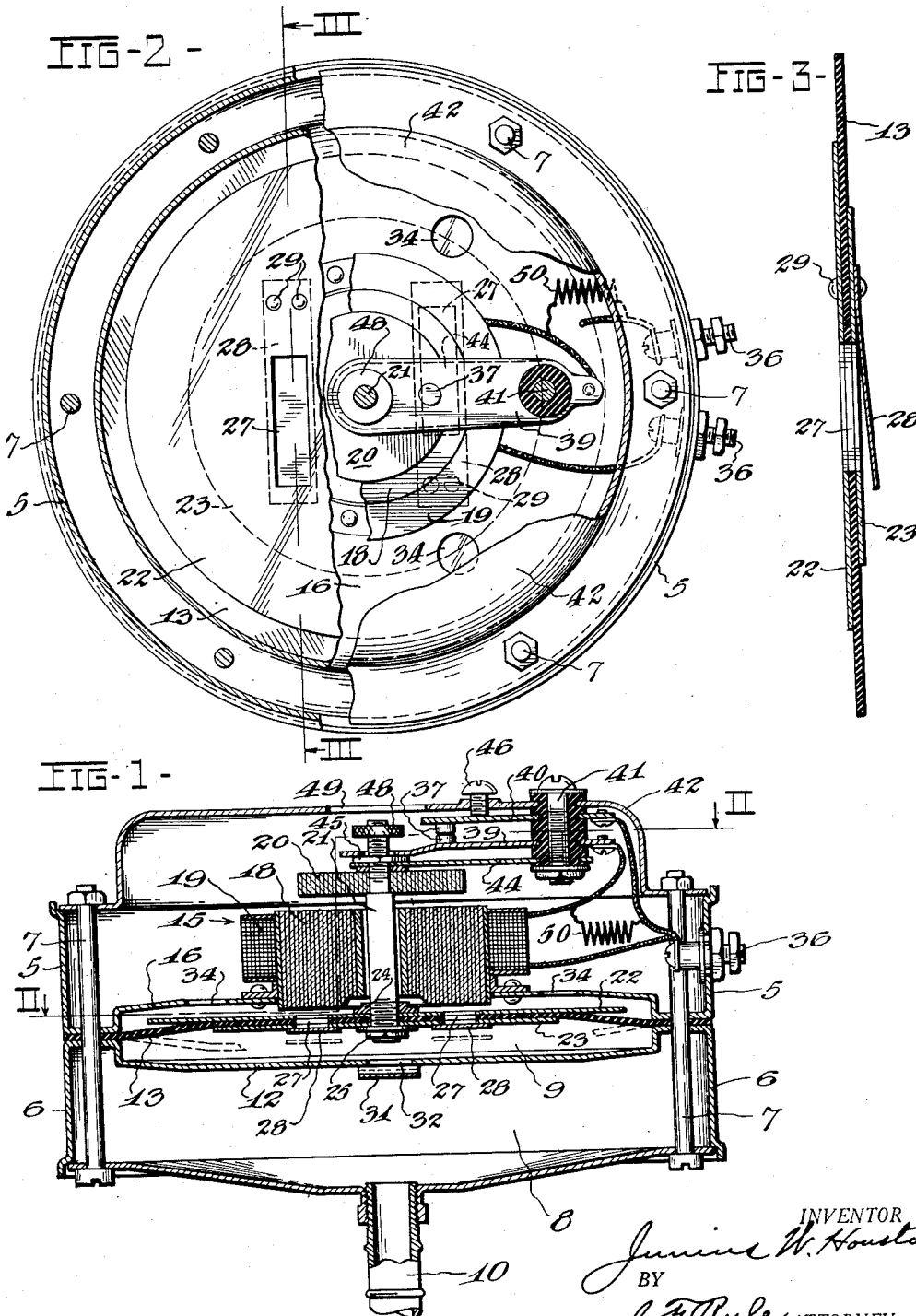


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ELECTROMAGNETIC PUMP
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ELECTROMAGNETIC PUMP

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My invention relates to apparatus for pumping gaseous fluids. More particularly, it relates to electromagnetically operated mechanism for pumping air or other gaseous fluid wherein a driving member is rapidly reciprocated under the influence of electromagnetic impulses, and operates to compress or exert a driving force on the air or other gas which is being acted upon.

In its preferred form, the invention comprises an electromagnet and its armature, means for imparting electric impulses to the magnet windings and thereby causing a rapid reciprocation of the armature, a compression chamber, a driving element in the form of a diaphragm or plate which forms a wall of said chamber and is connected to the armature to be reciprocated thereby, and valves controlling the ingress and egress of a gaseous fluid to and from the compression chamber.

The valves are operated in synchronism with the rapidly vibrating driving element. The compression valves which control the entrance of air or gas to the compression chamber, must be tightly closed during each compression stroke in order to obtain an effective compression or pumping action. I have found that the usual forms of valves and valve operating means are ineffective, owing to the rapid rate of vibration required and the resistance which the air or gas offers to the quick closing movements of the valves, so that they are not fully closed throughout the compression stroke. This results in leakage and weak compression.

An object of the present invention is to overcome this difficulty by providing means for effectively closing the valves in synchronism with the movements of the driving or compression element, and thereby obtaining full compression and a powerful pumping action. In the attainment of this object, I provide resilient or spring actuated compression valves which preferably have a normal rate of vibration corresponding to the rate at which the driving element is reciprocated, and also provide means for imparting magnetic impulses to the valves in harmony with the movements of the driving element and in a manner to obtain a positive and effective action of the valves.

A further object of the invention is to provide a fluid pump which is simple in construction, reliable and efficient in operation, and which embodies the novel features of construction and method of operation hereinafter set forth.

Other objects of the invention will appear hereinafter.

The present application discloses a construction which is similar in many respects to that disclosed in my copending application, Serial Number 742,081, filed August 30, 1934, and is a continuation of said copending application as to all subject-matter common to both applications.

Referring to the accompanying drawing:

Fig. 1 is a sectional elevation of a preferred form of the apparatus.

Fig. 2 is a part sectional plan view at the line II—II on Fig. 1.

Fig. 3 is a section at the line III—III on Fig. 2.

The invention will now be described as constructed and used for pumping air, although it will be understood that it may be used for pumping any gaseous fluid. The illustrated embodiment of the invention comprises a fluid pumping mechanism having a housing which includes an upper section 5 and a lower section 6 which are secured together by clamping bolts 7. The lower section provides an expansion chamber 8 into which air is admitted from a compression chamber 9. The expansion chamber is provided with an outlet opening from which extends a pipe or conduit 10 through which the air under pressure is conducted.

The lower section 6 of the housing includes a horizontally disposed top plate 12 which is offset downwardly to form the lower wall of the compression chamber 9. The upper wall of the compression chamber comprises a circular diaphragm or disk 13 made of rubber, leather or other flexible material. The annular margin of the diaphragm is clamped between the upper section 5 and lower section 6 of the housing.

An electromagnet 15 has a fixed mounting within the housing above the compression chamber 9. As shown, the electromagnet comprises a laminated body or field 18 on which is mounted a field coil 19. The electromagnet is secured to a circular plate 16 which forms the bottom wall of the housing section 5, said plate 16 being offset upwardly from the diaphragm 13. The laminated armature 20 of the electromagnet is mounted on a connecting rod or post 21 which extends downward through a central opening in the magnet and is attached adjacent to its lower end, to the diaphragm 13.

A circular driving plate or disk 22 overlies the flexible diaphragm 13, and a valve plate 23 of somewhat smaller diameter than the plate 22, underlies the diaphragm. The plates 22 and 23 are clamped to the diaphragm and to the post 21 by clamping nuts 24 and 25 on the lower threaded end of the post. The plates 22, 23 and the dia-

phragm 13 have aligned holes therethrough providing ports 27 for compression valves 28. These valves, as shown, are flat strips of resilient metal, preferably spring steel or iron, and are secured to the valve plate by rivets 29. The compression valves are made of magnetic material for a purpose hereinafter set forth.

A check valve 31 attached to the under surface of the plate 12, controls a port 32 through which the air under pressure passes from the compression chamber 9 to the expansion chamber 8. The valve 31 may be similar to the compression valves 28 but may be made of non-magnetic material. A series of holes 34 in the wall 16 permit the free passage of air to the ports 27.

The terminals of the field coil 19 are connected to binding posts 36 to which may be attached conductors leading to a battery or other source of electric current. A circuit-interrupting device is interposed between the field coil and one of the binding posts 36. It comprises a pair of contacts 37 on arms 39 and 40 connected in the circuit of the field coil. The arms 39 and 40 may be in the form of flat spring metal strips clamped on a screw threaded post 41 attached to the cover plate 42 of the housing.

A leaf spring 44 is secured at one end to the post 41 and at its opposite end is clamped to the rod 21 by a nut 45. The spring 44 serves to lift the armature when it is demagnetized. A resistance unit 50 is connected across the contact points 37 to prevent harmful sparking. An adjusting screw 46 bears against the contact arm 40 and permits adjustment of the contact points to compensate for wear.

The arm 39 is extended beyond the contact points 37 and provided with an opening through which the upper, threaded end of the rod 21 projects. An adjusting nut 48 threaded on the rod provides a means for adjusting the frequency and amplitude of movement of the armature and diaphragm as hereinafter described. The cover plate 42 is provided with an air inlet opening 49 which also provides easy access to the adjusting nut 48.

The operation is as follows: When the field coil 19 is connected in a direct current circuit, the magnet 18 is energized and draws the armature 20 downward and thereby moves the connected driving plate 22 and diaphragm 13 downward. The air in the compression chamber 9 is thus compressed and opens the check valve 31, so that the air under pressure passes into the expansion chamber 8. As the driving plate 22 and valve plate 23 are quite stiff or rigid, they move bodily downward with a piston-like action, expelling a comparatively large volume of air from the compression chamber. The flexible, elastic diaphragm 13 permits the piston action of the driving plate, such action taking place without objectionable sound vibration of the plate or diaphragm.

As the driving plate nears the limit of its downward stroke, the nut 48 engages the arm 39 and moves it downward a short distance, thereby separating the contacts 37 and breaking the circuit through the field coil. The electromagnet being thus deenergized, the leaf spring 44 quickly lifts the armature and connected parts, returning them to the position shown in Fig. 1.

The upward movement of the driving plate 22 and diaphragm tends to create a partial vacuum in the chamber 9 so that air is drawn in through the ports 27, the compression valves 28 being opened as indicated in broken lines (Fig. 1). At the same time, the check valve 31 is held closed

and prevents escape of air from the expansion chamber 8 back into the chamber 9. As the armature completes its upward movement, the contacts 37 are again brought together, reestablishing the circuit and initialing another cycle of operations.

The leaf spring valves 28 and 31 are preferably constructed to have a normal rate of vibration equal to or corresponding to the frequency of the reciprocations of the magnet armature and the diaphragm. This facilitates the opening and closing movements of the valves in synchronism with the movements of the diaphragm.

As before noted, the compression valves 28 are made of magnetic material, so that when the electromagnet is energized, a magnetic pull is applied to the valves. This pull is in a direction to close the valves and is added to the force due to the spring action of the valve which tends to close on account of its own resiliency. The magnetic force is applied to the valves just in advance of the downward movement of the armature so that the valves are fully closed substantially at the instant the driving plate 22 commences its compression stroke and are magnetically held closed during the entire or major portion of the compression stroke. As the circuit is broken just prior to the completion of the compression stroke, the valves are deenergized in time to permit them to open as soon as there is a downward air pressure differential at the valve ports 27. This pressure differential is initiated during the early portion of the upward piston movement.

I have discovered and proved by experiment that the magnetizing of the compression valves in the manner above described, is very effective in causing a positive action of the valves by which they are completely closed and held closed throughout the compression stroke and are opened to freely admit air to the compression chamber during the return stroke. As the magnetic pull on the valves is initiated slightly in advance of the compression movement of the piston, the valves are fully closed by the time compression begins, so that air leakage is prevented. I have found that without the magnetic pull on the valves, as when they are made of non-magnetic material, there is a lag in their closing movement. This allows an outward flow of air through the valve ports as the compression stroke of the driving plate commences. The outward rush of air and the pressure thus built up between the valves and their seats, interferes with and retards the closing movement of the valves, and greatly augments the air leakage so that the compression in the chamber 9 is comparatively weak. The magnetic action as above described, overcomes this difficulty, and as I have proved by experiment, greatly increases the effectiveness of the apparatus by enormously increasing the volume and pressure of air which is pumped thereby.

The magnetization of the valves further serves reliably to hold them closed during the compression stroke when the apparatus is subjected to jars or vibration, as, for example, when mounted on automobiles and used to supply air for reed horns or other signaling devices.

Although the compression valves are shown mounted on the diaphragm or driving plate, it will be understood that in some instances they might be located elsewhere, and, generally speaking, in any convenient position to control the entrance of air to the pressure chamber. The posi-

tion of the check valve 31 or check valves may in like manner be varied.

The compression valve or valves are conveniently placed within the influence of the electromagnet which actuates the diaphragm or driver for pumping air, but may be actuated by any electromagnet in the same periodically interrupted circuit, or which is periodically energized in synchronism with the magnetic impulses in the pumping magnet.

The magnetic impulses, whether produced by an intermittent current under the control of a circuit interrupter, such as herein shown, or by an alternating current, or otherwise, preferably have a high frequency. The time intervals between successive impulses may be only a small fraction of a second. By adjusting the nut 48 up or down, the rate and amplitude of vibration may be adjustably varied through a rather wide range.

Modifications may be resorted to within the spirit and scope of my invention as defined in the appended claims.

I claim:

1. Fluid pumping apparatus comprising a chamber, means for periodically expanding and contracting said chamber, means providing a passageway communicating with the interior of the chamber, a valve controlling said passageway, and electro-responsive means for periodically actuating the valve in synchronism with the periodic expansion and contraction of said chamber.

2. Fluid pumping apparatus comprising an electromagnet, means for causing periodic impulses in the electromagnet, means providing a fluid chamber and including a pumping element periodically actuated by the electromagnet, said pumping element operable to pump fluid into said chamber, and an electromagnetically controlled spring valve having a normal rate of vibration corresponding to the frequency of said impulses and controlling the admission of fluid to said chamber.

3. Fluid pumping apparatus comprising an electromagnet, means for causing periodic impulses in the electromagnet, means providing a fluid chamber and including a pumping element periodically actuated by the electromagnet, said pumping element operable to pump fluid into said chamber, and a valve controlling the admission of fluid to said chamber, said valve comprising magnetic material and being located within the influence of said electromagnet and periodically actuated thereby.

4. Fluid pumping apparatus comprising means providing a fluid chamber, said means including a driving element, electro-responsive means for periodically imparting a driving movement to said element and thereby contracting said chamber, a valve controlling the entrance of fluid to said chamber, and means operating periodically in synchronism with the said movements of the driving element to impart a closing impulse to the valve in advance of the contraction of said chamber.

5. Fluid pumping apparatus comprising means providing a fluid chamber, said means including a driving element, electro-responsive means for periodically imparting a driving movement to said element and thereby contracting said chamber, a magnetic valve controlling the admission of fluid to said chamber, and means for imparting magnetic impulses to the valve in synchronism with the contractions of said chamber and thereby closing the valve.

6. Fluid pumping apparatus comprising means providing a fluid chamber, said chamber comprising a diaphragm forming a wall thereof, an electromagnet, an armature therefor, means for periodically energizing the electromagnet and thereby reciprocating the armature, means for transmitting said reciprocations to the diaphragm, a port opening into said chamber, and a magnetic valve actuated by the electromagnet and controlling said port.

7. Fluid pumping apparatus comprising means providing a fluid chamber, said chamber comprising a diaphragm forming a wall thereof an electromagnet, an armature therefor, means for periodically energizing the electromagnet and thereby reciprocating the armature, means for transmitting said reciprocations to the diaphragm, and a magnetic valve in the diaphragm and controlling the admission of fluid to said chamber, said valve being within the magnetic influence of the electromagnet and periodically actuated thereby in synchronism with the reciprocations of the diaphragm.

8. Fluid pumping apparatus comprising an electromagnet, means for causing periodic impulses in the electromagnet at equal time intervals of predetermined frequency, means providing a fluid chamber and including a pumping element periodically actuated by the electromagnet at said frequency, said pumping element operable to pump fluid into said chamber, said chamber having a port through which fluid is admitted to the chamber, and a spring valve having a normal rate of vibration corresponding to the frequency of said impulses and vibrating in synchronism with said impulses, said valve being positioned and arranged to control the admission of fluid to said chamber.

9. In a fluid pump, a wall forming a fluid chamber, said wall including an inflexible fluid driving plate and a flexible outer portion for sealing purposes, a valve of magnetic material in said plate, valve means controlling the outlet from said chamber, and electromagnetic means for imparting vibratory movement to said plate and for periodically magnetizing said valve and thereby actuating it in synchronism with the vibratory movements of said plate.

10. In a fluid pump, a vibratory driven plate, a valve of magnetic material carried by said plate, and electromagnetic means for concomitantly actuating said plate and magnetizing the valve and thereby causing the valve to be actuated in synchronism with the vibrations of the said driven plate.

11. In a fluid pump, a vibratory driven plate, a valve of magnetic material carried by said plate, a flexible member supporting the outer edge of said plate and providing a fluid tight connection therewith, and electromagnetic means for concomitantly actuating said plate and magnetizing the valve and thereby causing the valve to be actuated in synchronism with the vibratory movements of the said driven plate.

12. A fluid pump comprising a housing having an inlet and an outlet, an outwardly opening valve controlling said outlet, a substantially inflexible driven plate, means providing a flexible air-tight connection between the outer edge of said plate and said housing, an inlet valve in said plate, means to close said inlet valve upon movement of said plate in one direction, said inlet valve being adapted to open upon movement of the plate in the opposite direction, and means to impart vibratory movement to said plate to cause

ingress of fluid through said plate when moved in a direction away from said outlet valve and to force fluid past said outlet valve.

13. In a fluid pump, a vibratory driven plate, a gaseous fluid inlet valve of magnetic material, mechanism for imparting vibratory movement to said plate, and electromagnetic means operating in timed relation to the vibrations of said plate for periodically magnetizing the valve and thereby actuating it in one direction.

14. In a fluid pump, a vibratory driven plate, means forming with said plate a pressure chamber, a valve port opening into said chamber, a valve of magnetic material controlling said port and movable to closed position by fluid pressure within said chamber, and electromagnetic means for concomitantly actuating said plate and magnetizing the valve and thereby supplementing the action of fluid pressure in closing the valve.

15. In a fluid pump, a wall forming a chamber, said wall having an opening extending there-through, a leaf valve of magnetic material covering said opening, means for causing periodic fluctuations of the pressure in said chamber, said valve being movable to open and closed positions by the pressure differential thereon caused by said fluctuations, and means for periodically magnetizing the valve in synchronism with said fluctuations and thereby supplementing the action of said fluid pressure differential on the valve.

16. In a fluid pump, a wall forming a chamber, said wall having an opening extending there-

through, a leaf valve of magnetic material over said opening, means for causing a periodic flow of air through said opening into said chamber, said valve being opened by the pressure of the inflowing air, and means for periodically magnetizing the valve in timed relation to the air flow periods and thereby periodically exerting a magnetic valve closing pull on the valve.

17. In a fluid pump, the combination of a vibratory driven plate having a valve opening therein, a leaf valve of magnetic material carried by said plate and closing said opening, and electromagnetic means for vibrating the driven plate and causing an intermittent flow of air through the valve opening, the valve being movable to open position by the pressure of the air, said electromagnetic means being operable to periodically magnetize the valve and cause closing movements thereof in synchronism with the vibrations of the said driven plate.

18. In a fluid pump, the combination of a wall forming a chamber, said wall having an opening extending therethrough, a magnetic valve for periodically closing said opening, means for causing periodic fluctuations of the fluid pressure in said chamber, said valve being mounted for vibratory movement under the influence of said pressure fluctuations, and electromagnetic means for periodically magnetizing the valve in synchronism with said fluctuations.

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