Aug. 17, 1965 W. A. RAY 3,200,591

POLARIZED SOLENOID ACTUATING SYSTEM

Filed Sept. 30, 1963

FIG. 1.

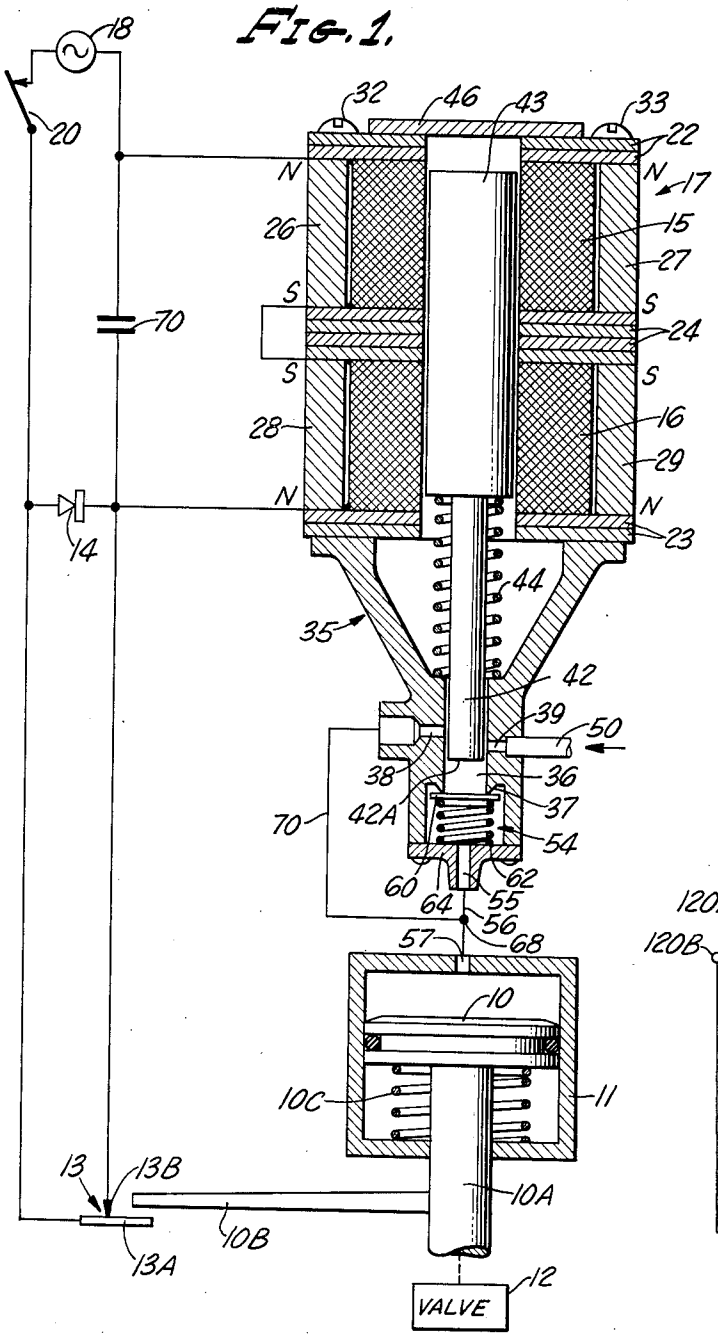


FIG. 3

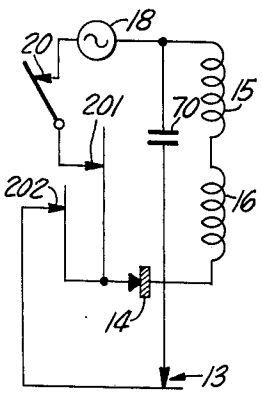
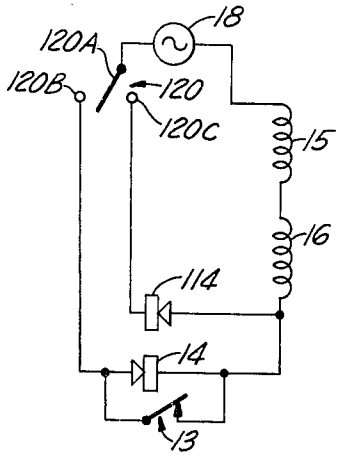


FIG. 2.



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POLARIZED SOLENOID ACTUATING SYSTEM

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The present invention relates to hydraulic control systems in which an element such as, for example, a piston comprising a valve actuator is electrically controlled.

Large prior art valves have heretofore been operated using a motor having its rotor either coupled directly or indirectly through hydraulic means to an operating element of the valve. In accordance with some of the features of the present invention, a reciprocating motor-type drive is used to control a hydraulic system for uniquely applying pressure to the operating element for the valve. While the present application describes a valve control system, the invention in its broader aspects is not so limited since it will be obvious to those skilled in the art that the invention has utility for other purposes and is, in general, useful for controlling pressures to a cylinder containing a spring-urged piston to which pressures are selectively applied.

Another important feature of the present invention involves the construction of a reciprocating motor which is particularly useful in the control of a hydraulic system.

Another feature of the invention resides in the construction of an electrically driven pump which involves a polarized solenoid construction having its coil producing either one of three functions depending upon whether (1) the coil is de-energized; (2) the coil is energized with alternating current; or (3) the coil is energized with rectified D.C. In this first condition, i.e. with the coil de-energized, a spring acting on the armature of the solenoid construction urges a plunger, attached to such armature, to a position within a fluid chamber wherein, at that time, the plunger allows fluid communication between a pressure relief port and a second port, such relief port being in communication with a cylinder containing a spring-urged piston such that the piston may then return to its normal position by spring forces acting thereon with the fluid displaced by the piston flowing, in turn, through the relief port, the chamber and the second port. In the second condition, i.e. with the coil energized with A.C., the armature and plunger attached thereto vibrate about a mean position to achieve a pumping action in the chamber, the plunger serving to maintain the relief port closed and to periodically open the second port for entrapping fluid which is discharged into the cylinder through a spring-urged valve that normally closes one end of the chamber, to thereby pump fluid into the cylinder and to move the piston therein against its spring-urging means. In the third condition, which is achieved when the piston is moved to its fully actuated position to cause the solenoid coil to be energized with rectified D.C., the pumping action terminates and the plunger closes both the relief port and the second port to maintain the pressure in the cylinder and the piston in its fully actuated position.

It is therefore a general object of the present invention to provide improved means and techniques for accomplishing the above-indicated features.

Another general object of the present invention is to provide a system and component parts thereof functioning to produce the results indicated above.

A specific object of the present invention is to provide an improved pump using a polarized solenoid construction.

Another specific object of the present invention is to provide a reciprocating motor containing a single coil but responsive to three different conditions.

Another specific object of the present invention is to provide a novel construction for a polarized solenoid.

Another specific object of the present invention is to provide a hydraulic actuating system characterized by its simplicity, flexibility, inexpensiveness and its fail-safe feature involving restoration of parts to their normal positions upon current failure.

Another specific object of the present invention is to provide a system of this character using a polarized solenoid performing three basic functions in accordance with the method of electrically operating the solenoid.

Another object of the present invention is to provide an arrangement of this character in which a hydraulically operated means may be selectively positioned in any one of a range of positions.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 illustrates a construction and system embodying features of the present invention.

FIGURE 2 illustrates a modification of the present invention.

FIGURE 3 illustrates another modification of the present invention.

Referring to FIGURE 1, a purpose of the system shown therein is to position a piston **10** within its cylinder **11**, the piston **10** having its rod **10A** serving as a control for valve **12**, and, as illustrated, such rod **10A** carries a switch-actuating member **10B** which, in a predetermined condition of valve **12**, engages and moves the movable switch arm **13A** from its normally engaged stationary contact **13B** to open switch **13**. This switch **13** is used to either short-circuit the rectifier **14** or to allow such rectifier **14** to be connected in series with the two coils **15** and **16** of the solenoid construction **17**, to thereby provide a means whereby such coils **15**, **16** may be energized either with A.C. or with rectified D.C. One terminal of coil **15** is connected to one terminal of the A.C. source **18**, the other terminal of coil **15** being connected to one terminal of coil **16** having its other terminal connected to stationary conact **13B** and also to one terminal of rectifier **14**, the other terminal of rectifier **14** and the switch arm **13A** being connectable through the on-off switch **20** to the other terminal of source **18**.

The coils **15** and **16** are sandwiched between an upper series of disc-shaped laminations **22** and a lower series of like disc-shaped laminations **23** with a third series of like disc laminations **24** separating the two coils **15** and **16**. Magnetic polarization is accomplished using four ceramic-type permanent magnet bars **26**, **27**, **28**, and **29** each having their north and south poles oriented as shown in FIGURE 1, the bar magnets **26** and **27** being sandwiched between laminations **22** and **24** on opposite sides of coil **15** and the bar magnets **28** and **29** being sandwiched between laminations **23** and **24** on opposite sides of coil **16**, the coils and bar magnets being maintained in such sandwiched relationship by non-magnetic machine screws **32** and **33** which extend through apertured portions in the laminations **22**, **24** and **23** and which are threaded into an open yoke supporting structure **35** which is formed at its lower end to provide a fluid chamber **36**, a valve seat **37** and ports **38** and **39** communicatable with the chamber **36**. A plunger **42** extends into the chamber **36** and forms an extension of the armature **43**. A coil compression spring **44**, acting between a portion of the yoke structure **35** and the armature **43**, normally urges the armature **43** (in the open position of switch **20**) against

the bar stop 46 mounted on the series of laminations 22; and in such normal condition (switch 20 open) the plunger 42 allows communication of the ports 38 and 39 through chamber 36.

In the condition shown in FIGURE 1 wherein switch 20 is closed and switch 13 short-circuits the rectifier 14, an A.C. current flows through the coils 15 and 16 causing the armature 43 and the plunger 42 attached thereto to vibrate about a mean position to achieve a pumping action. During such pumping action, the end 42A of plunger 42 moves between an upper position and a lower position, the upper position being above port 39 but below port 38 and the lower position of the end 42A being below port 39. In other words, the port 38 during such pumping action remains closed while the port 39, to which a fluid inlet line 50 is connected, is periodically opened and closed, to periodically entrap fluid in chamber 36 and to displace the entrapped fluid. The entrapped and displaced fluid flows through the check valve 54 and port 55 and conduit 56 and cylinder opening 57 into the interior of cylinder 11. It is noted that the check valve 54 includes the disc 60 which is urged against its seat 37 by the coil compression spring 62 having one of its ends bearing on the valve plate 60 and the other one of its ends bearing on the cover member 64, the cover member 64 having the port 55. This conduit 56 is also connected to the port 38 through the T connection 68.

This pumping action results in pressurizing the cylinder 11, causing the piston 10 to move downwardly against the action of the coil compression spring 10C having one of its ends illustrated as bearing on the piston 10 and the other one of its ends bearing on a wall of cylinder 11.

The piston 10 then continues to move downwardly, operating the valve 12, and in a predetermined condition of the valve 12, the arm 10B opens the switch 13 to place the previously short-circuited rectifier 14 in series circuit with the coils 15 and 16, in which case, then, these coils 15 and 16 are energized with a rectified D.C. and reciprocating or pumping action ceases. Because of the unidirectional current flowing through the coils 15 and 16 at this time, the armature 43 is maintained against the action of spring 44 in a position lower than its previously described mean position of oscillation with the plunger end 42A below the port 39, thereby maintaining both ports 38 and 39 closed and maintaining all of the previously pumped fluid in the cylinder 11 in an entrapped condition. Should there be some leakage from cylinder 11, the piston 10 moves upwardly under the influence of spring 10C to allow the switch 13 to close, upon which the previously mentioned pumping action is initiated and continues until the switch 13 is again opened. Upon opening of switch 20, the spring 44 moves the plunger 42 upwardly to allow the ports 38 and 39 to intercommunicate, and the prestressed coil spring 10C moves the piston 10 upwardly, displacing the fluid in front of piston 10 through the opening 57, T connection 68, conduit 70 and ports 38 and 39 to the fluid inlet line 50.

Thus, in operation of the system, upon failure in source 18 (or when switch 20 is open), the spring 44 urges the plunger 42 to its extreme upper position wherein ports 38 and 39 are in communication through chamber 36 and the piston 10 is allowed to move to its uppermost position under the influence of spring 10C. Under the condition shown in FIGURE 1 wherein switches 20 and 13 are both closed, the plunger 42 reciprocates, maintaining, however, port 38 closed and pumps fluid from inlet line 50 through check valve 54 into cylinder 11 and causing the piston 10 to move downwardly until its arm 10B opens switch 13, in which case pumping action ceases and the plunger end 42A is maintained below the port 39 to entrap previously pumped liquid in cylinder 11 and thereby maintain the piston 10 in its lower or actuated condition.

It will be noted that the permanent magnet bars 26, 27, 28, and 29 are so polarized that the upper bars 26 and 27 tend to move the armature 43 upwardly and the lower permanent magnet bars 28, 29 tend to move the armature 43 downwardly, considering the armature 43 to be in its central position shown in FIGURE 1 wherein the upper end of armature 43 is spaced below the magnetizable laminations 22 and the lower end of armature 43 is spaced above the magnetizable laminations 23.

When the series-connected coils 15 and 16 are energized with an A.C. current, the armature 43, normally pressed into engagement with the bar stop 46 by the biasing spring 44, moves downwardly, seeking a central position within the assembled coils 15 and 16 but is unable to reach a static position because of the magnetic polarization produced by the bar magnets 26, 27, 28, and 29. Thus, during one half cycle of the alternating energizing current, the magnetic flux produced thereby is in opposition to the magnetic flux produced by the permanent magnet bars 26 and 27 and in aiding relationship to the magnetic flux produced by permanent magnet bars 28 and 29, thereby unbalancing the balanced polarized condition, and the armature 43 moves downwardly, but during the next half cycle of the alternating energizing current the conditions are reversed, the effect of permanent magnet bars 26 and 27 being strengthened and the effect of permanent magnet bars 28 and 29 being weakened with the result that the armature 43 moves upwardly. Thus, during successive half cycles of the energizing current, there is corresponding upward and downward movement of the armature 43, i.e. the armature 43 and plunger 42 connected thereto vibrate.

When the coils 15 and 16 are energized with a unidirectional voltage, i.e. under the condition when switch 13 is open, the magnetic flux produced by coils 15 and 16 is such that such flux is in aiding relationship to the flux produced by permanent magnet bars 28 and 29 and is in opposition to the magnetic flux produced by the upper permanent magnet bars 26 and 27 and thus the armature 43 is maintained in a substantially static condition in a lower position wherein the plunger end 42A is below the port 39 to maintain the same closed.

In the modification shown in FIGURE 2, the switch 20 of FIGURE 1 is replaced by a single-pole, double-throw switch 120 having a central open position and an additional rectifier 114 is added. Considering the switch arm 120A and its stationary contact 120B, which is connected to one terminal of rectifier 14 and one terminal of switch 13, the operation is as described above. The switch 120 has its stationary contact connected to one terminal of the added rectifier 114, the other terminal of rectifier 114 being connected to that terminal of coil 16 to which the rectifier 14 is connected. It should be noted, however, that the rectifiers 114 and 14 are poled differently so that when the switch arm 120A engages the contact 120B, the unidirectional current which then flows through the coils 15 and 16 is opposite to that unidirectional current which flows when the switch arm 120A contacts the stationary contact 120C. The contact 120C and added rectifier 114 thus serve as a means whereby the action of spring 44 may be supplemented or, in some cases, eliminated since when the coils 15 and 16 are energized through rectifier 114, the armature 43 is moved to an upper position in contrast to the lower position to which the armature 43 is moved when the coils 15, 16 are energized through rectifier 14.

In some cases the two coils 15, 16 may be replaced by a single coil.

It will also be observed that the structure described is open in that an open yoke 35 is provided and a simple bar stop is provided to allow fluid circulation in those cases when the assembly is mounted in an oil bath from which the oil is used to operate the piston 10. This open structure allows freedom of movement of the armature 43.

If desired, a filter capacitor 70 may be connected across the series circuit comprising the series connected coils 15 and 16 as illustrated in FIG. 1.

Also in FIG. 1 it is noted that the amount of clearance

between piston 42 and cylinder 36 illustrated therein is for illustrative purposes since it is preferred that such clearance be in terms of thosuandths of an inch and may be as small as a fraction of a thousandth of an inch.

In the modification shown in FIG. 3 a two pole sequential switch 201, 202 is incorporated to provide a positioning form of control. It will be seen that FIGS. 1 and 3 are similar with the switch 201 being connected in a series circuit which comprises, source 18, switch 20, switch 201, rectifier 14 and coils 16 and 15 in that order; and switch 202 is connected in series with switch 13 and rectifier 14. In operation of the switches 201, 202 to closed position, switch 201 is first closed followed by a subsequent closure of switch 202; and in operation to open position, switch 202 first opens followed by a subsequent opening of switch 201. Thus there are three conditions established during operation of the composite switch 201, 202, namely either (a) both switches 201 and 202 are closed, (b) only switch 201 is closed or (c) both switches 201 and 202 are open.

Under condition (a) above the operation of the system of FIG. 3 is as described above in connection with FIG. 1. Under condition (b) above with only switch 201 closed and switch 202 open (a condition corresponding to the opening of switch 13) the piston 10 is maintained in a stationary position above (FIG. 1) the position it is maintained when the arm 10B opens switch 13. Thus this condition (b) is established by operation of switch 201, 202 to maintain piston 10 in a selected intermediate position above its lowermost position.

Under condition (c) above i.e. with both switches 201, 202 in their open positions, the plunger 42 urged by spring 44 is in a position to uncover ports 38 and 39 and the piston 10 returns to its uppermost position under the influence of spring 10C. Thus the provision of the composite switch 201, 202 provides a thrust action, a holding action or return action corresponding respectively to conditions (a) (b) and (c) above. Upon failure of the power source 18 or opening of switch 20 the piston 10 returns to its uppermost position and thus it will be seen that switch 20 or any other additional switch which may be placed in series therewith is capable of overriding the control imposed by the composite switch 201, 202.

It will be apparent that means such as for example a knob or electromagnet actuator may be used to produce operation of the above described composite sequential switch 201, 202.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In a system of the character described, a first fluid cylinder; a first piston in said cylinder; a second fluid cylinder; a second piston in said second cylinder; check valve means in said first cylinder opened by pressure developed in said first cylinder by movement of said first piston therein; said check valve means having its outlet in communication with said second cylinder; a pair of radially extending and longitudinally spaced ports in said first cylinder; one of said ports being in communication with said second cylinder; the other of said ports being in communication with a fluid source; contact means, means controlled by the position of said second piston for actuating said contact means, electromagnetic means controlled by said contact means for producing movement of said first piston with respect to said ports; and a utilization means connected to said second piston.

2. In a system of the character described, a first piston-cylinder assembly comprising a first piston and a first cylinder; a second piston-cylinder assembly comprising a second piston and a second cylinder; said first cylinder having first and second radially extending and longitudinally spaced ports; conduit means extending between one end of said first cylinder and one end of said second cylinder; check valve means in said conduit means which is opened in accordance with positive pressures developed in said first cylinder; first said port being in communication with said one end of said second cylinder; the second said port being in communication with a fluid source; contact means, means controlled by the position of the said second piston for actuating said contact means, electromagnetic means controlled by said contact means and operable for vibrating said first piston to alternately open and close said second port while maintaining said first port closed; means for selectively controlling said electromagnetic means to maintain said first piston in a position wherein both said ports are closed and to maintain said first piston in a position wherein both said ports are open; and a utilization device connected to said work piston.

3. In a system of the character described, a pair of aligned solenoid coils; a first magnetizable structure interposed between adjacent ends of said coils; a second magnetizable structure mounted adjacent an outermost end of one of said coils; a third magnetizable structure mounted adjacent an outermost end of the other of said coils; a first pair of permanent magnet bars extending generally parallel with and on opposite sides of said one coil; said bars extending between said first and said second structures and having the same magnetic pole adjacent said first structure; a second pair of permanent magnet bars extending generally parallel with and on opposite sides of said other coil; said second pair of bars having the same magnetic poles adjacent said first structure; the magnetic poles of said first and second pairs of bars being the same at said first structure; a plunger moveable in said coils and extending into each of said coils; plunger stop means on said second structure; a stem carried on said plunger and serving as a first piston; an open ended cylinder through and within which said first piston moves said plunger extending through a first end of said cylinder; means mounting said cylinder on said third magnetic structure; a coil compression spring between said plunger and said cylinder and normally urging said plunger towards said stop means; said cylinder having a first port and a second port each extending radially therethrough; check valve means in the other or second end of said cylinder; said first port being located closer to said first end than is said second port with a space in said cylinder between said ports; said check valve means having an outlet and being opened by pressure developed in said cylinder by movement of said plunger; first conduit means extending between said outlet and said first port; said second port being connected to a fluid source; a work cylinder; a work piston in said work cylinder; second conduit means communicating said outlet with one end of said work cylinder; spring means urging said work piston towards said one end of said work cylinder; an element operated by said work piston; normally closed switching means operated to an open condition upon movement of said work piston to a predetermined position; an on-off switch; rectifier means; a series electrical circuit which includes each of said coils, said on-off switch and said rectifier means; said series circuit terminating at terminals for connection to a source of alternating current; said switching means being connected in parallel with said rectifier means to alternatively allow either an A.C. current or a rectified D.C. current to flow through said coils; said coils when de-energized allowing said plunger stem to uncover both said first and second ports; said coils when energized producing a vibratory movement of said plunger stem through a range of movement wherein said first port remains closed by said stem and said second port is alternately opened and closed to produce a pumping of fluid into said work cylinder; said coils when energized with rectified D.C. current maintaining said stem in a position wherein it closes said first and second ports.

4. In a system of the character described, a first piston-cylinder assembly including a first piston and a first cylinder; a second piston-cylinder assembly including a second piston and a second cylinder; check valve means interconnecting said first and second cylinders; said first cylinder having a first and a second port spaced longitudinally with respect to the first piston therein; said first port being in communication with said second cylinder; a fluid source in communication with said second port; contact means, means controlled by the position of said second piston for actuating said contact means, electromagnetic operating means controlled by said contact means and operatively connected to said first piston and having three operating conditions, said operating means in a first of said conditions incorporating means for maintaining said first piston in a position wherein said first piston uncovers both said first and second ports; said operating means in a second condition incorporating means for vibrating said first piston about a mean position between said first and second ports without uncovering said first port and alternately covering and uncovering said second port; said operating means in a third condition incorporating means for maintaining said first piston in a position wherein said first piston covers both said first and second ports; and utilization means connected to said second piston.

5. A system as set forth in claim 4 in which spring means acts on said second piston in a direction tending to displace fluid from said second cylinder to said first cylinder through said first port; and said check valve means allows substantial fluid flow only in the direction from said first to said second cylinders.

6. A system as set forth in claim 4 in which said operating means includes a polarized solenoid operator with an armature connected to said first piston, said means operative in a first condition including a spring, said means operative in a second condition including an A.C. energizing circuit for said solenoid operator, and said means operative in a third condition including a unidirectional energizing circuit for said solenoid operator.

7. In a system of the character described, an electromagnetic operator, including a pair of axially aligned coils and an armature, a first magnetic structure between adjacent ends of said coils, a second magnetic structure near an outer end of one of said coils, a third magnetic structure near an outer end of the other one of said coils, first permanent magnet means between said first and second magnetic structures, second permanent magnetic means between said first and third magnetic structures, the first and second permanent magnetic means having poles of the same polarity at said first magnetic structure, and means for alternately applying an A.C. current or a unidirectional current to said coils.

8. A system as set forth in claim 7 in which spring means act between said permanent magnet, magnetic structures, and said armature to urge the armature towards a first position, said coils when energized with A.C. current producing vibration of said armature about a second mean position, and said coils when energized with unidirectional current maintaining said armature in a third position.

9. A system as set forth in claim 8 including a piston cylinder assembly having a pair of relatively moveable elements, one of said elements being connected to said armature, and the other of said elements having stationary ports cooperating with said piston differently in corresponding different ones of said positions of said armature.

10. A system as set forth in claim 8 including an open frame member on which said magnetic structures are supported, a piston connected to said armature and slidable on said frame member, a fluid cylinder cooperating with said piston and having a pair of ports therein longitudinally spaced with respect to the axis of said piston, urging means effective to urge said piston to a position wherein both of said ports are closed, said coils when energized with A.C. current producing an oscillatory condition of said piston to alternately open and close one of said ports while maintaining the other port closed, and said coils when energized with unidirectional current maintaining both of said ports closed by said piston.

11. A system as set forth in claim 10, including a second piston-cylinder assembly including a second cylinder and a second piston, check valve means between said first and second cylinders, said other port being in communication with said second cylinder, said one port being in communication with a fluid source, and spring means acting between said second piston and said second cylinder tending to displace fluid from said second cylinder, through said other port to the first cylinder.

12. A system as set forth in claim 11, including means operated in accordance with the position of said second piston for alternately energizing said coils with either A.C. or unidirectional current of a first polarity.

13. A system as set forth in claim 10 in which said urging means includes a spring acting between said frame member and said armature.

14. A system as set forth in claim 12 in which said urging means includes an energizing circuit for energizing said coils with a unidirectional current of a second polarity.

15. In a system of the character described, a polarized solenoid construction including a movable element thereof, said structure when energized with A.C. current producing a vibratory movement of said element about a first mean position, said structure when energized with a unidirectional current maintaining said element in a second position, means operatively connected to said construction for maintaining said element in a third position, and fluid control means operatively connected to said element and controlled differently in accordance with each of said first, second, and third positions of said element.

16. A system as set forth in claim 15 in which said means for maintaining said element in said third position includes a spring.

17. A system as set forth in claim 15 in which said means for maintaining said element in said third position includes an electrical circuit for energizing said structure with a unidirectional current.

18. A system as set forth in claim 1 including means for selectively positioning and maintaining said second piston in one of a plurality of positions within the range of its movement.

19. In a system of the character described an electromagnetic actuator including coil means therefor, rectifier means, means for connecting said coil means to a source of alternating current through said rectifier means, switch means, circuit means including said switch means in parallel with said rectifier means, and means operated by said actuator for operating said switch means.

20. A system as set forth in claim 19 including second switch means in series with said coil means and said rectifier means, third switch means in said circuit means in series with said switch means, said second and third switch means being sequentially operable such that either said second switch means is closed and said third switch means being open or said second and third switch means are both closed or said second and third switch means are both open.

References Cited by the Examiner

UNITED STATES PATENTS

2,620,628	12/52	Ray	60—52
2,751,753	6/56	Ray	60—52

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