Oct. 31, 1950 H. A. BOORSE ET AL 2,528,415

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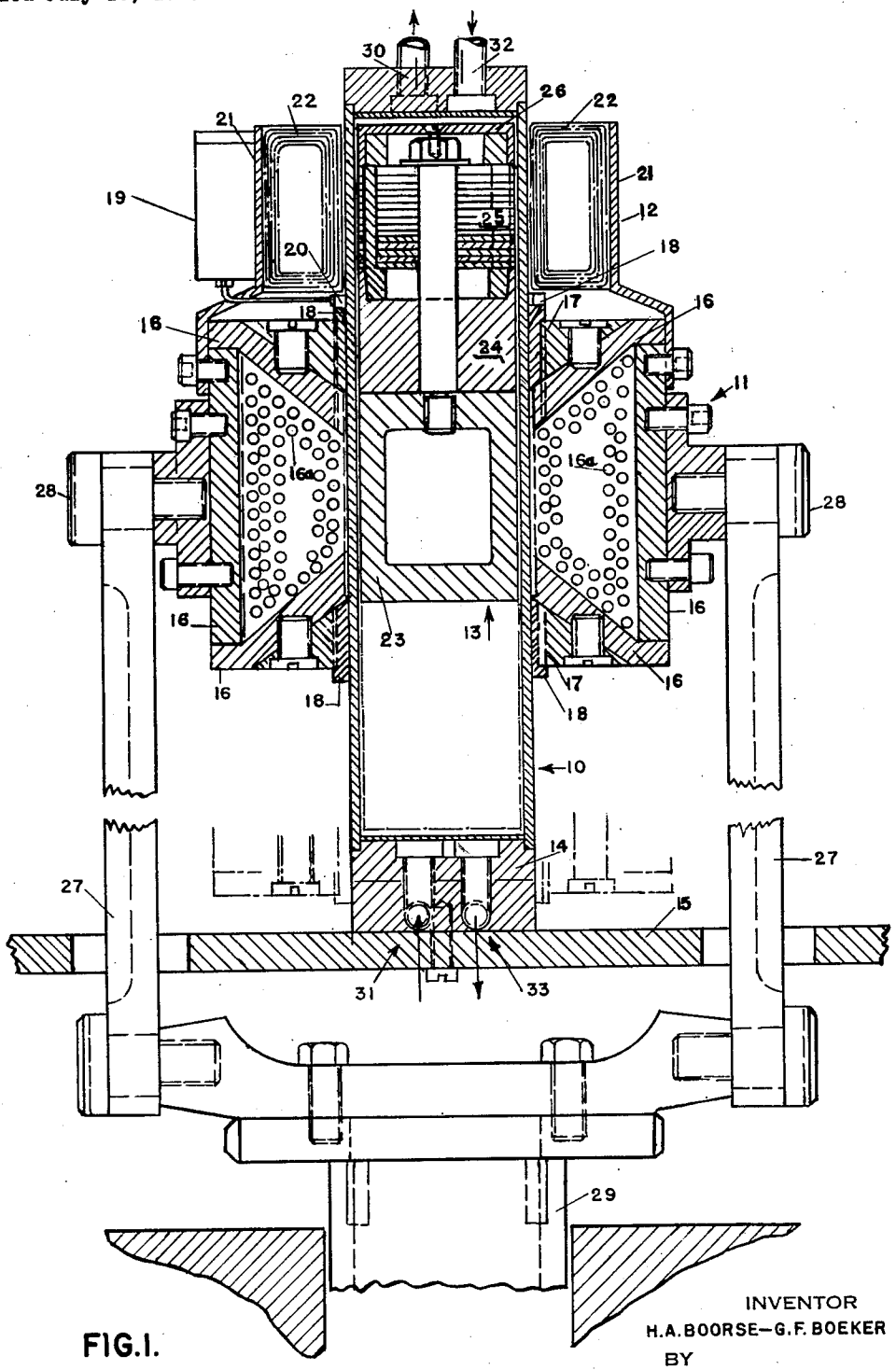

FIG. I.

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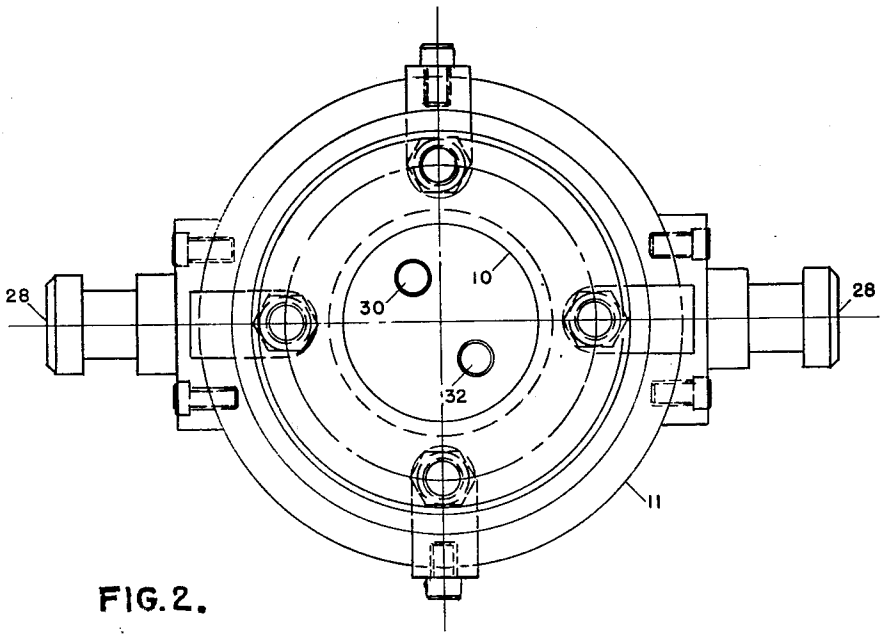

FIG. 2.

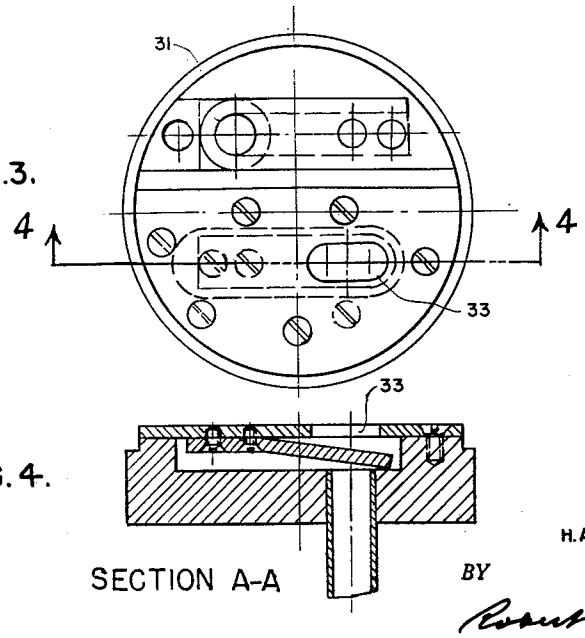

FIG. 3.

FIG. 4.

SECTION A-A

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9 Claims. (Cl. 103—53)

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The present invention relates to an improved pump particularly adapted for pumping corrosive, poisonous or noxious fluids while materially reducing leakage and minimizing reaction between the pumped fluid and lubricants within the pump.

Pumping corrosive fluids has been difficult because such fluids often react with the working parts of the pump, as well as with lubricants therefor. As a result, the pumped fluid tends to become contaminated; and the pump wears excessively because its parts do not operate effectively or satisfactorily. While it is sometimes possible to produce working parts formed of a material resistant to the corrosive fluid passing through the pump, the problem of reaction with the lubricants cannot be solved so readily; because the lubricants required by conventional pumps are limited in character and tend to react with many corrosive fluids.

Another problem involved in pumping corrosive fluids is the escape of the fluid, which naturally tends to react with nearby objects. Also, the quantity of escaped or leaking fluid is unfortunately increased as a result of the corrosion of or attack upon the working parts of the pump, and by the attack of the corrosive fluid on the lubricants. Under these circumstances the pump is not only forced to operate without proper lubrication, thus developing leaks, but its sealing means for preventing escape of the fluid is often rendered less effective if not completely ineffective.

It is therefore a principal object of the present invention to provide apparatus especially adapted to pump fluids of the aforementioned character and in which a piston operates in a cylinder without other working parts extending into the cylinder from the outside, thereby eliminating conventional and often ineffective sealing means, such as, stuffing boxes, sealing rings, and the like.

It is another object of the invention to provide a pump in which means situated exteriorly of the cylinder is provided for simultaneously rotating and reciprocating a piston within the cylinder.

Another object of the invention is to provide a pump of the foregoing general nature in which piston reciprocating means and piston rotating means may be separately adjusted or regulated thereby enabling the piston to be rotated at a relatively high speed without forcing it to reciprocate at an excessive speed.

A further object of the invention is to provide a pump in which the pumped fluid may operate as the lubricant for the piston, and in particular

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to provide a pump suitable for pumping gases and therefore utilizing a gas as a piston lubricant.

Finally, it is an object of the invention to provide an effective substantially leak-proof pump in which the piston is rotated at such a speed that a fluid film is forced into a relatively small clearance between the piston and the interior walls of the cylinder, and, as a result, provides proper hydrodynamic lubrication, with either gases or liquids.

Other objects and advantages of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Fig. 1 is a vertical sectional view of one modification of the present invention.

Fig. 2 is a top plan view of the form of the invention illustrated in Fig. 1.

Fig. 3 is an insert plan view of the lower valves illustrated in Fig. 1, showing in detail the mechanism of the valve structure.

Fig. 4 is a vertical sectional view of the construction illustrated in Fig. 3 and is taken along the line 4—4 of Fig. 3 in the direction of the arrows.

Generally speaking, the modification of the invention illustrated in the drawings comprises a fixed cylinder 10 about the outer walls of which a magnet, preferably an electromagnet or solenoid 11, is mounted for reciprocation. The electromagnet 11 carries a stator member 12 of a motor. Within the cylinder 10 a movable piston 13 is situated, and a portion 23 of this piston is formed of a magnetic material whereas another portion 25 comprises a rotor member of a motor. The stator 12 and rotor 25 comprise an electromotor for rotating the piston 13. Accordingly, the piston is adapted to reciprocate within the cylinder as the electromagnet reciprocates exteriorly thereof, and is adapted to rotate while thus reciprocating because of the co-action of the rotor and stator members of the motor.

Referring in detail to the modification of the invention shown in the drawings, the cylinder 10 is fixed to and supported by a base member 14. The latter is, in turn, fixed to and supported by suitable means such as a metal casing or framework of the pump or some foundation such as that indicated in the drawing at 15. Preferably the foundation or base 15 is formed of a non-magnetic material in order to avoid interference with the action of the electromagnet 11. For example it may be formed of aluminum. Also,

the cylinder 10 and cylinder base 14 should be formed of non-magnetic material, and in the present instance the former was made of non-magnetic stainless steel, and the latter of brass. Other suitable non-porous materials could be employed provided that they are non-magnetic and therefore do not attract and "short circuit" the magnetic flux created by the electromagnet. As more fully pointed out hereinafter such flux should be attracted by the portion 23 of the piston 13 to insure proper operation of the pump.

The structure of electromagnet 11 may vary somewhat provided that it is mounted for reciprocation exteriorly of the cylinder 10 and is operatively connected with suitable means for reciprocating it. In the modification shown in the drawings, the electromagnet comprises a generally annular 3-piece framework or member shown at 16 in which the pieces are suitably fastened together so that the member is generally trapezoidal in cross section as illustrated in Fig. 1. This member 16 is, of course, formed of a suitable magnetic material such as iron or steel and in the embodiment of the invention illustrated, it was actually formed of Swedish iron. Within the member 16 suitable electro-windings shown at 16a are situated. These windings are connected to suitable electric conductors (not shown) leading to a source of electric current for actuating the magnet. The reference numeral 17 indicates a brass cap attached to the member 16 in the manner shown in order to strengthen and unify the structure of the magnet, and bronze or other suitable bearing members are provided at 18 in order that the electromagnet may effectively reciprocate along the outer surfaces of the cylinder without deleterious effects.

While any suitable means of lubricating the electromagnet for reciprocation may be employed, the means illustrated in the drawings comprises a drop oiling mechanism shown at 19. This mechanism, generally speaking, consists of a suitable reservoir with a conduit leading to an oil distributing means 20. This may be a mechanical means for feeding oil dropwise at the outer walls of the cylinder, a wick, or some other device for distributing the proper quantity of oil to the cylinder or to the sliding surfaces of the electromagnet.

The motor stator member 12 is carried by the electromagnet 11 by means of the frame 21 which is bolted to the electromagnet as shown in Fig. 1. It will be noted that this stator member is so constructed that it is positioned closely adjacent the outer surfaces of the cylinder 10, and since it is carried by the electromagnet 11, it reciprocates with the latter. The stator member possesses suitable conductors or windings 22. These conductors may be selected and constructed so as to create a desired type of electromotor stator effective to operate with the electromotor rotor to form a type of motor suitable for the purpose. A number of different types of windings may be employed, and one skilled in the art may select or construct a suitable stator and rotor member to fit his purpose.

The piston 13 is substantially freely movable within the interior of the cylinder 10; that is, no connecting rod or like working part extends into the cylinder from the outside and is attached to the piston. A portion 23 of the piston 13 is formed of a magnetic material such as cold-rolled steel and is machined and dimensioned carefully to fit within the cylinder 10 to provide a relatively small clearance between its outer walls and the inner walls of the cylinder. To the portion 23 there is attached by suitable fastening elements another portion 24 which serves as a base for, or part of the electromotor rotor. This portion 24 is formed of non-magnetic material such as aluminum, and is machined to substantially the same outer dimensions as the portion 23 so that the portions 23 and 24 form a smoothly joined integrated piston. The electromotor rotor member is supported by or may form a part of the portion 24. This rotor member possesses conductors or windings shown at 25 suitably fixed to a supporting frame and connected to the portion 24 by bolting means in the manner indicated in Fig. 1. It is preferable to place a cap or cover 26 over the top of the windings in order to provide a closed end for the piston. The electro-rotor member, and especially the conductors 25 thereof, co-acts with the stator member so that the rotor and stator constitute parts of an electromotor. Accordingly, the type of stator member and its construction may be varied somewhat, dependent upon the type of electromotor desired and upon the construction of the stator member of the motor.

The form of the invention illustrated in the accompanying drawings operates as follows: The electromagnet 11 is reciprocated back and forth along the exterior wall of the cylinder 10 by the yoke 27. This yoke is pivotally attached to the electromagnet 11 at 28, 28 and is rigidly secured to a suitable drive shaft 29 by means of a cross head in the manner clearly shown in Fig. 1. The details of the construction of the drive shaft and yoke may vary provided that suitable mechanical means is provided for reciprocating the electromagnet 11 at a relatively high speed. Any suitable means for reciprocating the drive shaft, and therefore for reciprocating the electromagnet 11, may be employed.

As the electromagnet moves toward the top of the cylinder 10 it will drag or move the piston 13 in the same direction because of the magnetic attraction of the portion 23 for the electromagnet 11. In other words the electromagnet 11 creates a strong magnetic field in the neighborhood of the walls of the portion 23; and since the latter are formed of a magnetic material this magnetic field attracts the portion 23 and holds it as shown in Fig. 1; that is, juxtaposed with respect to the electromagnet 11. Accordingly, as the electromagnet moves along the outer walls of the cylinder 10 so does the piston move within the cylinder.

As the piston closely approaches the top end of the cylinder 10 it tends to compress the fluid being pumped and finally forces it out of the outlet 30 (Fig. 2). A suitable valve arrangement is provided whereby the fluid may escape from the outlet 30 when forced thereinto. For instance, a reed type valve (more fully explained below) may be employed. In this construction, a reed or flap is adapted to open when fluid is pressed against it or sucked away from it, to permit the fluid to escape through an outlet and to be drawn into an inlet in the proper timed relationship. However, other types of valves could be used, if desired. It will be noted that in the modification of the invention illustrated, the pump is adapted to pump fluids when the piston moves in either direction within the cylinder. Accordingly, as the cylinder moves toward the top of the piston in the manner explained above, fluid

is drawn into the lower inlet 31 while it is being forced out of the upper outlet 30. A suitable valve permitting the inflow of fluid into the cylinder is inserted in the inlet 31. Accordingly fluid is simultaneously forced out of the upper portion of the cylinder while it is being drawn into the lower portion thereof. When the piston moves from the top of the cylinder toward the bottom, the reverse process takes place; that is, fluid is drawn into the upper portion of the cylinder through the upper inlet 32 and is forced out of the lower outlet 33.

The operation of a typical reed type valve is particularly illustrated in Fig. 4. As there shown, the lower outlet 33 is opened to permit pumped fluid to escape from the piston on its downward stroke. The valve in the upper inlet 32 is open at this time. When the piston is on its upward stroke, the valves in the lines 32 and 33 are forced shut closing the upper inlet and the lower outlet. The reeds or flaps are so arranged, however, that on this upward stroke the lower inlet 31 and the upper outlet 30 are opened to permit pumped fluid to escape from the top part of the cylinder while fluid is being drawn into the bottom part thereof.

As the piston 13 reciprocates within the cylinder 10 it also rotates. It is rotated by the electromotor comprising the stator 12 and rotor 25 previously described. It will be noted that the stator is carried by the electromagnet 11 and that the rotor is closely adjacent the stator member; and, in fact, is separated therefrom only by the walls of the cylinder 10. Accordingly the rotor and stator members are always juxtaposed to provide proper operation of the motor for rotating the piston. Rotation of the piston is especially desirable in the event that a gas is pumped, inasmuch as this rotation forces gas into the relatively small clearance between the piston and the walls of the cylinder tending to building up the gas pressure in this clearance and thereby providing a gas film which acts as a lubricant for the moving piston. While this lubricating effect of the pumped fluid is not confined to gases, it is particularly useful if a gas is pumped; since otherwise the pumped gas would not provide very satisfactory lubrication for the piston.

It will be noted that the piston 13 may be rotated at a high speed if desired by properly arranging the construction of the motor which drives it. It is advantageous to set the speed of rotation of the piston at a desired value. It will be further noted that this means of adjusting the speed of rotation of the piston; that is, by the construction of the motor, does not depend upon the reciprocating mechanism. Accordingly the speed of rotation of the piston may be controlled independently of the speed of reciprocation of the piston. The speed of the reciprocation may, of course, be readily controlled by suitable mechanical means such as adjusting the speed of operation of the drive shaft or its reciprocating mechanism. Accordingly the piston may be reciprocated relatively slowly and rotated relatively rapidly, enough to avoid metal to metal contact between the piston and cylinder walls. In fact, a suitable reciprocating speed may be secured by adjusting the reciprocating mechanism, while a suitable rotating speed may be secured by properly adjusting the motor, and these adjustments may be made independently of each other, or only one adjustment made if desired. This is an important advantage over former pumps and permits the piston to be rotated at a relatively high

speed in order that a gas may effectively lubricate the piston without requiring an excessive rate of reciprocation which would tend to reduce pumping effectiveness, to cause excessive wear, and generally be undesirable.

It should be pointed out that instead of ar electromagnet which carries a motor stator mem ber or instead of having distinct or differen stator and electromagnet elements, it is contem plated that these elements may be combined into a single unit adapted to reciprocate along the exterior walls of the pump cylinder. Such a unit would serve the purpose of both the electro magnet and motor stator member in that it woul attract the piston to cause its reciprocation an serve as the stator of the motor and therefor cause the piston to rotate as well. This uni could be provided through suitably arranging conductors in or on a support or frame so that a magnetic field is created which serves to operate the rotor and also to attract the magnetic material in the piston for reciprocating it. Naturally the rotor is provided with suitably arranged conductors so that it will operate wit the reciprocable unit.

It will be noted that the present apparatus is especially effective in pumping corrosive, po sonous, or noxious gases; because the cylinder is completely sealed from the outside, assuming course that an effective valve system is installe. The manner of operating the piston by means of the electromagnet and motor permits the piston to be lubricated effectively by means of the pumped fluid itself, thereby avoiding problems resulting from reaction of the pumped fluid and lubricants within the pump. The construction of the device minimizes leakage and escape of the noxious gases or other fluids passing through the pump, while prolonging the life of the pump by insuring effective lubrication at all times the pump is in operation.

As pointed out hereinbefore, the working parts as well as other portions of the pump coming into contact with the pumped corrosive fluid may be formed of a material resistant to the corrosive action of such fluid. The material or materials selected for forming the parts of the present pump should not corrode extensively enough when contacted by the contemplated pumped fluid or fluids to cause serious or appreciable interference with effective action of the pump. A material suitable for this purpose should, of course, also be strong enough and otherwise acceptable for forming pump parts. As a rule such a material or such materials may be found. The materials mentioned expressly hereinbefore serve as examples and operated satisfactorily for pumping a number of corrosive fluids including halogens and some of their compounds such as certain very corrosive gaseous fluorides.

However, it may be desirable in some instances to plate the interior walls of the cylinder 10, the outer walls of the piston 13, at least those portions formed of a material susceptible to corrosion and possibly to plate other parts of the pump contacted by the pumped fluid. These parts may be plated by known means with a material resistant to corrosion by the pumped fluid. In this way it is possible to provide a magnetic material or to provide a non-magnetic material as required; and protect these parts by the plated coating. A part formed of a magnetic material does not necessarily have to be plated with a magnetic material and also a part formed of a non-magnetic material does not necessarily

have to be plated with a non-magnetic material. The thin layer of plated material does not interfere with the attraction of the magnetic flux. Naturally the plated material may be magnetic when the plated part is magnetic or non-magnetic when the part is non-magnetic. For example, the ferrous metal magnetic parts described and illustrated herein may be plated with nickel. While plating is preferable, other means of applying a suitable protective coating may be employed such, for instance, as dipping, spraying and the like.

In addition to providing an effective means for pumping fluids, the present apparatus avoids loss of the pumped material resulting from reaction of such material with working parts of the pump or with lubricants within it. This is especially valuable in case the pumped material is expensive or difficult to obtain.

Having illustrated and described our invention and having explained the principles thereof, it will be understood nevertheless that, within the scope of the appended claims, the invention may be practiced otherwise than specifically illustrated and described. Furthermore, the phraseology or terminology employed herein is for purposes of description and not of limitation; for it is not intended to limit the invention beyond the requirements of the prior art.

We claim:

1. In a pump having a cylinder; a piston movable in said cylinder, reciprocable piston operating means mounted exteriorly of said cylinder, a member comprising a part of said means and possessing electric conductors wound to provide a magnetic field when carrying current, reciprocable driving means operatively connected with said piston operating means, and electric conductors associated with said piston and constructed to co-act with said magnetic field for rotating the piston, at least a portion of said piston being formed of a magnetic material co-active with said field to provide for reciprocation of the piston.

2. In a gas pump having a cylinder, a piston movable in said cylinder and adapted to be lubricated by the pumped gas, means operatively associated with said piston for reciprocating it, and means operatively associated with said piston for rotating it, said means being so constructed and arranged as to be independently adjustable from without said cylinder, whereby the speed of rotation and the speed of reciprocation of said piston may be separately adjusted.

3. A pump comprising a stationary cylinder, means for introducing a fluid into said cylinder and for removing pumped fluid therefrom, a piston movable in said cylinder and having at least a portion formed of a magnetic material, movable means situated exteriorly of said cylinder for creating a magnetic field, said movable means being slidable with respect to the cylinder and thereby being adapted to operate said piston, motivating means operatively connected with said movable means, an electrically actuated motor having an element associated with said movable means as well as an element associated with said piston, said elements being co-active when energized to impart rotary motion to said piston.

4. A pump comprising a stationary cylinder formed of a non-magnetic material, means for introducing a fluid into said cylinder and for removing pumped fluid therefrom, a movable piston at least partly formed of a magnetic material, electromagnetic means mounted on said cylinder exteriorly thereof, reciprocable driving means operably connected with said electromagnetic means, an electromotor stator member carried by the last said means, and an electromotor rotor member carried by said piston, whereby said piston may be simultaneously reciprocated and rotated within said cylinder.

5. A pump comprising a stationary cylinder formed of a non-magnetic material, inlet and outlet means including a valve system for introducing a fluid into said cylinder and for removing pumped fluid therefrom, a movable piston in said cylinder, said piston having a portion formed of a magnetic material, a solenoid mounted on said cylinder exteriorly thereof, means operably connected with said solenoid for reciprocating it, the stator portion of an induction type electromotor carried by said solenoid, and a rotor portion of said electromotor carried by said piston, whereby said piston may be rotated at a relatively high speed without an excessive speed of reciprocation.

6. A pump comprising a stationary cylinder formed of a non-magnetic material, means for introducing a fluid into said cylinder and for removing pumped fluid therefrom, a movable piston in said cylinder, said piston being at least partly formed of a magnetic material, an electromagnet slidably mounted on said cylinder exteriorly thereof, means operably connected with said electromagnet for reciprocating it, an electromotor stator member carried by said electromagnet, and an electromotor rotor member carried by said piston, said rotor member and said stator member constituting an electromotor adapted to rotate said piston at a relatively high speed, said piston being lubricated by a layer of said fluid and said rotation assisting in maintaining said layer.

7. Gas pumping apparatus which comprises a stationary cylinder formed of a non-magnetic material, inlet and outlet means including valves for introducing a gas into said cylinder and for removing pumped gas therefrom, a movable piston in said cylinder, said piston being at least partly formed of a magnetic material, a solenoid slidably mounted on said cylinder exteriorly thereof, driving means operably connected with said solenoid for reciprocating it, an electromotor stator carried by said solenoid, and an electromotor rotor carried by said piston, whereby said piston may be simultaneously reciprocated and rotated within said cylinder, a portion of said gas being forced as a result of said rotation between said piston and the walls of said cylinder for lubricating said piston.

8. A pump comprising a stationary cylinder formed of a non-magnetic material, means for introducing a fluid into said cylinder and for removing pumped fluid therefrom, a movable piston in said cylinder, an electromagnet slidably mounted on said cylinder exteriorly thereof, driving means operably connected with said electromagnet for reciprocating it, an electromotor stator carried by said electromagnet and an electromotor rotor carried by said piston, a portion of said piston including electric conductors juxtapositioned with respect to said stator and co-active therewith for rotating said piston, and a portion of said piston being formed of a magnetic material juxtapositioned with respect to said electromagnet and co-active therewith to maintain said juxtapositioned elements in their aforesaid relative positions, thereby causing said piston to reciprocate with said electromagnet.

9. A pump comprising a cylinder that is totally enclosed except for inlet and outlet means for the fluid being pumped; a piston reciprocable in said cylinder, said piston comprising an electromotor rotor and a portion formed of a magnetic material, an electromagnet adjacent to the external surface of said cylinder and adapted to cooperate magnetically through the wall of said cylinder with said portion of said piston to cause said piston to move axially in said cylinder, and an electromotor stator mounted adjacent to the external surface of said cylinder and adapted to cooperate through the wall of said cylinder with said rotor to rotate said piston, whereby said piston is simultaneously rotated and reciprocated in said cylinder.

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