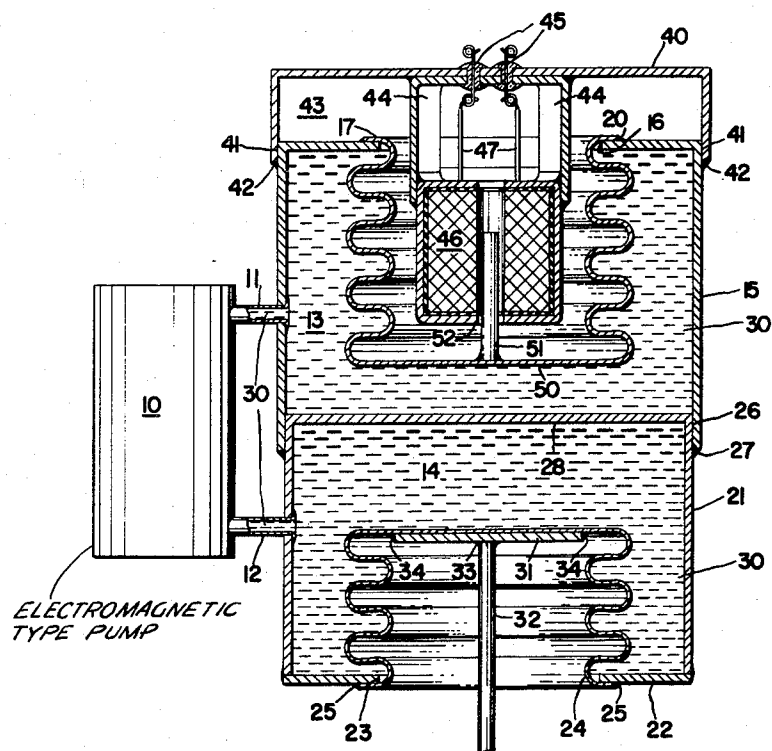


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CONDUCTIVE FLUID ACTUATOR

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CONDUCTIVE FLUID ACTUATOR

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The present invention is directed to a conductive fluid filled actuator which is operated by two force producing electromagnetic devices.

A conductive fluid actuator having a single electromagnetic force producing pump is improved by the addition of an electromagnetic actuator in the form of a solenoid. The present application discloses two conductive fluid filled chambers having bellows sealing each of the chambers. Interconnected between the two chambers is an electromagnetic conductive fluid or Faraday type pump. This type of pump has a continuously open, fluid flow channel. The pumping action is a result of the flow of an electric current and a magnetic field in the passage wherein the electric current and magnetic field are mutually perpendicular to one another. The interaction of the current and field was recognized by Faraday and provides a propelling or pumping pressure of somewhat the same type as a conventional mechanical pump. It will be appreciated that if the two variable volume chambers are so associated, that the movement of the conductive fluid from one chamber will cause a decrease in its volume, while the movement will cause an increase in the volume of the second chamber. This movement of fluid and change in volume of chambers is utilized to move a mechanical load.

In the present invention the basic movement described above is utilized to overcome the force of a load. A second electromagnetic device, in the form of a solenoid and plunger, is attached to the input chamber or bellows so as to be capable of moving or collapsing the bellows. Upon this movement a resultant change of distribution of conductive fluid between the chambers results and accomplishes a movement of the load being controlled. In effect, the solenoid and its plunger can move a substantial sized load due to the initial bias or pressure placed on the system by the Faraday or electromagnetic type pump. The details of a typical embodiment are explained below. From the above discussion it becomes obvious that the presently disclosed conductive fluid actuator has distinct advantages over actuators of other types.

The primary object of the present invention is to disclose an actuator that is capable of moving a substantial load while utilizing an exceedingly small control voltage or power.

Another advantage of the present arrangement is to disclose an actuator capable of moving a load in a substantially silent and trouble-free fashion.

Yet another object of the present arrangement is to disclose an actuator that can be operated on either alternating current or direct current without any inconvenience or changes in its basic construction.

These and other objects will become clearly apparent when the single figure disclosed is considered in detail with the following specification.

In the disclosure, figure 10 represents a Faraday or electromagnetic type of pump having an inlet 11 and an

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outlet 12. Many types of internal configurations are possible in the electromagnetic type pump but it is understood that the only requirement for the present arrangement is that the pump have a continuously open channel or passage means from the inlet 11 to the outlet 12. This channel is not blocked in any manner by impeller blades, pistons, or other moving mechanical objects. The pump 10 can be energized by alternating or direct current with the only requirement being that a means is provided within the pump 10 to supply an electric current and a magnetic field which are mutually perpendicular to one another and which cross the passage means from the inlet 11 to the outlet 12. Any combination of alternating current and direct current components are permissible as long as the current and flux are at sometime in phase and are mutually perpendicular to one another. Many examples of this type of pump are known to those versed in the art and it is believed that no detailed showing is either warranted or necessary.

The inlet 11 of the fluid passage is connected to a variable volume chamber generally shown at 13. This chamber will be designated as the input chamber. The outlet 12 of the passage means is connected to a second or output variable volume chamber 14. The variable volume chamber 13 is formed of a cup-shaped member 15 having an opening 16 sealed by a bellows 17. The seal is accomplished by means of welding or soldering at 20. The variable volume output chamber 14 is formed of a cup-shaped member 21 having an end plate 22 which in turn has an opening 23. The opening 23 is sealed by a bellows 24 by means of welding or soldering at 25. The cup-shaped member 21 is inserted in the cup-shaped member 15 at 26 and is sealed by welding or soldering at 27. By this arrangement the cup-shaped member 21 forms a fixed wall at 28 which separates the chambers 13 and 14. The chambers 13 and 14, as well as the pump passage means, are filled with a conductive fluid 30. The conductive fluid 30 can be any type of fluid which will readily conduct electricity and is more commonly found in the state as a conductive liquid or a liquid metal. When a liquid metal is utilized a common form would be mercury. In addition to mercury other liquid metals are available for use at the room ambients. An example of this type of liquid metal would be a combination of sodium and potassium which is liquid to 12° Fahrenheit. Other liquid metals can be utilized at higher temperatures, such as sodium or potassium by themselves. As indicated the most convenient fluid for use is either mercury or the sodium-potassium mixture which is commonly referred to as NaK.

In considering the arrangement which has been described to this point it is obvious that if the pump 10 is operated to move the conductive fluid from the input tube 11 to the output tube 12 that the bellows 17 will expand while the bellows 24 is compressed. With this operation the variable volume chamber 13 decreases in volume while the chamber 14 increases in volume. The movement of the fluid can be utilized to perform a work function as will be described below.

Attached to the end of bellows 24 is a plate 31 and a shaft 32. The shaft and plate can be formed of integral members or can be attached to one another in any convenient manner as by welding at 33. In the disclosed embodiment the plate 31 is attached to bellows 24 by a soldered joint 34. If the volume of chamber 14 is increased with a resultant collapsing of the bellows 24 the plate 31 and the shaft 32 are caused to move in a downward direction. The movement of shaft 32 in a downward direction can be utilized to operate any convenient mechanical type of load. With this arrangement the

load, which has not been shown, would also have a bias means which would tend to force the shaft 32 in an upward direction if the driving force created by the pump 10 were removed. If the energization of pump 10 stops, the force tending to restore the bellows 24 to its extended position would quite easily move the fluid 30 from the chamber 14 back through the open passage means in pump 10 to the chamber 13. It is thus apparent that a pump of the electromagnetic or Faraday type, in that it has a continuously open passage means, has a distinct advantage in the present type of arrangement.

In addition to the structure shown a cup member 40 is inserted over the end of cup 15 at 41 and is attached by welding or soldering at 42. The cup member 40 forms an air tight chamber 43 which includes the interior of the bellows 17. In order to provide ease of operation the chamber 43 can be evacuated, and if this is the case all joints are necessarily air tight. Attached to the cup-shaped member 40 is a bracket 44. Passing through the bracket 44 and the cup 40 are two insulated terminals 45. These terminals are of the glass bead type and are well known in the electrical art.

The bracket 44 within the chamber 43 supports a conventional solenoid 46 which has energizing leads 47 attached to the terminal 45. With this arrangement the solenoid 46 can be energized within the evacuated chamber 43 by the application of electric power to terminals 45. The solenoid 46 can be constructed so as to be operable either on alternating current or direct current and its construction is well known and will not be described in detail.

Attached to the end 50 of the bellows 17 is a magnetic plunger 51. The plunger 51 passes into the center 52 of the solenoid 46 so that when the bellows 17 is in its most extended state the plunger 51 is extended and not centered in the solenoid 46. If the solenoid 46 were energized under these conditions a magnetic attraction would be generated to pull the plunger 51 into the center of the opening 52 and thereby create a force in an upward direction on the end 50 of the bellows 17.

The operation of the present device can best be understood if its two basic functions are considered independent of one another. The first function is the energization of the pump 10 with sufficient power to move the conductive fluid 30 from the variable volume chamber 13 to the variable volume chamber 14. The power supplied in propelling the conductive fluid 30 is just sufficient to overcome the load attached to shaft 32 and the bellows 24 is collapsed to the position shown in the drawing. With the movement of the conductive fluid 30 from the variable volume chamber 13 to chamber 14, the bellows 17 is extended to its maximum dimension as shown. The extension of bellows 17 moves the wall 50 to its most downward position thereby pulling the magnetic plunger 51 out of the tube 52 to the position as indicated in the drawings. If an appropriate electric potential is applied across the terminals 45 an attraction is generated in the solenoid 46 for the plunger 51. The attraction moves the plunger 51 to its most centered position, that is in an upward direction. The movement of the plunger 51 moves the wall 50 of the bellows 17 in an upward direction thereby increasing the volume of the variable volume chamber 13. Since there is no impediment in the pump 10 or the passages 11 and 12, the conductive fluid 30 moves from the chamber 14 to the chamber 13 thereby causing the bellows 24 to expand. The expansion of bellows 24 in turn moves the shaft 32 in an upward direction and returns the load attached to the shaft 32 to an initial or unoperated position.

It becomes apparent that the bulk of the work power supplied in overcoming the load attached to shaft 32 is supplied directly to the pump 10 and that this energization is continuous and constant in nature. Only a slight amount of power is required for the operation of

the solenoid 46 to overcome the almost balanced condition established by the energization of the pump 10. With the present arrangement it becomes apparent that most of the power utilized in doing the mechanical work is derived from the energization of pump 10 whereas only an insignificant amount of control power is required for the energization of the solenoid 46 to yield a control function. With the present arrangement it therefore becomes obvious that an unusual electromechanical actuator has been provided. The actuator is capable of doing substantial work while it is controllable by a very slight additional power to a separate electromechanical unit.

The present device has many applications and can be modified in a number of ways. The power supplied to the terminals 45 can come from any source of alternating or direct current potential, such as an amplifier, a manually controlled power source, or any other type of electrical output system. The actuator can be modified in numerous ways as to the location of the solenoid 46 and the manner in which it is operated. Further, a purely mechanical amplifying arrangement can be utilized with the present arrangement to obtain the same end result. For these reasons it is apparent that those skilled in the art could vary the specific disclosure contained in the present specification extensively within the scope of the invention. For this reason the applicant wishes to be limited in the scope of the invention only by the appended claims.

I claim as my invention:

1. A conductive fluid actuator for operating a load: input and output variable volume chambers joined by continuously open passage means; a conductive fluid filling said chambers and said passage means; means establishing a mutually perpendicular electric current and magnetic field in said passage means; said electric current and said magnetic field creating a force in said fluid to propel some of said fluid from said input to said output chambers against the load to in turn move the load from a first position; force producing means attached to one of said chambers and capable of increasing the volume of said input chamber; and control means connected to said force producing means to controllably increase the volume of said input chamber and thereby reduce the volume of said output chamber; said change in volumes of said chambers causing said output chamber to return the load towards its first position.

2. A conductive fluid actuator for operating a load: input and output variable volume chambers joined by continuously open passage means; a conductive fluid filling said chambers and said passage means; electromagnetic conductive fluid pump means establishing a mutually perpendicular electric current and magnetic field in said passage means; said electric current and said magnetic field creating a force in said fluid to pump some of said fluid from said input to said output chambers against the load to in turn move the load from a first position; force producing means attached to said input chamber and capable of increasing the volume of said input chamber; and control means connected to said force producing means to controllably increase the volume of said input chamber and thereby reduce the volume of said output chamber; said change in volumes of said chambers causing said output chamber to return the load to its first position.

3. A conductive liquid actuator for operating a load: input and output variable volume chambers joined by continuously open passage means; a conductive liquid filling said chambers and said passage means; electromagnetic conductive liquid pump means establishing a mutually perpendicular electric current and magnetic field in said passage means; said electric current and said magnetic field creating a force in said liquid to pump some of said liquid from said input to said output chambers against the load to in turn move the load

from a first position; electromagnetic force producing means attached to said input chamber and capable of increasing the volume of said input chamber; and electrical power means connected to said force producing means to energize said force producing means to controllably increase the volume of said input chamber and thereby reduce the volume of said output chamber; said change in volumes of said chambers causing said output chamber to return the load to its first position.

4. A liquid metal actuator for operating a load: input and output chambers joined by continuously open passage means; said chambers each having a flexible wall and being therefore variable in volume; a liquid metal filling said chambers and said passage means; an electromagnetic liquid metal pump establishing a mutually perpendicular electric current and magnetic field in said passage means; said electric current and said magnetic field creating a force in said liquid metal to pump some of said liquid from said input to said output chambers against the load to in turn move the load from a first position; solenoid means mounted adjacent to the flexible wall of said input chamber and having an armature attached to said wall; said armature moving to increase the volume of said input chamber when said solenoid means is energized; and electrical power means connected to said solenoid means to controllably move said armature to increase the volume of said input chamber and thereby reduce the volume of said output chamber; said change in volumes of said chambers causing said output chamber to return the load towards its first position.

5. A conductive liquid actuator for operating a load: input and output chambers joined by continuously open passage means; said chambers each having a bellows sealed portion and being therefore variable in volume; a conductive liquid filling said chambers and said passage means; means establishing a mutually perpendicular electric current and magnetic field in said passage means; said electric current and said magnetic field creating a force in said liquid to propel some of said liquid from

said input to said output chambers against the load to in turn move the load from a first position; solenoid means mounted adjacent to the bellows of said input chamber and having an armature attached to said bellows; said armature moving to increase the volume of said input chamber when said solenoid means is energized; and an electrical power source connected to said solenoid means to controllably move said armature to increase the volume of said input chamber and thereby reduce the volume of said output chamber; said change in volumes of said chambers causing said output chamber to return the load toward its first position.

6. A liquid metal actuator for operating a load: input and output variable volume chambers joined by a continuously open passage; each said chamber having a bellows sealed portion; a liquid metal filling said chambers and said passage; an electromagnetic liquid metal pump establishing a mutually perpendicular electric current and magnetic field in said passage; said electric current and said magnetic field creating a force in said liquid metal to pump some of said liquid metal from said input to said output chambers against the load to in turn move the load from a first position; a solenoid and solenoid plunger mounted adjacent to the bellows of said input chamber; said solenoid plunger attached to said bellows to increase the volume of said input chamber upon energizing said solenoid; and an electrical power source connected to said solenoid to controllably move said solenoid plunger to increase the volume of said input chamber and thereby reduce the volume of said output chamber; said change in volumes of said chambers causing said output chamber to return the load towards its first position.

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