Feb. 7, 1967 S. KOFINK 3,302,582

ELECTROMAGNETIC PUMP

Filed March 15, 1965 4 Sheets-Sheet 1

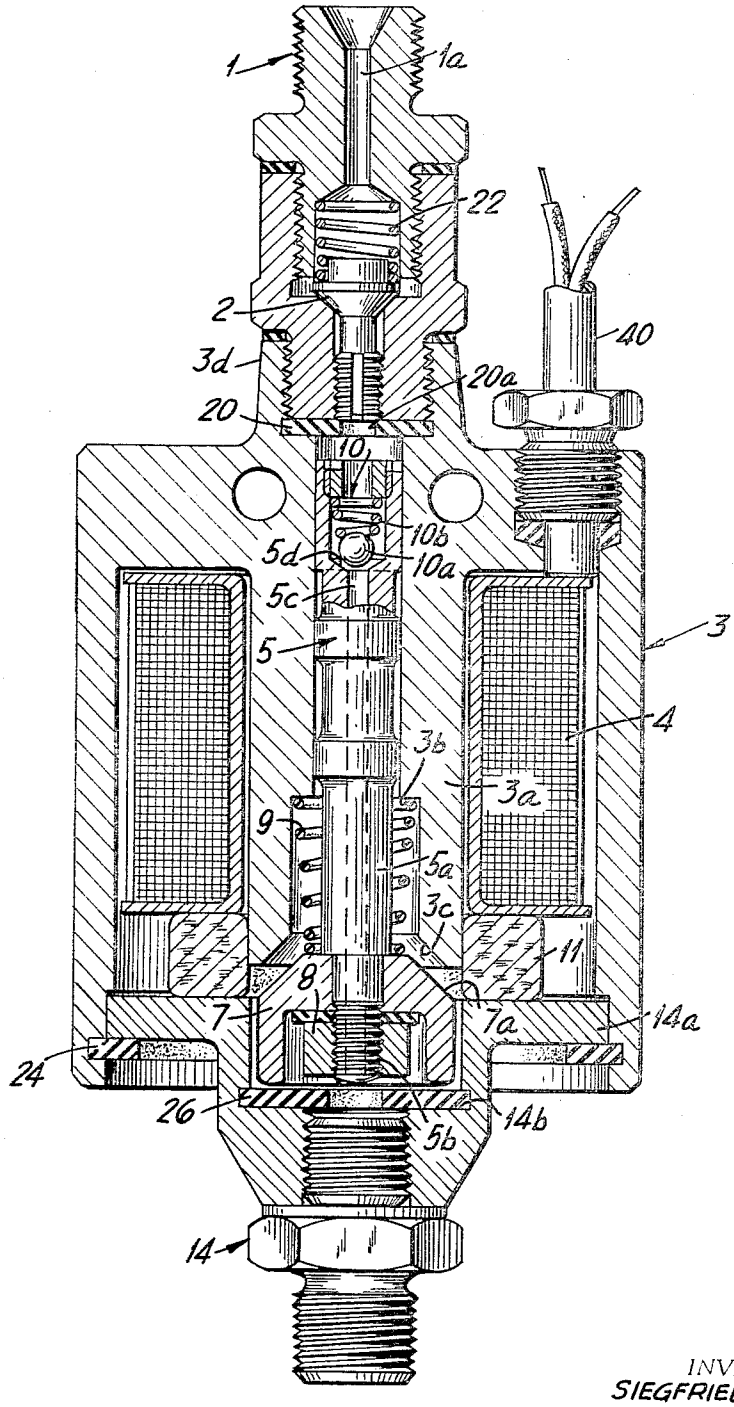


FIG. 1

INVENTOR.
SIEGFRIED KOFINK

BY

McGlew & Torrey
ATTORNEYS.

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ELECTROMAGNETIC PUMP

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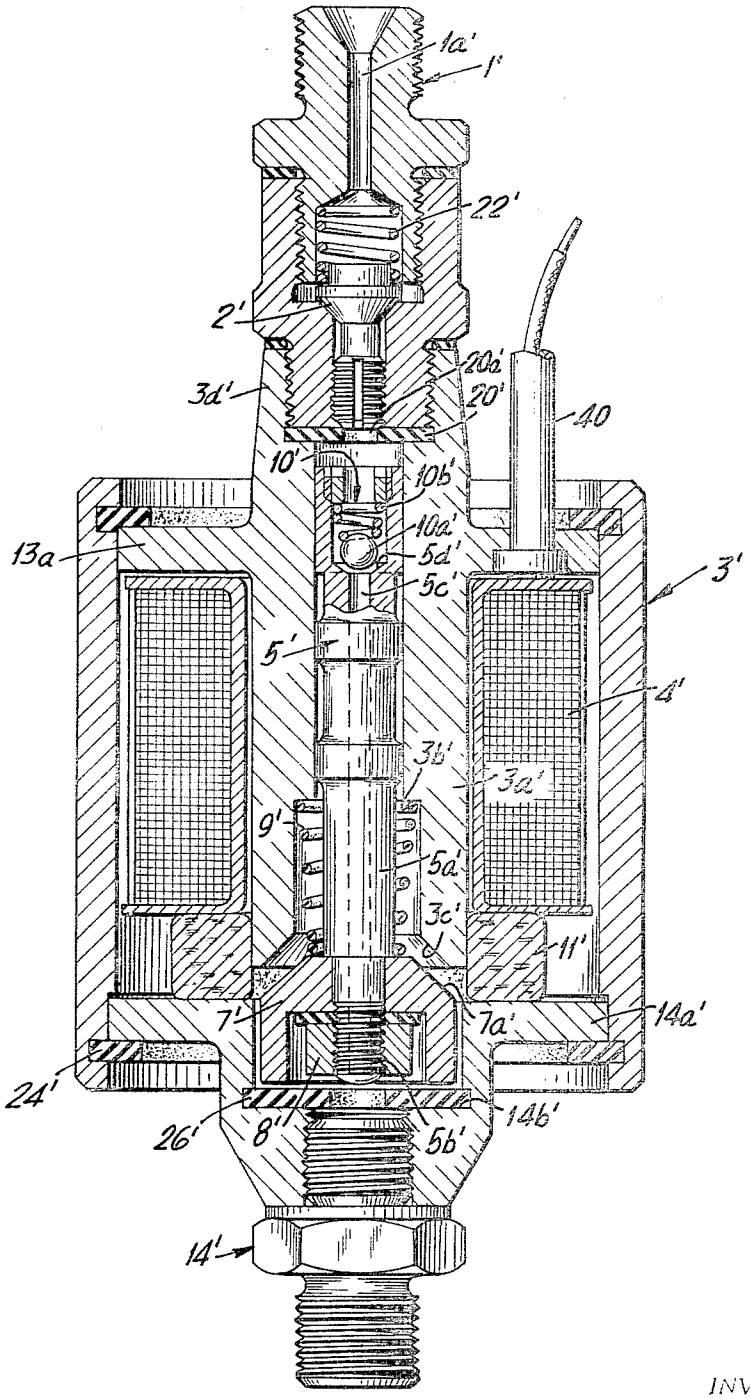


FIG. 2

INVENTOR.
SIEGFRIED KOFINK

BY

McGlew & Toren
ATTORNEYS.

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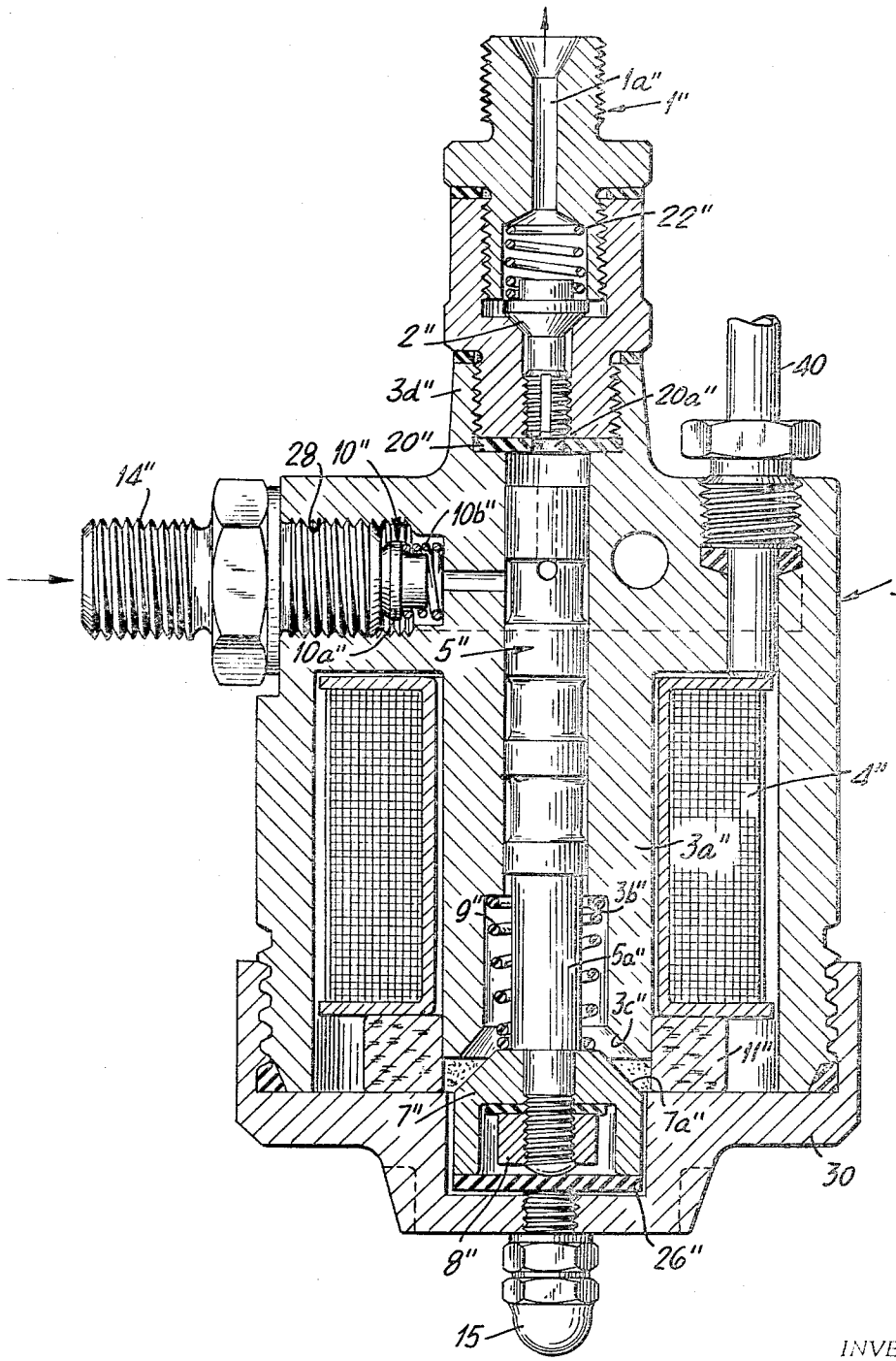


FIG. 3

INVENTOR.
SIEGFRIED KOFINK

BY

McGlew & Toren
ATTORNEYS.

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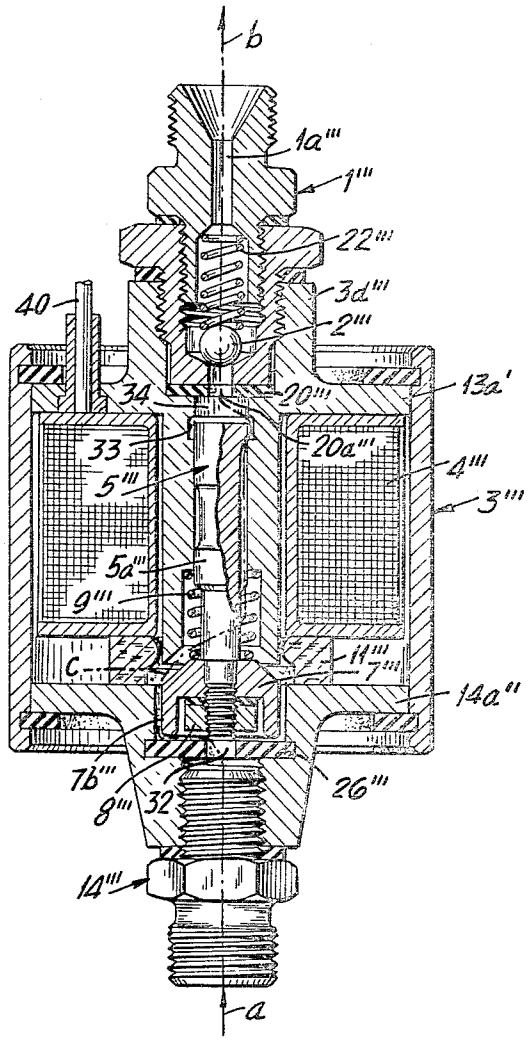


FIG. 4

INVENTOR.
SIEGFRIED KOFINK

BY

McGlew & Toren
ATTORNEYS.

United States Patent Office

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Patented Feb. 7, 1967

3,302,582

ELECTROMAGNETIC PUMP

Siegfried Kofink, Zell (Neckar), Germany, assignor to J. Eberspacher, Neckar, Germany

Filed Mar. 15, 1965, Ser. No. 444,097
Claims priority, application Germany, Mar. 14, 1964, K 52,386; June 27, 1964, K 53,338
19 Claims. (Cl. 103—53)

This invention relates in general to a pump construction, and in particular to a new and useful fuel piston pump, particularly for oil furnaces, having a reciprocating piston with a piston rod of non-magnetic material and an armature connected thereto which is arranged centrally in respect to a magnetic coil which is electrically excited for actuating the pump.

Oscillating armature pumps are known which can be designed with or without valves and which work on the principle of either lifting magnets or rotary magnets. Valveless pump systems with oscillating armature drives are also known for lower outputs where the piston oscillates in a non-magnetizable guide tube and is driven through this tube. A disadvantage of the known construction is their low efficiency, particularly because of the great gaps in the magnetic circuit, so that a high exciting energy is required for operation.

The disadvantages of the prior art are eliminated in accordance with the invention by a pump construction which includes the pump piston which carries at one end an armature which projects into the pump cover and is arranged centrally in respect to a magnetic actuating coil. The piston rod itself is made of a non-magnetic material at least in the range of the armature. With a construction of this type the armature is arranged free on the piston rod so that an economic small-sized pump design may be effected.

A further feature of the construction is that the armature is arranged within the housing carrying the magnetic coil and is limited in its end positions by elastic and damping stops. This results in a noiseless operation of the piston pump.

Another important feature of the invention is that the return spring for the piston and armature is made of a non-magnetic rubber-like material, and due to such a construction a progressive effect is achieved.

Still another important aspect of the invention is that the armature is always surrounded by fuel or the pumping liquid which further results in a damping action. In order to obtain a compact design, the suction valve is advantageously arranged in the pump piston and the fuel is supplied through the hollow piston rod and the hollow pump piston.

In accordance with still another feature of the invention, there is provided a pump having a resilient element or gasket with annular inlet slot on the suction side instead of a suction valve through which the fuel can enter the cylinder chamber. In such an arrangement, the armature is advantageously employed as a valve body which is pressed in the rest position under the pressure of the return spring of the pump against the gasket having the slot. A fuel magnetic valve is thus formed in a simple manner.

Accordingly, it is an object of this invention to provide an improved pump construction in which a pump piston and armature are arranged centrally in respect to a magnetic coil.

A further object of the invention is to provide a pump construction, particularly for fuels, which includes a piston which reciprocates centrally within an armature coil and is at least partially of non-magnetic material and carries at its outer end an armature for actuation of the piston upon excitation of an adjacent magnetic coil.

A further object of the invention is to provide an electromagnetically actuated pump which includes a pump piston of non-magnetic material which is slidable centrally within an armature coil and which includes resilient elements arranged at each end thereof to limit the stroke of the movable parts and to dampen the movement thereof in the limit ranges.

A further object of the invention is to provide a pump which includes an electromagnetically actuated reciprocable piston having an armature portion which is adapted to be seated at its end position during operation on a valve seat forming member in the inlet of the pump.

A further object of the invention is to provide a pump which is simple in design, rugged in construction and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

In the drawings:

FIG. 1 is a transverse sectional view of a fuel pump constructed in accordance with the invention;

FIG. 2 is a view similar to FIG. 1 of another embodiment of the invention;

FIG. 3 is a view similar to FIG. 1 of still another embodiment of the invention; and

FIG. 4 is a view similar to FIG. 1 of still another embodiment of the invention.

Referring to the drawings in particular, the invention embodied in FIG. 1 comprises a cylindrical housing generally designated **3** which is opened at one end. A magnetic coil **4** is positioned around a central hollow cylindrical formation **3***a* of the housing. A hollow cylinder forming a pump piston **5** is slidable within the cylindrical formation **3***a* and in accordance with the invention either the entire piston **5** or piston rod portion **5***a* thereof is made of non-magnetic material. In the embodiment illustrated, the piston rod portion **5***a* is made non-magnetic in the range of an attached armature **7** which is made of magnetic material for oscillation under the influence of the coil **4**. The piston rod portion **5***a* includes a threaded extension **5***b* over which is threaded a nut **8** for securing the armature **7** in position against a shoulder of the piston rod **5***a*.

In accordance with a further feature of the invention, a return spring **9** of non-magnetic material such as rubber is arranged around the piston rod **5***a* and bears at one end on a ledge portion **3***b* of the housing **3**, and at its opposite end against the armature **7**. The armature **7** is bevelled at **7***a* in a complementary manner to a double portion **3***c* of the housing **3**.

The piston **5** and the piston rod **5***a* are provided with a central bore **5***c* for the flow of fuel therethrough, and a discharge valve or one way valve generally designated **10** is arranged at the upper end thereof as indicated in FIG. 1. The discharge valve **10** includes a ball member **10***a* which is biased against a seat **5***d* of the piston **5** under the urging of a spring **10***b*. The ball member **10***a* is movable off its seat against the biasing force, of the spring when the pressure of the fluid being pumped is raised by the reciprocating action of piston **5** to a predetermined amount.

A double pressure socket fitting generally designated **1** is threaded into an internally projecting threaded shoulder **3***d* of the housing **3**, with a gasket **20** interposed therebetween. The gasket **20** has a central discharge opening **20***a* which is aligned with the bore **1***a* of the fitting which is closed by a pressure valve **2** under the force of a spring **22**. On the pressure stroke of the piston **5**, the

pressure valve 2 is lifted of its seat and fuel is discharged through a bore 1*a* of the pressure fitting 1.

The suction end of the pump is closed by a suction fitting generally designated 14 having a flange portion 14*a* which closes the open end of the housing 3 and is held therein by a gasket element or ring 24. An internal ledge portion 14*b* thereof carries a gasket 26. A gasket 11 is interposed between the armature coil 4 and the flange portion 14*a* of the inlet fitting 14. This gasket is necessary to prevent the escape of fuel around the cylinder formation 3*a* and the flange portion 14*a*.

The entire construction is very compact and the armature 7 is arranged in respect to the coil 4 such that the magnetic flux conditions will be excellent.

In the embodiment of FIG. 2 similar parts are similarly designated, but with primes added thereto. In this embodiment, the housing 3' is designed as a tubular member which is open at each end and accommodate therewith a hollow cylindrical formation 3*a*' having a flange portion 13*a* forming a top or end cover for the pump.

In the embodiment of FIG. 3, there is provided a housing 3'' which is provided with a lateral threaded bore 28 for receiving a suction fitting generally designated 14''. In this embodiment, an inlet valve generally 10'' is associated directly with the fitting 14'' and includes a valve member 10*a*'' which is seated against a valve seat defined in the inlet fitting 14'' under the influence of a spring 10*b*''. An adjusting screw 15 is threaded into an end plate or cover 30 which is threaded over the exterior of the housing 3'' and bears against a gasket 26'' to fix its location for varying the limit position of movement of the armature 7''.

In the embodiment of FIG. 4, the housing 3''' is of a construction similar to that of the FIG. 2 embodiment, but the piston rod 5*a*''' and the piston 5''' are made of solid construction. In this embodiment, the armature includes cylindrical side walls 7*b*''' which bear against the gasket 26''' to seal an inlet opening 32 in the gasket. Thus, the armature forms a tight seal with the gasket 26''' and acts in a surprisingly simple manner as a valve body which is pressed by the force of the return spring 9''' and by the gradient pressure of the fuel in the discharge line 1*a*'' against the seat of the gasket when the pump is disconnected.

During the operation of the pump, the direction of the fuel flow is indicated as through the suction fitting 14''' by the arrow *a* and along the dotted line *c* for discharge through the discharge fitting 1''', as indicated by the arrow *b*. It should be noted that the fuel flow is through the opening 32 and around the armature 7''' and upwardly into an annular passage 33 and into the pumping chamber 34. The gasket 11''' seals the space defining the flow channel *c* in a simple manner from the housing 3''', as indicated in FIG. 4.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

In each embodiment, current is supplied to the armature 4 through an electrical cable connection 40 at the upper portion of the housing 3.

What is claimed is:

1. A piston pump, particularly for pumping fuel for oil furnaces, comprising means defining a cylinder, a hollow piston reciprocable in said cylinder, the bore of said piston defining a passage for the flow of fluid therethrough, an armature connected to said piston, said piston having a piston rod portion of non-magnetic material at least in the range of said armature, a magnet coil around said cylinder and adjacent said armature, discharge conduit and valve means connected to said cylinder, and inlet conduit and valve means connected to said cylinder including means defining a concentric annular slot in said cylinder which is in communication on the suction side of said cylinder through the bore of said piston.

2. A piston pump, particularly for pumping fuel for oil furnaces, comprising means defining a cylinder, a hollow piston reciprocable in said cylinder, the bore of said piston defining a passage for the flow of fluid therethrough, an armature connected to said piston, said piston having a piston rod portion of non-magnetic material at least in the range of said armature, a magnet coil around said cylinder and adjacent said armature, discharge conduit and valve means connected to said cylinder, and inlet conduit and valve means connected to said cylinder including means defining a concentric annular slot in said cylinder which is in communication on the suction side of said cylinder through the bore of said piston; said armature comprising a valve seat, and spring means biasing said armature against said means defining an annular slot for closing of said inlet means.

3. A piston pump, particularly for pumping fuel for oil furnaces, comprising means defining a cylinder, a hollow piston reciprocable in said cylinder, the bore of said piston defining a passage for the flow of fluid therethrough, an armature connected to said piston, said piston having a piston rod portion of non-magnetic material at least in the range of said armature, a magnet coil around said cylinder and adjacent said armature, discharge conduit and valve means connected to said cylinder, and inlet conduit and valve means connected to said cylinder including means defining a concentric annular slot in said cylinder which is in communication on the suction side of said cylinder through the bore of said piston, housing means surrounding said cylinder and said magnet coil, said inlet means closing off one end of said housing means and a gasket disposed between said inlet means and said coil.

4. A piston pump, particularly for pumping fuel for oil furnaces, comprising means defining a cylinder, a hollow piston reciprocable in said cylinder, the bore of said piston defining a passage for the flow of fluid therethrough, an armature connected to said piston, said piston having a piston rod portion of non-magnetic material at least in the range of said armature, a magnet coil around said cylinder and adjacent said armature, discharge conduit and valve means connected to said cylinder, and inlet conduit and valve means connected to said cylinder including means defining a concentric annular slot in said cylinder which is in communication on the suction side of said cylinder through the bore of said piston, a cylindrical housing enclosing said armature and said cylinder, said housing including said inlet conduit means at one end and an outlet means at an opposite end for closing off each end of said housing, said inlet means defining recess for said armature which extends outwardly from one end of said cylinder, said armature being movable toward and away from this end of said cylinder in the recess upon actuation of said magnetic coil.

5. A piston pump, particularly for pumping of fuel for oil furnaces, comprising means defining a cylinder, a hollow piston reciprocable in said cylinder, the bore of said piston defining a passage for the flow of fluid therethrough, an armature connected to said piston, said piston having a piston rod portion of non-magnetic material at least in the range of said armature, a magnet coil around said cylinder and adjacent said armature, discharge conduit and valve means connected to said cylinder, and inlet conduit and valve means connected to said cylinder including means defining a concentric annular slot in said cylinder which is in communication on the suction side of said cylinder through the bore of said piston, a cylinder housing enclosing said armature and said cylinder, said housing including said inlet conduit means at one end and an outlet means at an opposite end for closing off each end of said housing, said inlet means defining recess for said armature which extends outwardly

from one end of said cylinder, said armature being movable toward and away from this end of said cylinder upon actuation of said magnetic coil, said armature being freely mounted on said piston rod.

6. A piston pump, particularly for pumping fuel for oil furnaces, comprising means defining a cylinder, a hollow piston reciprocable in said cylinder, the bore of said piston defining a passage for the flow of fluid therethrough, an armature connected to said piston, said piston having a piston rod portion of non-magnetic material at least in the range of said armature, a magnet coil around said cylinder and adjacent said armature, discharge conduit and valve means connected to said cylinder, and inlet conduit and valve means connected to said cylinder including means defining a concentric annular slot in said cylinder which is in communication on the suction side of said cylinder through the bore of said piston, a cylinder housing enclosing said armature and said cylinder, said housing including said inlet means at one end and an outlet means at an opposite end for closing off each end of said housing, said inlet means defining a recess for said armature which extends outwardly from one end of said cylinder, said armature being movable toward and away from this end of said cylinder upon actuation of said magnetic coil, said armature being freely mounted on said piston rod, and resilient stop means in alignment with said piston rod and said armature for stopping said piston rod and said armature in each end position.

7. A piston pump, particularly for pumping fuel for oil furnaces, comprising means defining a cylinder, a hollow piston reciprocable in said cylinder, the bore of said piston defining a passage for the flow of fluid therethrough, an armature connected to said piston, said piston having a piston rod portion of non-magnetic material at least in the range of said armature, a magnet coil around said cylinder and adjacent said armature, discharge conduit and valve means connected to said cylinder, and inlet conduit and valve means connected to said cylinder including means defining a concentric annular slot in said cylinder which is in communication on the suction side of said cylinder through the bore of said piston, a cylinder housing enclosing said armature and said cylinder, said housing including said inlet means at one end and an outlet means at an opposite end for closing off each end of said housing, said armature being freely mounted on said piston rod, resilient stop means in alignment with said piston rod and said armature for stopping said piston rod and said armature in each end position, and anti-magnetic spring means biasing said armature toward the respective stop.

8. A pump comprising an electromagnetic actuating coil, means defining a pump cylinder within said coil having a beveled end adjacent one end of said coil, a piston reciprocable in said pump cylinder, an inlet connected to one end of said pump cylinder, an outlet connected to the other end of said pump cylinder, inflow and outflow valve means associated with said pump cylinder for permitting flow through said inlet into said cylinder and out said outlet upon reciprocating of said piston, and armature having a beveled end adapted to seat against the beveled end of said pump cylinder in an actuated position and connected to said piston and arranged adjacent said coil and being movable upon excitation of said coil to cause reciprocation of said piston to said beveled end of said pump cylinder, and means biasing said armature away from the beveled end of said pump cylinder.

9. A pump comprising an electromagnetic actuating coil, means defining a pump cylinder within said coil having an end defining an armature stop, a piston reciprocable in said pump cylinder, an inlet connected to one end of said pump cylinder, an outlet connected to the other end of said pump cylinder, inflow and outflow valve means associated with said pump cylinder for permitting flow through said inlet into said cylinder and out said outlet upon reciprocation of said piston, an armature connected to said piston and concentrically arranged in respect to said coil and being movable with said piston upon excitation of said coil against said armature stop, and means to bias said armature away from said armature stop.

10. A pump comprising an electromagnetic actuating coil, means defining a pump cylinder within said coil, having an end defining an armature stop, a piston reciprocable in said pump cylinder, an inlet connected to one end of said pump cylinder, an outlet connected to the other end of said pump cylinder, inflow and outflow valve means associated with said pump cylinder for permitting flow through said inlet into said cylinder and out said outlet upon reciprocation of said piston including a valve carried by said piston which is opened when said piston is moved in a suction stroke for the inflow of fluid through the bore of said piston, and an armature connected to said piston and arranged adjacent said coil and being movable upon excitation of said coil against said stop to pump fluid in said pump cylinder, said piston having a bore therethrough for the flow of fluid through said piston and means to return said armature to a position away from said armature stop upon deenergizing of said armature.

11. A pump comprising an electromagnetic actuating coil, means defining a pump cylinder within said coil, a piston reciprocable in said pump cylinder, an inlet connected to one end of said pump cylinder, an outlet connected to the other end of said pump cylinder, inflow and outflow valve and conduit means associated with said pump cylinder for permitting flow through said inlet into said cylinder and out said outlet upon reciprocation of said piston, and an armature connected to the inlet end of said piston and arranged adjacent said coil and being movable upon excitation of said coil to cause reciprocation of said piston, and means in said inflow and outflow valve and conduit means forming a resilient stop in alignment with said armature for limiting the end movement thereof.

12. A pump comprising an electromagnetic actuating coil, means defining a pump cylinder within said coil, a piston reciprocable in said pump cylinder, an inlet connected to one end of said pump cylinder, and outlet connected to the other end of said pump cylinder, an armature connected to said piston and arranged adjacent said coil and being movable upon excitation of said coil to cause reciprocation of said piston, an inlet fitting connected to said pump cylinder, and a resilient member having a slot defined therethrough arranged in alignment with said armature and said inlet fitting and forming a stop for the limiting of the movement thereof, discharge conduit and valve means associated with said pump cylinder for permitting flow out said outlet upon reciprocation of said piston, and said armature being engageable with said resilient member to close off the inflow of fluid to said cylinder.

13. A pump comprising an electromagnetic actuating coil, means defining a pump cylinder within said coil, a piston reciprocable in said pump cylinder, an inlet connected to one end of said pump cylinder, and outlet connected to the other end of said pump cylinder, an armature connected to said piston and arranged adjacent said coil and being movable upon excitation of said coil to cause reciprocation of said piston, an inlet fitting connected to said pump cylinder, and a resilient member having a slot defined therethrough arranged in alignment with said armature and said inlet fitting and forming a stop for the limiting of the movement thereof, discharge conduit and valve means associated with said pump cylinder for permitting flow out said outlet upon reciprocation of said piston, said armature being engageable with said resilient member to close off the inflow of fluid to said cylinder, a housing surrounding said cylinder and said electromagnetic coil, and an adjustment member threaded into said

housing and engageable with said resilient member for displacing said resilient member to vary the stop position of said armature.

14. A pump comprising an electromagnetic actuating coil, means defining a pump cylinder within said coil, a piston reciprocable in said pump cylinder, an inlet connected to one end of said pump cylinder, an outlet connected to the other end of said pump cylinder, inflow and outflow valve means associated with said pump cylinder for permitting flow through said inlet into said cylinder and out said outlet upon reciprocation of said piston, and an armature connected to said piston and arranged within said coil and being movable upon excitation of said coil to cause reciprocation of said piston, said inflow and outflow valve means including means defining a connecting conduit adjacent one end of said cylinder and in alignment therewith, and further means defining a flow conduit extending into said cylinder at an angle thereto.

15. A pump comprising housing means defining an inner pump cylinder and an outer wall spaced therefrom, a discharge fitting connected to one end of said housing in alignment with said pump cylinder, an inlet fitting connected to the opposite end of said housing in alignment with said pump cylinder, an electromagnetic coil disposed between said pump cylinder and said outer wall, a piston slidable in said pump cylinder and including a piston rod portion being of non-magnetic material at least adjacent said armature, an armature connected to the inlet end of said piston and being substantially concentric therewith and with said coil, said coil being excitable to cause reciprocation of said armature with said piston discharge valve means in said discharge connection for permitting the discharge of fluid from said pump upon reciprocation of said pump, inlet valve means in said inlet fitting for permitting the inflow of fluid into said cylinder upon reciprocation of said piston, and means for biasing said armature to a non-actuating position.

16. A pump comprising housing means defining an inner pump cylinder and an outer wall spaced therefrom, a discharge fitting connected to one end of said housing in alignment with said pump cylinder, an inlet fitting connected to the opposite end of said housing in alignment with said pump cylinder, an electromagnetic coil disposed between said pump cylinder and said outer wall, a piston slidable in said pump cylinder and including a piston rod portion being of non-magnetic material at least adjacent said armature, an armature connected to the inlet end of said piston and being substantially concentric therewith and with said coil, said coil being excitable to cause reciprocation of said armature with said piston, discharge valve means in said discharge connection for permitting the discharge of fluid from said pump upon reciprocation of said pump, inlet valve means in said inlet fitting for permitting the inflow of fluid into said cylinder upon reciprocation of said piston, means for biasing said armature to a non-actuating position, and a resilient member disposed in said inlet in alignment with said armature and forming a limiting stop for movement thereof.

17. A pump comprising housing means defining an inner pump cylinder and an outer wall spaced therefrom, a discharge fitting connected to one end of said housing in alignment with said pump cylinder, an inlet fitting connected to the opposite end of said houisng in alignment with said pump cylinder, an electromagnetic coil disposed between said pump cylinder and said outer wall, a piston slidable in said pump cylinder and including a piston rod portion being of non-magnetic material at least adjacent said armature, an armature connected to the

inlet end of said piston and being substantially concentric therewith and with said coil, said coil being excitable to cause reciprocation of said armature with said piston, discharge valve means in said discharge connection for permitting the discharge of fluid from said pump upon reciprocation of said pump, inlet valve means in said inlet fitting for permitting the inflow of fluid into said cylinder upon reciprocation of said piston, and means for biasing said armature to a non-actuating position, said inlet valve means including a resilient member having a slot, said armature being wider than said slot and being biased by spring means against said resilient means for closing said slot.

18. A pump comprising housing means defining an inner pump cylinder and an outer wall spaced therefrom, a discharge fitting connected to one end of said housing in alignment with said pump cylinder, an inlet fitting connected to the opposite end of said housing in alignment with said pump cylinder, an electromagnetic coil disposed between said pump cylinder and said outer wall, a piston slidable in said pump cylinder and including a piston rod portion being of non-magnetic material at least adjacent said armature, an armature connected to the inlet end of said piston and being substantially concentric therewith and with said coil, said coil being excitable to cause reciprocation of said armature with said piston, discharge valve means in said discharge connection for permitting the discharge of fluid from said pump upon reciprocation of said pump, inlet valve means in said inlet fitting for permitting the inflow of fluid into said cylinder upon reciprocation of said piston, and means for biasing said armature to a non-actuating position, a resilient member disposed in said inlet in alignment with said armature and forming a limiting stop for movement thereof, and means for adjusting the position of said resilient means and thereby the limit position of said armature.

19. A pump comprising housing means defining an inner pump cylinder and an outer wall spaced therefrom, a discharge fitting connected to one end of said housing in alignment with said pump cylinder, an inlet fitting connected to the opposite end of said housing alignment with said pump cylinder, an electromagnetic coil disposed between said pump cylinder and said outer wall, a piston slidable in said pump cylinder and including a piston rod portion being of non-magnetic material at least adjacent said armature, an armature connected to the inlet end of said piston and being substantially concentric therewith and with said coil, said coil being excitable to cause reciprocation of said armature with said piston, discharge valve means in said discharge connection for permitting the discharge of fluid from said pump upon reciprocation of said pump, inlet valve means in said inlet fitting for permitting the inflow of fluid into said cylinder upon reciprocation of said piston, and means for biasing said armature to a non-actuating position, said piston being hollow to define a flow passage therethrough leading from said inlet to said discharge, said inlet valve means being located in said passage.

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ROBERT M. WALKER, *Primary Examiner.*