Feb. 10, 1970 H. K. HETZ 3,494,294

PUMP ASSEMBLY

Filed June 27, 1968 4 Sheets-Sheet 1

FIG. 1.

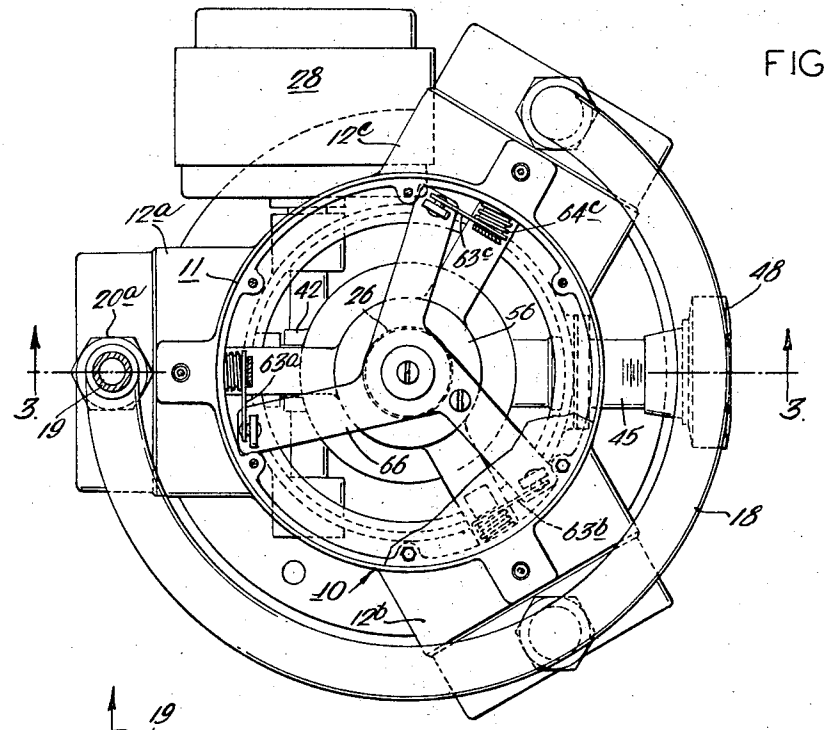
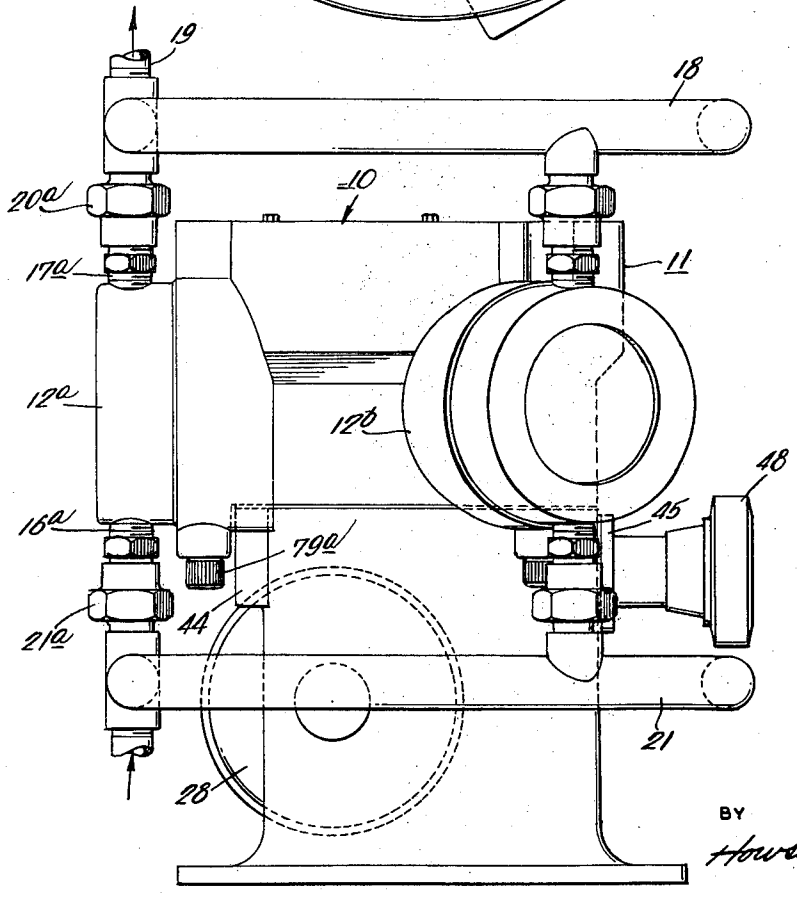



FIG. 2.




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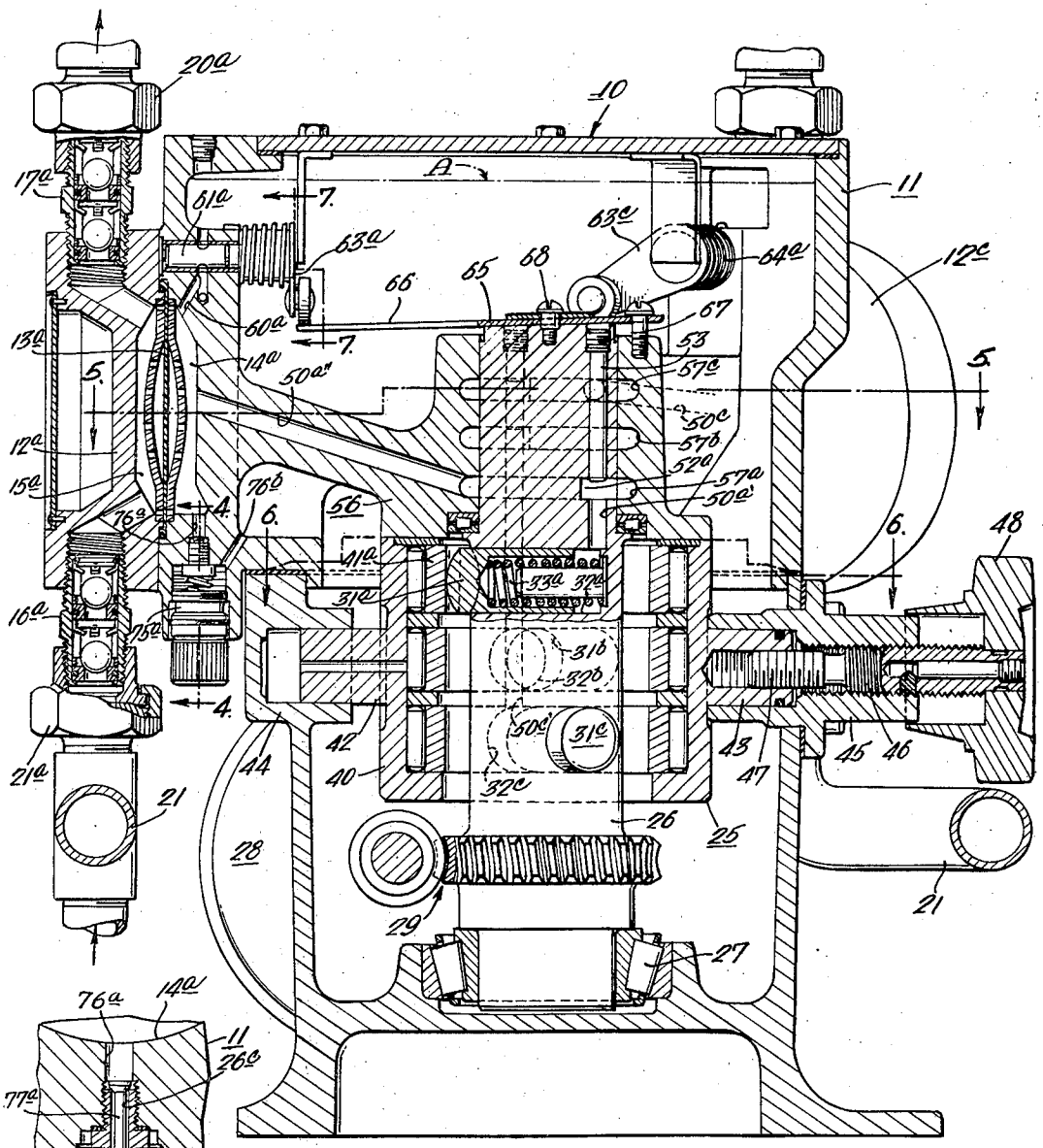
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Feb. 10, 1970 H. K. HETZ 3,494,294

PUMP ASSEMBLY

Filed June 27, 1968 4 Sheets-Sheet 2

FIG. 3.



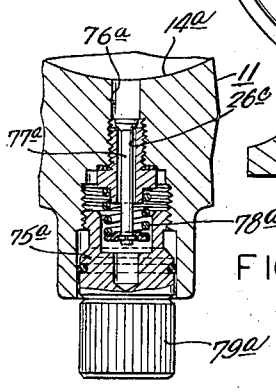


FIG. 4.

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Feb. 10, 1970 H. K. HETZ 3,494,294

PUMP ASSEMBLY

Filed June 27, 1968 4 Sheets-Sheet 3

FIG. 5.

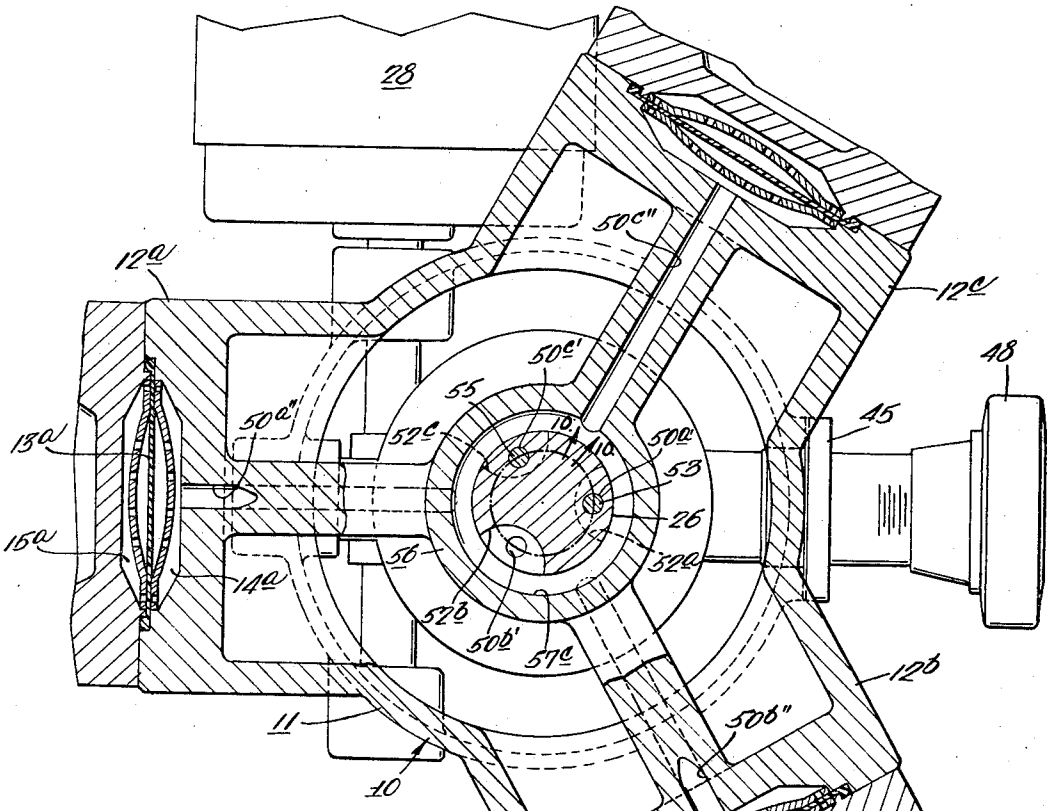
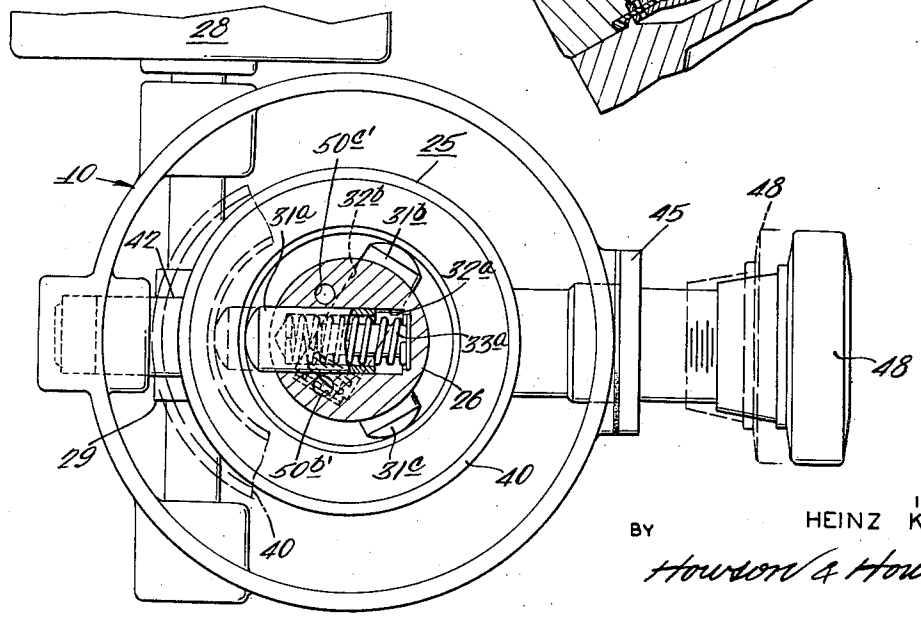



FIG. 6.




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Feb. 10, 1970 H. K. HETZ 3,494,294

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Filed June 27, 1968 4 Sheets-Sheet 4

FIG. 10.

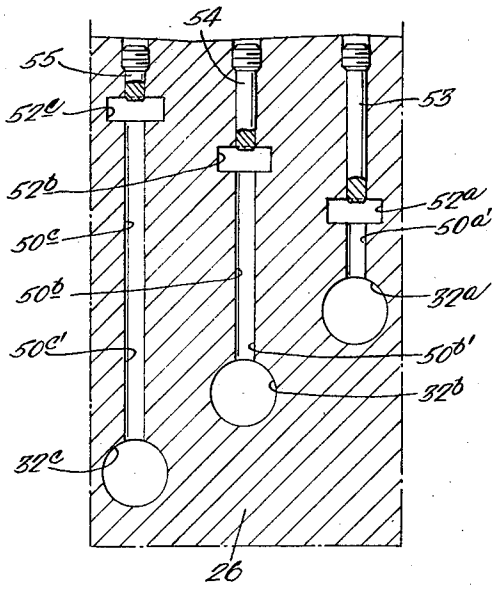
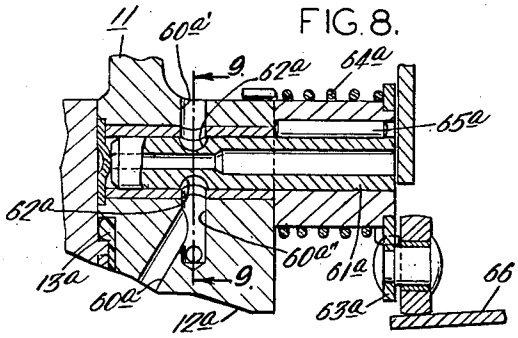



FIG. 8.



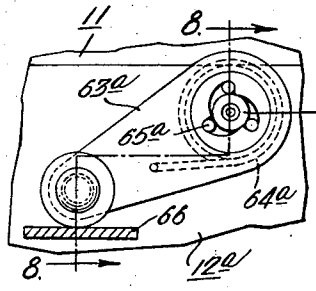




FIG. 7.

FIG. 9.

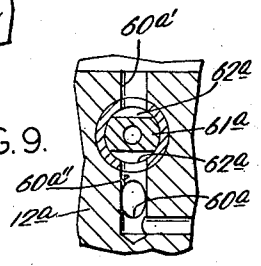
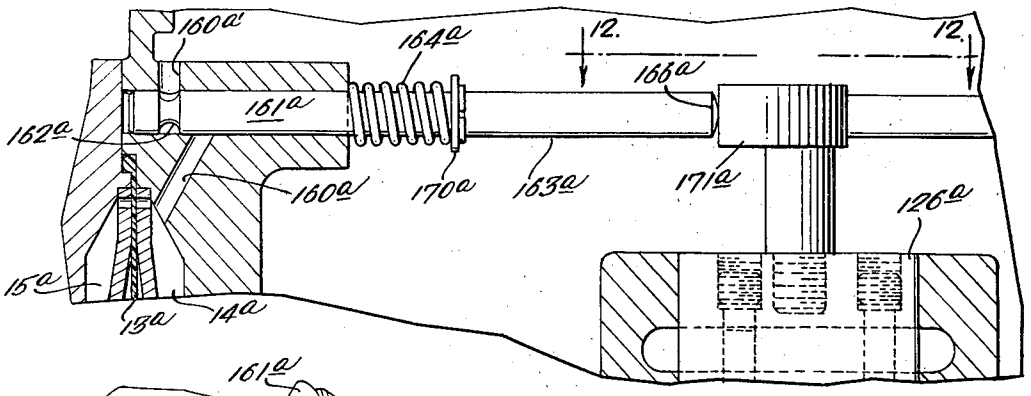



FIG. 11.



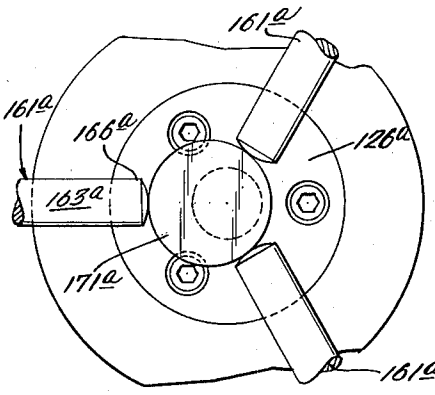




FIG. 12.

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United States Patent Office 3,494,294 Patented Feb. 10, 1970



3,494,294

# PUMP ASSEMBLY

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Int. Cl. F04b 35/02, 45/04
U.S. Cl. 103—152 23 Claims

## ABSTRACT OF THE DISCLOSURE

A series of diaphragm pumps mounted on a housing are provided with a discharge manifold which interconnects valve-controlled outlets on the pumps. The diaphragm pumps are operated in common by a rotary pump in the housing which supplies fluid pulses in phased relationship to the diaphragm pumps so that the output from the discharge manifold is substantially free from pulsations. In addition, the pumping chambers of the diaphragm pumps are periodically vented to the housing interior by venting means operated by the rotary pump.

This invention relates to pumps, and more particularly it relates to proportioning-pump assemblies in which a series of diaphragm pumps are operated by a rotary pump of the orbiting-piston type.

At present, diaphragm-type proportioning pumps are utilized in applications which require the pumping of fluids at accurately-controlled rates. In addition to requiring accurate pumping rates, however, many applications require a pump which is capable of pumping at a relatively-constant discharge flow so that its output is substantially free from flow pulsations. Although it is possible to reduce the pressure pulsations by increasing the frequency with which the diaphragm flexes, this expedient is undesirable, since, in addition to generating substantial amounts of undesirable vapors in the pumping chamber, vibrations are created which produce noise and tend to induce destructive stresses in the pump. In addition to shortening the life of the pump, the optimum efficiency of the pump is not realized because frictional and inertial forces created by the pulsating output tend to reduce the pump efficiency. The vapors generated within the pumping chamber also tend to reduce the performance of the pump.

Since proportioning pumps are frequently installed in confined spaces, it is desirable that they be of compact construction; however, notwithstanding their compactness, they must also posses sufficient capacity to meet the various pumping-rate requirements.

With the foregoing in mind, it is an object of the present invention to provide an improved proportioning-pump assembly capable of providing an output which is substantially free from pressure pulsations.

A further object of the present invention is to provide a novel proportioning-pump assembly which in addition to being compact, has a relatively high capacity.

As another object, this invention provides an efficient pump assembly which is quiet in operation and which is substantially free from vibrations.

More particularly, the present invention provides a pump assembly having a housing and a plurality of diaphragm pumps mounted on the housing. Each pump has a pumping chamber, a working chamber, and a flexible diaphragm mounted for flexure intermediate these chambers to flow fluid through each working chamber. The working chambers each have a valve-controlled inlet and a valve-controlled outlet. The working chamber inlets are connected together by an intake manifold, and the outlets are connected together by a discharge manifold. A rotary pump within the housing sequentially supplies



pulsating fluid to the pumping chambers. The rotary pump has a rotor member having a series of cavities in which a like number of pumping pistons are mounted and reciprocated upon rotor rotation by a cylindrical guide member surrounding the pistons and adjustably mounted on the housing. Conduit means is provided to transmit the fluid pulses produced by the pumping pistons to the pumping chambers. The conduit means includes a plurality of passages each opening at one end into one cavity and each opening at its other end into one pumping chamber. In addition, means is provided for venting vapors generated within the pumping chambers. The venting means includes a venting passageway, a transfer element mounted in the passageway for displacement into alternate venting positions, and camming means responsive to rotation of the rotor for displacing the transfer element. Pocket means formed in the transfer element registers with the passageway to convey vapors from the pumping chambers to the housing interior and to convey pumping fluid from the housing interior to the pumping chambers to replace the vapors vented therefrom.

In addition to these objects, other objects, features and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a top plan view of a pump assembly embodying the present invention and in which the housing of the pump assembly is partially broken away to illustrate the interior thereof;

FIG. 2 is a side elevational view of the pump assembly of FIG. 1 illustrating the intake and exhaust manifolds which interconnect the diaphragm pumps;

FIG. 3 is a longitudinal sectional view taken along line **3—3** of FIG. 1 and illustrating the details of construction of the pump assembly;

FIG. 4 is an enlarged view in longitudinal section of a pumping-fluid make-up valve taken along line **4—4** of FIG. 3;

FIG. 5 is a transverse sectional view taken along line **5—5** of FIG. 3 to illustrate a portion of the conduit means for the rotary pump;

FIG. 6 is a transverse sectional view taken along line **6—6** of FIG. 3 to illustrate the pumping pistons of the rotary pump;

FIG. 7 is a side view of the transfer-element operator taken along line **7—7** of FIG. 3;

FIG. 8 is a sectional view of the transfer element taken along line **8—8** of FIG. 7;

FIG. 9 is a sectional view of the pocket means on the transfer element taken along line **9—9** of FIG. 8;

FIG. 10 is a fragmentary vertical sectional view taken along line **10—10** of FIG. 4 with the pistons removed, and developed to illustrate the passages interconnecting the rotor cavities and the rotor vents;

FIG. 11 is a partially-sectioned, side elevational view of the modification of the present invention; and

FIG. 12 is a top plan view of the modification of FIG. 11 taken along line **12—12** thereof.

Referring now to the drawings, FIG. 3 illustrates a pump assembly **10** which comprises a housing **11** and a plurality of diaphragm-type pumps mounted in spaced-apart relationship around the upper portion of the housing **11**. The pumps are designated as **12***a*, **12***b* and **12***c* in counterclockwise order around the housing **11**, with the letter subscripts indicating the sequence in which fluid pulses are transmitted to the pumps. Each diaphragm pump is similarly constructed, and, by way of example, the pump **12***a* has a flexible diaphragm **13***a* mounted therein to define a pumping chamber **14***a* and a working chamber **15***a*. A valve-controlled inlet **16***a* is connected to the lower portion of the working chamber **15***a*, and a

valve-controlled outlet 17*a* is connected to the upper portion of the working chamber 15*a* for flowing work fluid upwardly through the working chamber 15*a* upon flexure of the diaphragm 13*a*. For additional details of the construction and operation of the diaphragm pumps of this type, reference is made to U.S. Patent 3,374,750 granted Mar. 26, 1968 of which the present invention is an improvement.

In accordance with the present invention, a discharge or exhaust manifold 18 is provided to balance the output from the pump assembly by conjoining the output from the working chambers into a single output stream, and, to this end the exhaust manifold 18 is toroidally-shaped having a single outlet 19 at one end thereof. The discharge manifold 18 is connected to the valve-controlled outlet of each working chamber, for example by a conventional threaded coupling 20*a* connected to the outlet 17*a* on the diaphragm pump 12*a*. The other working chamber outlets are similarly connected to the exhaust manifold 18 as seen in FIGS. 1 and 2.

In a like manner, a similarly-shaped intake manifold 21 is connected to the valve-controlled inlet of each working chamber by a conventional threaded coupling, for instance by a coupling 21*a* connected to the diaphragm pump 12*a* and illustrated by way of example in FIGS. 2 and 3. If desired, the intake manifold 21 may be removed, and each valve-controlled inlet may be connected to a separate source of work fluid, which may comprise different fluids or chemical solutions. With this arrangement, an additional advantage of the present invention is realized, since the conjoining of the output from each working chamber provides a mixing action in the exhaust manifold 18.

In accordance with the principal object of the present invention, each diaphragm pump is supplied with pulsating pumping fluid, and the fluid pulsations are supplied thereto in phased relationship to provide a balanced output from the discharge manifold. The fluid pulsations are sinusoidal in character, having a positive-pressure portion and a negative-pressure portion. The positive-pressure portion flexes the diaphragm outwardly to expel work fluid from the working chambers, and the negative-pressure portion flexes the diaphragm inwardly to draw work fluid into the working chambers. In the present invention the valve-controlled inlet and the valve-controlled outlet for the working chambers cooperate with the discharge manifold to algebraically add the output from each of the diaphragm pumps so that the output of work fluid from the exhaust manifold is substantially free from pulsations. To this end, a rotary pump 25 (FIG. 3) is mounted in the housing 11, and comprises a rotor member 26 centrally located within the housing 11 and supported for rotation on an upright axis by a thrust bearing 27. The rotor member 26 is rotated by a conventional electric motor 28 which is connected to the rotor member 26 by a suitable gear arrangement 29.

The phase relationship of the fluid pulsations is determined by the number and angular orientation of pumping pistons around the rotor axis. In the present invention a plurality of cavities are formed in spaced-apart relationship around the periphery of the rotor member 26, and each mounts a piston therein. The number of cavities is equal to the number of diaphragm pumps mounted on the housing; in the present instance three radial cavities 32*a*, 32*b*, and 32*c* (see FIG. 10) corresponding to the three diaphragm pumps 12*a*, 12*b* and 12*c* extend inwardly from the periphery of the rotor member 26 and intersect the rotor axis at 120° increments in vertically-spaced intervals therealong. A like number of pistons 31*a*, 31*b*, and 31*c* are mounted for reciprocation within the cavities and, by way of example, each piston 31*a* has an outer end which is biased outwardly of the cavity 32*a* by a conventional compression spring 33*a*. Displacement of the piston inwardly against the bias of the spring produces the positive-pressure fluid pulse and displacement of the piston outwardly by the spring produces the negative-pressure fluid pulse. Thus, since the pumping pistons are spaced 120° apart on the rotor member, the sinusoidal pumping cycles are displaced by 120° and the fluid pulsations produced are in phased relationship. This rotary pump construction also balances the rotor member to reduce vibrations in the pump assembly. Furthermore, this arrangement provides a compact pump assembly having greatly increased capacity over conventional diaphragm-type pump assemblies as illustrated in the aforementioned U.S. Patent.



The stroke of the pistons and therefore the displacement of the pump assembly is controlled by a cylindrical guide member 40 which is mounted eccentric to the rotor axis and which reciprocates the pistons in phased relationship upon rotation of the rotor member. The guide member 40 surrounds the pistons and extends upwardly along the rotor member 26, and a reaction ring 41*a* for example, is provided interiorly of the guide member 40 to engage the outer end of each piston for reducing frictional forces therebetween.

The displacement of the pump is adjusted by varying the eccentricity of the control member 40 with respect to the axis of rotation of the rotor member 26. For this purpose the guide member 40 is mounted on the housing for adjustment on an axis transverse to the rotor axis, in the present instance at right angles thereto. Diametrically opposed trunnions or protrusions 42 and 43 extend outwardly from the guide member 40 and are mounted for sliding movement within journals 44 and 45 respectively which are provided on the housing 11. Means to adjust the eccentricity of the guide member 40 is provided by a screw 46 which is threaded into the journal 45 and which engages the protrusion 43 on the guide member 40. The screw 46 has a portion 47 having pitch which differs from the pitch of the threads formed in the journal 45 to thereby provide a fine adjustment of the guide member 40 which is free from substantial play. A control knob 48 is secured to the outer end of the screw 46 to facilitate the manual rotation of the screw for adjusting the eccentricity of the guide member 40.

In accordance with the primary object of the present invention, fluid pulsations are produced in phased relationship by a rotary pump, and, for the purpose of supplying the fluid pulsations in sequence to the diaphragm pumps, conduit means is provided. To this end, the conduit means comprises a plurality of passages corresponding in number to the pumping chambers, in the present instance three passages 50*a*, 50*b* and 50*c*. Each passage has a rotor portion 50*a'*, 50*b'* or 50*c'* which opens at its lower end into one of the rotor cavities 32*a*, 32*b* or 32*c*, and each passage has a stator portion 50*a''*, 50*b''* or 50*c''* (see FIG. 5) which opens at the outer end into one of the pumping chambers 14*a*, 14*b* or 14*c*. As may be clearly seen in the developed view of FIG. 10, each passage 50*a'*, 50*b'* or 50*c'* extends axially upward from each cavity 32*a*, 32*b* or 32*c* and terminates in one of a plurality of circumferentially and vertically-spaced lateral ports 52*a*, 52*b* or 52*c* adjacent the upper end of the rotor member 26. Dowels or plugs 53, 54 and 55 extend downwardly within the passages and terminate at the upper edge of the ports to thereby form the upper limit of each rotor passage. The stator portion of each passage extends inwardly from each pumping chamber and terminates adjacent the upper end of the rotor member 26 in fluid communication with the rotor portion of each passage through its associated port.

In the preferred embodiment of the present invention a distributor 56 interconnects the rotor and stator portions of the passages to provide continuous fluid communication therebetween. To this end, the distriubutor 56 has a central bore which rotatably receives the upper portion of the rotor member 26. A plurality of annular channels or grooves 57*a*, 57*b* and 57*c* are formed at spaced apart intervals along the inner peripheral surface of the

distributor bore, to register with the lateral ports **52***a*, **52***b* and **52***c* which are formed in the rotor member **25**. Each groove in turn is conected to the stator portion of a respective passage to thereby provide a generally upward path for the pulsating pumping fluid from the pumping cavities to the pumping chambers, for example, from the cavity **32***a* through the rotor portion of the passage **50***a'* into the distributor groove **57***a*, and from the groove **57***a* through the stator portion of the passage **50***a''* into the pumping chamber **14***a*.

In accordance with another important feature of the present invention, means is provided for venting vapors generated within each pumping chamber during the course of operation of the pump. To this end, each pumping chamber is provided with a passageway. For example a passageway **60***a* in FIG. 3 extends upwardly from the upper portion of the chamber **14***a* and opens into the interior of the housing **11** below the level to which the housing is filled with pumping fluid as indicated at A. In the preferred embodiment of the present invention, a transfer element **61***a* intersects the passageway **60***a* to define an upper portion **60***a'* in fluid communication with the interior of the housing **11** and a lower portion **60***a''* in fluid communication with the interior of the housing **11** and a lower portion **60***a''* in fluid communcation with the pumping chamber **14***a*. The transfer element **61***a* has pocket means **62***a* (FIG. 9) formed therein, and the transfer element is displaceable to dispose the pocket **62***a* between alternate positions registering respectively with the upper portion of the passageway and the lower portion thereof for collecting vapors from the lower portion and transferring them to the upper portion, and for receiving pumping fluid from the upper portion for transfer to the lower portion. In this manner, the volume of vapors vented from the pumping chamber into the housing interior is replaced by a similar volume of pumping fluid transferred to the pumping chamber from the housing interior.

The transfer element **61***a* has a reduced body portion with recesses forming the pocket means **62***a*, and, in the preferred embodiment of the present invention is mounted for rotation in the passageway **60***a* in response to actuation by displacing means. The transfer element has an operator **63***a* which is biased downwardly by a torsion spring **64***a*. A one-way clutch **65***a* is connected to the transfer element intermediate the operator **63***a* and the reduced body portion **62***a* to thereby rotate the transfer element in increments within the passageway in response to actuation by the displacing means.

The displacement of each operator, and consequently the rotation of each transfer element within each passageway, is effected in the present invention by camming means operable in response to rotation of the rotor member **26**. To this end, the camming means comprises a camming surface **65** formed on one end of the rotor member **26** transverse to its axis of rotation, and a follower engaging the camming surface and each operator for cooperating therewith to oscillate each operator in response to rotation of the rotor member. The follower comprises a spider or wobble-plate **66** (FIGS. 1, 3) which is mounted eccentric to the axis of rotation of the rotor member **26** by a fastener **67**, and which is maintained in engagement with the camming surface by means of a conventional fastener or screw **68** coaxial with the rotor axis. Rotation of the rotor member causes the spider **66** to wobble about the central fastener **68** to thereby oscillate each operator in sequence. In this manner, the vapors generated within each pumping chamber are periodically vented to the interior of the housing **11**.

In a modified form of venting arrangement, a transfer element **161***a* is mounted for displacement transversely to a passageway **160***a* as may be seen in FIG. 11. Similarly to the preferred embodiment, the passageway **160***a* has a lower portion and an upper portion **160***a'*, and the upper portion is offset from the lower portion along the displacement path of the transfer element **161***a*. Pocket means, in the present instance a circumferential recess **162***a*, is formed in the transfer element to alternately register respectively with the lower and upper portions of the passageway to function similarly to the transfer element in the preferred embodiment. In this embodiment, however, the pocket means is biased into registry with the lower portion of the passageway by a conventional compression spring **164***a* which bears against a shoulder **170***a* formed on the transfer element **161***a*. A cam **171***a* is mounted on the rotor member **126***a* and engages a follower **166***a* which is connected to the transfer element by an operator **163***a*. Rotation of the rotor member **126***a* displaces the transfer element **161***a* against the bias of the compression spring **164***a* to alternately register the pocket means **162***a* respectively with the lower and upper portions of the passageway.

In order to keep each pumping chamber constantly supplied with pumping fluid during the course of pump operation, and in order to fill each pumping chamber prior to initial start-up, a make-up or check valve is connected to each pumping chamber to afford unidirectional fluid flow from the housing interior to each pumping chamber. For example, as shown in FIGS. 3 and 4, a valve **75***a* is connected to the bottom of the chamber **14***a*. To this end, the check valve **75***a* has a bore **76***a* opening into the bottom of the pumping chamber **14***a* and a port **76***b* in fluid communication with the bore and opening into the housing interior. A valve member **77***a* is mounted in registry with the bore **76***a* and is biased to normally block fluid flow through the bore by a spring **78***a*. The valve member is displaced against the bias of the spring and make-up pumping fluid is drawn into the pumping chamber if the pumping fluid pressure within the pumping chamber is reduced below that of the pressure within the housing **11** when the diaphragm **13***a* is in its inwardly flexed limit position, as may occur during the negative or suction portion of the pumping cycle. The valve member is normally closed by the spring during the positive or pumping portion of the pumping cycle. In addition, a knurled operator **79***a* is threadedly mounted on the check valve **75***a* in alignment with the valve member **77***a*, so that the spring pressure may be relieved by rotating the operator **79***a* into engagement with the valve member **77***a* to fill the pumping chamber at initial start-up.

In operation, the pump housing **11** is filled with pumping fluid to the level indicated at A, and each check valve is adjusted to fill each pumping chamber with pumping fluid. The intake manifold **21** is connected to a suitable source of work fluid or feed chemical, and the discharge manifold **18** is connected to the process system.

In operation, the control member **40** is displaced to its start-up position on its adjustment axis by rotation of the knob **48**. The motor **28** is then energized, and as the rotor member **26** rotates, the pistons **31***a*, **31***b* and **31***c* are cammed inwardly in sequence against the bias of the springs **33***a*, **33***b* and **33***c* so that one piston is compressing fluid within its cavity, another piston is sucking fluid into its cavity, and the third piston is functioning intermediate these pumping functions. Thus, in this manner the fluid pulses produced are in phased relationship with respect to each other.

The phased pulses are transmitted to the pumping chambers through the rotor portion of the conduit means passages **50***a'*, **50***b'* and **50***c'* into the distributor grooves **57***a*, **57***b* and **57***c*, and through each stator portion of the passages **50***a''*, **50***b''* and **50***c''* into each pumping chamber **14***a*, **14***b* and **14***c*. The pulsating pumping fluid in each pumping chamber thereby flexes each of the diaphragms to effect a flow of work fluid upwardly through the working chambers. The flow of work fluid from each working chamber is conjoined in the exhaust manifold **18** to thereby produce an output which is substantially free from flow pulsations.

In addition, as the rotor member **26** rotates, the wobble-plate **66** is oscillated by the camming surface **65** on the rotor member **26**. Each transfer-element operator, for example **63***a*, is thereby displaced against the bias of its spring to rotate each transfer element **61***a* in increments through the one-way clutch connected thereto. In this way, vapors collected within the pocket means **62***a* are released to the housing interior hwen the pocket means is rotated into registry with the upper portion of each passageway, and pumping fluid received within the pocket means from the housing interior is flowed into the pumping chamber when the pocket means is rotated into registry with the lower portion of the passageway. Accordingly, air or vapors are periodically vented from each pumping chamber.

Thus, from the foregoing it may be seen that a novel pump assembly has now been provided which is compact, has a relatively high capacity, and is capable of producing an output which is substantially free from flow pulsations.

While a preferred embodiment of the present invention has been described in detail, various modifications, alterations or changes may be made without departing from the spirit and scope thereof as defined in the appended claims.

What is claimed is:

**1.** A pump assembly comprising:

a housing adapted to be filled with pumping fluid to a predetermined level;

a plurality of diaphragm pumps mounted on said housing, each of said diaphragm pumps having a diaphragm mounted therein to define a pumping chamber and a working chamber, a valve-controlled inlet and a valve-controlled outlet for each working chamber;

a discharge manifold connecting the valve-controlled outlets of said pumps to conjoin the outputs of said pumps;

a rotary pump for sequentially supplying fluid pulses to the pumping chambers, said rotary pump comprising

a rotor member mounted in said housing for rotation about an axis, said rotor having a plurality of transverse cavities each formed therein in spaced-apart relationship around the periphery thereof,

a piston mounted for reciprocation in each cavity and having an outer end projecting outwardly therefrom,

a guide member mounted on said housing surrounding and engaging the outer end of each piston to control the reciprocation of the pistons,

conduit means providing fluid communication between said rotary pump and the plurality of diaphragm pumps including a like number of passages each opening at one end into one of said cavities and opening at the other end into one of the pumping chambers,

whereby upon rotation of said rotor member the pistons are reciprocated to sequentially supply fluid pulses to the chambers so that the output of work fluid from the discharge manifold is substantially free from flow pulsations.

**2.** A pump assembly in accordance with claim **1** wherein each of said cavities is disposed along the rotor axis at spaced-apart intervals, and said guide member has a cylindrical inner peripheral surface extending along the rotor to engage the outer end of each piston.

**3.** A pump assembly in accordance with claim **1** wherein each passage of said conduit means for said plurality of diaphragm pumps has a rotor portion and a stator portion, said rotor portion formed axially within said rotor member and opening into one of said transverse cavities, said stator portion positioned adjacent one end of said rotor member and opening at one end into one of the pumping chambers, and a distributor interconnecting said rotor portion and said stator portion so that fluid pulses produced within the rotor cavities are transmitted through the passages to the pumping chambers.

**4.** A pump assembly in accordance with claim **3** wherein the rotor portion of each passage terminates in spaced-apart ports adjacent to said one end of said rotor member, and said distributor rotatably receives said rotor member and has a plurality of channels formed therein, each channel being in registry with one of said ports during rotation of the rotor member.

**5.** A pump assembly according to claim **4** wherein said ports are spaced apart circumferentially and axially along the periphery of said rotor member and said distributor channels are annular for continual registry with each port upon rotation of said rotor member.

**6.** A pump assembly according to claim **5** wherein one of the rotary pump members is fixed and the other member is rotatable relative thereto, and said displacing means includes an operator connected to said transfer element for oscillating said transfer element and camming means engaging said operator for cooperating therewith to oscillate said transfer element within said passageway.

**7.** A pump assembly in accordance with claim **4** wherein said transfer element has a reduced body portion forming said pocket means mounted in said passageway to register said pocket means in alternation respectively with said upper portion and said lower portion of the passageway in response to actuation by said displacing means.

**8.** A pump assembly in accordance with claim **3** wherein said rotor axis is upright, said diaphragm pumps are mounted around the upper portion of said housing, said stator portion of each passage is provided adjacent to the upper end of said rotor member, and each axial passage extends upwardly in said rotor member from each cavity to provide a generally upward flow of pulsating pumping fluid from the cavities to the pumping chambers.

**9.** A pump assembly in accordance with claim **8** including means for periodically evacuating vapors from each of said pumping chambers, said evacuating means comprising:

a passageway extending upwardly from the upper portion of each pumping chamber into the housing interior below the predetermined pumping fluid level,

a transfer element intersecting each passageway to define an upper portion in fluid communication with the housing interior and a lower portion in fluid communication with the pumping chamber, said transfer element having pocket means formed therein and being displaceable to register said pocket means in alternation respectively with said lower portion and said upper portion for alternately transferring vapors upwardly through said passageway and transferring pumping fluid downwardly therethrough; and

means for displacing said transfer element in timed response to the rotation of said rotor member.

**10.** A pump assembly according to claim **9** wherein the upper portion of said passageway is aligned with the lower portion thereof and said transfer element is mounted for rotation in said passageway.

**11.** A pump assembly in accordance with claim **9** wherein said transfer element is mounted for displacement transversely to said passageway and said upper portion of the passageway is offset from said lower portion thereof along the displacement path of said transfer element, so that said pocket means registers in alternation between the upper and lower portions of said passageway upon displacement of said transfer element.

**12.** A pump assembly in accordance with claim **9** wherein said rotor member projects upwardly beyond said distributor, and said displacing means comprises a cam provided on said rotor member and a follower engaging said cam and cooperable therewith to oscillate said transfer element in response to rotation of said rotor member.

**13.** A pump assembly according to claim **12** wherein said rotor member is mounted centrally within said hous-

ing and said diaphragm pumps are spaced apart around the rotor axis so that said follower sequentially oscillates each transfer element upon rotation of the rotor member.

14. A pump assembly in accordance with claim 12 wherein said cam comprises a surface formed on one end of said rotatable member transverse to its axis of rotation, and said follower comprises a plate-like element mounted eccentric to the axis of rotation and engaging said surface and each operator to sequentially oscillate each transfer element upon rotation of the rotatable member.

15. A pump assembly in accordance with claim 8 wherein said camming means includes a cam provided on said rotatable member and a follower engaging said operator and said cam to oscillate said operator upon rotation of said rotatable member.

16. A pump assembly in accordance with claim 1 wherein said guide member is mounted eccentric to said rotor and said guide member has a reaction ring mounted for free rotation interiorly thereof in engagement with the outer end of each piston.

17. A pump assembly according to claim 16 including means to adjust the eccentricity of said guide member from the outside of said housing, said adjusting means including an adjusting screw threaded in said housing and engaging said guide member whereby the eccentricity of said guide member relative to the rotor axis may be adjusted during rotation of said rotary pump to thereby control the pulsations of said pumping fluid and the displacement of said pump assembly.

18. A pump assembly in accordance with claim 17 wherein said adjusting screw is also threaded into said guide member with a different pitch from the threading in the housing to thereby provide a fine adjustment which is free from substantial play.

19. A pump assembly in accordance with claim 16 wherein said pocket means includes a circumferential groove in said transfer element, and said transfer element is biased to normally register said groove with said lower portion of the passageway so that vapors collected within the groove are transferred to said upper portion for venting into the interior of said housing when said transfer member is displaced against said bias.

20. A pump assembly according to claim 1 including an exhaust manifold interconnecting the valve-controlled outlet of each working chamber to conjoin the output of the working chambers so that the output of work fluid from the exhaust manifold is substantially free from pulsations.

21. A pump assembly in accordance with claim 1 including an intake manifold interconnecting the valve-controlled inlet of each working chamber to provide a common flow path for work fluid between the working chambers and a supply of work fluid.

22. A pump assembly in accordance with claim 1 wherein said passageway extends upwardly from the upper portion of said pumping chamber, and said transfer element intersects said passageway to define an upper portion and a lower portion, said lower portion being in fluid communication with said pumping chamber, said upper portion being in fluid communication with the interior of said housing for transferring vapors thereto and receiving pumping fluid therefrom when the housing is filled to a predetermined level with pumping fluid.

23. A pump assembly comprising:

a housing adapted to be filled with pumping fluid to a predetermined level

a plurality of diaphragm pumps mounted on said housing, each of said pumps having a diaphragm mounted therein to define a pumping chamber and a working chamber, a valve-controlled inlet and a valve-controlled outlet for each working chamber;

a rotary pump in the housing for supplying fluid pulses to each pumping chamber, said rotary pump comprising

a first member having a plurality of cavities formed transversely thereto in spaced-apart relationship around the periphery thereof,

a piston mounted for reciprocation in each cavity and having an end projecting radially from said first member,

a second member having a cylindrical surface engaging each piston to control the reciprocation of the pistons upon relative rotation between the members,

conduit means providing fluid communication between said rotary pump and said plurality of diaphragm pumps including a like number of passages each opening at one end into one of said cavities and opening at the other end into one of the pumping chambers,

means for periodically evacuating vapors from each of said pumping chambers including

a passageway providing fluid communication between each pumping chamber and the housing interior, said passageway opening into the housing below the predetermined pumping fluid level,

a transfer element mounted adjacent each pumping chamber for displacement between alternate transfer positions, said transfer element having pocket means operable to register with said passageway for collecting a predetermined volume of vapors therefrom for transfer to the other alternate position, said pocket means receiving a predetermined volume of pumping fluid in said other alternate position for transfer to said passageway; and

means for periodically displacing said transfer element in timed response to the relative rotation between said members;

whereby upon reciprocation of the pistons and flexure of the diaphragms, vapors produced with the pumping chambers are transfered into the housing interior.

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