Feb. 23, 1954 S. PRESENTEY 2,669,937

RECIPROCATING PUMP

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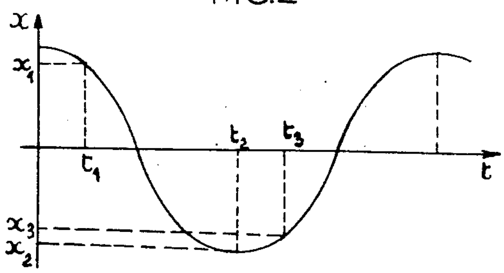
FIG.2



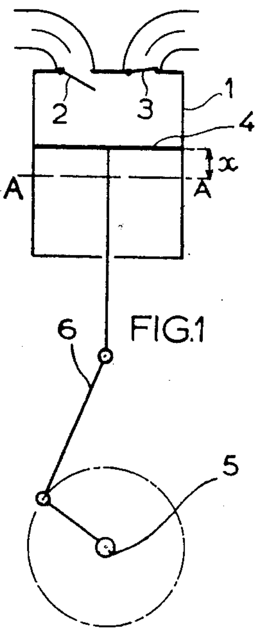


FIG.1

FIG.3

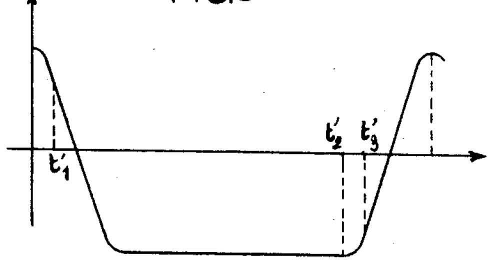


FIG.4

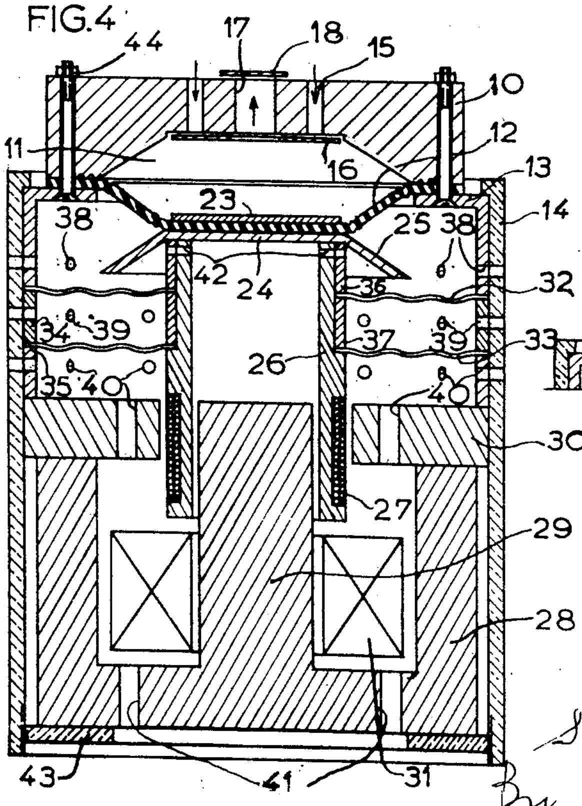
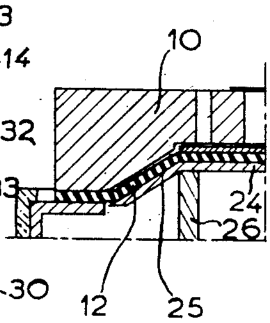


FIG.5



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Feb. 23, 1954 S. PRESENTEY 2,669,937

RECIPROCATING PUMP

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FIG.6

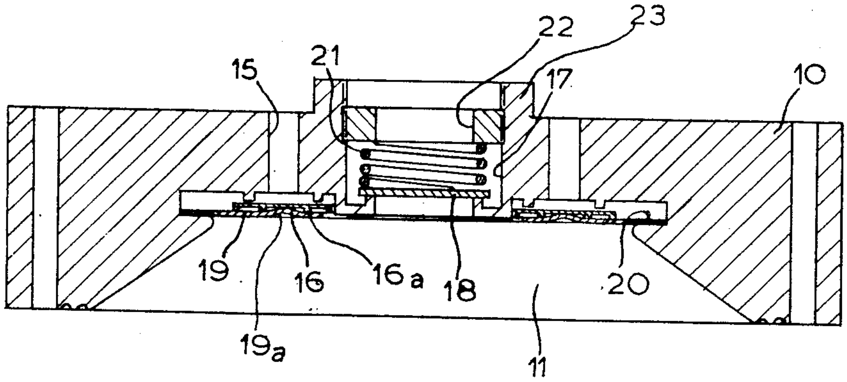
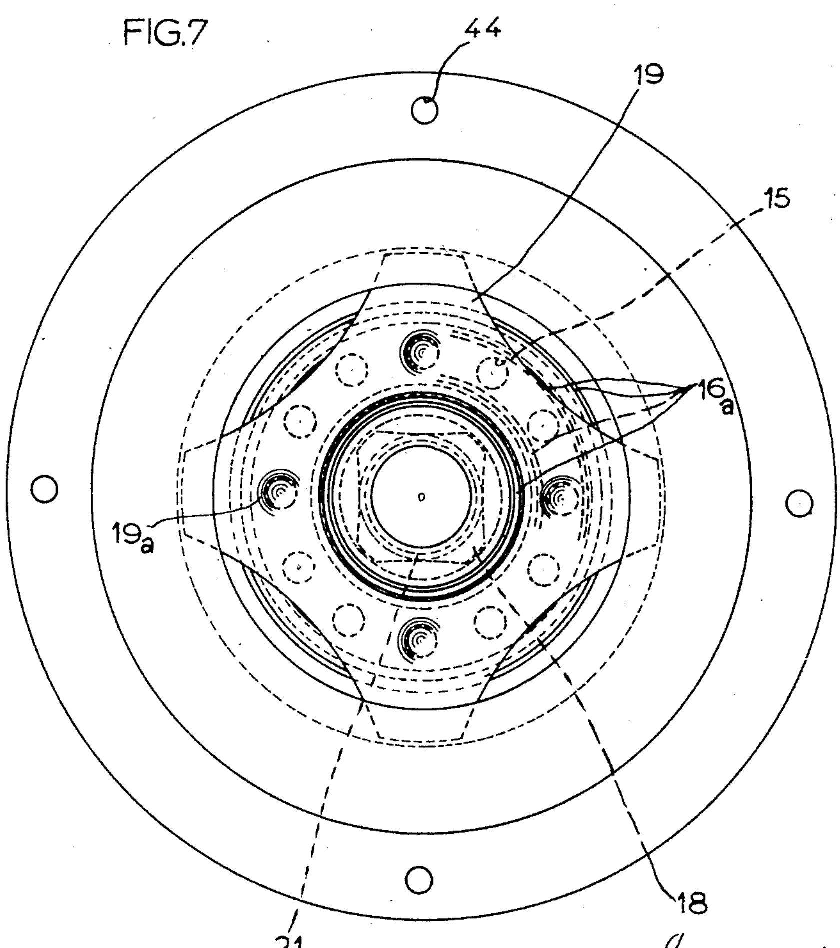


FIG.7



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RECIPROCATING PUMP

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FIG. 8a

SIMPLE RECTIFIER

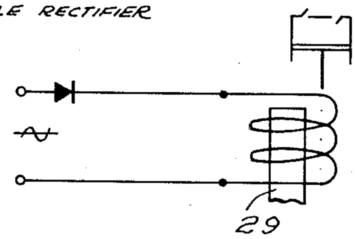


FIG. 8b

WAVEFORM

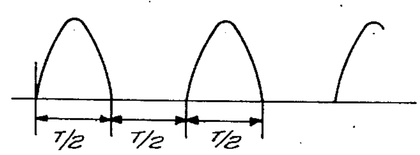


FIG. 9a

SHUNTED RECTIFIER

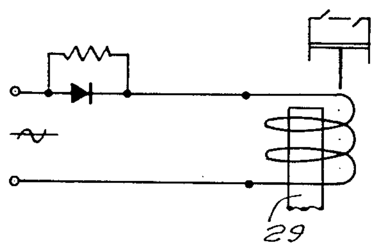


FIG. 9b

WAVEFORM

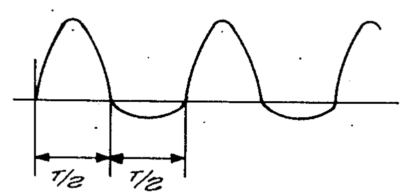


FIG. 10a

POLARISED RECTIFIER

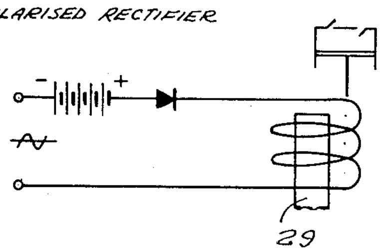
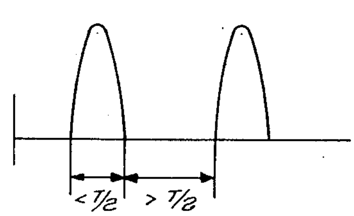


FIG. 10b

WAVEFORM



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Patented Feb. 23, 1954

2,669,937

UNITED STATES PATENT OFFICE

2,669,937

RECIPROCATING PUMP

Shelley Presentey, Bordeaux, France

Application November 8, 1950, Serial No. 194,587

Claims priority, application France June 23, 1950

15 Claims. (Cl. 103—53)

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This invention relates to reciprocating pumps of the type comprising an enclosure or chamber communicating through intake valves with a source of fluid under an initial pressure, and through delivery valves with a space constituting a receiver for a fluid under a final pressure, the said chamber including a movable wall to which a reciprocating movement is imparted, thereby in each successive operating cycle, to expand said capacity and thus to fill it through said intake valves, and then to contract said capacity and thus to evacuate it through said delivery valves. The above-mentioned movable wall may, and will in the ensuing disclosure, be described as a piston: it may indeed be formed as a piston slidable in a cylindrical enclosure or compression chamber, but it might just as well consist of a deformable wall element, such as a bellows, etc.

One object of my invention is to provide a pump of this kind in the form of a portable, inexpensive and mechanically simple unit adapted to serve, e. g., as an air compressor for medical uses, spray, aerosol treatments, tire inflating, refrigerators and the like.

Another object is the provision of a means for controlling the reciprocating movements of the movable wall of a pump capacity adapted to improve the operating conditions of said pump and specifically to increase the frequency of operation thereof greatly in excess of the range heretofore attainable in apparatus of the type specified.

Various devices have been suggested in this field, some of them using conventional mechanical drive transmissions such as crank-and-connecting rod systems, while others employ turbines. However, the presence of rotary parts, bearings, pivotal connections, and so forth, makes such systems comparatively expensive and requires a certain amount of maintenance and lubrication on the part of the user. Another type of pump is known, the so-called vibrator pump, wherein a movable wall of the intake and compression capacity is coupled with the movable armature of an electro-magnet the electrical supply of which is controlled in known manner by the movements of the said armature itself. This type of apparatus necessarily has a low operating frequency owing to the mechanical and electro-magnetical inertia of its components and is hardly suitable to the construction of pumps for gaseous fluids, even though it has been used with some measure of success in connection with liquid pumps (e. g. gasoline pumps).

My present invention provides, in a first aspect, a drive device for pumps of the type described, wherein the reciprocating movements of the movable wall of the capacity are produced by an electro-dynamic motor of the type including a movable winding through the airgap of a magnetic circuit, said movable wall being rigidly coupled with said movable winding. Owing to this arrangement, it becomes possible to eliminate all delicate mechanical members such as shafts, journals, bearings, and the like, as well as lubrication. The resulting unit is exceedingly rugged, very simple to use, requiring no maintenance by the user and, in addition, opens up a whole range of possibilities of fundamental importance in the field under consideration.

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The apparatus may be supplied either directly from a source of substantially sinusoidal alternating current of suitable frequency, or through the medium of a device for distorting the actuating current wave form in a way to improve the efficiency of the pump.

More specifically, the invention is directed to a control or drive system characterized by the fact that the force applied to the movable wall of the chamber will be a succession of pulses spaced by idle intervals.

An analytical investigation into the operation of pumps provided with automatic intake and discharge valves, that is valves adapted to open and close under the sole action of the pressure differentials established between the operating capacity on the one hand and the source—and receiver-spaces on the other, and with due allowance for the inertia and spring-return characteristics of said valves, shows that, as a result of my method, it becomes possible to increase to a marked extent the operating frequency (i. e. the number of operating cycles per unit time) of a pump without impairing its efficiency: now a high operating frequency means a smaller chamber for a given discharge capacity and hence a smaller, lighter and cheaper pump unit.

In particular, it becomes possible to select an operating frequency equivalent to the normal frequency of the power-supply or line network, i. e. 50 cycles per second in most cases in Europe, and 60 cycles per second in the United States, and this considerably simplifies the problem of energy supply to the apparatus of the invention.

The characteristic features and advantages of the invention, as well as further objects thereof, will appear from the ensuing description, which relates to one exemplary embodiment selected by way of illustration with reference to the accompanying drawings, wherein:

Fig. 1 is a diagram of a pump of conventional type;

Fig. 2 is a graph of the piston motion in such a pump;

Fig. 3 is a similar graph explanatory of the method of the invention;

Fig. 4 is a partly diagrammatic axial cross section of an air-pump according to the invention;

Fig. 5 is a detail view of a portion of the pump shown in Fig. 4 in a different position;

Fig. 6 is an enlarged sectional elevation of the upper part or valve-box of the pump shown in Fig. 4 showing the structure of some parts in detail;

Fig. 7 is a corresponding view in plan.

Figs. 8*a*, 9*a*, and 10*a* are respectively diagrammatic illustrations of different electrical circuits which may be used with the apparatus of the invention.

Figs. 8*b*, 9*b*, and 10*b* are respectively illustrations of the wave forms produced by the circuits of Figs. 8*a*, 9*a*, and 10*a*.

As shown diagrammatically in Fig. 1, a conventional lift-and-force pump comprises a chamber or pump housing **1** communicating through one or more inlet or intake valves **2** with a fluid-supply space and through one or more outlet or discharge valves **3** with a receiver-space, and comprises a piston **4** driven in reciprocation to either side of a reference level A—A from a rotary drive shaft **5** through a mechanical movement-converting system **6** of the connecting rod and crankshaft type.

In all usual cases, the variations of the distance x of the piston from its reference level as a function of time are substantially sinusoidal in character as illustrated in Fig. 2. In this graph it is assumed that at an initial instant, the piston stood at its uppermost position at the start of its downward or suction stroke, the discharge valve being open or closed, and that the intake valve or valves were closed. After the piston has started on its downward or suction stroke, the discharge valve closes under the action of the pressure prevailing in the receiver space, and possibly under the additional action of a return spring. A depression is thus generated in the chamber as the piston during its suction stroke moves away from said uppermost position. As the piston reaches a certain level x_1 at the time t_1, this suction becomes high enough to cause the intake valve to open. At this point the useful part of the intake stroke sets in, and this useful part will terminate as the piston reaches its lower dead centre position, i. e. the level x_2, at the time t_2. The piston then starts on its compression stroke. The intake valve is closed under the action of the internal pressure which builds up, and possibly under the additional action of a return spring, while the discharge valve opens as soon as the piston reaches a certain level x_3 at the time t_3. At this point the useful part of the compression and delivery stroke commences.

It is clear that the efficiency of the pump depends essentially on the fraction of the cycle which is occupied by the idle periods required to reach the positions x_1 and x_3, that is, to cause the operation of the valves especially that of the intake valve. The inertia of the valves being imposed by practical considerations, their opening and closure will occur at a predetermined value of the internal depression, and the fraction of the cycle required to attain this depression will be substantially constant all other factors being equal, so that if the operating frequency is increased, in the sinusoidal type of operation assumed, then the remaining part of the cycle's duration will, from a given instant, become insufficient to allow of the chamber being adequately filled. This will explain the fact that the efficiency of a pump operating in the sinusoidal mode of operation, rapidly drops off as the operating frequency reaches and exceeds a definite value.

In practice, a rate of 900 to 1000 cycles per second is an upper limit which is not easily surpassed with the currently known systems.

The chart of Fig. 3 illustrates a method of control or drive according to the invention, characterized by the fact that the displacements imposed on the piston, instead of being purely sinusoidal in character, rather assume the character of distorted sinusoids or even that of separate pulses with intervening idle periods of substantial duration occurring at the lowermost position of the piston. In particular, during the piston's travel from its upper to its lower position, i. e. during the suction stroke, the piston is notably accelerated. For a given value of the inertia of the intake valve or valves, and in order to reach a similar rate of internal depression as in the corresponding sinusoidal mode of operation, the time t'_1 required by said intake valves to open, is found in such conditions to be reduced as the downward movement of the piston is effected faster. The piston remains at its lowermost position until the time t'_2 and it may be seen that the time available for the filling of the cylinder under the action of the pressure in the fluid-source space is correspondingly increased. The instant at which the intake valves close and also that at which the discharge valves open, is for example t'_3, and the remainder of the upward stroke of the piston is that corresponding to the compression and discharge phase. This upward part of the pulses may have a slope not necessarily identical with that of the downgoing part.

It is interesting to consider in reference to Figures 2 and 3 a wave shape factor s, which will be defined as follows:

for sinusoidal operation (Fig. 1):

$$s=(t_2-t_1)/t_1$$

for pulse operation (Fig. 2):

$$s'=(t'_2-t'_1)/t'_1$$

Obviously $s'>s$. Due to the pulse type of operation, the filling period of the chamber is increased over that obtained in the sinusoidal mode of operation, for an equal frequency: in other words, it is possible to obtain a filling period of such a long duration as may only be realized at a substantially lower frequency in sinusoidal operation; or again, for a given efficiency, it becomes possible to increase the operating frequency and hence reduce the volume of the pump. The provision of such a drive using mechanical means becomes impracticable for comparatively high frequencies. On the other hand, it is exceedingly simple to provide a drive device according to the invention, which will now be described in detail with reference to the exemplary embodiment of Figs. 4 to 7.

This example relates to an air pump consisting of a head plate **10** forming the top or valve-box, of frustoconical sectional configuration, of the variable-volume capacity or compression chamber **11**, and having associated with a flexible wall element or diaphragm of rubber or equivalent flexible material 12 (termed hereinafter the reciprocable fluid displacement member) which provides its lower wall. This diaphragm may consist of a disc simply cut out of a sheet of rubber, or a specially formed part, e. g. a molded cap as illustrated. The diaphragm is clamped at its periphery between the margin or the head plate 10 and a metal annulus 13 which in turn is rigidly mounted in a general cylindrical casing 14. The compression chamber 11 communicates through a circumferential set of apertures 15 sealed by an annular intake valve 16 with the atmosphere, and through a central passage 17 sealed by a discharge valve 18, with a receiver space not shown. The details of this section of the pump are visible in Fig. 7, where it is seen that the intake valve 16 is applied against the orifices 15 by a spring 19 in the form of a spider wedged at its corners in a circular groove 20 formed for this purpose in the upper part of chamber 11. The intake valve is preferably provided with splines such as 16*a* at its under face, and projections such as 19*a* formed on the spring 19 (e. g. simply punched or struck out therefrom) engaging into a groove defined by these splines. As a result of this device, a kind of self-centring effect is obtained for the intake valve member, which averts the necessity of having to mount this member in a guide conduit and thereby reducing the pressure losses at intake. It is further seen that the discharge valve member 18 consists of a spider-shaped flange applied over the discharge passage by a spring 21 abutted against a nut 22 screwed in a cylindrical boss or socket 23 serving as a union for connecting the pump with any load apparatus.

The central part of the movable wall element 12 (Fig. 4) is clamped between a thin rigid disc 23 and a cap 24 formed with a frustoconical flange 25, the profile of this cap member conforming substantially to that of the upper part of chamber 11. The cam 24 is secured to the top of a cylinder 26 made of plastic material or light non-magnetic alloy, longitudinally slotted and providing a bobbin or casing for a winding 27 arranged in the airgap of a magnetic circuit 28 including a core 29 and a field plate 30; the magnetic field in said circuit may be permanent or it may be provided by an exciter winding such as 31. It will be recognized that an electro-dynamic motor is thus provided of the kind used for instance in loud-speakers, and which in the present instance will be adapted to impart a reciprocatory motion to the movable wall element 12 of the pump upon a suitable alternating current being made to flow through the movable winding 27.

The movable winding is suspended from and centred by two spider members 32, 33 outwardly clamped between clamping rings 34, 35 and the annulus 13, and inwardly between circular rings 36, 37 provided for this purpose on the free outer surface of the cylinder 26. These spiders may each be widely recessed in the way well known in the art of loud-speaker construction, and they may be made from plastics or resilient metal or any other suitable material. When made of resilient material, they may participate in assuring the resilient return action required in the motion assumed by the movable coil.

Several sets of holes 38, 39, 40, 41 place the casing in communication with the atmosphere and prevent the occurrence of any excess pressure outside the compression chamber of the pump itself. Similar apertures 42 may be formed in the movable cylinder 26 as well.

The motor as a whole is secured in the casing 14, for instance by a nut 43, while the valve-box is secured by bolts 44.

The motor thus provided may be supplied in sinusoidal alternating current, but preferably, according to the invention and as stated previously, a supply of the pulse type is used, whereby all of the difficulties encountered in apparatus of conventional and purely mechanical design, are averted. In either case, the movable winding in the movable wall 12 of the compression chamber 11 will move between a lowermost position, shown in Fig. 4, and an uppermost position, which may be that illustrated in Fig. 5. It is interesting to note that, owing to the electrodynamic drive of the invention, it becomes quite practicable and safe to increase the amplitude of the movements of the movable wall element to a point where said wall element will strike the ceiling of the compression chamber, that is, the amplitude of the drive current may be chosen equal or greater than the value for which the stroke of the movable wall element becomes equal to the height dimension of the chamber; for the drive is so flexible as to preclude any possibility of breakage.

The frusto-conical flange 25 of the cap 24 provides a support for the free portion of the flexible wall element 12 and supports the same during the period of compression when the wall element has a tendency to be inflated. Owing to this arrangement, the flexible wall element is practically subjected to no resilient stress whatever, its operation being restricted to a sequence of to-and-fro buckling movements to either side of its clamped margin.

A very important advantage of the device according to the invention lies in the possibility of operating it at the frequency of the network, i. e. at either 50 cycles or 60 cycles per second (3000 or 3600 per minute), as the case may be. This greatly simplifies the problem of supply. Thus, the simplest way of providing a pulse-drive device according to the invention, is to supply it with simply rectified A.-C., as is shown diagrammatically in Fig. 8*a*, Fig. 8*b* showing the wave form produced by the arrangement of Fig. 8*a*. Of course, any of a wide number of known means, may be used to foreshorten the duration of the pulses applied; thus, polarized rectifiers (Fig. 10*a*), shunted rectifiers (Fig. 9*a*), grid-control thyratrons, saturated transformers and inductors, etc., may be used. Figs. 9*b* and 10*b* respectively show the wave forms produced by the circuits of Figs. 9*a* and 10*a*.

Experience shows that with the use of simply rectified A.-C., hence with a filling period, i. e. an idle inter-pulse period, hardly if at all longer in duration than one half-cycle, very satisfactory efficiency factors are already obtained at a rate of 3000 or 3600 cycles per minute, as supplied by the usual networks.

It appears hardly necessary to lay stress on the advantages provided by the invention; still, I may again emphasize the ease with which pulses of known and predetermined wave form may be provided, the elimination of all delicate mechanical organs (shafts, bearings, reciprocating rods, and the like) and of lubrication, etc.

The invention is by no means restricted to the single form of embodiment illustrated and described by way of example. Numerous and diverse developments and/or variants may obviously be conceived. Thus, the invention is applicable to a pump using a piston or a diaphragm. In the case of an apparatus of the type described, practically noiseless operation may be obtained by lining the valve members and the upper face of the disc 23 with a thin coating of rubber or equivalent substance.

What I claim is:

1. A fluid pump device comprising a casing, a head-plate, a recess in said plate, a flexible diaphragm, means for peripherally clamping said diaphragm around said recess, said recess and said diaphragm defining a variable volume chamber, intake and delivery valve means adapted to this chamber, a cap member of a shape conformed to that of said recess and secured to a central portion of said diaphragm outside of said chamber, a magnet integral with said casing and providing a magnetic circuit including an air-gap, a hollow nonmagnetic bobbin adapted to reciprocate through said air-gap and coupled to said cap, an electric coil wound on said bobbin to reciprocate in and through said air-gap and means for supplying periodical electric current to said coil.

2. A fluid pump device according to claim 1, comprising resilient spider means extending between said bobbin and said casing and adapted to center said coil within said air-gap.

3. A fluid pump device according to claim 1 comprising resilient spider means between said bobbin and said casing, adapted to center said coil within said air-gap and to exert a returning force on said diaphragm in operation.

4. A fluid pump device comprising a casing, a recessed head plate forming a frustoconical top or valve-box for said casing tapering towards a base, a flexible diaphragm peripherally clamped to said plate, thus defining therewith a variable volume fluid chamber, a central outlet passage and a circumferential set of inlet passages being provided in said base, an annular intake valve member within said chamber adapted to seal the openings of said inlet passages thereinto, a spring in the form of a spider wedged at its corners in a circular groove formed in said box around said base and thereby adapted to apply said intake valve member against said inlet passages, a discharge valve member resiliently applied over said outlet passage, driving means secured on said diaphragm over a central portion thereof opposite to said base, a magnet forming a magnetic circuit including an air-gap, a coil coupled to said driving means and adapted to reciprocate through said air-gap, and means for supplying periodical electric current to said coil.

5. A fluid pump device according to claim 4 wherein said annular intake valve member is provided with circular splines defining annular grooves therebetween and projections are provided on said spring to engage said grooves, whereby a self centering effect is obtained for said intake valve member.

6. A reciprocable fluid pump arrangement, comprising, in combination, a pump housing; inlet valve means and outlet valve means communicating with the interior of said pump housing; a reciprocable fluid displacing member operatively connected to said pump housing and being adapted to carry out intermittent suction and compression strokes sucking into said pump housing during said suction strokes fluid through said inlet valve means and delivering from said pump housing during said compression strokes fluid through said outlet valve means; a magnetic structure including a stationary part and a movable part, said movable part being connected to said reciprocable fluid displacing member and being arranged at a slight distance apart from said stationary part, one of said parts including an electric coil and the other of said parts including a magnetic body so that supply of an alternating current to said coil will result in a reciprocating suction and compression movement of said movable part relative to said stationary part of said magnetic structure and in corresponding suction and compression strokes, respectively, of said reciprocable fluid displacing member; means for producing an alternating current having cycles being each composed of a short and a long cycle portion, the current continuously changing during said short cycle portion from one peak value to the opposite peak value, said short cycle portion being substantially shorter than said long cycle portion; and means connecting said alternating current producing means to said coil so as to energize said coil for said suction movement of said movable part during each long cycle portion of said alternating current and for said compression movement of said movable part during each short cycle portion of said alternating current, thereby opening said inlet valve means during each of said long cycle portions and opening said outlet valve means during each of said short cycle portions.

7. A reciprocable fluid pump arrangement, comprising, in combination, a pump housing; inlet valve means and outlet valve means communicating with the interior of said pump housing; a reciprocable fluid displacing member operatively connected to said pump housing and being adapted to carry out intermittent suction and compression strokes sucking into said pump housing during said suction strokes fluid through said inlet valve means and delivering from said pump housing during said compression strokes fluid through said outlet valve means; a magnetic structure including a stationary part consisting of a magnetic body, and a movable part connected to said reciprocable fluid displacing member and being arranged at a slight distance apart from said stationary part, an electric coil arranged on said movable part so that supply of an alternating current to said coil will result in a reciprocating suction and compression movement of said movable part relative to said stationary part of said magnetic structure and in corresponding suction and compression strokes, respectively, of said reciprocable fluid displacing member; means for producing an alternating current having cycles being each composed of a short and a long cycle portion, the current continuously changing during said short cycle portion from one peak value to the opposite peak value, said short cycle portion being substantially shorter than said long cycle portion; and means connecting said alternating current producing means to said coil so as to energize said coil for said suction movement of said movable part during each long cycle portion of said alternating current and for said compression movement of said movable part during each short cycle portion of said alternating current, thereby opening said inlet valve means during each of said long cycle portions and opening said outlet valve means during each of said short cycle portions.

8. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum

volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; and a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means, said coil reciprocating in said air gap when said coil is supplied with an alternating current, whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the alternating current supplied to said coil.

9. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means; and means for supplying a low frequency current to said coil so as to reciprocate the same in said air gap, whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the low frequency current supplied to said coil.

10. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means; and means for supplying a low frequency current to said coil so as to reciprocate the same in said air gap, said supplying means including a wave form distorting device, whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the low frequency current supplied to said coil.

11. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means; and means for supplying a low frequency current to said coil so as to reciprocate the same in said air gap, said supplying means including a rectifying device distorting the wave form of the low frequency current, whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the low frequency current supplied to said coil.

12. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means; and means for supplying a low frequency current to said coil so as to reciprocate the same in said air gap, said supplying means including a wave form distorting device, whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the low frequency current supplied to said coil, the distorted wave form of the alternating current supplied to said coil consisting of a short cycle portion and a long cycle portion being substantially longer than said short cycle portion, said coil being arranged so as to cause said flexible wall element to set up a positive pressure during said short cycle portion and a partial vacuum during said long cycle portion.

13. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means; and means for supplying a low frequency current to said coil so as to reciprocate the same in said air gap, said supplying means including a wave form distorting device,

whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the low frequency current supplied to said coil, the distorted wave form of the alternating current supplied to said coil consisting of a short cycle portion and a long cycle portion being substantially longer than said short cycle portion, said coil being arranged so as to cause said flexible wall element to set up a positive pressure during said short cycle portion and a partial vacuum during said long cycle portion, said long cycle portion consisting of a first part having a duration approximately equal to that of said short cycle portion and a second part during which the distorted wave form remains substantially constant.

14. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means; and means for supplying a low frequency current to said coil so as to reciprocate the same in said air gap, said supplying means including a rectifying device distorting the wave form of the low frequency current, whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the low frequency current supplied to said coil, the distorted wave form of the alternating current supplied to said coil consisting of a short cycle portion and a long cycle portion being substantially longer than said short cycle portion, said coil being arranged so as to cause said flexible wall element to set up a positive pressure during said short cycle portion and a partial vacuum during said long cycle portion.

15. In a reciprocable fluid pump, in combination, walls forming a fluid chamber; a flexible wall element forming part of said walls of said chamber, said flexible wall element being reciprocable from a first position into a second position and vice versa, said first and second positions of said flexible wall element corresponding, respectively, to the minimum and maximum volumes of said fluid chamber; intake and discharge valves arranged in said walls and opening, respectively, when a partial vacuum and a positive pressure are set up in said fluid chamber by a reciprocating movement of said flexible wall element; driving means rigidly connected with said flexible wall element; a magnetic circuit having an air gap; a movable coil arranged in said air gap of said magnetic circuit and rigidly connected to said driving means; and means for supplying a low frequency current to said coil so as to reciprocate the same in said air gap, said supplying means including a rectifying device distorting the wave form of the low frequency current, whereby said flexible wall element is imparted a reciprocating movement causing said intake and discharge valves to close and open in a cycle depending on the wave form of the low frequency current supplied to said coil, the distorted wave form of the alternating current supplied to said coil consisting of a short cycle portion and a long cycle portion being substantially longer than said short cycle portion, said coil being arranged so as to cause said flexible wall element to set up a positive pressure during said short cycle portion and a partial vacuum during said long cycle portion, said long cycle portion consisting of a first part having a duration approximately equal to that of said short cycle portion and a second part during which the distorted wave form remains substantially constant.

SHELLEY PRESENTEY.

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