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(54) Title: FLUID-POWERED PROPORTIONING PUMP AND SYSTEM FOR DISPENSING FLUID INCLUDING PUMP

(57) Abstract: A fluid-powered motor includes a motor configured to convert fluid pressure into mechanical work and a valve assembly operably coupled to the motor. The motor includes a first chamber, a second chamber, a piston separating the first chamber and the second chamber, and a rod operably coupled to the piston. The valve assembly is configured to selectively control flow of fluid to the first chamber and the second chamber. The valve assembly includes a housing, a first spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the rod of the motor, and a second spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the first spool. The valve assembly controls the flow of fluid such that the piston reciprocates, thereby causing reciprocation of the rod.



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FLUID-POWERED PROPORTIONING PUMP AND SYSTEM FOR DISPENSING FLUID INCLUDING PUMP

DESCRIPTION

Related Applications

[001] This application claims the benefit of priority under 35 U.S.C. § 119(e) of U.S. Provisional Application No. 60/831,792, filed on July 19, 2006, the disclosure of which is incorporated herein by reference.

Field of the Disclosure

[002] The present disclosure relates to fluid motor devices configured to convert a portion of the energy of fluid flow into reciprocating movement, and, more particularly, to devices including a fluid-powered motor operably associated with a fluid pump. Additionally, the present disclosure relates to fluid circuits configured to proportion and/or dispense two or more fluids.

Background

[003] Fluid pumps may be powered by electric motors. Fluid pumps driven by electric motors may have a number of drawbacks. For example, in some applications, fluid pumps driven by electric motors may be undesirable for safety reasons. For instance, when pumping solvents, acids, oils, and/or flammable liquids, it can be disadvantageous, or even dangerous, to operate high-voltage or high-current electric motors to drive the pumps. In addition, fluid pumps driven by electric motors may not easily start from a stalled condition and/or stop into a stalled condition. In some applications it may be desirable to provide intermittent fluid flow, which requires cyclic starting and stopping of fluid flow. As a result, fluid pumps driven by electric motors may not provide satisfactory operation.

[004] One alternative to driving pumps with electric motors is using fluid motors to drive pumps. Existing fluid motors, however, may suffer from a number of potential drawbacks. For example, fluid motors may include valve ports that limit fluid flow through the motor in a manner that results in a pressure drop and/or

turbulence through the fluid motor. As a result, when a powering fluid is saturated with a gas, for example, when the fluid is a gas-saturated carbonated water, too much pressure drop and turbulence through a fluid motor may cause CO₂ to bubble out of solution, which adversely affects the precision of a fluid-powered proportioning pump used for pumping and/or proportioning carbonated water and a mixer, such as a syrup. In addition, some fluid motors may experience internal valve leakage in the motor while shifting between operational positions, which may adversely affect the precision of fluid proportioning.

[005] Existing fluid dispensing systems include post-mix beverage dispensers. The design of existing post-mix beverage dispensers for dispensing post-mix fountain drinks, such as, for example, COCA COLA® and PEPSI®, is now relatively standardized around the world. Post-mix fountain drinks may often include a syrup and a water component that mix as the fluids fall into a serving cup. For drinks using, for example, carbonated water, as a component, the ratio of syrup to water may be approximately 1 to 5. In some post-mix beverage dispensers, a dispensing valve provides a proportioning function and the on/off function for the syrup and water components. Such post-mix dispensers commonly require periodic calibration and adjustment as the proportioning is provided by orifices using pressure compensation.

[006] In some existing dispensers, pressurized syrup is provided to a dispensing valve by a gas-operated diaphragm pump from an ambient-pressure, flexible syrup bag contained in a cardboard box. A gas for conveying the syrup under pressure is typically provided from a pressurized CO₂ tank. The syrup boxes, tubing, controls, and a pump are collectively referred to as a "bag-in-box" (BIB) system, and the pump is commonly referred to as a bag-in-box (BIB) pump. In some dispensing systems, the BIB pump may draw from several syrup bags and pump syrup to several dispensing valves. In some existing dispensers, water may be provided to a dispensing valve under pressure. If the fluid (e.g., a drink) is non-carbonated, the water pressure may be provided by either existing domestic water line pressure or, if too low, a water-pressure booster pump. If the fluid, (e.g., a drink) is carbonated, pressure for the carbonated water may be provided by a carbonator pump and CO₂ line pressure.

[007] One desire of the present disclosure may be to provide a device that converts a first fluid flow and/or pressure into mechanical motion via a fluid motor and converting the mechanical motion into a fluid flow and pressure via a fluid pump.

[008] Another desire of the present disclosure may be to provide a fluid motor, wherein the energy for first stage valve actuation is supplied by piston displacement.

[009] Yet another desire of the present disclosure may be to provide a fluid motor, wherein the energy for second stage valve actuation is provided by the flow and pressure of a first powering fluid, which is controlled via a first stage valve.

[010] Still another desire of the present disclosure may be to provide a fluid motor, wherein the energy for valve actuation is supplied by a pressure differential across the fluid motor and/or across a pressurizing pump associated with a first fluid.

[011] Still a further desire of the present disclosure may be to provide a fluid motor, wherein valve actuation is enabled by proximity of a piston to an end of a piston chamber, wherein a shaft driven by the piston makes contact with a valve first stage configured to operate a valve second stage, thereby allowing shifting of a multi-port valve.

[012] Yet a further desire of the present disclosure may be to provide a multi-port valve having concentric elements.

[013] Yet another desire of the present disclosure may be to provide a multi-port valve element, which may prevent pinching of o-ring seals during operation.

[014] Still a further desire of the present disclosure may be is to provide a device configured to stop and/or restart in response to a first fluid flow and/or pressure.

[015] Another desire of the present disclosure may be to provide a device configured to stop and/or restart in response to a second fluid flow and/or pressure.

[016] Yet an additional desire of the present disclosure may be to provide a fluid motor configured to stop and/or restart in response to input fluid flow and/or pressure.

[017] Still a further desire of the present disclosure may be to provide a fluid motor configured to stop and/or restart in response to shaft pressure.

[018] An additional desire of the present disclosure may be to provide accurate, volumetric proportioning of two or more fluids.

[019] A further desire of the present disclosure may be to provide a fluid motor-driven proportioning pump having a fixed ratio.

[020] Still a further desire of the present disclosure may be to provide a fluid motor-driven proportioning pump having an adjustable ratio.

[021] Yet another desire of the present disclosure may be to provide a device configured to operate when the fluids are in a liquid state and/or a gas state.

[022] A further desire of the present disclosure may be to provide a device configured to sense a reciprocating motion for controlling and/or measuring operation.

[023] Still an additional desire of the present disclosure may be to provide a fluid circuit configured to deliver multiple fluids from multiple sources to multiple destinations.

[024] Yet another desire of the present disclosure may be to provide a two-stage motion valve having concentric elements.

[025] A further desire of the present disclosure may be to provide an anti-stalling, motion valve that does not include the use of spring and/or elastic elements.

[026] Yet another desire of the present disclosure may be to provide an anti-stalling motion valve, which exhibits substantially silent operation in comparison to spring-operated valve arrangements.

[027] The present disclosure may seek to satisfy one or more of the above-mentioned desires. Although the present disclosure may obviate one or more of the above-mentioned desires, it should be understood that some aspects of the disclosure might not necessarily obviate them.

SUMMARY

[028] In the following description, certain aspects and embodiments will become evident. It should be understood that the invention, in its broadest sense,

could be practiced without having one or more features of these aspects and embodiments. It should be understood that these aspects and embodiments are merely exemplary.

[029] One aspect of the invention relates to a fluid-powered motor including a motor configured to convert fluid flow into mechanical work. The motor includes a first chamber, a second chamber, and a piston separating the first chamber and the second chamber from one another. The piston is configured to reciprocate. The motor further includes a rod operably coupled to the piston. The fluid-powered motor further includes a valve assembly operably coupled to the motor. The valve assembly is configured to selectively control flow of fluid to the first chamber and the second chamber. The valve assembly includes a housing, a first spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the rod of the motor, and a second spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the first spool. The valve assembly selectively controls the flow of fluid into the first chamber and the second chamber such that the piston reciprocates, thereby causing reciprocation of the rod.

[030] According to another aspect, a fluid-powered pump includes a fluid-powered motor and a fluid pump.

[031] According to yet another aspect, a proportioning pump for controlling flow of relative amounts of two fluids includes a fluid-powered pump. A first fluid flows into the fluid-powered motor, a second fluid is pumped by a fluid pump, and flow of the first fluid into the fluid-powered motor and the second fluid pumped by the fluid pump results in a proportion being substantially maintained between the volume of the first fluid flowing into the fluid-powered motor and the volume of the second fluid pumped by the fluid pump.

[032] According to still a further aspect, a valve assembly includes a housing, a rod portion configured to operably couple the valve assembly to a fluid-powered motor, a first spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the rod portion, and a second spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the first spool. At least one of the

first spool and the second spool includes a groove configured to receive a seal, and the groove defines castellations configured to reduce the likelihood of pinching of the seal.

[033] In yet a further aspect, a system for dispensing fluid includes a fluid-powered motor including a motor configured to convert fluid flow into mechanical work. The motor includes a first chamber, a second chamber, a piston separating the first chamber and the second chamber from one another, the piston being configured to reciprocate, and a rod operably coupled to the piston. The fluid-powered motor further includes a valve assembly operably coupled to the motor. The valve assembly is configured to selectively control the flow of fluid to the first chamber and the second chamber. The system further includes a pump including a pump housing, a pump piston configured to reciprocate within the pump housing, and a pump rod operably coupled to the pump piston and the rod of the fluid-powered motor. The pump piston separates the pump housing into a first pump chamber and a second pump chamber. The system further includes a dispenser configured to supply fluid. The fluid-powered motor is configured to operate via flow of a first fluid, such that the piston reciprocates, thereby causing the pump rod and pump piston to reciprocate and pump a second fluid.

[034] According to yet another aspect, a fluid transfer device is disclosed. The fluid transfer device includes a housing and a reciprocating piston in the housing. The piston and the housing may be configured to at least partially define at least two variable-volume chambers. The two chambers may be in a state of fluid isolation, such that fluid in one of the chambers does not enter into any other chamber. An inlet chamber port and an outlet chamber port may be associated with each of the at least two chambers. A valve is responsible for cyclically redirecting the fluid flow to achieve a reciprocating motion. A valve includes two stages. A shaft position acts on the first stage, the first stage acts on the second stage, and the second stage is responsible for redirecting the fluid flow. With such an exemplary arrangement, the possibility of the valve assembly stopping in an indeterminate stage may be greatly reduced.

[035] According to still a further aspect, a device may be used as a fluid motor coupled to a fluid pump. The flow and/or pressure of a first fluid through a

reciprocating piston, fluid motor mechanically coupled to a reciprocating, fluid pump causes a flow and pressure of a second fluid in a predetermined ratio with respect to the first fluid. It is not necessary for the flow and pressure of the first fluid to be the same as the flow and pressure of the second fluid.

[036] In yet another aspect, a device may have utility for a variety of diverse applications without the need of electrical energy. Such applications include, but are not limited to, proportioning, sampling, metering, flow detection, energy recovery, pressure intensification, and pumping. The device may result in advantages of cost, performance, simplicity, and materials sufficient to displace devices in existing applications and enable potential new applications. For example, two or more streams (liquid or gas) may be proportioned, where one stream has a source pressure higher than its destination pressure and serves as an energy source to operate a reciprocating motor. The streams may have a source pressure lower than the destination pressure and use a pump powered by a motor to provide pressure and proportioning.

[037] According to some aspects, examples of applications where a fluid pumped or maintained under pressure includes the pumping of water, solvents, acids, oils, and/or flammable liquids. As stated above, in some of these applications, use of an electric motor may be disadvantageous for safety reasons. Further, some of these applications may require starting the motor from a stalled condition and stopping into a stalled condition. Such tasks may not be easily accomplished using an electric motor. According to some aspects, double diaphragm, gas-operated pumps may be used. The device according to some aspects may use a pressurized liquid and/or a pressurized gas.

[038] For applications involving both the pressurization of a fluid and the discharge of a pressurized fluid, waste energy may be reclaimed according to some aspects. An example is reverse osmosis, where feed water is pressured by a pump to drive the water through a semi-permeable membrane. Most of the pressurized water may be discharged to a drain, with no re-use of pressurization energy. According to some aspects, a device may use the energy of the pressurized discharge water to provide most of the pressurization of the feed water of a subsequent membrane by cascading, multiple effect, which may consequently

reduce the pump and motor requirements for feed water pressurization. This may be advantageous where, for example, available energy is limited, such as on submarines or on mobile potable, water-purification equipment for soldiers.

[039] According to still further aspects, a system may be used in applications where a powering fluid is available and reciprocating motion is desired. A fluid motor shaft may be coupled to a load other than a pump. For example, a fluid motor may be coupled to a reciprocating cutter.

[040] According to yet another aspect, a system may be used in applications where a small flow of high-pressure fluid is desired, and a large flow of low pressure fluid is available. For example, in a hydraulic intensifier, the energy of a high flow and low pressure hydraulic oil may be used to operate the fluid motor, which, in turn, operates a smaller cross section pump to create a low flow of high pressure hydraulic oil. The increase in pressure may be proportional to the ratio of the flows and the cross-sections of the motor and pump.

[041] According to still a further aspect, a system may be used in dispensing applications, where two or more fluids are mixed in a predetermined adjustable or non-adjustable ratio. Examples include: diluting and mixing herbicides and pesticides into water for agricultural spraying, diluting and mixing fertilizer into irrigation water for agricultural and horticultural use, diluting and mixing soap concentrate into water for washing equipment for clothes, dishes, parts and the like, diluting and mixing an oil concentrate into water for machine tool lubrication, for the addition of chemical into the make-up water of process tanks, and/or for diluting and mixing a syrup into a beverage. Such a dispensing system would not preclude adding other components in other ways upstream or downstream of a proportioning pump, whether a liquid, gas, or solid is added. According to some aspects, a system may function by using the flow and/or pressure of the water as the first fluid for the fluid motor. The additive fluid as the second fluid may be pumped by the fluid pump in a ratio proportional to the cross sections of the fluid motor and fluid pump, multiplied by their effective stroke. The discharge of both may then be mixed.

[042] According to still another aspect, a system may be used in applications where two or more fluids are mixed in a selectable, adjustable, and/or

non-adjustable ratio. An exemplary system may include a fluid motor driving multiple fluid pumps, where the pumps may be selectably operable. A pump may be made selectably operable via closing a pump's discharge with a valve, thereby diverting the flow through a relief valve. A relief valve may be internal or external to an associated pump. In the case of an internal relief valve, for example, the flow may be diverted upon reaching a relief pressure between a pump outlet and pump inlet. Alternatively, or in addition, a pump may be made selectably operable via a diverting valve, which returns a pumped fluid from a downstream side to an upstream side. The device(s) and/or method(s) of providing selectability are merely exemplary, and other device(s) and/or method(s) may be employed.

[043] According to another aspect, an exemplary application for a system is a post-mix dispenser using a fluid-powered proportioning pump having multiple pumps. Each pump may be associated with a separate syrup and/or supplemental flavoring. With selectability enabled at a dispenser valve, a dispenser valve may supply a drink proportioned with water and one or more syrups as desired. Additionally, a supplemental flavoring may be added to the drink via selection, simultaneously during dispensing of the drink. Supplemental flavoring may be added to the drink in selectable amounts by the length of time that the flavor's pump is enabled. A dispenser may include one or more proportioning pumps of the described arrangement.

[044] In still a further aspect, an exemplary system may be used in applications that require indicating a flow rate and/or totalizing a flow. For example, the flow to be measured may be used as the fluid through the fluid motor. At least one sensor may detect the reciprocating motion of the piston. The signal from the sensor may provide information convertible into flow rate and/or total flow information. A sensor may be provided that can detect the piston motion without direct contact, for example, without a shaft penetrating the housing.

[045] According to another aspect, a system may be used in sampling applications. For example, a fluid to be sampled powers a fluid motor. A fluid pump draws some of the discharge fluid of the fluid motor as a second fluid. The flow from the fluid pump may be used as the sample. The sampling ratio may be proportional to the ratio of the cross-section of the fluid pump and motor.

[046] According to yet a further aspect, a system may be used in a common application, such as, for example, beverage dispensing. Since pressurized domestic water is almost always available as a powering fluid, some exemplary devices may be substituted for a compressed gas-operated diaphragm pump via the use of domestic water as an energy source, the spent water of which may then be sent to the drain or to storage for re-use. For beer dispensing, for example, an exemplary circuit may include domestic water as the powering fluid and beer may be the pumped fluid, which is delivered to a dispensing valve. Alternatively, or in addition, a powering fluid may be contained in a closed circuit that includes a pressure booster pump with (or without) an accumulator tank. For post-mix dispensing, an exemplary circuit may include domestic water as the powering fluid, and syrup may be the pumped fluid, which is delivered to the dispensing valve. Additionally, water and syrup may be delivered to an accumulator, including the special case of using a carbonator as the accumulator, before final delivery to a dispensing valve.

[047] According to some aspects, a system may have the advantage of not requiring electricity for power or control. For example, the system may operate as a fluid motor, a fluid pump, a combined fluid motor and pump, and/or a proportioning device, as desired for the application. According to some aspects, the system may cease operation when the flow of one or more fluids has ended, and the system may resume operation when the flow is re-established. Thus, the system may be able to maintain a pumped fluid pressure (i.e., the system may be stallable).

[048] According to some aspects, a system may include a stroke compensator configured to make the ratio of a fluid-powered proportioning pump with double acting pump the same in both stroke directions. According to some aspects, the system contemplates the use of single acting, double acting, external, internal, fixed ratio, adjustable ratio, multiple, and/or single pumps. According to some aspects, the system may include a stroke signal device usable for flow control, flow rate measurement, and/or flow totalizing.

[049] According to still a further aspect, a system may be suitable for use in a wide range of applications. For example, some exemplary aspects may include use as (1) a fluid motor in combination with a direct or indirect stroke sensor; (2) a

fluid motor in combination with a shaft and one or more external pumps; (3) a fluid motor for driving a reciprocating load other than a pump; and (4) a fluid motor having an external pump that is resistant to cross-contamination.

[050] Additional objects and advantages of the disclosure will be set forth in part in the description that follows, and in part will be obvious from the description, or may be learned by practice of the disclosure. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed. Aside from the structural and procedural arrangements set forth above, the invention could include a number of other arrangements such as those explained hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[051] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and together with the description, serve to explain the principles of the invention. In the drawings,

[052] Fig. 1 is a schematic, partial section view of an exemplary embodiment of a pump and an exemplary embodiment of a motor operably associated with the exemplary pump;

[053] Fig. 2 is a schematic section view of an exemplary embodiment of a valve shown in one operational condition;

[054] Fig. 3 is a schematic section view of the exemplary valve shown in Fig. 2 in a second operational condition;

[055] Fig. 4 is a schematic section view of the exemplary valve shown in Fig. 2 in a third operational condition;

[056] Fig. 5 is a schematic section view of the exemplary valve shown in Fig. 2 in a fourth operational condition;

[057] Fig. 6 is a schematic perspective view of an exemplary embodiment of a valve;

[058] Fig. 7 is a schematic, block diagram of an exemplary embodiment of a dispensing circuit, including an exemplary embodiment of a fluid-powered proportioning pump; and

[059] Fig. 8 is a schematic, block diagram of an exemplary embodiment of a dispensing circuit including an exemplary embodiment of a fluid-powered proportioning pump.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[060] Reference will now be made in detail to exemplary embodiments of the invention. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

[061] Fig. 1 schematically depicts an exemplary embodiment of a fluid motor 10 and an exemplary embodiment of a fluid pump 20. The exemplary fluid motor 10 includes end cap 100, shaft 106, cylindrical motor case 108, end cap 102, and piston 104. A variable volume chamber 112 is formed by end cap 102, piston 104, and case 108. Another variable volume chamber 110 is formed by end cap 100, piston 104, and case 108.

[062] An exemplary valve assembly 114 operably associated with the fluid motor 10 and the fluid pump 20 is shown in Fig. 1. The exemplary valve assembly 114 is a shaft position-responsive, pilot-operated, four-way valve. (For clarity, a manifold providing communication between the fluid motor 10 and the valve assembly 114 is not shown, but exemplary fluid paths are shown schematically.) The valve assembly 114 includes an inlet port 136 and an inlet port 138, which communicate within and then through the manifold. The valve assembly further includes an outlet port 140, which communicates through the manifold.

[063] The exemplary fluid motor 10 includes a chamber 110, which communicates with valve assembly 114 via a passageway 144 included in the manifold. The fluid motor 10 also includes a chamber 112, which communicates with the valve assembly 114 via a passageway 142 in the manifold.

[064] The exemplary fluid pump 20 includes an end cap 118, a shaft 106, a cylindrical motor case 120, an end cap 116, and a piston 130. The fluid pump 20 includes a variable volume chamber 132 formed by end cap 118, piston 130, and case 120, and a variable volume chamber 134 formed by the end cap 116, the piston 130, and the case 120. A pump inlet port 122 communicates with the chamber 132 and the chamber 134 via a manifold 126 and check valves 146. A

pump outlet port 124 communicates with the chamber 132 and the chamber 134 via a manifold 128 and check valves 146. The shaft 106 extends from the fluid motor 10 through the valve assembly 114 to the fluid pump 20. Although shaft 106 is shown penetrating end cap 118, it could alternatively terminate at the piston 130. Although the shaft 106 is shown penetrating the end cap 100, it could alternatively terminate at the piston 104. During exemplary operation, a first fluid enters an inlet port of valve manifold (not shown) to the valve inlet port 136 and the valve inlet port 138, where it is directed by the valve assembly 114 to either motor chamber 112 or motor chamber 110.

[065] Fig. 2 is a schematic section view of an exemplary embodiment of the valve assembly 114 shown in an operational condition in which the shaft 106 is positioned at an extreme position toward the fluid motor 10. The exemplary valve assembly is a multi-port valve assembly, which includes concentric elements: shafts 106, a shaft connector 207, a first-stage valve spool 210, an inner valve element 208, a second-stage valve spool 206, and an outer valve element 204. The exemplary valve assembly 114 includes a motor end cap 102, and an end cap 116. According to some embodiments, the valve elements use static and dynamic seals, such as, for example, o-rings that are shown but not specifically identified. Of these valve assembly elements, the shafts 106, first-stage valve spool 210, and second-stage valve spool 206 are configured to reciprocate within the valve assembly 114. As shown in Fig. 2, the first-stage valve spool 210 and the second-stage valve spool 206 are positioned toward to fluid motor 10 to illustrate one exemplary operational condition.

[066] According to the exemplary embodiment, a variable volume valve chamber 212 is formed by outer valve element 204, second stage valve spool 206, end cap 116, and inner valve element 208. A variable volume valve chamber 214 is formed by outer valve element 204, second stage valve spool 206, motor end cap 102, and inner valve element 208. As will be explained in more detail below, ports and passageways are used to achieve a reciprocating function of the fluid motor 10. A motor inlet communicates through a manifold (not shown) to valve inlet port 226 and valve inlet port 234. A motor outlet communicates through a manifold (not shown) to valve outlet port 230. Valve motor port 228 communicates through a

manifold (not shown) through passageway 142 to motor chamber 112. Valve motor port 232 communicates through a manifold (not shown) through passageway 144 to motor chamber 110. A passageway 220 communicates selectively with variable volume valve chamber 212 through a manifold (not shown) to a high pressure source.

[067] Selective communication is determined by position of first-stage valve spool 210. A passageway 222 communicates selectively with variable volume valve chamber 214 through a manifold (not shown) to a high pressure source. Selective communication is determined by position of first-stage valve spool 210. The motor inlet pressure may provide the high pressure for passageway 220 and passageway 222 via a manifold (not shown). Alternatively, the pressure source may be from a source separate from a first powering fluid.

[068] Via a manifold (not shown) in flow communication with a low pressure source, a passageway 202 within shaft 106 communicates selectively with variable volume valve chamber 214 and/or variable volume chamber 212 through shaft ports 236. Selective communication may be determined by the position of first-stage valve spool 210. The motor outlet pressure may provide the low pressure for passageway 202 by means of a manifold (not shown). Alternatively, or in addition, the pressure source may be provided by a source separate from a first powering fluid, such as, for example, venting to drain or to atmosphere.

[069] When, for example, shaft 106 approaches the limit of its travel, one shaft shoulder 216 or the other shaft shoulder 218 contacts first stage valve spool 210 and shifts it. As the spool 210 shifts, the configuration of internal ports and passages change, eventually leading to a pressure reversal in valve chamber 214 and valve chamber 212. The pressure reversal in valve chamber 214 and valve chamber 212 causes second-stage spool valve 206 to shift. A shift in second-stage spool valve 206 changes the configuration of ports and passages, leading to a flow reversal of a first powering fluid to and from motor chamber 112 and motor chamber 110. A flow reversal in a fluid motor 10 causes a reversal in travel direction in motor piston 104 and shaft 106. This reversal, in turn, defines a limit of travel in one direction. This cycle repeats as shaft 106 approaches the other limit of travel. In particular, a first-stage spool valve 210 responds to a shaft position. A

second-stage spool valve 206 responds to a position of a first-stage spool valve 210. A piston 104 and shaft 106 of a fluid motor responds to a position of a second-stage spool valve 206.

[070] Operation of the valve assembly 114 may be understood with reference to Figs. 3, 4, and 5, which schematically depict exemplary flow and pressure changes in exemplary valve assembly 114 by showing the changing positions of a shaft 106, first-stage spool valve 210, and second-stage spool valve 204. For example, as shown in Fig. 2, shaft 106, second-stage spool valve 206, and first-stage spool valve 210 are at extreme positions in the direction of arrow 242 (i.e., toward the fluid motor 10). The subsequent movement of shaft 106 is in the direction of arrow 224.

[071] During exemplary operation, a first powering fluid enters an inlet port through a manifold (not shown), flows to valve port 234, and communicates with valve port 232 as a result of a passageway created by the position of second-stage valve spool 206. A powering fluid then flows through a manifold (not shown) to motor chamber 110. The motor chamber 110 expands and motor chamber 112 contracts. The displaced fluid of chamber 112 flows through a manifold (not shown) to valve port 228, and then to port 230 as a result of a passageway created by position of the second-stage valve spool 206. The displaced fluid then flows through a manifold (not shown) to an outlet port (not shown). Port 226 is also in communication with a powering fluid. However, the flow is blocked because no passageway has been created by second-stage valve spool 206. Inlet pressure (i.e., a relatively higher pressure) communicates with chamber 212 through passageway 220 and through port 244 in inner valve element 208. Discharge pressure (i.e., a relatively lower pressure) communicates with chamber 214 through passageway 202 within shaft 106, through shaft port 236, through spool valve port 240, and through inner valve element port 238. The resulting pressure imbalance causes an unbalanced force, thereby positioning second-stage valve spool 206 in its extreme position in the direction of arrow 242 (i.e., toward fluid motor 10). Inlet pressure (i.e., a relatively higher pressure) is blocked from communicating with chamber 214 because the position of first-stage spool valve 210 results in no passageway for the fluid.

[072] Fig. 3 is a schematic section view of the exemplary valve shown in Fig. 2 in a second operational condition with the shaft 106 at an intermediate position, the first-stage valve spool 210 at an extreme position toward the fluid motor 10, and the second-stage valve spool 206 at an extreme position toward the fluid motor 10. As shown in Fig. 3, the second-stage spool valve 206 and the first-stage spool valve 210 are at their extreme position in direction of arrow 242, and the shaft 106 has moved to an intermediate position in the direction of arrow 224 toward the fluid pump 20. A shaft shoulder 216 makes contact with first-stage spool valve 210. Further movement of the shaft 106 in a direction 224 will result in movement of the first-stage spool valve 210 in direction of arrow 224. The movement of the shaft 106 is in the direction of the arrow 224.

[073] During exemplary operation, a first powering fluid enters an inlet port through a manifold (not shown) to the valve port 234 and communicates with the valve port 232 as a result of a passageway created by position of second-stage valve spool 206. A powering fluid then flows through a manifold (not shown) to motor chamber 110. Motor chamber 110 expands and motor chamber 112 contracts. The displaced fluid of chamber 112 flows through a manifold (not shown) to valve port 228 and then to port 230 as a result of a passageway created by position of the second-stage valve spool 206. The displaced fluid then flows through a manifold (not shown) to an outlet port (not shown). Port 226 is also in communication with a powering fluid. However, the flow is blocked to port 226 because no passageway has been created by second-stage valve spool 206. Inlet pressure (i.e., a relatively higher pressure) communicates with the chamber 212 through passageway 220 and through port 244 in inner valve element 208. Discharge pressure (i.e., a relatively lower pressure) communicates with the chamber 214 through passageway 202 within shaft 106, through shaft port 236, through spool valve port 240, and through inner valve element port 238. The resulting pressure imbalance causes an unbalanced force, thereby positioning second-stage valve spool 206 in its extreme position in the direction of arrow 242. Inlet pressure (i.e., a relatively higher pressure) is blocked from communicating with chamber 214 because the position of first-stage valve spool 210 results in no passageway.

[074] Fig. 4 is a schematic section view of the exemplary valve assembly 114 shown in Fig. 2 in a third operational condition with the shaft 106 positioned toward the fluid pump 20, first-stage valve spool 210 positioned toward the fluid pump 20, and the second-stage valve spool 206 positioned toward the fluid motor 10. In particular, shaft 106 and first-stage valve spool 210 are at their extreme position in direction of arrow 224, and second-stage valve spool 206 is in an extreme position in the direction of arrow 242. Second-stage valve spool 206 is just beginning to move in the direction of arrow 224. A shaft shoulder 216 makes contact with the first-stage valve spool 210, and further movement of the shaft 106 in the direction of arrow 224 is not possible because it is at the limit of its travel. The direction of movement of shaft 106 is about to reverse in the direction of arrow 242.

[075] During exemplary operation, a first powering fluid enters an inlet port through a manifold (not shown) to valve port 234 and communicates with valve port 232 as a result of a passageway created by the position of the second-stage valve spool 206. A powering fluid then flows through a manifold (not shown) to motor chamber 110. Motor chamber 110 expands, and motor chamber 112 contracts. The displaced fluid of motor chamber 112 flows through a manifold (not shown) to valve port 228 and then to port 230 as a result of a passageway created by the position of the second-stage valve spool 206. The displaced fluid then flows through a manifold (not shown) to an outlet port (not shown). Port 226 is also in communication with a powering fluid. However, the flow is blocked because no passageway has been created by the second-stage valve spool 206. Inlet pressure (i.e., a relatively higher pressure) communicates with chamber 214 through passageway 222 and through port 238 in valve element 208. Discharge pressure (i.e., a relatively lower pressure) communicates with chamber 212 through passageway 202 within shaft 106, through shaft port 236, through spool valve port 240, and through inner valve element port 244. The resulting pressure imbalance causes an unbalanced force, which causes the second-stage valve spool 206 to shift in the direction of arrow 224. Inlet pressure (i.e., a relatively higher pressure) is blocked from communicating with chamber 212 because the position of the first-stage spool valve 210 results in no passageway.

[076] Fig. 5 is a schematic section view of the exemplary valve shown in Fig. 2 in a fourth operational condition, with the shaft 106 located at an extreme position toward the fluid pump 20, the first-stage valve spool 210 located at an extreme position toward the fluid pump 20, and the second-stage valve spool 206 located at an extreme position toward the fluid pump 20. In particular, the shaft 106, the second-stage spool valve 206, and the first-stage spool valve 210 are at their extreme position in the direction of arrow 224, and the shaft 106 is beginning to move in the reverse direction, (i.e., in the direction of arrow 242). The shaft 106 travels a distance before the shaft shoulder 218 makes contact with first-stage valve spool 210.

[077] During exemplary operation, a first powering fluid enters an inlet port through a manifold (not shown) to valve port 226 and communicates with valve port 228 as a result of a passageway created by the position of second-stage valve spool 206. A powering fluid then flows through a manifold (not shown) to motor chamber 112. The motor chamber 112 expands, and the motor chamber 110 contracts. The displaced fluid of motor chamber 110 flows through a manifold (not shown) to valve port 232 and then to port 230 as a result of a passageway created by the position of second-stage valve spool 206. The displaced fluid then flows through a manifold (not shown) to an outlet port (not shown). Port 234 is also in flow communication with a powering fluid. However, the flow is blocked because no passageway has been created by the second-stage valve spool 206. Inlet pressure (i.e., a relatively higher pressure) communicates with chamber 214 through passageway 222 and through port 238 in valve element 208. Discharge pressure (i.e., a relatively lower pressure) communicates with chamber 212 through passageway 202 within the shaft 106, through shaft port 236, through spool valve port 240, and through inner valve element port 244. The resulting pressure imbalance causes an unbalanced force, which positions second-stage valve spool 206 in its extreme position in the direction of arrow 224. Inlet pressure (i.e., a relatively higher pressure) is blocked from communicating with chamber 212 because the position of first-stage valve spool 210 results in no passageway.

[078] The first-stage valve spool 210 reverses the actuating pressure on the second-stage valve spool 206 responsive to the position of the shaft 106. As

first-stage valve spool 210 travels between its limits of travel, it will create a null state where neither high pressure nor low pressure communicates with chamber 212 or chamber 214.

[079] According to some embodiments, powering fluids may include powering liquids and/or a powering gas or gases, such as, for example, compressed gas. Thus, the term “fluid” is meant to include any gas, liquid, and/or mixed phase, including gas and liquid.

[080] According to some embodiments, various static and/or dynamic seals may be incorporated into the fluid motor, fluid pump, and/or valve assembly. For example, gaskets, adhesives, o-rings and/or various combinations may be used for static seals. Close running fits, piston rings, packings, o-rings, lip seals, and/or combinations thereof may be used for dynamic seals of pistons and rods. Other seals may be used.

[081] According to some embodiments, multiple fluid pumps may be operated via a single fluid motor. For example, in addition to the exemplary fluid pump shown in Fig. 1, one or more additional fluid pumps may be added via shaft extensions and/or pistons operating in stacked chambers, for example, via the repetition of pump housings. It should be noted that the chambers and/or pistons need not have the same cross section and/or displacement per stroke. Any type of fluid pump including a reciprocation motion may be suitable for mounting to a fluid motor according to some embodiments. Some examples of such fluid pumps include piston pumps, diaphragm pumps having a diaphragm operable via a reciprocating motion. Other types of fluid pumps may also be used. Although the exemplary valve assembly depicted herein is shown positioned between the fluid pump and the fluid motor, alternative locations may include positioning the valve assembly on one end of a fluid motor and on one end of a fluid pump.

[082] Fig. 6 is a schematic perspective view of an exemplary embodiment of a valve spool 206. The exemplary valve spool 206 includes a castellated o-ring groove wall. The exemplary concentric valve spool 206 may operate according to one or more of the exemplary descriptions relating to Figs. 2-5. The exemplary valve spool 206 defines a hollow, substantially cylindrical shape. The valve spool 206 includes a port relief 352, a port relief 350, and a port relief 348. The valve

spool 206 further includes end o-ring grooves 340. The valve spool 206 may further include a first set of o-ring grooves 344 and a second set of o-ring grooves 346. Each set of o-ring grooves includes, for example, three o-ring grooves having notches 354 forming castellations in the o-ring grooves. Such castellations may reduce the likelihood of, for example, pinching of the o-ring seals as the valve spools 206 and 210 move relative to one another and/or other portions of the valve assembly 114.

[083] The exemplary valve spool 206 may be configured to receive, for example, dynamic o-ring seals in grooves 344 and grooves 346, which may be biased for expansion out of their respective grooves as valve spool 206 shifts and extends through a widening space as grooves 344 and/or grooves 346 enter a low pressure zone and are no longer confined. When not confined, an o-ring of groove 344 and/or groove 346 may begin to expand. This expansion may be countered by a new pressure relief path formed under an o-ring by notches 354. The notches 354 may be configured to be small enough compared to a cross section of an o-ring, so as not to form an extension opportunity themselves. The notches 354 may be configured so as to not contribute to leakage as a seal is formed when o-rings are confined by the bottom of an o-ring groove 344 and/or groove 346 and the inner cylindrical surface of outer valve element 204.

[084] Fig. 7 is a schematic, block diagram of an exemplary embodiment of a dispensing circuit including an exemplary embodiment of a fluid-powered proportioning pump. The exemplary embodiment shown in Fig. 7 includes a single dispenser valve, such as may be used, for example, in post-mix beverage dispensing. The exemplary circuit illustrated anticipates that fluid pressure in line 408 will be higher than fluid pressure in line 424 and that pressure in line 420 is higher than the pressure in line 414. The circuit is configured such that other devices may be included in the circuit before or after the fluid-powered proportion pump, such as devices that add additional components (ingredients) to the powering fluid, the pumped fluid, or both. The exemplary circuit is configured such that powering fluid flow may be stopping and/or starting via devices, including booster pumps, manually-operated valves, and/or power-operated valves (e.g., solenoid valves). Such devices may be responsive to a controller, sensor, and/or

limit device. The exemplary circuit is configured to incorporate a fluid-powered proportion unit having multiple pumps, which may proportion multiple additional ingredients.

[085] A fluid-powered proportioning unit may include a motor section 412, a valve section 416, and a pump section 418. According to the exemplary embodiment shown in Fig. 7, a powering fluid source 400 supplies a booster pump 404 through a line 406. The booster pump 404 supplies a pressurized fluid to the fluid-powered proportion unit through line 408. According to exemplary operation, if the pressure of fluid source 400 is already high enough to operate a fluid powering proportioning unit in the system, then the booster pump 404 may be excluded from the exemplary circuit. A second pumped fluid source 402 communicates with an inlet of pump section 418 of a fluid-powered proportioning pump through line 414. A powering fluid is discharged from a motor through line 424. A second pumped fluid is discharged through line 420. Lines 424 and line 420 join to form line 422, which contains a proportioned flow of a first powering fluid and a second pumped fluid that communicates with dispenser outlet 426. Proportioned flow 430 exits the dispenser at dispenser outlet 426 to be received in product container 428. According to some embodiments, a line 410 may provide flow communication between fluid source 400 and valve assembly 416, for example, to permit fluid flow to a destination of lower pressure, which may result in greater energy availability for valve operation.

[086] The proportioned flow may be dispensed in alternative ways. For example, line 424 and line 420 may be configured to deliver respective flows unjoined or unmixed prior to the dispense point 426, and mixing could occur as a separate operation. According to some embodiments, a dispense point may be the termination point as a subsystem in a larger system. According to some embodiments, a dispense point may be a nozzle rather than a faucet. The character of dispense point may be determined according to the application needs.

[087] Fig. 8 is a schematic, block diagram of an exemplary embodiment of a dispensing circuit including an exemplary embodiment of a fluid-powered proportioning pump, wherein the dispenser system includes an array of fluid-powered, proportioning pumps and dispenser valves, such as may be used in, for

example, post-mix beverage dispensing systems. According to the exemplary embodiment shown, to provide energy for operation of a fluid motor 412 and valve section 416, the circuit illustrated anticipates that the fluid pressure in line 438 will be higher than the fluid pressure in line 424. The pressure in line 474 is higher than the pressure in line 414, and fluid flow is attained by pump section 418. To provide energy for operation of a fluid motor 454 and valve section 452, the exemplary circuit illustrated anticipates that the fluid pressure in line 440 will be higher than the fluid pressure in line 450. The fluid pressure in line 476 is higher than the pressure in line 448, and fluid flow is attained by pump section 458.

[088] The exemplary circuit is configured such that other devices may be included in the circuit before and/or after the fluid-powered proportioning pump, such as devices that add additional components (ingredients) to the powering fluid, to the pumped fluid, or both. The circuit may be configured to stop and/or start flow of a powering fluid by devices including booster pumps, manually-operated valves, and power-operated valves (e.g., solenoid valves). Such devices may be configured to be responsive to a controller, sensor, and/or limit device. The circuit may be configured to include a fluid-powered proportioning unit having, for example, multiple pumps that may proportion multiple additional ingredients.

[089] According to some embodiments, a fluid-powered proportioning unit includes a fluid motor section 412, a valve assembly 416, and a pump section 418. A powering fluid source 400 supplies a booster pump 404 through line 406, and the booster pump 404 supplies a pressurized fluid to distribution manifold 470. A branch circuit includes a line 472 branching off of manifold 470. A valve 436 is configured to interrupt the flow of a first powering fluid, and the valve 436 may be, for example, a solenoid valve responsive to a dispenser controller (not shown). Line 438 is in flow communication with valve assembly 416 and subsequently motor section 412.

[090] During exemplary operation, if the pressure of fluid source 400 is already high enough to operate a fluid powering proportioning unit in the application, then the booster pump 404 may be excluded from the circuit. A second pumped fluid source 402 is in flow communication with an inlet of pump section 418 of a fluid-powered proportioning pump through line 414. A powering fluid is

discharged from a fluid motor through line 424. A second pumped fluid is discharged through line 474. Lines 424 and line 474 join to form line 422, which may contain a proportioned flow of a first powering fluid and a second pumped fluid that enters accumulator 434. The accumulator 434 allows dispensing of a proportioned flow without the necessity of operation of a fluid-powered proportioning pump. The accumulator 434 may include a pressure switch to which a dispenser controller responds. The accumulator 434 may be of a type, such as, for example, a freezer barrel for frozen drinks.

[091] According to exemplary operation, when dispenser valve 426 is opened, proportioned product flows from the accumulator 434, through line 432, through dispenser valve 426, and into product container 428.

[092] According to some embodiments, a branch circuit begins from line 444 extending from the manifold 470. A valve 442 interrupts the flow of a first powering fluid. The valve 442 may be, for example, a solenoid valve responsive to a dispenser controller (not shown). Line 440 is in flow communication with the valve section 452 and subsequently the motor section 454.

[093] If the pressure of the fluid source 400 is already high enough to operate a fluid-powered proportioning unit for the application, then the booster pump 404 may be excluded from the circuit. A second pumped fluid source 446 is in flow communication with an inlet of pump section 458 of a fluid-powered proportioning pump through line 448. A powering fluid is discharged from a motor through line 450, and a second pumped fluid is discharged through line 476. Lines 450 and line 476 join to form line 456, which contains a proportioned flow of a first powering fluid and a second pumped fluid that enters an accumulator 458. The accumulator 458 permits dispensing of a proportioned flow without the necessity of operation of a fluid-powered proportioning pump. The accumulator 434 may be of a specialized type, such as, for example, a carbonator, and may include a high-low level switch to which a dispenser controller responds. During exemplary operation, when the dispense valve 466 is opened, proportioned product flows from accumulator/carbonator 458 through line 464, through dispenser valve 466, and into product container 468. Carbon dioxide gas enters carbonator 458 through line 460 from pressurized carbon dioxide source 462.

[094] It will be apparent to those skilled in the art that various modifications and variations can be made to the structures and methodologies described herein. Thus, it should be understood that the invention is not limited to the subject matter discussed in the specification. Rather, the present invention is intended to cover modifications and variations.

WHAT IS CLAIMED IS:

1. A fluid-powered motor comprising:
a motor configured to convert fluid flow into mechanical work, the motor comprising
a first chamber,
a second chamber,
a piston separating the first chamber and the second chamber from one another, the piston being configured to reciprocate, and
a rod operably coupled to the piston; and
a valve assembly operably coupled to the motor, the valve assembly being configured to selectively control flow of fluid to the first chamber and the second chamber, the valve assembly comprising,
a housing,
a first spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the rod of the motor, and
a second spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the first spool,
wherein the valve assembly selectively controls the flow of fluid into the first chamber and the second chamber such that the piston reciprocates, thereby causing reciprocation of the rod.
2. The fluid-powered motor of claim 1, wherein the housing, the first spool, and the second spool are concentric with respect to one another.
3. The fluid-powered motor of claim 1, wherein the valve assembly is configured such that as fluid flows into the first chamber, the piston moves toward the second chamber, thereby causing the rod to move in a first direction.

4. The fluid-powered motor of claim 3, wherein when the rod moves in the first direction, the first spool is moved in the first direction.

5. The fluid-powered motor of claim 4, wherein when the first spool reaches an end of travel in the first direction, the second spool moves in the first direction.

6. The fluid-powered motor of claim 4, wherein when the second spool reaches an end of travel in the first direction, fluid flow is directed into the second chamber such that the piston moves toward the first chamber and the rod moves in a second direction.

7. A fluid-powered pump comprising:
the fluid-powered motor of claim 1; and
a fluid pump.

8. The fluid-powered pump of claim 7, wherein the fluid pump comprises:
a pump housing;
a pump piston configured to reciprocate within the pump housing; and
a pump rod operably coupled to the pump piston and the rod of the fluid-powered motor,

wherein the pump piston separates the pump housing into a first pump chamber and a second pump chamber.

9. The fluid-powered pump of claim 8, wherein the first pump chamber and the second pump chamber each comprise an inlet orifice configured to draw fluid into the respective pump chamber as the pump piston moves to expand the respective pump chamber and an outlet orifice configured to expel fluid out of the respective pump chamber as the piston moves to contract the respective chamber.

10. The fluid-powered pump of claim 9, wherein the rod of the fluid-powered motor causes movement of the pump rod.

11. A proportioning pump for controlling flow of relative amounts of two fluids, the proportioning pump comprising:

the fluid-powered pump of claim 7,

wherein a first fluid flows into the fluid-powered motor and a second fluid is pumped by the fluid pump, and the flow of the first fluid into the fluid-powered motor and the second fluid pumped by the fluid pump results in a proportion being substantially maintained between the volume of the first fluid flowing into the fluid-powered motor and the volume of the second fluid pumped by the fluid pump.

12. A valve assembly comprising:

a housing;

a rod portion configured to operably couple the valve assembly to a fluid-powered motor;

a first spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the rod portion; and

a second spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the first spool,

wherein at least one of the first spool and the second spool comprises a groove configured to receive a seal, and

wherein the groove defines castellations configured to reduce the likelihood of pinching of the seal.

13. The valve assembly of claim 12, wherein the housing, the rod portion, the first spool, and the second spool form a nested relationship with respect to one another.

14. The valve assembly of claim 13, wherein the nested relationship comprises a concentric relationship.

15. A system for dispensing fluid, the system comprising:
a fluid-powered motor comprising
 a motor configured to convert fluid flow into mechanical work, the motor comprising,
 a first chamber,
 a second chamber,
 a piston separating the first chamber and the second chamber from one another, the piston being configured to reciprocate, and
 a rod operably coupled to the piston;
 a valve assembly operably coupled to the motor, the valve assembly being configured to selectively control the flow of fluid to the first chamber and the second chamber;
a pump comprising
 a pump housing,
 a pump piston configured to reciprocate within the pump housing, and
 a pump rod operably coupled to the pump piston and the rod of the fluid-powered motor,
 wherein the pump piston separates the pump housing into a first pump chamber and a second pump chamber; and
 a dispenser configured to supply fluid,
 wherein the fluid-powered motor is configured to operate via flow of a first fluid, such that the piston reciprocates, thereby causing the pump rod and pump piston to reciprocate and pump a second fluid.

16. The system of claim 15, wherein the system is configured to dispense the first fluid and the second fluid, wherein a volume of the first fluid is dispensed in a predetermined proportion with respect to the volume of the second fluid.

17. The system of claim 15, wherein the valve assembly comprises
a housing,
a first spool configured to reciprocate within the housing in response to the first fluid flowing into the valve assembly and movement of the rod of the motor, and

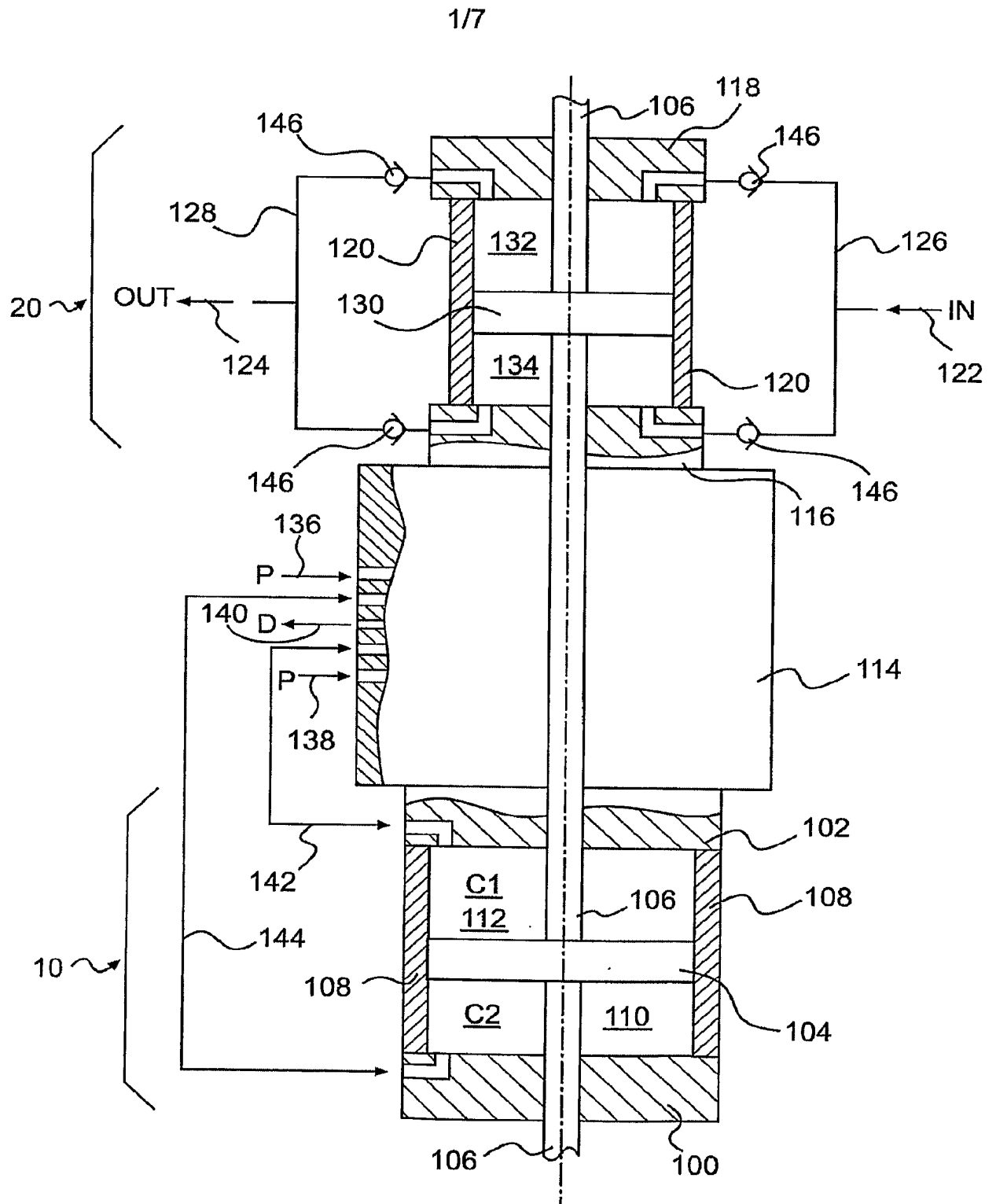
a second spool configured to reciprocate within the housing in response to fluid flowing into the valve assembly and movement of the first spool,

wherein the valve assembly selectively controls flow of the first fluid into the first chamber and the second chamber such that the piston reciprocates, thereby causing reciprocation of the rod.

18. The system of claim 15, wherein the housing, the rod portion, the first spool, and the second spool form a nested relationship with respect to one another.

19. The system of claim 18, wherein the first fluid differs from the second fluid, and the system is configured to dispense a beverage comprising the first fluid and the second fluid.

20. The system of claim 19, wherein the system is configured to substantially maintain a predetermined relationship between the volume of the first fluid dispensed and the volume of the second fluid dispensed.

**FIG. 1**

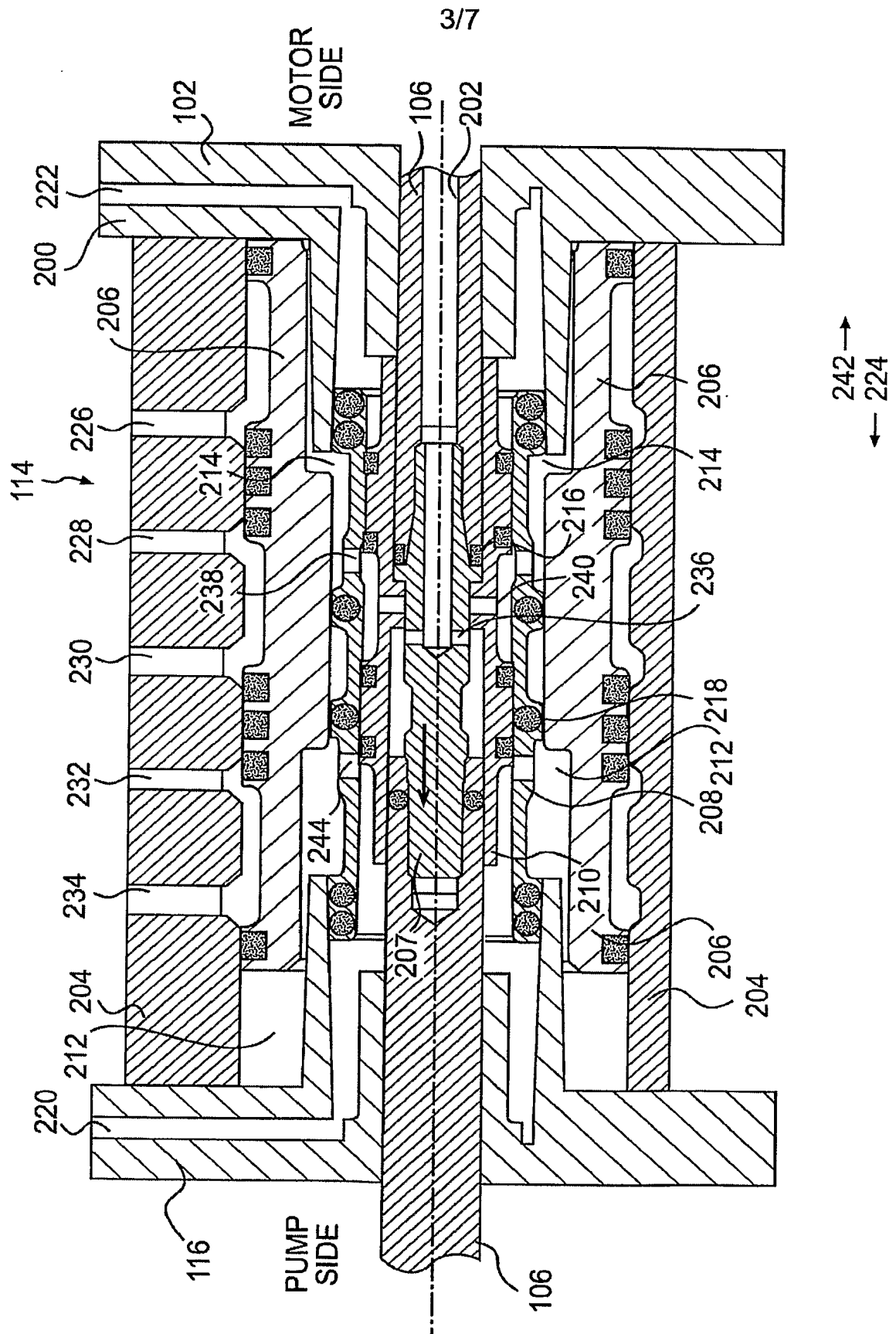


FIG. 3

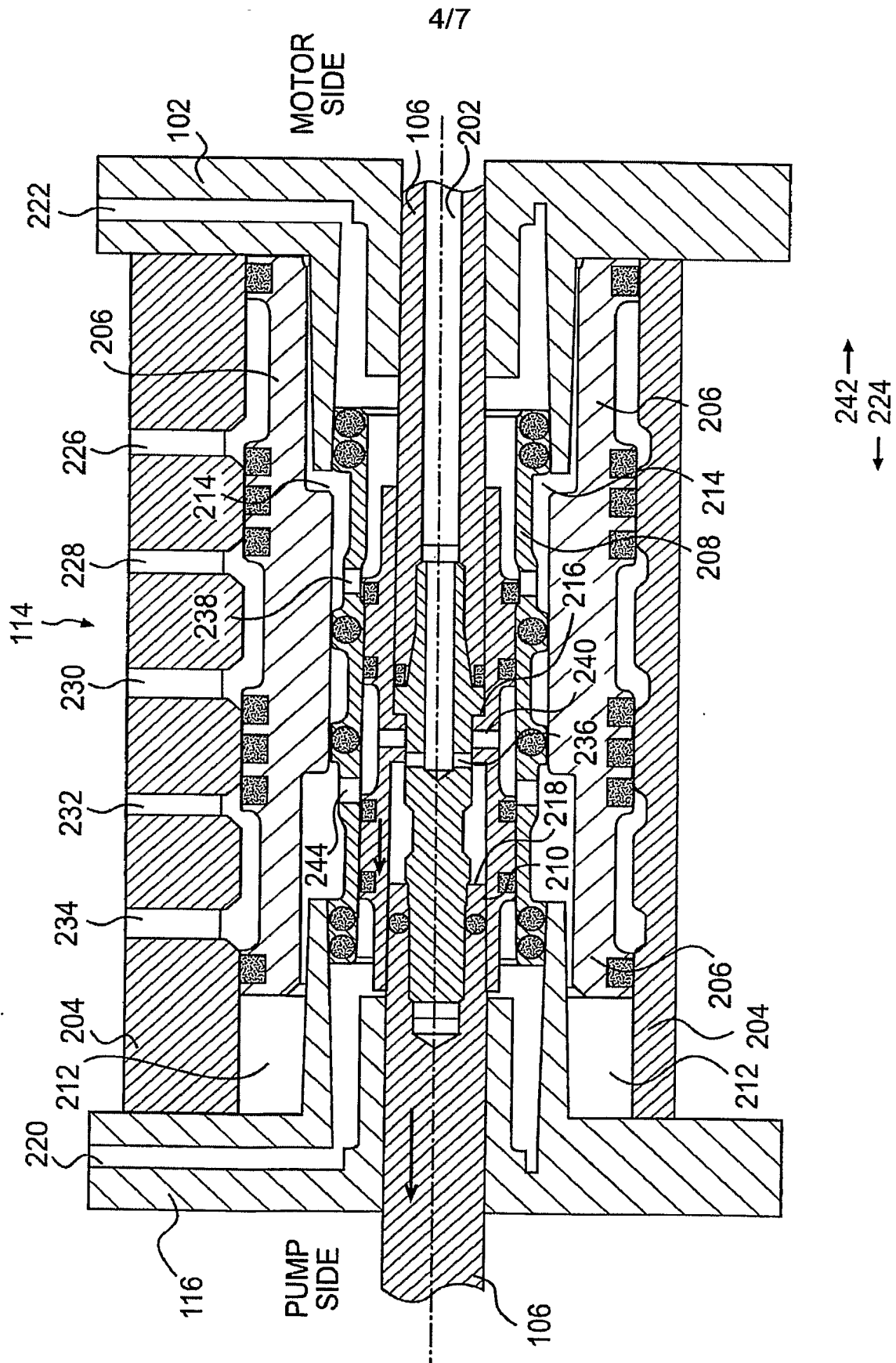


FIG. 4

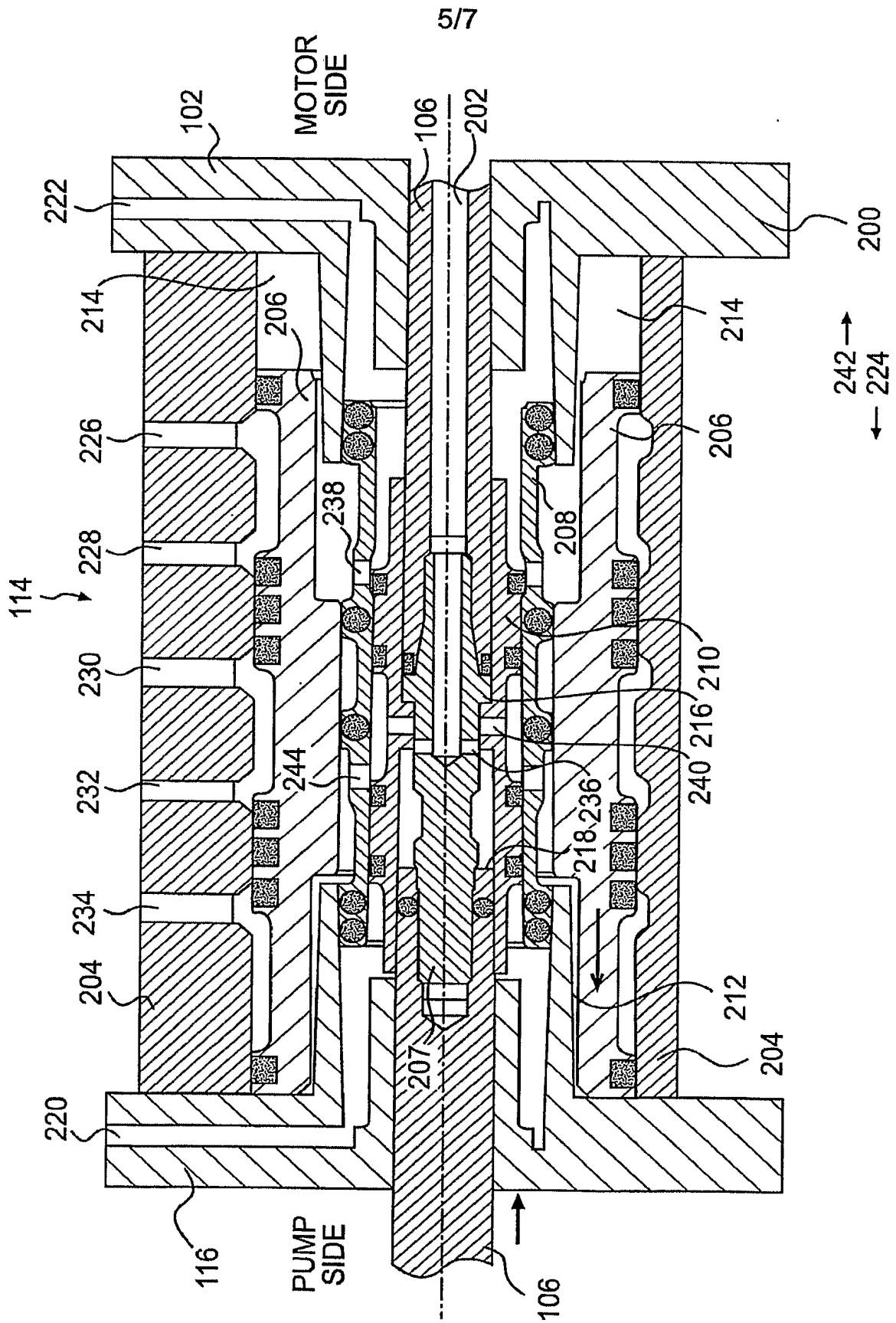


FIG. 5

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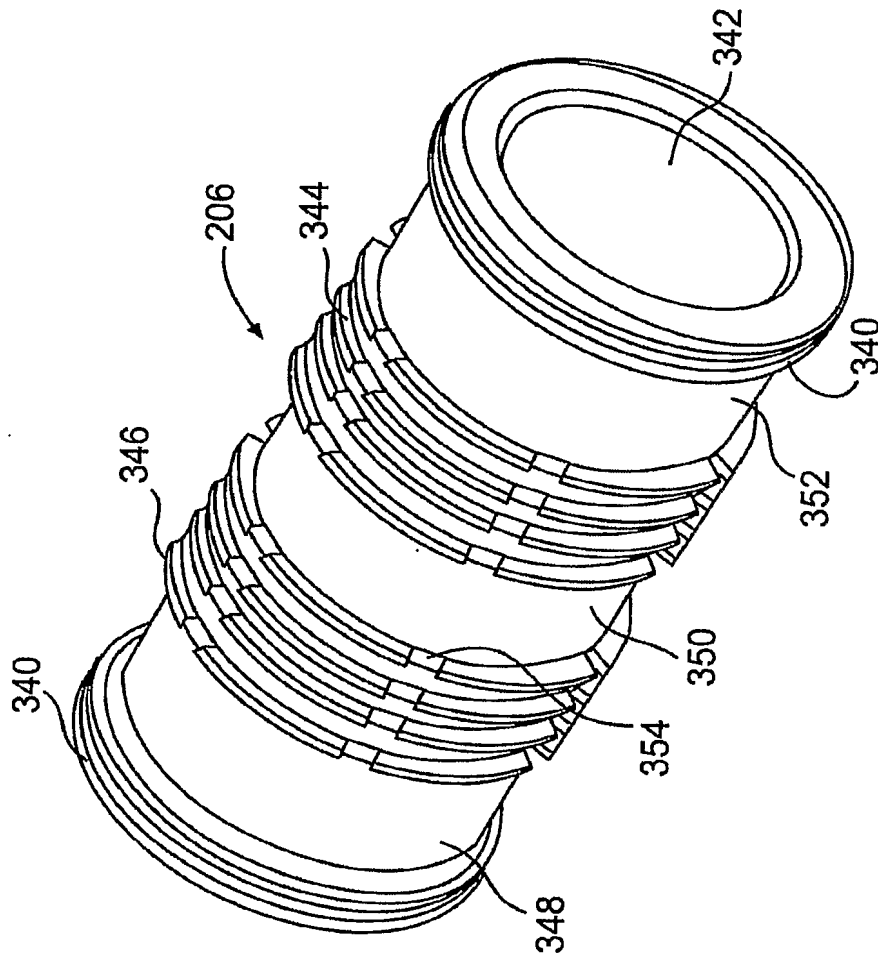


FIG. 6

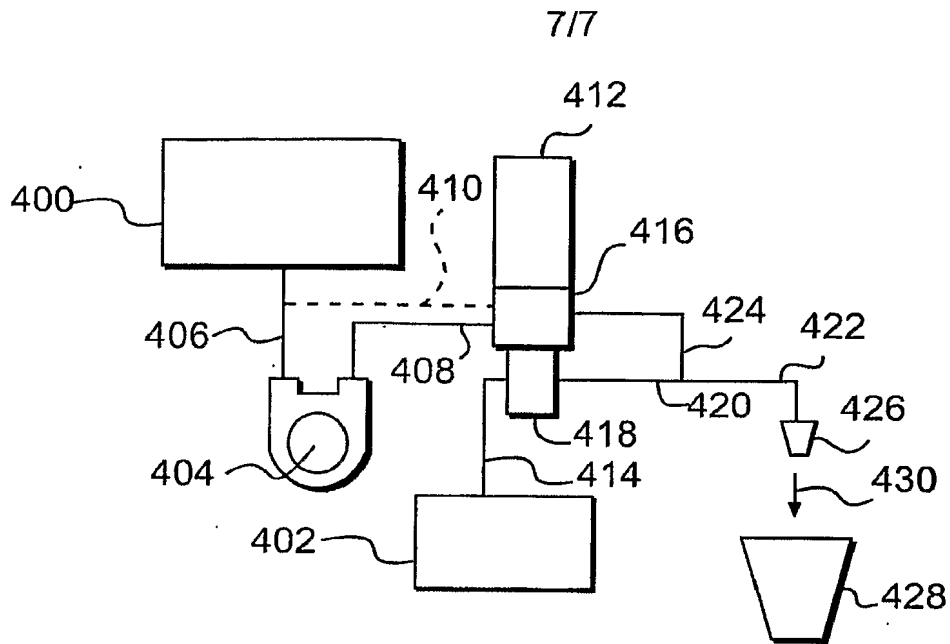


FIG. 7

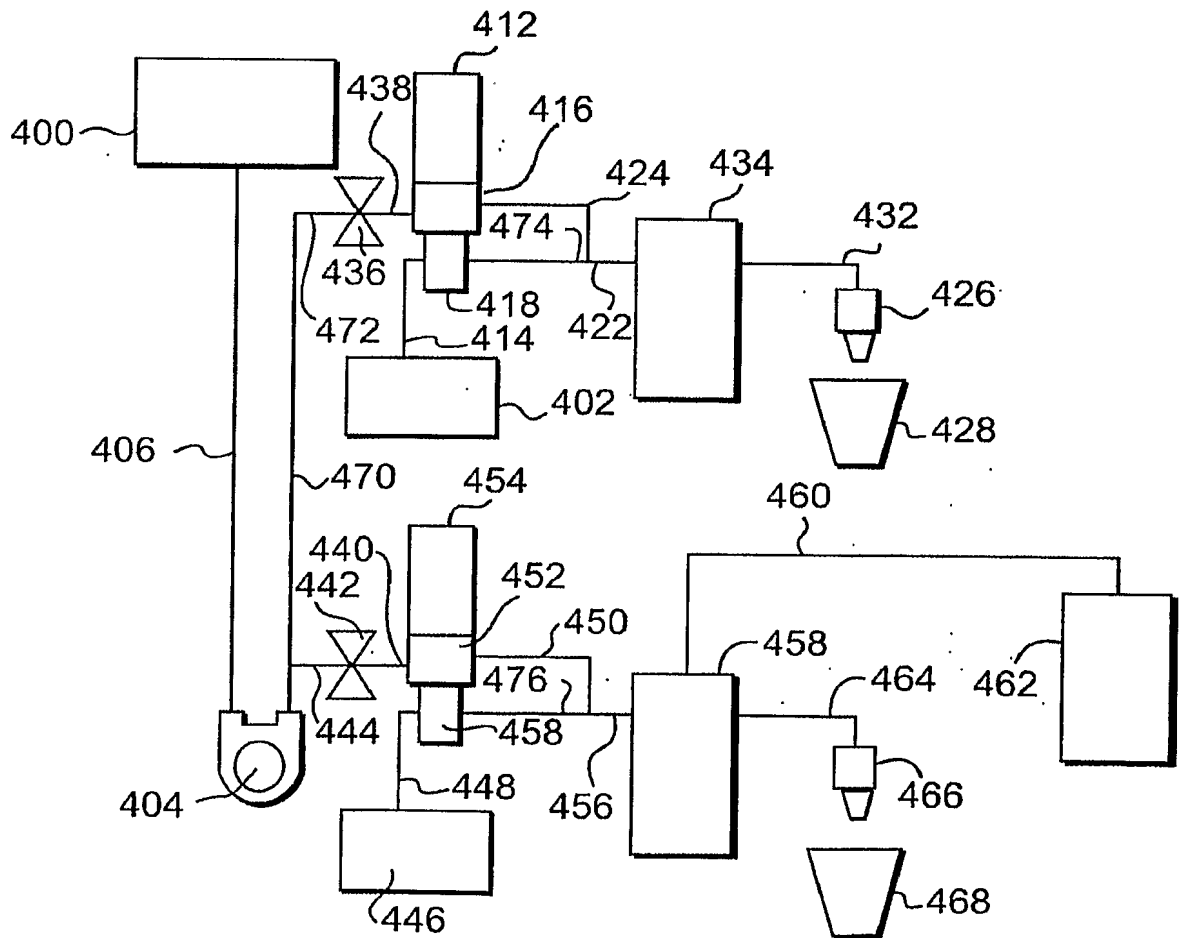


FIG. 8