

Oct. 24, 1961

W. L. CARLSON, JR
SELF-REVERSING APPARATUS

3,005,313

Filed Nov. 13, 1959

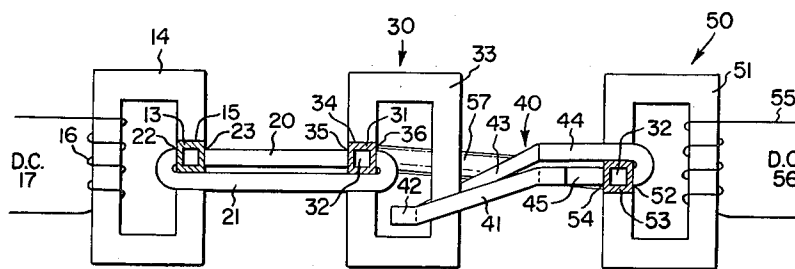
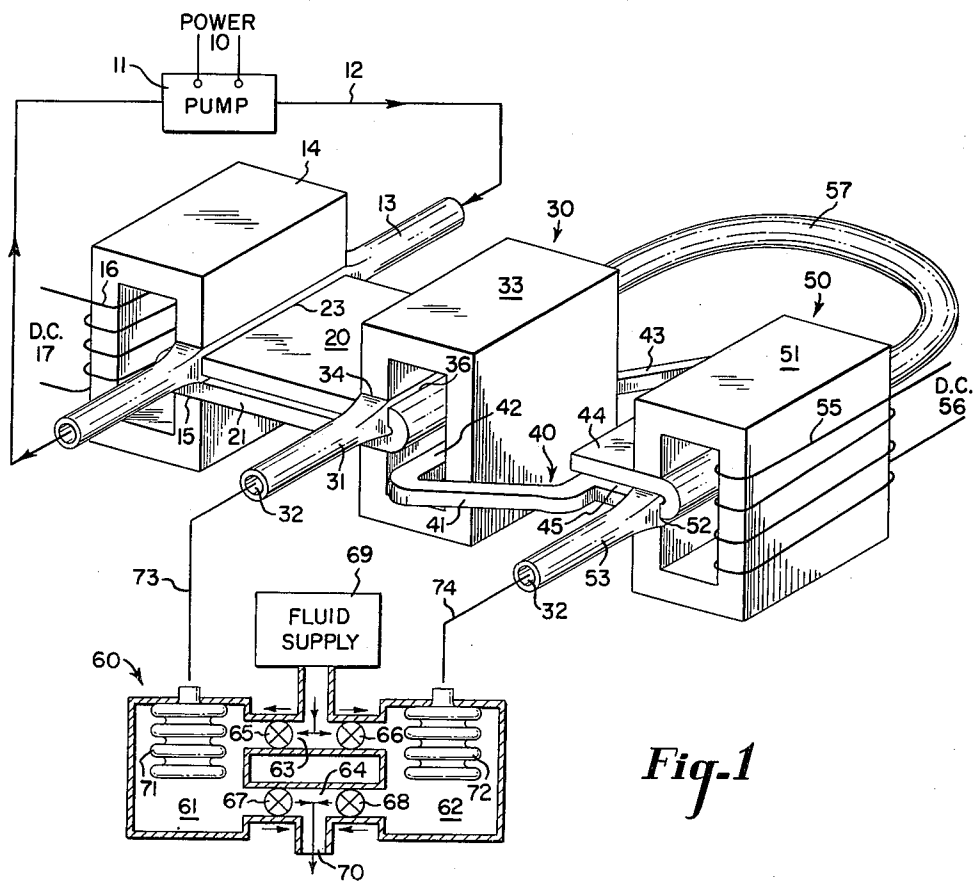


Fig. 2

INVENTOR.
WILLIAM L. CARLSON, JR.
BY *Alfred M. Feldman*
ATTORNEY

1

3,005,313

SELF-REVERSING APPARATUS

William L. Carlson, Jr., Bloomington, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Filed Nov. 13, 1959, Ser. No. 852,741

6 Claims. (Cl. 60—54.5)

The present invention is directed to a self-reversing device utilizing units which are normally operated in a unidirectional manner. More specifically, the present invention is disclosed as a device that is built up of a group of electromagnetic conductive fluid pump like units wherein the device is self-reversing to give a reciprocating action.

The invention disclosed is directed to a device which can be readily used as a pump, but has unique features not found in similar devices. The operation of the present device is based on a principle developed by Faraday many years ago and which has been commonly used as a means of propelling a conductive fluid. The more common terminology for the pump is an electromagnetic conductive fluid pump and there are many such pumps known in the art. The present invention utilizes the advantages of a conductive fluid pump to in turn move a nonconductive fluid without the need of more commonly utilized equipment such as pressure or immersion type switching. In the present invention a power source is used to energize an electromagnetic conductive fluid device, and this device then supplies a pressure to a conductive fluid system to operate variable volume chamber means. The variable volume chamber means in turn is utilized to move a second fluid through a set of check valves in the same manner as a piston driven pump. This is unusual in that the normal electromagnetic conductive fluid pump is capable of operating in a single direction only upon energization and will not normally reverse unless the electrical energy to either of two parts of the pump is switched.

The prior art, such as Spencer No. 1,792,449, recognized the advantage of utilizing a conductive fluid pump to vary the volume of a pair of chambers to in turn move a second fluid through check valves as is done in a piston driven type pump. The prior art, however, utilized the conductive fluid to open and short circuit contacts projecting down into the conductive fluid chambers to operate electromechanical reversing devices of the relay type. When a unit of this type is operated it is apparent that normal switching problems created by opening and closing an electric circuit within the chamber of the pump create undesirable end results. This would be particularly true if the chamber atmosphere were explosive in nature. The present invention is directed to an arrangement wherein the switches can be totally dispensed with and the pumping device is self-reversing at the end of each stroke or change in volume of the variable volume chambers associated with the device.

It is the primary object of the present invention to disclose an electromagnetic conductive fluid device that is capable of pumping a second fluid without the need of any type of switching function.

It is a further object of the present invention to disclose a self-reversing or oscillating type of electromagnetic conductive fluid pump.

2

It is still a further object of the present invention to disclose a pump wherein the only moving parts are the pumped fluid and the valving necessary to form a check valve system.

These and other objects will become apparent when the sheet of drawings is fully considered along with the present specification, wherein:

FIGURE 1 is a combined isometric and schematic representation of one form of the invention, and

FIGURE 2 is an elevation of the isometric part of the disclosure of FIGURE 1.

At the outset it should be understood that it is common to move a conductive fluid by means of an electromagnetic conductive fluid pump wherein the conductive fluid is caused to flow by an electric current and a magnetic field angularly disposed to each other and to the direction of flow of the fluid. This is the basic teaching of Faraday and is well known in the patent and commercial arts. In a direct current device the magnetic field can be created either by the direct current linking or encircling a magnetic structure or by the use of a permanent magnet. It is also possible to pump the conductive fluid by the use of an alternating current passing between electrodes through the conductive fluid while reacting with a magnetic field that is induced by the same current passing through a coil around the associated magnetic field structure.

In the conductive fluid art the more common conductive fluids are mercury, sodium, potassium, and a mixture of sodium and potassium which is normally referred to as NaK. While these are the more commonly utilized conductive fluids it is understood that the term conductive fluid can be broadly applied to conductive gases and any other medium which is capable of flowing and also carrying some degree of electric current. This general class of fluid will be referred to in the present specification as a conductive fluid. This differentiation in terminology is made in view of the fact that part of the presently disclosed device is capable of pumping a nonconductive fluid as well as a fluid which would be classed as conductive.

In FIGURE 1 there is disclosed a power source 10 which energizes a pump 11. The power source and pump can be of any type but preferably would be an electromagnetic conductive fluid pump. The pump supplies a continuous flow of conductive fluid in a fluid circuit 12 which is unidirectional in operation. The operation of the pump is continuous and since the fluid circuit is a complete loop the flow is substantially uniform. A portion of the circuit 12 is a tube 13 which passes through a magnetic structure 14 that has an opening or gap 15. The magnetic circuit also has a winding 16 and a direct current energizing source 17. Joined to the sides of the tube 13 of the fluid circuit 12 are two electrodes 20 and 21. The electrodes can be best seen in FIGURE 2, where they are shown in elevation. The electrode 21 passes through the gap 15 and joins the inner side of the tube 13 at 22. It is understood that the electrode 21 is properly insulated from the magnetic structure 14 and from the tube 13 except at the juncture or joint 22. The electrode 20 is joined to tube 13 at 23.

The structure as previously described, that is, the magnetic structure 14, the tube 13, and the electrodes 20 and 21, form a conventional electromagnetic conductive fluid flow device. In the present showing the

device is operated as a current generator wherein the direct current 17 supplied to the winding 16 creates a constant magnetic field in the magnetic structure 14. This flux passes across the gap 15 and reacts with the continuously flowing fluid in the circuit 12. The action of the continuously flowing conductive fluid in circuit 12 and the constant magnetic field generates an exceedingly high current, low voltage value of direct current.

In the present disclosure, this direct current generator forms no integral part of the invention and could be replaced by any suitable high current, low voltage, direct current voltage source. Since this type of source, that is a high current, low voltage source, is difficult to obtain a preferred arrangement for supplying the current has been detailed but in no way affects the operation of the novel portion of the unit. The current supply to electrodes 20 and 21 could come from a conventional transformer-rectifier arrangement if so desired.

The heart of the present invention is centered around two electromagnetic conductive fluid flow means 30 and 50. These two means are generally similar but are not identical in construction and operation. The first electromagnetic conductive flow means has fluid flow channel means 31 which contains a conductive fluid 32 which is capable of being moved in the electromagnetic conductive fluid means 30. The flow means 30 further has a magnetic structure 33 which has an associated gap 34 through which the channel 31 passes. Connected to the side 35 of the channel 31 is electrode 20. Connected to the side 36 of the channel 31 is electrode 21. The electrode 21 passes through the gap 34 in an insulated manner well known in the conductive fluid pump art.

An electric conductor means 40 links the magnetic structure 33. The electric conductor means is made up of a thick strap 41 of a conductive material, preferably such as copper. The thick strap 41 passes through the magnetic structure 33 at 42 and connects by means of a rear portion 43 to an electrode 44. The electrode 44 can be an integral part of the electric conductor means 40. A second electrode 45 is provided and is connected integrally with the conductor strap 41 to complete the electric conductor means 40. The electrode 44 passes through a magnetic structure 51 and joins the inner side 52 of a channel means 53 which in turn also contains the conductive fluid 32. The electrode 45 joins the channel means 53 at 54 so that current can pass in the electrical conductor means 40 between the electrodes 44 and 45, through the channel means 53 and conductive fluid 32. The magnetic structure 51 is then linked by a conventional coil 55 which is supplied with direct current from a source 56.

To complete the portion of the device described, a channel portion 57 connects the channel means 31 and 53 into a complete series type of conductive fluid circuit. Since the operation of the unit so far described depends on the balance of the structure as an integral part of the unit, the balance of the unit will be described in some detail before the operation is discussed.

Variable volume chamber means 60 is disclosed having two independent chambers 61 and 62 which are joined by two similar passage means 63 and 64. Check valves are provided in passage means 63 at 65 and 66 so that a second fluid from the fluid supply 69 can be caused to flow in the passage means 63 and through the check valves 65 and 66 to the chambers 61 and 62. A second pair of check valves 67 and 68 are provided to control the flow of the second fluid 69 out of chambers 61 and 62 through the passage 70. The arrangement just described, that is the fluid supply 69, the group of check valves and passage means, and the passage or opening 70, forms a conventional unidirectional arrangement for fluid flow when differential pressures or volumes are applied to chambers 61 and 62. The chamber 61 is sealed by a bellows 71 while chamber 62 is sealed by a bellows 72. The bellows 71 is connected by ap-

propriate piping 73 to the passage 31 while bellows 72 is connected by piping 74 to the passage 53. It is understood that the piping 73 and 74 along with bellows 71 and 72 are filled with the conductive fluid 32.

In the operation of the pump section involving the variable chamber means 60, it is understood that if the bellows 71 is caused to collapse that the fluid 32 in the bellows and associated passage means will cause the bellows 72 to expand. If this process is then reversed, that is bellows 72 collapsing and forcing bellows 71 to expand, it is understood that a conventional pumping arrangement is supplied wherein the fluid in 69 can be moved from the fluid supply through the check valves 65, 66, 67, and 68 in a manner well understood in the pump art. By the arrangement just described a reciprocating action of the bellows 71 and 72 can thus cause the pumping of the fluid from the fluid supply 69 and this fluid can be of any type at all. With the use of the present arrangement it is understood that the fluid supply 69 could readily be the atmosphere thereby creating an air pressure or could be some more viscous type fluid such as an oil.

In order to obtain the reciprocating action of the bellows 71 and 72 the device made up of the electromagnetic conductive fluid flow means 30 and 50 are supplied. The operation of this arrangement will now be detailed. At the outset it must be understood that certain physical and electrical relationships exist in electromagnetic conductive fluid devices. The first relationship is that if a magnetic field and an electric current are flowing in a direction angularly disposed to each other that a pressure develops in any conductive fluid exposed to this reaction. Conversely if a conductive fluid flows through a passage while a magnetic field in the associated magnetic circuit exists, a current will be generated in the associated angularly disposed electrodes.

Applying the above principles to the present invention it is understood that electrodes 20 and 21 supply a continuous current across the channel 31 through the conductive fluid 32. If the conductive fluid is caused to move, as by a mechanical disturbance of the bellows 71, an electric current will be generated between electrodes 44 and 45 in the conductor means 40. The generated electric current in the conductor means 40 links the device 30, and particularly links the magnetic circuit 33. The current in conductor means 40 linking the magnetic structure 33 creates a magnetic field in the magnetic circuit 33 that passes across the gap 34 which includes the conductive fluid 32. The magnetic flux in the magnetic circuit 33 reacts with the current flow in electrodes 20 and 21 to create a pumping pressure that aids the initial disturbance in the fluid 32. This causes the fluid flow in the device 50 to increase thereby increasing the generation of electric potential between electrodes 44 and 45. This in turn continues to activate the pumping pressure in unit 30.

The pumping pressure developed in the device 30 moves the fluid 32 in the device 50 thereby continuing the generation of the electric current in the conductor means 40 which in turn supplies a continuous pumping pressure. It is obvious therefore that once this device starts the fluid is moved from bellows 71 through the device 30 to the device 50 and into the bellows 72. The pressure developed in this system is such that when the bellows 71 has collapsed and bellows 72 has fully expanded the pumping pressure is overcome and the system stalls due to the mechanical limitations of the expansion and contractions of the bellows and/or the fluid pressure in chambers 61 and 62. At this point the natural resilience of the bellows 71 and 72 tends to force the fluid 32 to reverse its direction in the units 30 and 50. This slight reversal of fluid flow causes the unit 50 to generate an electric current in conductor means 40 in the opposite direction or of an opposite polarity to that originally developed. This reversal is supplied as a reversed current

5

to electrodes 44 and 45 which then reverses the pumping pressure created by the unit 30.

The reversal of pumping pressure in the unit 30 causes the fluid 32 to flow in the opposite direction from the first described direction thereby causing bellows 72 to collapse while expanding bellows 71. Again the bellows 71 and 72 reach their extremes thereby stalling the pumping pressure developed in the units 50 and 30. This again causes the fluid to stop and a slight reversal again occurs due to the resilience of bellows 71 and 72. At this time the conductive fluid device described again reverses and it should be understood that this process continues thereby causing a reciprocation of the fluid 32 and the bellows 71 and 72. This continuous reversal of the device is created without any type of switching and in effect creates a pair of moving pistons in the chamber means 60. This movement being continuously repetitive causes a pumping from the fluid source 69. It will thus be appreciated that a self-reversing electromagnetic conductive fluid pump arrangement has been provided and that no switching or similar problems arise in the operation of the unit. The arrangement which has been described is ideal for developing pressures in a nonconductive fluid by the use of an electromagnetic conductive fluid device that has no moving parts other than the conductive fluid and the bellows or variable volume chamber means 60. This arrangement provides for a very efficient pump capable of many applications.

While the device disclosed in the present specification has been described as a direct current device, it should be understood that the unit is capable of operation from an alternating current source. In such case the current supplied to the electrodes 20 and 21 could be an alternating current from a stepped-down type transformer. Along with this arrangement the coil 55 would be energized from an alternating current source of the proper phase and as long as the proper phase relationship is maintained between the energization of coil 55 and of the electrodes 20 and 21 the device will be self-reversing at the proper times to cause the described operation. Since the structure of such an arrangement is quite complicated and more difficult to visualize, the simplified form of a direct current unit has been specifically described in the present application.

It should be understood that the invention of the present application can be modified in many ways and applied to various types of devices. As such the applicant wishes to be limited in the scope of his invention only in view of the scope of the appended claims.

I claim as my invention:

1. In a direct current electromagnetic conductive fluid operated reciprocating device: a first electromagnetic conductive fluid unit with a fluid flow channel wherein a conductive fluid is caused to flow by a direct electric current and a magnetic field angularly disposed to each other and to the direction of flow of said fluid; direct current source means continuously supplying said electric current; a second electromagnetic conductive fluid unit with a second fluid flow channel wherein said conductive fluid flows with a resultant second electric current and a constant unidirectional magnetic field angularly disposed to each other and to the direction of flow of said fluid; two bellows sealed conductive fluid filled chambers connected by said channels in a single series fluid circuit; and electric conductor means encircling the said first fluid unit and forming a current conductor for said second unit to generate said first magnetic field in said first channel; said device automatically reversing the direction of flow of said fluid upon said fluid being stalled by said bellows sealed chambers being operated to an extreme position.

2. In a self-reversing electromagnetic conductive fluid device: a first electromagnetic conductive fluid unit with a fluid flow channel wherein a conductive fluid is caused to flow by an electric current and a magnetic field angularly disposed to each other and to the direction of

6

flow of said fluid; direct current source means continuously supplying said electric current; a second electromagnetic conductive fluid unit with a second fluid flow channel wherein said conductive fluid flows with a second electric current and a constant unidirectional magnetic field angularly disposed to each other and to the direction of flow of said fluid; two variable volume conductive fluid filled chambers connected by said channels in a single series fluid circuit; and electric conductor means encircling said first fluid unit and forming current conductor means for said second unit to conduct said second current thereby generating said first magnetic field in said first channel.

3. In an electromagnetic conductive fluid device: a first electromagnetic conductive fluid unit with a fluid flow channel wherein a conductive fluid is caused to flow by an electric current and a magnetic field angularly disposed to each other and to the direction of flow of said fluid; direct current source means supplying said electric current; a second electromagnetic conductive fluid unit with a second fluid flow channel wherein said conductive fluid flows with a second electric current and a second magnetic field angularly disposed to each other and to the direction of flow of said fluid; two variable volume chambers containing said fluid and connected by said channel in a single fluid circuit; and electric conductor means linking said first fluid unit and forming current conductor means for said second unit to conduct said second current thereby generating said first magnetic field in said first channel.

4. In a device of the class described: first electromagnetic conductive fluid flow means with fluid flow channel means wherein a conductive fluid is caused to flow by an electric current and a magnetic field angularly disposed to each other and to the direction of flow of said fluid; current source means supplying said electric current; second electromagnetic conductive fluid flow means with said fluid flow channel means wherein said conductive fluid flows with a second electric current and a second magnetic field angularly disposed to each other and to the direction of flow of said fluid; load means containing said conductive fluid and connected by said channel means in a single series fluid circuit; and electric conductor means linking said first fluid flow means and forming current conductor means for said second flow means to pass said second current thereby generating said first magnetic field in said channel means.

5. In a device of the class described: first electromagnetic conductive fluid flow means with fluid flow channel means wherein a conductive fluid is caused to flow by an electric current and a magnetic field angularly disposed to each other and to the direction of flow of said fluid; second electromagnetic conductive fluid flow means with said fluid flow channel means wherein said conductive fluid flows with a second electric current and a second magnetic field angularly disposed to each other and to the direction of flow of said fluid; load means containing said conductive fluid and connected by said channel means in a single series fluid circuit; and electric conductor means linking said first fluid flow means and forming current conductor means for said second flow means to pass said second current thereby generating said first magnetic field in said channel means.

6. In a device of the class described: first electromagnetic conductive fluid flow means with fluid flow channel means wherein a conductive fluid is caused to flow by an electric current and a magnetic field angularly disposed to each other and to the direction of flow of said fluid; current source means supplying said electric current; second electromagnetic conductive fluid flow means with said fluid flow channel means wherein said conductive fluid flows with a second electric current and a second magnetic field angularly disposed to each other and to the direction of flow of said fluid; variable volume chamber means containing said conductive fluid and connected by said channel means in a single fluid circuit; and electric

conductor means linking said first fluid flow means and forming current conductor means for said second flow means to pass said second current thereby generating said first magnetic field in said channel means; said device automatically reversing the direction of flow of said fluid upon said fluid being stalled by said chamber means being operated to an extreme position thereby providing a reciprocating motion.

References Cited in the file of this patent

UNITED STATES PATENTS

192,072 Jamieson ----- June 19, 1877

5

1,282,145
1,792,449
2,258,415
2,434,705
2,715,190

745,460

Tobler ----- Oct. 22, 1918
Spencer ----- Feb. 10, 1931
Lago ----- Oct. 7, 1941
Lago ----- Jan. 20, 1948
Brill ----- Aug. 9, 1955

FOREIGN PATENTS

Great Britain ----- Feb. 29, 1956

10