CLAIMS

I claim:

1. A fluid pump for a linear actuator, comprising:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of a fluid chamber formed on opposite sides of a piston disposed within said fluid chamber;

a driven pump element disposed within said housing;

a first shuttle disposed on a first axial side of said driven pump element and movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along a first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along a second fluid flow path;

a first check valve disposed on a second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve disposed on said second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a second shuttle disposed on said second axial side of said driven pump element and movable between a first position in which said second shuttle causes said first check valve to assume said open position and a second position in which said second shuttle causes said second check valve to assume said open position;

wherein rotation of said driven pump element in a first rotational direction results in movement of said first shuttle to said first fluid flow position, movement of said first check valve to said open position and movement of said second shuttle to said second position and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in movement of said first shuttle to said second fluid flow position, movement of said second valve to said open position and movement of said second shuttle to said first position.

2. The fluid pump of claim 1 wherein each of said first and second check valves includes:

a valve housing defining first and second fluid ports;

a ball disposed within said housing; and,

a spring biasing said ball against a valve seat formed in said valve housing between said first and second fluid ports to prevent fluid flow between said first and second fluid ports.

3. The fluid pump of claim 1 wherein said first shuttle is movable to a neutral position between said first and second fluid flow positions.

4. The fluid pump of claim 3 wherein said first shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said first shuttle is in said neural position.

5. The fluid pump of claim 1 further comprising first and second springs disposed on opposite sides of said first shuttle and biasing said first shuttle to a neutral position different from said first and second fluid flow positions.

6. The fluid pump of claim 5 wherein said first shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position.

7. A fluid pump for a linear actuator, comprising:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of a fluid chamber formed on opposite sides of a piston disposed within said fluid chamber;

a driven pump element disposed within said housing;

means for controlling fluid flow between said inlet port and said driven pump element; and,

means for controlling fluid flow between said driven pump element and said first and second outlet ports

wherein rotation of said driven pump element in a first rotational direction results in fluid flow between said inlet port and said driven pump element along a first fluid flow path, fluid flow from said driven pump element to said first outlet port and fluid flow from said second outlet port to said driven pump element and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in fluid flow between said inlet port and said driven pump element along a second fluid flow path, fluid flow from said driven pump element to said second outlet port and fluid flow from said first outlet port to said driven pump element.

8. The fluid pump of claim 7 wherein said means for controlling fluid flow between said inlet port and said driven pump element comprises a shuttle movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along said first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along said second fluid flow path.

9. The fluid pump of claim 8 wherein shuttle is movable to a neutral position between said first and second fluid flow positions.

10. The fluid pump of claim 9 wherein said shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said shuttle is in said neural position.

11. The fluid pump of claim 8 further comprising first and second springs disposed on opposite sides of said shuttle and biasing said shuttle to a neutral position different from said first and second fluid flow positions.

12. The fluid pump of claim 11 wherein said shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position.

13. The fluid pump of claim 7 wherein said means for controlling fluid flow between said driven pump element and said first and second outlet ports comprises:

a first check valve disposed on a second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve disposed on said second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a shuttle disposed movable between a first position in which said shuttle causes said first check valve to assume said open position and a second position in which said shuttle causes said second check valve to assume said open position.

14. A linear actuator, comprising:

a tube defining a fluid chamber;

a piston disposed within said fluid chamber;

a pushrod coupled to said piston for movement with said piston;

a fluid pump including:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of said fluid chamber formed on opposite sides of said piston;

a driven pump element disposed within said housing;

a first shuttle disposed on a first axial side of said driven pump element and movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along a first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along a second fluid flow path;

a first check valve disposed on a second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve disposed on said second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a second shuttle disposed on said second axial side of said driven pump element and movable between a first position in which said second shuttle causes said first check valve to assume said open position and a second position in which said second shuttle causes said second check valve to assume said open position;

wherein rotation of said driven pump element in a first rotational direction results in movement of said first shuttle to said first fluid flow position, movement of said first check valve to said open position and movement of said second shuttle to said second position and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in movement of said first shuttle to said second fluid flow position, movement of said second valve to said open position and movement of said second shuttle to said first position; and,

a motor coupled to said driven pump element.

15. The linear actuator of claim 14 wherein each of said first and second check valves includes:

a valve housing defining first and second fluid ports;

a ball disposed within said housing; and,

a spring biasing said ball against a valve seat formed in said valve housing between said first and second fluid ports to prevent fluid flow between said first and second fluid ports.

16. The linear actuator of claim 14 wherein said first shuttle is movable to a neutral position between said first and second fluid flow positions.

17. The linear actuator of claim 16 wherein said first shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said first shuttle is in said neural position.

18. The linear actuator of claim 14 further comprising first and second springs disposed on opposite sides of said first shuttle and biasing said first shuttle to a neutral position different from said first and second fluid flow positions.

19. The linear actuator of claim 18 wherein said first shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position.

20. The linear actuator of claim 14 wherein rotation of said driven pump element in said first rotational direction results in fluid flow from said driven pump element back to said reservoir and rotation of said driven pump element in said second rotational direction results in fluid flow from said reservoir to said driven pump element.

21. The linear actuator of claim 14 further comprising:

a lid disposed within said fluid reservoir; and,

means for biasing said lid in a first direction

wherein said lid is movable within said reservoir in response to fluid pressure acting in a second direction, opposite said first direction, to vary the fluid volume of said fluid reservoir.

CLAIMS

1. A fluid pump for a linear actuator, comprising:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of a fluid chamber formed on opposite sides of a piston disposed within said fluid chamber;

a driven pump element disposed within said housing;

a first shuttle disposed on a first axial side of said driven pump element and movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along a first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along a second fluid flow path;

a first check valve disposed on a second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve disposed on said second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a second shuttle disposed on said second axial side of said driven pump element and movable between a first position in which said second shuttle causes said first check valve to assume said open position and a second position in which said second shuttle causes said second check valve to assume said open position;

wherein rotation of said driven pump element in a first rotational direction results in movement of said first shuttle to said first fluid flow position, movement of said first check valve

to said open position and movement of said second shuttle to said second position and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in movement of said first shuttle to said second fluid flow position, movement of said second valve to said open position and movement of said second shuttle to said first position.

2. The fluid pump of claim 1 wherein each of said first and second check valves includes:

a valve housing defining first and second fluid ports;

a ball disposed within said housing; and,

a spring biasing said ball against a valve seat formed in said valve housing between said first and second fluid ports to prevent fluid flow between said first and second fluid ports.

3. The fluid pump of claim 1 wherein said first shuttle is movable to a neutral position between said first and second fluid flow positions.

4. The fluid pump of claim 3 wherein said first shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said first shuttle is in said neutral position.

5. The fluid pump of claim 1 further comprising first and second springs disposed on opposite sides of said first shuttle and biasing said first shuttle to a neutral position different from said first and second fluid flow positions.

6. The fluid pump of claim 5 wherein said first shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position.

7. A fluid pump for a linear actuator, comprising:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of a fluid chamber formed on opposite sides of a piston disposed within said fluid chamber;

a driven pump element disposed within said housing;

means for controlling fluid flow between said inlet port and said driven pump element; and,

means for controlling fluid flow between said driven pump element and said first and second outlet ports

wherein rotation of said driven pump element in a first rotational direction results in fluid flow between said inlet port and said driven pump element along a first fluid flow path, fluid flow from said driven pump element to said first outlet port and fluid flow from said second outlet port to said driven pump element and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in fluid flow between said inlet port and said driven pump element along a second fluid flow path, fluid flow from said driven pump element to said second outlet port and fluid flow from said first outlet port to said driven pump element.

8. The fluid pump of claim 7 wherein said means for controlling fluid flow between said inlet port and said driven pump element comprises a shuttle movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along said first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along said second fluid flow path.

9. The fluid pump of claim 8 wherein shuttle is movable to a neutral position between said first and second fluid flow positions.

10. The fluid pump of claim 9 wherein said shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said shuttle is in said neutral position.

11. The fluid pump of claim 8 further comprising first and second springs disposed on opposite sides of said shuttle and biasing said shuttle to a neutral position different from said first and second fluid flow positions.

12. The fluid pump of claim 11 wherein said shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position.

13. The fluid pump of claim 7 wherein said means for controlling fluid flow between said driven pump element and said first and second outlet ports comprises:

a first check valve disposed on a second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve disposed on said second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a shuttle disposed movable between a first position in which said shuttle causes said first check valve to assume said open position and a second position in which said shuttle causes said second check valve to assume said open position.

14. A linear actuator, comprising:

a tube defining a fluid chamber;

a piston disposed within said fluid chamber;

a pushrod coupled to said piston for movement with said piston;

a fluid pump including:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of said fluid chamber formed on opposite sides of said piston;

a driven pump element disposed within said housing;

a first shuttle disposed on a first axial side of said driven pump element and movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along a first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along a second fluid flow path;

a first check valve disposed on a second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve disposed on said second axial side of said driven pump element and movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a second shuttle disposed on said second axial side of said driven pump element and movable between a first position in which said second shuttle causes said first check valve to assume said open position and a second position in which said second shuttle causes said second check valve to assume said open position;

wherein rotation of said driven pump element in a first rotational direction results in movement of said first shuttle to said first fluid flow position, movement of said first check valve to said open position and movement of said second shuttle to said second position and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in movement of said first shuttle to said second fluid flow position, movement of said second valve to said open position and movement of said second shuttle to said first position; and,

a motor coupled to said driven pump element.

15. The linear actuator of claim 14 wherein each of said first and second check valves includes:

a valve housing defining first and second fluid ports;

a ball disposed within said housing; and,

a spring biasing said ball against a valve seat formed in said valve housing between said first and second fluid ports to prevent fluid flow between said first and second fluid ports.

16. The linear actuator of claim 14 wherein said first shuttle is movable to a neutral position between said first and second fluid flow positions.

17. The linear actuator of claim 16 wherein said first shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said first shuttle is in said neutral position.

18. The linear actuator of claim 14 further comprising first and second springs disposed on opposite sides of said first shuttle and biasing said first shuttle to a neutral position different from said first and second fluid flow positions.

19. The linear actuator of claim 18 wherein said first shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position.

20. The linear actuator of claim 14 wherein rotation of said driven pump element in said first rotational direction results in fluid flow from said driven pump element back to said reservoir and rotation of said driven pump element in said second rotational direction results in fluid flow from said reservoir to said driven pump element.

21. The linear actuator of claim 14 further comprising:

a lid disposed within said fluid reservoir; and,

means for biasing said lid in a first direction

wherein said lid is movable within said reservoir in response to fluid pressure acting in a second direction, opposite said first direction, to vary the fluid volume of said fluid reservoir.

22. The linear actuator of claim 8 wherein said first and second fluid flow paths do not extend around either longitudinal end of said shuttle.

23. A fluid pump for a linear actuator, comprising:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of a fluid chamber formed on opposite sides of a piston disposed within said fluid chamber;

a driven pump element disposed within said housing;

a first shuttle movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along a first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along a second fluid flow path;

a first check valve movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a second shuttle movable between a first position in which said second shuttle causes said first check valve to assume said open position and a second position in which said second shuttle causes said second check valve to assume said open position;

wherein rotation of said driven pump element in a first rotational direction results in movement of said first shuttle to said first fluid flow position, movement of said first check valve to said open position and movement of said second shuttle to said second position and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in movement of said first shuttle to said second fluid flow position, movement of said second valve to said open position and movement of said second shuttle to said first position

wherein said first shuttle is movable to a neutral position between said first and second fluid flow positions and said first shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position.

24. The fluid pump of claim 23 wherein said first shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said first shuttle is in said neutrall position.

25. The fluid pump of claim 23 further comprising first and second springs disposed on opposite sides of said first shuttle and biasing said first shuttle to said neutral position.

26. A linear actuator, comprising:

a tube defining a fluid chamber;

a piston disposed within said fluid chamber;

a pushrod coupled to said piston for movement with said piston;

a fluid pump including:

a housing defining an inlet port configured for fluid communication with a fluid reservoir and first and second outlet ports configured for fluid communication with first and second portions of said fluid chamber formed on opposite sides of said piston;

a driven pump element disposed within said housing;

a first shuttle movable between a first fluid flow position permitting fluid flow between said inlet port and said driven pump element along a first fluid flow path and a second fluid flow position permitting fluid flow between said inlet port and said driven pump element along a second fluid flow path;

a first check valve movable between a closed position and an open position permitting fluid flow between said driven pump element and said first outlet port;

a second check valve movable between a closed position and an open position permitting fluid flow between said driven pump element and said second outlet port; and,

a second shuttle movable between a first position in which said second shuttle causes said first check valve to assume said open position and a second position in which said second shuttle causes said second check valve to assume said open position;

wherein rotation of said driven pump element in a first rotational direction results in movement of said first shuttle to said first fluid flow position, movement of said first check valve to said open position and movement of said second shuttle to said second position and rotation of said driven pump element in a second rotational direction opposite said first rotational direction results in movement of said first shuttle to said second fluid flow position, movement

of said second valve to said open position and movement of said second shuttle to said first position;

wherein said first shuttle is movable to a neutral position between said first and second fluid flow positions and said first shuttle inhibits fluid flow along said first and second fluid flow paths when in said neutral position; and,

a motor coupled to said driven pump element.

27. The linear actuator of claim 26 wherein said first shuttle defines first and second labyrinth seals configured to inhibit fluid flow along said first and second fluid flow paths when said first shuttle is in said neutral position.

28. The linear actuator of claim 26 further comprising first and second springs disposed on opposite sides of said first shuttle and biasing said first shuttle to said neutral position.

29. The linear actuator of claim 26 wherein rotation of said driven pump element in said first rotational direction results in fluid flow from said driven pump element back to said reservoir and rotation of said driven pump element in said second rotational direction results in fluid flow from said reservoir to said driven pump element.

30. The linear actuator of claim 26 further comprising:

a lid disposed within said fluid reservoir; and,

means for biasing said lid in a first direction

wherein said lid is movable within said reservoir in response to fluid pressure acting in a second direction, opposite said first direction, to vary the fluid volume of said fluid reservoir.