

[54] **ELECTROMAGNETIC PUMP OR MOTOR
DEVICE**

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[58] Field of Search **417/418, 417, 416;
318/125; 310/24, 34, 30, 35**

[56] **References Cited**

UNITED STATES PATENTS

3,282,219 11/1966 Blackwell et al. 417/418

3,422,765 1/1969 Schoch 417/418
3,515,966 6/1970 Valroger et al. 417/418 R

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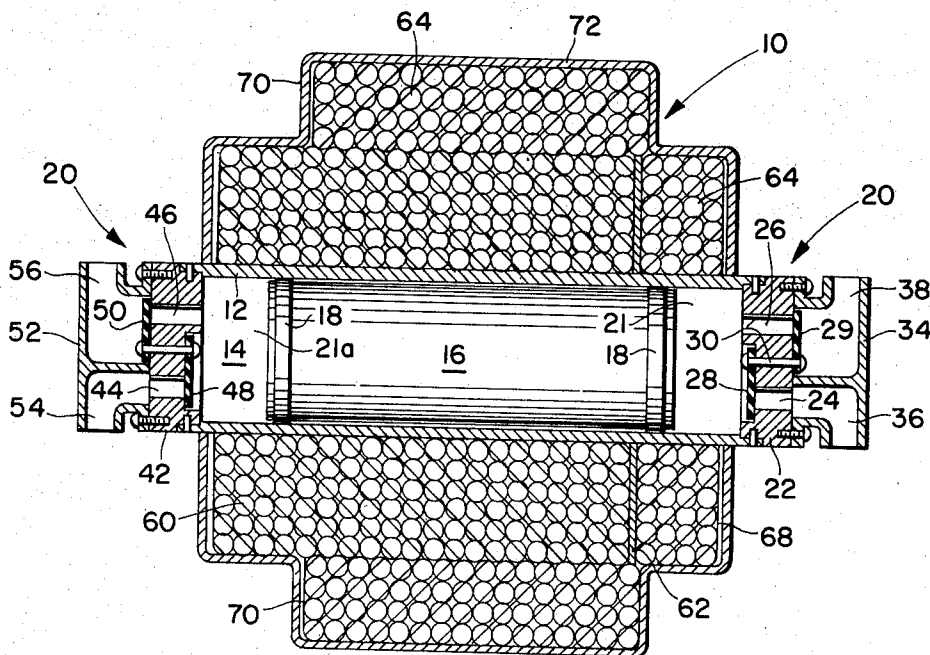
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[57]

ABSTRACT

An electromagnetic plunger-cylinder device including two alternately energized solenoid coils wound about the cylinder to reciprocate the plunger therewithin, the inner end of one coil being wrapped around the inner end of the other coil, thereby to control the stroke or air gap of the plunger.

5 Claims, 2 Drawing Figures



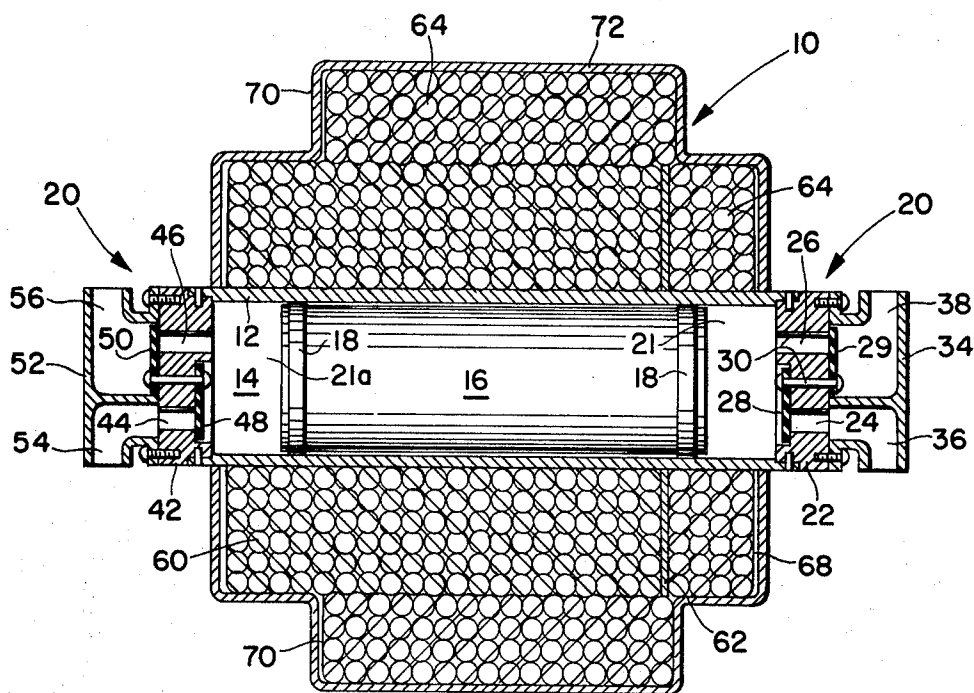


FIG. 1

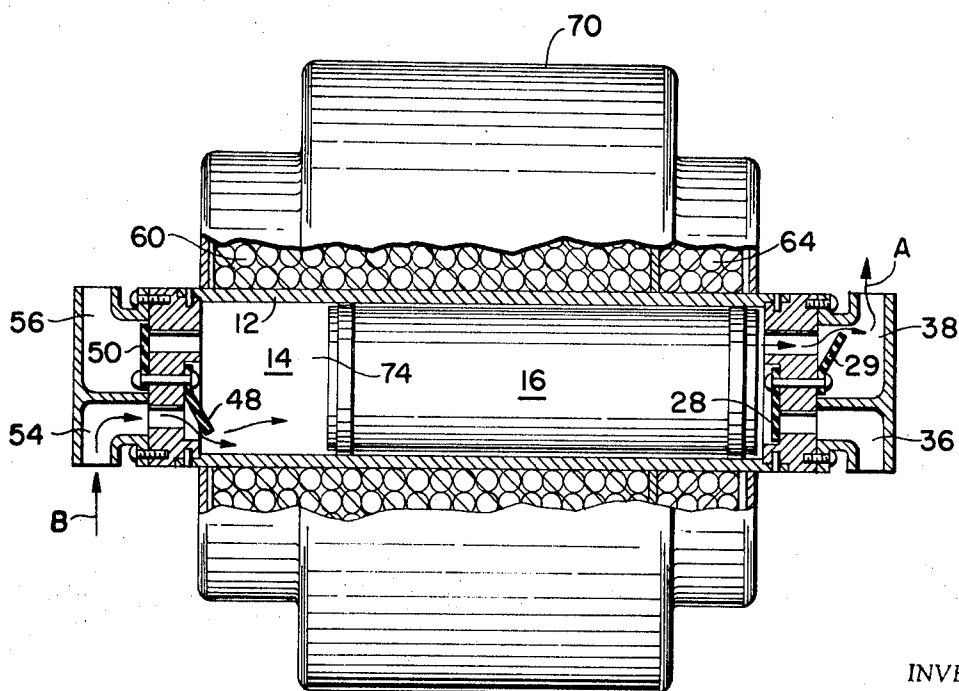


FIG. 2

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ELECTROMAGNETIC PUMP OR MOTOR DEVICE

The present invention relates as indicated to an electromagnetic pumping device and, more particularly, to a pumping device in which air gap is controlled and pumping force increased over conventional pumps having an equivalent size and piston reciprocation rate.

Pumping or compressing of a fluid by reciprocation of a plunger within a cylinder bore having either closed or selectively closed ends is well known in the art. One conventional means of effecting the plunger reciprocation is the helical winding of two distinct solenoid coils about the cylindrical member, with the inner ends of the two coils either abutting or being slightly longitudinally spaced apart. Reference may be had to the Strong et al, U. S. Pat. No. 2,686,280 for a disclosure of such a conventional electromagnetic piston pump.

This conventional type of pump can be adapted to given functional requirements by varying the dependent design parameters of piston stroke length, reciprocation rate, and pumping force. However, certain structural factors are known that control the interrelated parameters for pumps having either abutting or spaced apart coils.

Considering the pump with abutting coils first, the length of travel of the piston or plunger, known as air gap, is always equal to the length of an individual coil. Thus with a coil of given length, it is impossible to reduce the air gap to permit greater force, and a more rapid rate of reciprocation can be obtained only by increasing the amount of ampere-turns in the coil. Such an increase in ampere turns requires increased current with additional generation of heat which may result in destruction of the device or have harmful effects on the fluid being pumped. In addition, a pump with abutting coils is known to require a plunger of greater length than either of the individual coils. Such plunger because of its length distorts or stretches the lines of force in a non-uniform manner to vary from cycle to cycle the point of plunger stroke. A reduction of plunger weight in an attempt to get a better and more uniform braking effect on the large plunger by the smaller coil results in reduction of force and speed of reciprocation. Therefore, any attempt to control air gap or braking efficiency in a pump with abutting coils of fixed length leads to design characteristics that render the device impractical.

In a pump having the coils slightly longitudinally spaced apart, the lines of magnetic force must travel increased distances to pull the plunger therewithin. Accordingly, an increase in plunger stroke results in a decrease in both effective magnetic force and plunger reciprocation rate. Therefore, spacing of the coils is likewise an ineffective or impractical means of controlling air gap.

Accordingly, it is the primary object of the present invention to provide a positive displacement electromagnetic piston pump with increased pumping force and displacement capabilities over that available in a conventional motor and pump tandem of substantially equal size and piston reciprocation rate. This object is accomplished through the expedient of controlling air gap by winding the inner end of one solenoid coil about the inner end of the other solenoid coil, thereby to overlap one with respect to the other for a limited longitudinal extent.

Another important object of the present invention is to provide a fluid control system in association with the electromagnetic piston pump that is responsive to piston reciprocation simultaneously to draw and pump such fluid during both forward and return movements of the plunger.

It is another object of the present invention to provide an electromagnetic pumping or compressing device that typically may be used in refrigeration, heating, cooling, vacuum, air compressing and liquid booster systems and is manufactured from readily obtainable materials in high speed, automatic production processes. Furthermore, the reciprocating motion of the plunger may be adapted to a drive or mechanical motion device.

These and other objects of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principle of the invention may be employed.

In the drawing:

FIG. 1 is a cross-section of the pumping device of the present invention with the plunger being in a centered or neutral position within the cylinder bore; and

FIG. 2 is an elevation broken away to show the plunger at the end of its forward stroke with the arrows indicating fluid movement on both the compression and suction sides of the plunger.

Referring now in more detail to the drawing and initially to FIG. 1, the pumping or compressing device indicated generally at 10 includes an elongated cylinder 12 having an axial bore 14 therethrough. Such cylinder preferably is made of non-magnetic materials, such as 300 series stainless steel, ceramics, teflon, copper or combinations of materials which minimize friction. Plunger 16 is slidably received in bore 14 for reciprocal movement therewithin and is preferably composed of magnetic material, although a laminate of different magnetic materials may be used. The exterior surface of the plunger 16 is coated with a material, such as chrome plating, ceramics, teflon, etc., that is environmentally suitable for use with the fluid to be pumped. Annular piston rings 18 are provided to seal the plunger 16 to the inner wall of cylinder 12, thereby to maintain the pressure differential on opposite sides of the plunger created by reciprocal movement of the same. However, if the desired compressive force is low or there is no need for an absolute low or negative pressure zone for purposes of fluid intake, plunger 16 may be directly fitted into cylinder 12 with the close manufacturing tolerances being sufficient to effect a reasonable seal between the same, whereby the plunger may perform reduced compressive and suction functions without piston rings 18.

The ends of cylinder 12 and consequently bore 14 are closed off and selectively sealed by valve plate assemblies indicated generally at 20. Such assemblies are preferably made of non-magnetic materials such as 300 series stainless steel or aluminum and may be press-fitted into the cylinder 12 and secured by high temperature adhesives or attached by conventional fastening

means. The plunger 16, bore 14, and valve plate assemblies 20 define therebetween two chambers 21 and 21A of varying volume depending upon plunger position.

Referring in detail to the valve plate assembly at the right end of the pumping device as viewed in FIG. 1, plate 22 has two offset bores 24 and 26 extending axially therethrough. Reed or check valves 28 and 29 are connected to plate 22 by suitable fastening means 30 and cover the inside and outside ends of bores 24 and 26, respectively, thereby normally to block fluid flow through the same. An adapter member 34 is connected to the outside surface of plate 22 and defines inlet passage 36 and outlet passage 38, such passages being in fluid communication with bores 24 and 26, respectively.

The left hand valve plate assembly is substantially identical to that just described and includes plate 42 with axial bores 44 and 46 extending therethrough. Such bores are normally closed by check valves 48 and 50, respectively. Adapter member 52 defines inlet and outlet passages 54 and 56 which are selectively in fluid communication with bores 44 and 46, respectively.

It will be appreciated that conduits or tubing in the fluid flow system could be attached to the ends of the adapted members 34 and 52 to complete the sealed and closed pumping or compressing device. In a typical refrigeration application of the device, conduits attached to inlet passages 36 and 54 emanate from the evaporator, while conduits connected to outlet passages 38 and 56 lead to the condenser.

A solenoid coil 60 of predetermined longitudinal and radial extent is wound about non-magnetic cylinder 12. The winding operation can be performed either directly upon the cylinder or a spool 62 may be positioned about the cylinder accurately to establish coil length and diameter. A second electromagnetic solenoid coil 64 is formed by winding wire circumferentially about the cylinder 12 between annular end stops 68 and 70. The wire of the second coil is initially wound from the right hand end of the cylinder as viewed in FIG. 1, and when spool 62 is reached, the wire is wound up and directly over coil 60 until it abuts stop 70, thereby to overlap one coil with respect to the other for a predetermined longitudinal extent. It will be appreciated that both coils may be pre-wound onto spools of desired size and configuration and then placed about the cylinder. The coils are adapted alternately to be energized by an electrical system at a variable rate of cycles per minute dependent upon force and displacement requirements.

A housing 72 of soft steel or the like is connected at its radially inner ends to cylinder 12 and fully encapsulates both of the solenoid coils. The housing is thus operative to conduct lines of flux toward the cylinder bore to maximize the force field for each coil.

The overlap of coil 64 with respect to coil 60 is always of sufficient length to permit the elongated plunger 16 to remain in a field of strong magnetic force regardless of either its position within bore 14 or the sequence of energizing the two electromagnetic coils. Coil 64 may be extended past the defined point of minimum overlap to decrease the cubic displacement and increase the force. It has been found that overlapping the coils in the manner described significantly decreases the air gap in the bore between the plunger end and the valve plate assembly. The decrease in air gap permits a greater pumping force or a greater volumet-

ric displacement or a variable combination of the two through an increased reciprocation rate, without a significant increase in either overall pump size or current requirements.

The operation of the electromagnetic pumping device can best be described in context with FIG. 2. The energization of coil 64 will cause plunger 16 to become magnetized and the action of the field in the solenoid on the poles created on the plunger results in such plunger rapidly moving within coil 64 and centering in the field of force. The centering of the plunger within the field acts as a magnetic damper or brake on plunger 16, with plate 22 (and plate 42) being slightly set back to preclude contact between plunger and valve plate assembly.

The forward stroke of the piston effected by energization of coil 64 compresses the fluid contained within chamber 21 and pushes the gas thus compressed through check valve 29 and into the fluid flow system as indicated by arrows A. The increased pressure of such fluid is greater than the inlet fluid pressure in passage 36, whereby check valve 28 remains in the normally seated position shown. At the same time, the volume of chamber 21A is proportionately increased by the plunger movement to develop a low or negative sealed pressure zone. This low pressure is less than the pressure in the fluid flow system whereby check valve 48 is opened to allow entry of fluid through inlet port 54 as indicated by arrows B, and the check valve 50 is seated to preclude delivery of such fluid through passage 56.

At the completion of the forward stroke, the left hand end of plunger 16 remains well inside of coil 60 and therefore within a potentially strong magnetic force field, as shown in FIG. 2. Thus when coil 64 is de-energized and coil 60 substantially simultaneously energized, the magnetic force field of coil 60 will quickly pull magnetized plunger 16 to the left until the centering effect of plunger and coil stops such plunger to complete the piston cycle. Thus the reciprocal movement of plunger 16 is quickly and smoothly effected without complicated electrical systems, springs, end stops or mechanical linkages. The return stroke has the opposite effect on the valves shown; specifically, check valves 28 and 50 will open while check valves 48 and 29 will close. This position of the valves enables the device to draw fluid into chamber 21 through inlet port 36 and to deliver compressed fluid from chamber 21A to the outlet passage 56.

It will be appreciated from the above description that an electromagnetic device is provided that increases pumping force and reciprocation rate by controlling air gap. Such device may be used in any type of environment requiring reciprocal movement of a piston and is, of course, not limited to the specific embodiment shown. For example, a piston rod or saw blade could be connected to the plunger to extend axially beyond the cylinder member.

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

1. An electromagnetic pump or motor device comprising a cylinder having a bore therein, a plunger of magnetic material slidably received in said bore, a first solenoid coil positioned about said cylinder, and a second solenoid coil positioned about said cylinder with a portion of said second coil overlapping said first coil,

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said coils being alternately energized to produce respective magnetic fields for alternately attracting said plunger to reciprocate the same in said bore.

2. The electromagnetic device of claim 1 wherein a fluid is contained within said bore and said cylinder includes means at both ends of the bore to discharge said fluid during a plunger compression stroke and to receive fluid during a plunger suction stroke.

3. The electromagnetic device of claim 2 wherein each of said means comprises a valve plate assembly having two check valves therein, one of said check valves being operative to open during the compression stroke and the other check valve being operative to

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open during the suction stroke.

4. The electromagnetic device of claim 3 wherein the plunger in its reciprocal movement is stopped at the end of each stroke by centering on the field of force of the energized coil, the valve plate assemblies being slightly set back from the end of the bore to preclude contact between such assemblies and the plunger.

5. The electromagnetic device of claim 1 wherein the plunger is of sufficient length regardless of bore position to at least partially extend beyond the center of either coil, thereby to maintain said plunger in a potentially strong magnetic field.

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