake valves 20 are opened by the suction or the pressure of the fluid, which is acted upon by atmospheric pressure or otherwise. Upon reverse motion of the cross-head, the pump chamber is collapsed, whereupon the intake valves 20 close, and the output valves 22 are forced open by the discharge from the pump chamber.

As a result of the actuation of the pumps in succession constantly in the same direction about the circular intake manifold 18, there is a constant change of the location of a low pressure point in the intake manifold 18, and the point of low pressure rotates with the rotation of the shaft 56. It is fundamental that liquid flows from a point of high pressure to one of low pressure, and consequently there is a rotation of the liquid being pumped in the circular manifold 18. This causes the liquid to keep in suspension any foreign materials, such as sand, dirt, or other matter that might be in the liquid being pumped, and the same is true in the case of chemical or food liquids which have solids entrained with them.

If desired, a manifold similar to the manifold 18 may be used for the discharge manifold, but the discharge manifold 19 is preferably of the shape shown, to give a more direct discharge. It is different in design from the intake manifold, on account of the fact that the intake manifold had to be designed to leave space for the base 16, whereas the output manifold 19 involved no such restrictions in its design.

It will be observed that in the construction of the present pump the number of different castings has been reduced to a minimum. The two sections of the intake manifold are identical, all of the valve units are identical, all of the pump units are identical, all of the guide units are identical, all of the cross-heads are identical, and all of the arms of the supporting spider are identical in construction. Therefore, the present pump may be constructed very economically, and the matter of replacing worn or broken parts is also simplified, because it is necessary to carry in stock only one of each of these parts to replace breakage in any part of the machine. The parts need not be machined so accurately, and may be manufactured according to volume production methods, because the floating member 147 permits a considerable latitude of movement in case such movement is rendered necessary due to inaccuracies of manufacture.

The present pump has a substantially constant

retaining ring 181. Like the retaining ring 173 and the surface 174, the pump head 23 and retaining ring 181 have engaging flat surfaces and are secured together by securing bolts.

- 5 The retaining ring 181 also has the rabbeted formation and groove complementary to the bead on the inner edge of the diaphragm, and the groove for the diaphragm in the ring 181 is smaller than the diaphragm so that the diaphragm is clamped as described with respect to the outer edge.

10 The pump housing has its chamber 182 formed with a rear or outer curved wall 183, which may be substantially concentric in curvature with the inner surface 184 of the pump head 23. This provides sufficient space for the pump head movement with the use of a minimum amount of material.

- 15 The pump head comprises a circular cast metal member, having a flat inner face, as described, and having a centrally located inwardly projecting lug 185 with a threaded bore 186. A connecting rod 114 has its threaded end threaded into the bore 186 and secured by a lock nut 25 187, the other end of the connecting rod being secured to a cross-head 24, as previously described. When the shaft 56 rotates, therefore, the eccentric pin 138 moves in a circular path, causing the floating member 147 to move in a circular path and causing the cross-heads 24 to be actuated in a radial direction, inwardly and outwardly. The cross-heads are actuated outwardly in succession in the direction in which the shaft is rotated. Thus the pump diaphragms are moved outwardly to collapse the pump chambers 182 in succession, and the diaphragms are moved inwardly to expand the pump chambers in succession.

40 All of the valve units, whether they be intake valves 20 or output valves 22, may be identical in construction, thereby reducing the cost of the device and facilitating volume production of these parts.

- 45 Each valve comprises a substantially cylindrical housing 188 (Fig. 3), which is provided at its upper edge with a groove for receiving a gasket 189'. The cylindrical housing 188 merges into a lower tubular conduit 189 of reduced size, this conduit being provided with a flat end seating surface and an attaching flange 190 for securement to the intake manifold 18.

- 50 The valve housing 188 has a laterally projecting conduit 191 with an attaching flange 192, with apertures for screw bolts so that it may be secured to the intake conduit 167 of a pump unit. 55 Valve housing 188 has a substantially cylindrical chamber and an annular shoulder 193 at its lower end. The wall of the intake conduit 189 is rabbeted to receive a cylindrical flange 194 carried by a valve seat member 195. The valve seat member 195 has a radially extending body which engages the annular shoulder 193, and it is provided with a centrally located bore 196 surrounded by a partially spherical seat 197 to be engaged 65 by a ball valve 198.

70 The ball valves 198 comprise rubber covered metal cores, the metal core comprising three-fourths of the radius and the rubber covering comprising substantially one-fourth of the radius of the ball. They are, of course, heavier than the liquid which is to be pumped so that they will not float in the liquid, and they seat by virtue of gravity, but can be unseated by the pressure of air when the pump is pumping out

the air preliminary to the use of the pump for pumping the liquid.

The valve seat member 195 has a fairly close fit in the complementary formation in the chamber 188, but it is removable and is held in place by a cage 199. The cage 199 has a flat bottom 200, which engages the flat top of the valve seat member 195. It has a plurality of upwardly extending partially cylindrical frame members 201 joined at the bottom by an annulus 202 and at the top by an annulus 203. The top ring 203 has a groove for receiving a gasket 204. The gasket 204 is not for the purpose of effecting a liquid-tight seal, but it is resilient and is for the purpose of placing a resilient pressure on the cage 199 to hold the valve seat member 195 in place. 15

The spaces 205 between the frame members 201 are cut out to permit free flow of liquid, and the cage is so arranged that one of the spaces 205 comes directly opposite the discharge opening 191. To assure this location, the cage 199 may have a pin at the top which fits in a groove in the housing 188 and assures proper location of the cage with respect to the housing.

20 The ball 198 is slightly smaller than the cage 199, and the cage is of sufficient length so that the ball may rise well off the seat and permit free flow of the liquid through the valve.

The cover 206 (right, Fig. 3) comprises a cast metal member having an annular depending flange 207 that fits inside the annulus 203 of the cage 199. It extends out over both the packings 189' and 204, the former serving to provide a fluid-tight seal between the cover and the valve housing 188, and the latter serving to permit the cover to secure the cage in place. 35

The cover plate 206 is preferably provided with a pair of upwardly extending lugs 208 which are apertured to receive a pin 209 for pivotally supporting a locking lever 210. The pin 209 may be secured in place by cotters at each end, and the lever 210 is also pivotally supported by the two legs 211 of its forked end (Fig. 1), which are mounted on a stub shaft 212 (Fig. 2) carried by link 213. Link 213 is pivotally secured to the housing 188 by a stub shaft 214, which is mounted in a pair of laterally projecting lugs 215. 45

At the opposite side of each valve housing (upper left, Fig. 2), the housing is provided with a pair of laterally projecting lugs 216 in which a pin 217 is mounted for pivotally supporting a clamping rod 218. The rod 218 extends upwardly between the forked ends 219 at that end of the lever 210, and a wing nut 220, provided with elongated hand rods, is mounted on the threaded end of the rod 218 to engage the lever 210. Thus the cover plate 206 may be forced down tightly by screwing the wing nut 220 downward on the rod 218. It is a very simple matter, however, to loosen the cover by turning the wing nut 220 in a left-hand direction and then pivoting the lever 218 outward with respect to the legs 219. All of the valve housings have the same type of cover plate and other details of construction, and therefore further description is unnecessary. 65

Such a valve housing is mounted with its intake conduit 189 connected to the outlet conduit 169 of each pump unit 70-75. Such a valve housing is also provided for each inlet conduit 167 of each pump unit 70-75, the outlet conduit 191 of the valve housing being secured in this case to the intake 167 of the pump unit. All of the outlets 191 of the outlet valve housings 221-226 are connected by securing bolts to the inlets of the discharge manifold 19. 75

load on the shaft and produces a substantially constant flow of liquid. Pumps are already being manufactured which are designed to pump against a head of 80 feet with a safety factor of 5. The pump is economical in use of floor space, and its construction eliminates high and low torque values and excessive vibration. It is not necessary to use air pressure chambers to assure a constant flow of liquid in this pump, because this is accomplished by the actuation of the pump units in series.

All parts of the pump are readily accessible, and the valves may easily be removed and cleaned. The output manifold is so designed as to permit a stream-line discharge, which further tends to facilitate uniform flow from the pump.

The floating eccentric permits comparatively close and direct connections and eliminates expensive and complicated rods that would otherwise be necessary to drive six independent means from a single pin. It also provides uniform movement for each of the six units, which it is difficult to arrange with connecting rods, especially if they operate in a common plane.

Any of the driven members may be removed in a very simple manner, due to the simple construction of the floating member, and much wear on the cross-head rollers is eliminated by means of the floating eccentric member, the rotation taking place on the roller bearings at the eccentric pin. The diaphragms of the pump units may also be removed very easily and replaced, without taking down any other part of the pump, by merely removing the bolts which secure the diaphragms in place.

While I have illustrated a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

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

1. In a diaphragm pump, the combination of a driving member with a multiplicity of diaphragm pump units arranged about said driving member, said driving member having a floating member carried eccentrically thereby, and a multiplicity of different actuating means, including one for each pump unit, said actuating means being driven by said floating member in succession, thereby distributing load of said multiplicity of pumps throughout the cycle of said floating member, said pump units being connected to an intake manifold comprising a conduit having a closed circuit whereby the actuation of the pumps in succession causes rotary flow of the liquid being pumped in said intake manifold to prevent the settlement of sediment in the manifold.

2. In a diaphragm pump, the combination of a driving member with a multiplicity of diaphragm pump units arranged about said driving member, said driving member having a floating member carried eccentrically thereby, and a multiplicity of different actuating means, including one for each pump unit, said actuating means being driven by said floating member in succession, thereby distributing the load of said multiplicity of pumps throughout the cycle of said floating member, said pump units being connected to a streamline discharge manifold having a common discharge port connected to a multiplicity of

radially extending discharge conduits including one conduit for each pump unit.

3. In a diaphragm pump, the combination of a centrally located base with a multiplicity of radially extending arms carried by said base, each of said arms supporting a pump unit with intake and output valves, driving means carried by said base and connected to each of said pump units, and intake and output manifolds connected to the pump units through said valves, one of said manifolds comprising a closed circuit conduit embracing said base and having spaced inlets and spaced outlets to provide a gyratory action in said conduit preventing settlement of sediment, and the other of said manifolds comprising a centrally located conduit joined to a multiplicity of radially extending conduit arms connecting with the pump units through the valves.

4. In a diaphragm pump, the combination of a centrally located hollow base, said base being provided with a laterally projecting drive shaft fitting having bearings for a drive shaft, a drive shaft in said bearings and provided with a bevel pinion, a second bearing fitting mounted in said base and effecting a closure of the open bottom of said base, said second bearing fitting being provided with a bearing for a vertical shaft, a vertical shaft in said bearing, and a crown gear carried by said vertical shaft for meshing with said bevel pinion, said hollow base having a supply of lubricant for immersing said bevel pinion and crown gear and having access to said bearings, a plurality of radially extending supporting arms carried by said base, each of said arms being provided with cross head guides, a crank carried by said vertical shaft and having a crank pin provided with a bearing for supporting a floating annulus, said annulus being rotatably mounted on said crank pin and having an annular groove therein, a plurality of radially extending links, each link having a bearing extending into said annular groove and engaging the opposite sides thereof, cross heads carried by said links for guiding the reciprocating motion of said links, and diaphragm pumps actuated by said links successively when said vertical shaft is rotated, said cross-heads preventing tilting of said diaphragm pumps.

5. In a diaphragm pump, the combination of a centrally located hollow base, said base being provided with a laterally projecting drive shaft fitting having bearings for a drive shaft, a drive shaft in said bearings and provided with a bevel pinion, a second bearing fitting mounted in said base and effecting a closure of the open bottom of said base, said second bearing fitting being provided with a bearing for a vertical shaft, a vertical shaft in said bearing, and a crown gear carried by said vertical shaft for meshing with said bevel pinion, said hollow base having a supply of lubricant for immersing said bevel pinion and crown gear and having access to said bearings, a plurality of radially extending supporting arms carried by said base, each of said arms being provided with cross head guides, a crank carried by said vertical shaft and having a crank pin provided with a bearing for supporting a floating annulus, said annulus being rotatably mounted on said crank pin and having an annular groove therein, a plurality of radially extending links, each link having a bearing extending into said annular groove and engaging the opposite sides thereof, cross heads carried by said links for guiding the reciprocating motion of said links, and diaphragm pumps actuated by said links successively when said vertical shaft is ro-

tated, said diaphragm pumps comprising a plurality of separate units carried by said radial arms, and communicating at their intakes with an annular closed circuit manifold, whereby a rotating current is caused in said manifold to prevent the deposit of entrained solids.

6. In a diaphragm pump, the combination of a centrally located hollow base, said base being provided with a laterally projecting drive shaft fitting having bearings for a drive shaft, a drive shaft in said bearings and provided with a bevel pinion, a second bearing fitting mounted in said base and effecting a closure of the open bottom of said base, said second bearing fitting being provided with a bearing for a vertical shaft, a vertical shaft in said bearing, and a crown gear carried by said vertical shaft for meshing with said bevel pinion, said hollow base having a supply of lubricant for immersing said bevel pinion and crown gear and having access to said bearings, a plurality of radially extending supporting arms carried by said base, each of said arms being provided with cross head guides, a crank carried by said vertical shaft and having a crank pin provided with a bearing for supporting a floating annulus, said annulus being rotatably mounted on said crank pin and having an annular groove therein, a plurality of radially extending links, each link having a bearing extending into said annular groove and engaging the opposite sides thereof, cross heads carried by said links for guiding the reciprocating motion of said links, and diaphragm pumps actuated by said links successively when said vertical shaft is rotated, said diaphragm pumps comprising a plurality of separate units carried by said radial arms, and communicating at their intakes with an annular closed circuit manifold having circumferentially spaced intake apertures, whereby a rotating current is caused in said manifold to prevent the deposit of entrained solids, said diaphragm pumps communicating at their outlets with a streamlined outlet manifold comprising a plurality of conduits of same shape and length joined to a centrally located discharge outlet conduit.

7. In a diaphragm pump, the combination of a vertically extending drive shaft with a supporting base having a plurality of radially extending supporting arms, a plurality of diaphragm pump units, one of said units being carried by each of said arms, a crank having a vertically extending crank pin carried by the end of said drive shaft and having a bearing for engaging a floating annulus, said annulus being rotatably mounted on said crank pin and having a pair of annular opposed walls, cross head guides carried by said radially projecting arms and having cross heads slidably mounted in said guides for radial movement,

connecting rods for connecting said cross heads to the diaphragms of said pumps, rigid links for connecting said cross heads to transversely extending bearings, said bearings being located between the opposed walls of said annulus, whereby the diaphragm pumps are actuated in succession, and a closed circular conduit having symmetrically located intake apertures and having outlets to each of said pumps, serving as a manifold whereby said manifold is provided with a rotating current to prevent the deposit of entrained solids.

8. In a diaphragm pump, the combination of a vertically extending drive shaft with a supporting base with a plurality of radially extending supporting arms, a plurality of diaphragm pump units, one of said units being carried by each of said arms, a crank having a vertically extending crank pin carried by the end of said drive shaft and having a bearing for engaging a floating annulus, said annulus being rotatably mounted on said crank pin and having a pair of annular opposed walls, cross head guides carried by said radially projecting arms and having cross heads slidably mounted in said guides for radial movement, connecting rods for connecting said cross heads to the diaphragms of said pumps, rigid links for connecting said cross heads to transversely extending bearings to prevent tilting of said diaphragms, said bearings being located between the opposed walls of said annulus, whereby the diaphragm pumps are actuated in succession, and a closed circular conduit having symmetrically located intake apertures and having outlets to each of said pumps, serving as a manifold whereby said manifold is provided with a rotating current to prevent the deposit of entrained solids, said diaphragm pumps communicating at their outlets with a manifold having a centrally disposed outlet and having a plurality of similarly shaped streamlined conduits leading to said outlet.

9. In a diaphragm pump, the combination of a plurality of radially disposed circumferentially spaced diaphragm pump units with intake and output valves, rotary driving means connected to each of said pump units to actuate same in a continuous and successive order around said driving means, and intake and output manifolds connected to the pump units through said valves, the intake manifold comprising a closed circuit conduit provided with circumferentially spaced intake apertures and output ports for establishing a gyratory action of the fluid passing through said intake manifold in cooperation with the operation of said pump units to prevent settlement of sediment in said intake manifold.

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