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PRESSURE POWERED PUMP

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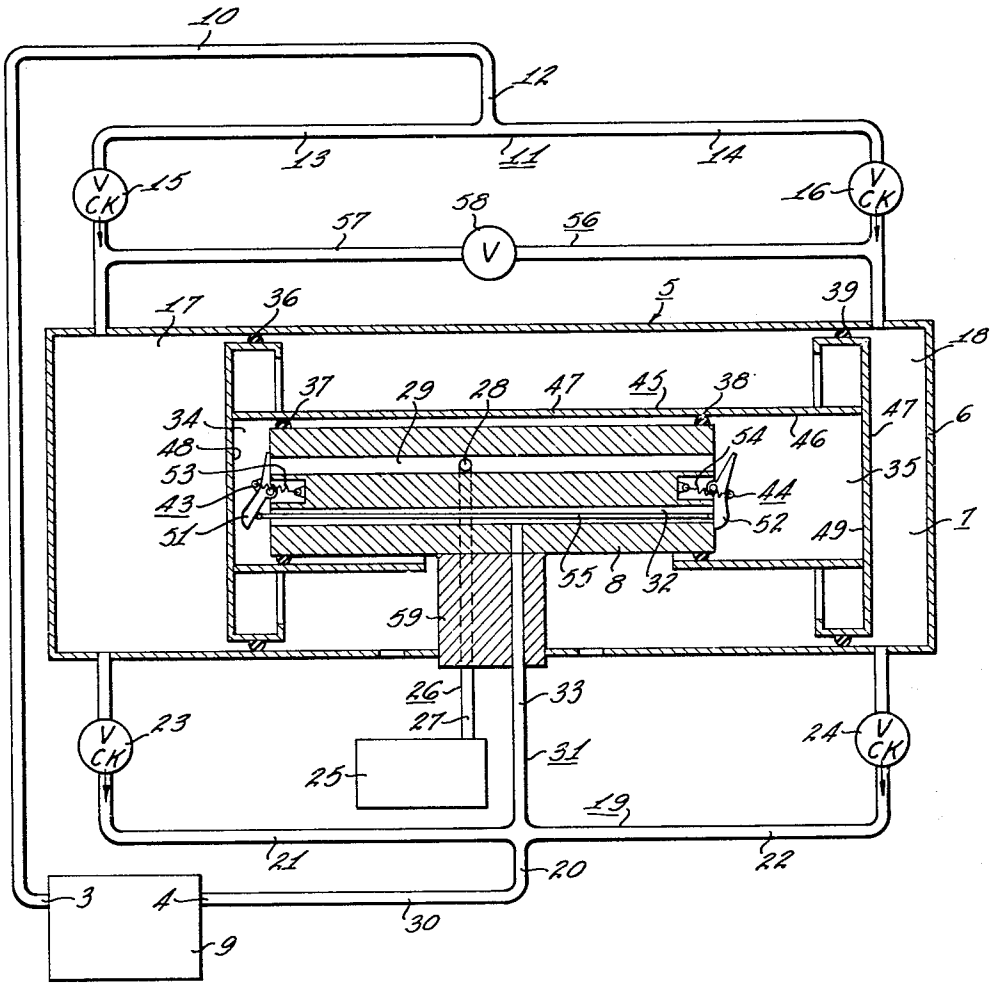

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PRESSURE POWERED PUMP

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This invention relates to pumps, particularly pumps that utilize fluid under pressure as a prime moving force.

Many situations arise where it is desirable to continuously supply and pump a mixture of fluids in determinable proportions. For example, two fluids may be required for a chemical reaction requiring a definite proportion in the mixture. Also, systems that consume fluids, especially where the fluid is only partly consumed and the remainder recirculated, require a continuing replenishment to make up the portion consumed. A singificant example of this latter situation is a fuel cell that requires a continual feeding of fuel fluid, consumes only a portion of the fuel fluid, and passes the remainder out of the fuel cell. Since the amount not consumed usually cannot practically be wasted it is recirculated through the fuel cell and provisions are made for adding more fluid as necessary. While this invention can be advantageously utilized in these or similar applications it is especially adaptable for use in a fuel cell system.

An important advantage of this invention is that the sole force utilized for pumping is the pressure of the fluid furnished to replenish the amount consumed. If this fluid is under pressure, no other pumping or moving apparatus is necessary. In accordance with this invention, the energy of this replenishment fluid under pressure is utilized to pump another fluid, such as the recirculated fluid from a fuel cell, and mix it in determinable proportions with the replenishment fluid.

The objects of this invention are: to provide a new and improved pump for mixing two fluids in determinable proportions; to provide a new and improved means for simultaneously pumping and mixing fluids in determinable proportions; to provide a new and improved means for circulating and supplying fluid to a fluid consuming system, such as a fuel cell; to provide a new and improved pump for simultaneously pumping and mixing fluids while utilizing the delivery pressure of one of the fluids for the prime moving force; and to provide a simple and effective means for recirculating and supplying fuel fluid to replace the fuel fluid consumed by a fuel cell.

Other advantages and objects will be apparent from the following detailed description:

The figure is a partly schematic, cross section drawing of an embodiment of this invention.

While the following description of a specific embodiment of this invention is in combination with a fuel cell, the invention can be used in any application where it is necessary to introduce new fluid into a circulating system or to proportionally mix two fluids. The new fluid may or may not be the same as that recirculated.

Referring to the figure, a pump 5 has a pump housing 6 forming a main chamber 7. A piston 45 having an inner surface 46 and an outer surface 47 is movable relative to the pump housing. The piston is located within the main chamber and encompasses a piston block 8 attached to the pump housing through a piston block support 59. A circulation chamber 17 and a circulation chamber 18 are formed within the main chamber between piston outer surface 47 and pump housing 6. A supply chamber 34 is formed between the piston block and an inner wall 48 of piston inner surface 46. A supply chamber 35 is formed between the piston block and an inner wall 49 of the piston inner surface. The movement of the piston expands one circulation chamber and one supply chamber while it contracts the other circulation and supply chamber. Ring seals 36, 37, 38 and 39 seal the chambers.

A fluid consuming apparatus, such as a fuel cell 9, is connected to the pump so that fluid from an outlet 3 of the fuel cell is drawn into the pump and is discharged from the pump to a fuel cell inlet 4. A fuel cell connecting pipe 10 connects fuel cell outlet 3 to an intake means 11 at an intake conduit 12 an another fuel cell connecting pipe 30 connects fuel cell inlet 4 to an outlet conduit 20. In practice, a means could be located between the outlet of the fuel cell and the pump to remove the end product usually water, formed by the chemical reaction in the fuel cell.

Pump 5 receives new fluid stored under pressure from a fluid source 25. The energy of this fluid stored under pressure is the prime moving force operating the pump to circulate the fluid from the fuel cell and combine it with the new fluid from the fluid source. Thus, the pump performs a dual function of pumping and mixing.

The pump includes: a means for circulating fluid through the fuel cell comprising intake means 11 for connecting the circulation chambers to the fuel cell outlet and discharge means 19 for connecting the circulation chambers to the fuel cell inlet; an operating means comprising an inlet means 26 for delivering the new fluid under pressure to the supply chambers from fluid source 25, an outlet means 31 for discharging from the supply chambers the fluid received under pressure from the fluid source, and a means for pumping both the circulating (recirculated) fluid through the fuel cell and the new fluid received from the fluid source to the fuel cell; and a control means 56 for adjusting the proportion of the circulating fluid to the new fluid that is pumped to the fuel cell.

The circulating means comprises intake means 11 which delivers fluid to the circulation chambers, and discharge means 19 which discharge fluid from the circulation chambers. The intake means includes intake conduit 12, intake pipes 13 and 14, and intake check valves 15 and 16. The discharge means includes discharge pipes 21 and 22 and check valves 23 and 24. Circulation chambers 17 and 18, which are part of the means for pumping, alternately and cyclically expand and contract upon movement of piston 45 to draw fluid from the intake means into the expanding chamber and force it from the contracting chamber to the discharge means. The inlet check valves prevent the contracting chamber from forcing fluid out through the inlet means while allowing the expanding chamber to draw fluid through the inlet means. The outlet check valves prevent the expanding chamber from drawing fluid from the discharge means while allowing the contracting chamber to force fluid into the discharge means.

Thus, the check valves also operate as part of the means for pumping to control the pumping action and circulate the fluid through the circulating means into and out of pump 5 in the proper direction to properly supply the fuel cell with the recirculated fluid.

The operating means comprises inlet means 26, outlet means 31, and the means for pumping. Its function is to receive the fluid under pressure from fluid source 25 and utilize the pressure of this fluid for the power to pump the fluid circulated from the fuel cell (as described above) and to pump the fluid from the fluid source to the fuel cell in a constant, determinable proportion to the circulated fluid.

The inlet means receives the fluid under pressure from the fluid source and delivers it to the supply chambers. The inlet means includes inlet connecting pipe 27 and inlet pipe 29 which connects with supply chambers 34 and 35. Inlet connecting pipe 27 opens into inlet pipe 29 at inlet connecting port 28.

The outlet means communicates wtih the discharge

means at an outlet conduit 21 and thereby connects the supply chambers to the fuel cell. The outlet means includes outlet pipe 32 and outlet connecting pipe 33. The outlet pipe communicates with both supply chambers and is alternately connected to the supply chambers by a cycling means which is part of the means for pumping.

The means for pumping includes circulation chambers 17 and 18 (which operate to pump the circulated fluid as described above) supply chambers 34 and 35 which operate to pump the new fluid, movable piston 45 which functions to expand and contract the circulation and supply chambers, and a cycling means which alternately connects the supply chambers to inlet means 26 and outlet means 31 thereby alternately connecting fluid source 25 and fuel cell 9 to each of the supply chambers. The connection of the supply chambers cyclically alternates between the inlet and outlet means so that one is always connected to one supply chamber and the other is connected to the other supply chamber.

The cycling means comprises a valving means having two positions and a means for switching the valving means from one position to the other. The valving means comprises pumping valves 43 and 44 each of which has two positions and functions to open either the inlet pipe or the outlet pipe while closing the other to its respective supply chamber. The means for switching the valving means comprises valve tripping levers 51 and 52 which are, as shown, part of the pumping valves; snap springs 53 and 54 which function to snap the pumping valves, when activated, from one position to the other; valve connecting rod 55 which connects the pumping valves to each other so that they operate in unison; and the parts of piston inner surface 46, piston inner walls 48 and 49, which coact with the valve tripping levers to change the positions of the pumping valves.

In the operation of the pump, the fluid under pressure flows from fluid source 25 through inlet means 26 to one of the supply chambers. With pumping valves 43 and 44 in the position shown in the figure, the fluid flows to supply chamber 35 and forces piston 45, which is movable relative to the pump housing, to move to the right (using the drawing as reference) thereby contracting supply chamber 34 (and expanding supply chamber 35) and forcing the fluid in supply chamber 34 out of the pump through outlet means 31. This occurs because pumping valve 43 is closed between the inlet means and supply chamber 34 while it is open between the outlet means and supply chamber 35. Piston 45 will continue moving to the right until piston inner wall 48 makes contact with and moves valve tripping lever 51 sufficiently to cause pumping valve 43 to move to its other position (not shown) through the action of snap springs 53 and 54. This reverses the open and closed connections to supply chambers 34 and 35. The pumping valve has now closed the outlet means at outlet pipe 32 and opened the inlet means at inlet pipe 29 relative to supply chamber 34. When pumping valve 43 is tripped, pumping valve 44 also trips to its other position because the two valves are connected by valve connecting rod 55.

As pumping valves 43 and 44 change position (opposite to that shown in the figure), the connections between the fluid source and the supply chambers are reversed and the fluid from the fluid source enters supply chamber 34 through inlet means 26 and the fluid present (previously received from the fluid source) in supply chamber 35 is forced out of supply chamber 35 into outlet means 31. The pressure of the fluid source causes the piston to move to the left until piston inner wall 49 strikes valve tripping lever 52 (which is now raised from the piston block) to cause it to snap back to the position shown in the figure.

In addition to pumping the new fluid to outlet conduit 20, the movement of piston 45 also expands one circulation chamber while contracting the other, as described earlier. With the pumping valves in the position shown in the figure and the piston moving to the right, the volume of circulation chamber 17 increases. The suction effect of the expanding chamber draws fluid from the fuel cell and fuel cell connecting pipe 10 through intake means 11 into circulation chamber 17. With circulation chamber 17 expanding, the part of the intake means that is flowing fluid comprises intake conduit 12, intake pipe 13, and intake check valve 15. (With the piston movement in the other direction, circulation chamber 18 is expanding and the part of the intake means that is flowing fluid comprises intake conduit 12, intake pipe 14, and intake check valve 16.) This action continues until the pumping valves are tripped to their other position to thereby reverse the direction of movement of the piston.

When the piston moves to the left (with the pumping valves in the position opposite to that shown in the figure) the volume of circulation chamber 17 decreases and the fluid in circulation chamber 17, previously drawn from the fuel cell, is forced out through discharge means 19 to outlet conduit 20 and to the fuel cell through fuel cell connecting pipe 30. While the piston moves to the left to contract circulation chamber 17, the part of the outlet means that is flowing fluid comprises discharge pipe 21 and discharge check valve 23. (With the piston movement in the other direction, the part of the discharge means that is flowing fluid comprises discharge pipe 22 and discharge check valve 24.)

Discharge means 19 and outlet means 31 communicate with each other at outlet conduit 20. It is at this point, in the embodiment shown, that the circulating fluid from the fuel cell pumped by the circulation chambers is combined with the fluid from the fluid source pumped by the supply chambers. Therefore, in each cycle of operation, the new fluid received under pressure from the fluid source and pumped out of both supply chambers is combined with the circulating fluid pumped out of both circulation chambers. Since the volume displaced by the contraction of the chambers is constant, the circulating fluid from the circulation chambers and the fluid received under pressure from the supply chambers are pumped by the means for pumping to the outlet conduit and the fuel cell at a constant volumetric proportion to each other. Since the proportion between these two delivered fluids (from the supply chambers and circulation chambers) is determined by the volumetric proportion between the supply chambers and circulation chambers, the delivered proportion can be determined by properly selecting the relative size of the chambers to meet the particular application requirements. There are, however, many different ways that the proportion between the chambers could be varied by changes in design of the chambers. For example, the distance of travel could be selectable and the chambers could be of irregular shape so that a change in distance of travel would vary the proportion between the displaced volumes.

While the volumetric proportion will always remain constant in the embodiment shown, the total output is determined by the rate of cycling (i.e., the number of movements of the piston per unit of time) and the total volume of all the chambers. By using a larger pump with larger chambers, the volume can be increased. The cycling rate is primarily determined by the pressure delivered from the fluid source, but this is influenced by the various resistances along the flow paths and the resistance to movement of the piston. Therefore, the rate of cycling can be controlled to some degree by judicious selection of the conduit sizes and flow path design to balance the resistances to flow between the incoming and outgoing flow paths.

By selecting the relative size of the chambers, it is possible to determine the proportion of new fluid to circulated fluid passing into the circulation means. However, the embodiment shown has greater versatility because this proportion can be easily varied from the determined volumetric ratio by control means 56. The con-

trol means comprises control pipe 57 and control valve 58 and enables circulation chamber 17 to be connected through a variable resistance to circulation chamber 18. By proper adjustment of control valve 58, the resistance to flow along the control means is varied and the fluid pumped from the contracting circulation chamber is divided so that part flows to the other circulation chamber and part flows to outlet conduit 20 in each cycle. The resistance to flow in the control means as compared to the resistance in the discharge means, fuel cell and its piping determines the proportion of fluid flowing between the two circulation chambers and the discharge means.

A similar control means could be connected between the supply chambers. This would also be capable of varying the proportion delivered to the outlet conduit but would also enable adjustment of the rate of cycling by reducing the effective pressure of the fluid source in the expanding supply chamber. This occurs because part (determined by the ratio of flow resistances) of the fluid under pressure would flow into the contracting supply chamber to reduce the pressure differential between the two chambers.

It will be obvious to those skilled in the art that the embodiments discussed or described may be varied or modified without necessarily departing from the spirit of the invention. It will also be obvious that the invention encompasses variations, combinations and adaptations of the described embodiment.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In combination, a fluid consuming apparatus of the type that consumes only a portion of the fluid received,
said apparatus having an inlet for receiving fluid and an outlet for discharging unconsumed fluid;
a fluid source supplying fluid under pressure; and
means, connected to receive fluid from the fluid source and connected to the apparatus inlet and outlet, for pumping unconsumed fluid from the apparatus outlet to the apparatus inlet and for pumping fluid received from the fluid source to the apparatus inlet at a determinable volumetric proportion to the pumped unconsumed fluid,
said means powered by the pressure of the fluid received from the fluid source.

2. A combination according to claim 1 wherein the means for pumping comprises control means for adjusting the said volumetric proportion.

3. In combination, a fluid consuming apparatus of the type that consumes only a portion of the fluid received having an inlet for receiving fluid and an outlet for discharging unconsumed fluid; a fluid source supplying fluid under pressure; and a pump comprising
a pump housing forming a main chamber;
a movable piston located within the main chamber to form a pair of alternately expanding and contracting circulation chambers and to form a pair of alternately expanding and contracting supply chambers,
said piston movable relative to the pump housing to draw unconsumed fluid from the apparatus outlet into each circulation chamber as it expands and to pump unconsumed fluid out of each circulation chamber as it contracts to the apparatus inlet;
intake means for connecting the apparatus outlet to the expanding circulation chamber;
discharge means for connecting the apparatus inlet to the contracting circulation chamber;
inlet means for connecting the fluid source to the supply chambers;
outlet means for connecting the apparatus inlet to the supply chambers; and
cycling means for connecting the inlet means alternately to the supply chambers to effect cyclic expansion and contraction of the circulation and supply chambers and for connecting the outlet means to the contracting supply chamber to pump fluid from the contracting supply chamber to the apparatus inlet.

4. A pump powered by the pressure of a first fluid received under pressure for pumping said first fluid and for pumping a second fluid from a second fluid source at a predetermined volumetric proportion to the first fluid,
said pump comprising
a pump housing forming a main chamber;
a movable piston located within the main chamber to form a pair of alternately expanding and contracting circulation chambers and a pair of alternately expanding and contracting supply chambers,
said piston movable relative to the pump housing to draw second fluid directly from the second fluid source into each circulation chamber as it expands and to pump second fluid out of each circulation chamber as it contracts;
intake means for connecting the second fluid source to the expanding circulation chamber;
discharge means for discharging second fluid out of the pump from each contracting circulation chamber;
inlet means for delivering first fluid to the supply chambers;
outlet means for discharging first fluid from the supply chambers; and
cycling means for connecting the inlet means alternately to the supply chambers in response to the position of the piston to effect cyclic expansion and contraction of the circulation and supply chambers and for connecting the outlet means to each supply chamber as it contracts to pump first fluid out of the pump.

5. A pump according to claim 4 wherein the discharge means and the outlet means are connected to each other.

6. A pump according to claim 4 having control means for adjusting said volumetric proportion.

7. A pump powered by the pressure of a first fluid received under pressure for pumping said first fluid and for pumping a second fluid from a second fluid source at a predetermined volumetric proportion to the first fluid,
said pump comprising
a pump housing forming a main chamber;
a movable piston located within the main chamber to form a pair of alternately expanding and contracting circulation chambers and a pair of alternately expanding and contracting supply chambers;
intake means external to the pump housing for connecting the second fluid source to the expanding circulation chamber;
said piston movable relative to the pump housing to draw second fluid directly from the intake means into each circulation chamber as it expands and to pump second fluid out of each circulation chamber as it contracts;
discharge means for discharging second fluid out of the pump housing from each circulation chamber as it contracts;
inlet means for delivering first fluid to the supply chambers;
outlet means for discharging first fluid from the supply chambers; and
cycling means for connecting the inlet means alternately to the supply chambers in response to the position of the piston to effect cyclic expansion and contraction of the circulation and supply chambers and for connecting the outlet means to each supply chamber as it contracts to pump first fluid out of the pump.

8. A pump powered by the pressure of a first fluid received under pressure for pumping said first fluid and for pumping a second fluid from a second fluid source at a predetermined volumetric proportion to the first fluid,
said pump comprising
a pump housing forming a main chamber;
a movable piston located within the main chamber to form a pair of alternately expanding and contracting circulation chambers and a pair of alternately expanding and contracting supply chambers,

said piston movable relative to the pump housing to draw second fluid directly from the second fluid source into each circulation chamber as it expands and to pump second fluid out of each circulation chamber as it contracts;

intake means for connecting the second fluid source to the expanding circulation chamber;

discharge means for discharging second fluid out of the pump housing from the contracting circulation chamber;

inlet means for delivering first fluid to the supply chambers;

outlet means for discharging first fluid from the supply chamber;

valving means having two positions for connecting the inlet means alternately to each of the supply chambers to effect cyclic movement of the piston by the pressure of the first fluid causing expansion of the supply chamber currently connected to the inlet means; and switching means for switching the valving means alternately from one position to the other in response to a predetermined minimum volume of the currently contracting supply chamber and for connecting the outlet means alternately to the supply chambers to connect the currently contracting supply chamber to the outlet means.

9. In combination, a fluid consuming apparatus of the type that consumes only a portion of the fluid received, said apparatus having an inlet for receiving fluid, an outlet for discharging unconsumed fluid; a fluid source supplying fluid under pressure; and a pump comprising a pump housing forming a main chamber, a piston located within the main chamber to form two circulation chambers and two supply chambers, said piston movable relative to the pump housing to expand one circulation chamber and one supply chamber while contracting the other circulation chamber and the other supply chamber, intake means for connecting the apparatus outlet to the expanding circulation chamber, discharge means for connecting the apparatus inlet to the contracting circulation chamber, inlet means for connecting the fluid source to the supply chambers, outlet means for connecting the apparatus inlet to the supply chambers, and cycling means for alternately connecting each of the supply chambers to the outlet means and the inlet means to move the piston and alternately and cyclically expand and contract the circulation chambers and the supply chambers.

10. A pump powered by the pressure of a first fluid received under pressure for pumping said first fluid and for pumping a second fluid from a second fluid source at a predetermined volumetric proportion to said first fluid, said pump comprising a pump housing forming a main chamber; a piston located within the main chamber to form circulation chambers and supply chambers, said piston movable relative to the pump housing to expand one circulation chamber and one supply chamber while contracting another circulation chamber and another supply chamber; intake means for delivering fluid only to the expanding circulation chamber; discharge means for discharging fluid from the contracting circulation chamber; inlet means for delivering first fluid to the supply chambers; outlet means for discharging fluid from the supply chambers; valving means having two positions, said positions alternately connecting the inlet means to the supply chambers to effect movement of the piston and connecting the output means to each supply chamber as it contracts; and means for switching the valving means from one position to the other in response to the position of the piston.

11. In combination, a fluid consuming apparatus of the type that consumes only a portion of the fluid received, said apparatus having an inlet for receiving fluid and outlet for discharging fluid; a fluid source supplying fluid under pressure; and a pump connected to the inlet and outlet of the apparatus and to the fluid source, said pump comprising a pump housing forming a main chamber, a piston located within the main chamber to form

two circulation chambers and two supply chambers, said piston movable relative to the pump housing to expand one circulation chamber and one supply chamber while contracting the other circulation chamber and the other supply chamber, intake means for connecting the apparatus outlet to the expanding circulation chamber, discharge means for connecting the apparatus inlet to the contracting circulation chamber, inlet means for connecting the supply chambers to the fluid source, outlet means for connecting the apparatus inlet to the supply chambers, valving means having two positions, said positions alternately connecting the inlet means and the outlet means to each of the supply chambers with the first position having the inlet means open to one supply chamber and closed to the other supply chamber and the outlet means open to the supply chamber closed to the inlet means and closed to the supply chamber open to the inlet means, and the second position having all the open connections of the first position closed and all the closed connections of the first position open, means for switching the valving means from one position to the other to cyclically expand and contract the circulation and supply chambers, and control means for adjusting the volumetric proportion between the first and second fluid pumped to the apparatus.

12. A pump comprising a pump housing forming a main chamber; a piston block located within the main chamber; a movable piston having an inner and outer wall located with the main chamber to form two alternately expanding and contracting circulation chambers between the outer wall and the pump housing, said piston encompassing the piston block to form two alternately expanding and contracting supply chambers between the piston block and the inner wall; intake means for delivering fluid to the expanding circulation chamber; discharge means for discharging fluid from the contracting circulation chamber; inlet means for delivering fluid under pressure to the supply chambers; outlet means for discharging fluid from the supply chambers; valving means having a first and second position, said first position connecting the inlet means to one supply chamber while connecting the outlet means to the other supply chamber, and said second position reversing the connections of the inlet means and the outlet means relative to the supply chambers; and means responsive to the position of the piston for switching the valving means from one position to the other position.

13. In combination, a fuel cell of the type consuming only a portion of fuel fluid received having an inlet for receiving fuel fluid and outlet for discharging unconsumed fuel fluid; a fluid source delivering fluid under pressure; and a pump connected to the inlet and outlet of the fuel cell and connected to the fluid source comprising a pump housing forming a main chamber, a piston block located within the main chamber, a piston having an inner and outer wall located with the main chamber to form two opposed circulation chambers between the outer wall and the pump housing, said piston encompassing the piston block to form two opposed supply chambers between the piston block and the inner wall, and said piston movable within the main chamber relative to the pump housing and the piston block to expand one circulation chamber and one supply chamber while contracting the other circulation chamber and the other supply chamber, intake means for connecting the fuel cell outlet to the expanding circulation chamber, discharge means for connecting the fuel cell inlet to the contracting circulation chamber, inlet means for connecting the fluid source to the supply chambers, outlet means for connecting the fuel cell inlet to the supply chambers, valving means having a first and second position, said first position connecting the fluid source to one supply chamber to effect movement of the piston to expand said one supply chamber while connecting the fuel cell inlet to the contracting supply chamber, and said second position reversing the connections of the fluid source and the fuel cell inlet relative

to the supply chambers to reverse the movement of the piston, and means for switching the valving means from the first position to the second position when one supply chamber reaches a minimum volume and from its second position to its first position when the other supply chamber reaches a minimum volume.

14. A combination according to claim 13 wherein said pump has an adjustable flow means connected between the circulation chambers.

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