

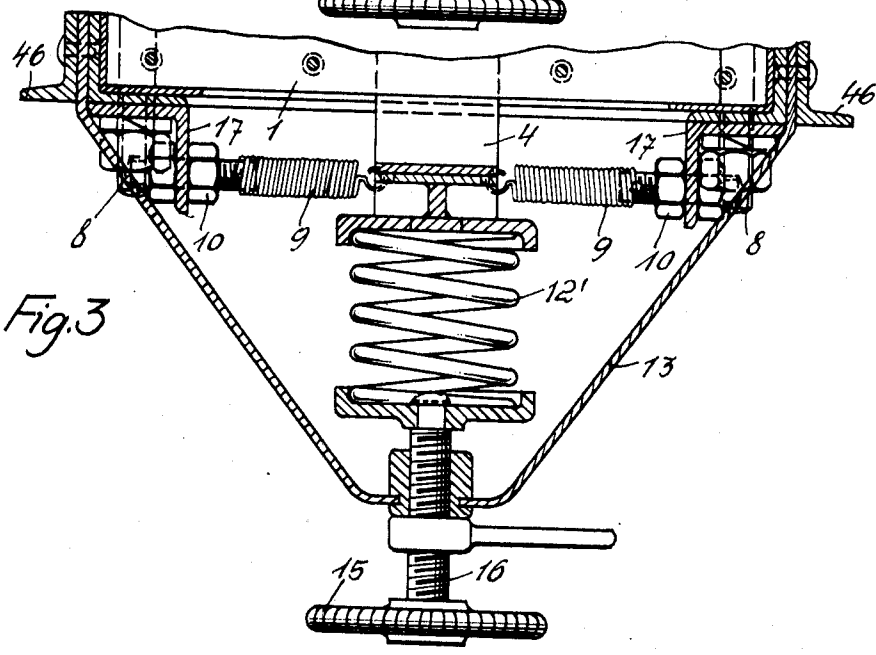
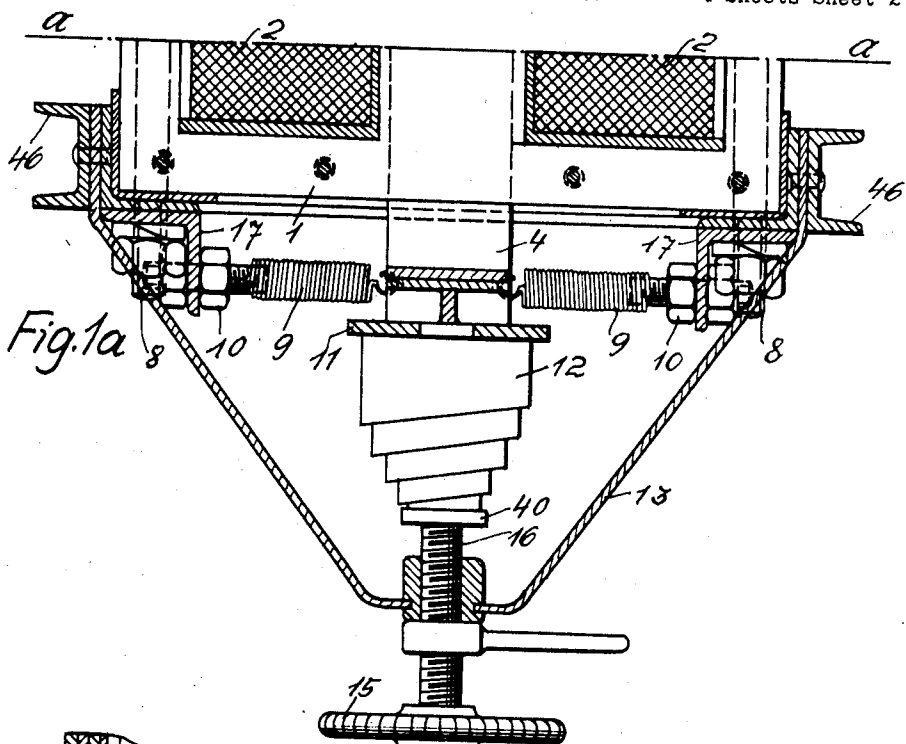
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ELECTRICALLY DRIVEN FLUID PUMP

Original Filed March 5, 1935 4 Sheets-Sheet 2



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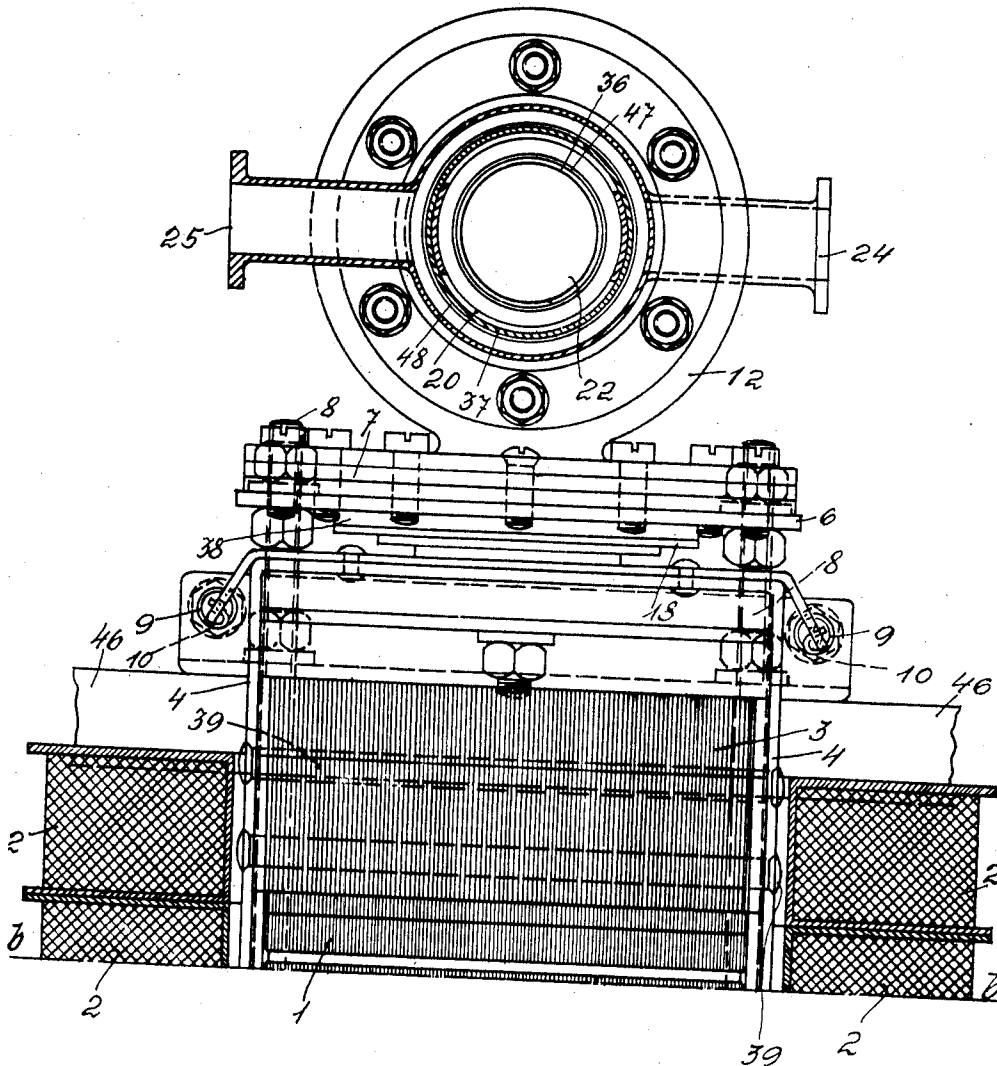
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Fig. 2



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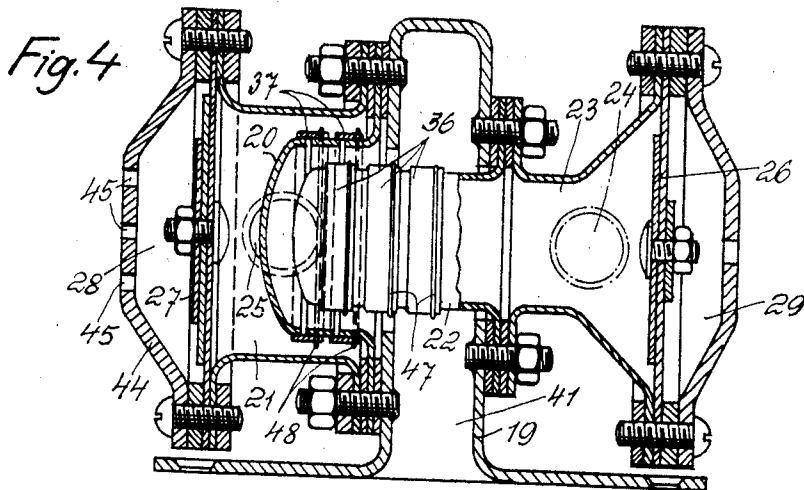
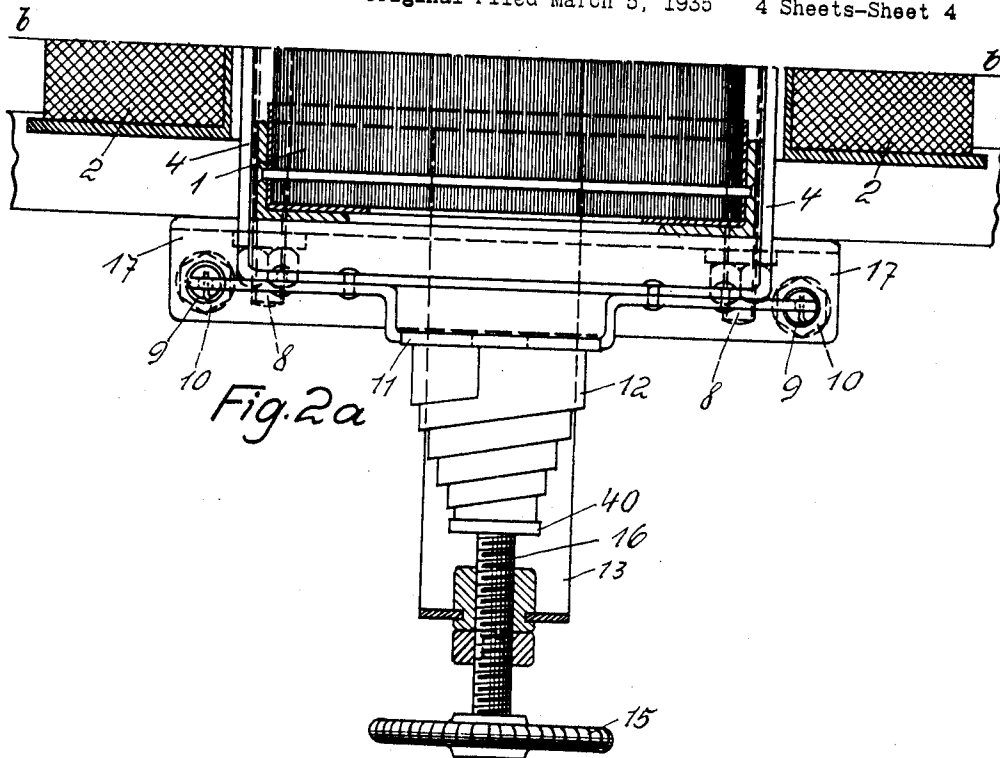
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UNITED STATES PATENT OFFICE

2,143,391

ELECTRICALLY DRIVEN FLUID PUMP

Georg Székely, Graz, Germany

Application March 5, 1935, Serial No. 9,365. Re-
newed September 23, 1938. In Austria March
9, 1934

19 Claims. (Cl. 103—53)

This invention relates to an electrically driven fluid pump, preferably a diaphragm pump, the working member of which, that is to say the piston or the diaphragm, is set in pulsating or vibratory motion by the reciprocating armature of an alternating current electromagnet, the spring means employed in conjunction with the vibrating assembly being so dimensioned and arranged that the natural frequency of the entire vibratory system (possibly including the simultaneously pulsating fluid mass) is exactly or approximately in harmony with the frequency of the magnetic attraction of the electromagnet, that is to say with the frequency of the alternating current used.

The putting into practice of the invention is illustrated, by way of example, in the accompanying drawings, in which:

Figs. 1 and 1a show in partly sectional elevation one form of construction of the pump unit according to the invention, it being necessary to imagine the two figures fitted together along the line of separation a—a.

Figs. 2 and 2a show the same unit in partly sectional side elevation, it being necessary to imagine these two figures fitted together along the line of separation b—b.

Figs. 3 and 4 show modified forms of construction of individual component parts of the unit.

The drawings indicate various expedients and advantages of a fundamental nature which will be discussed in greater detail in the due course.

The electromagnet 1 which drives the fluid pump is an alternating current electromagnet the winding 2 of which is traversed by alternating current taken from the main and thereby caused to exert upon the armature 3 an attractive force which fluctuates periodically in intensity. This magnet is provided with a circuit which is as far as possible closed in iron, in order that maximum electromagnetic energy may be developed with a minimum of weight and the smallest possible requirement in the matter of space. For this same reason the number and size of the air gaps interrupting the iron circuit are kept down to a minimum, while at the same time two of these air gaps are disposed obliquely to the direction of vibration of the armature.

The armature 3 is secured by means of cross-bars 39 to a frame-like connecting rod 4 which is rigidly attached to the central portion of the piston diaphragm 5 of suitable material such as rubber or leather with the interposition of a plurality of washers 38 of rubber or leather and a base plate 18 of rigid material. The outer edge

of this diaphragm 5 is firmly gripped between the parts 6 and 19 of the pump casing, which is supported on bolts 8, with the aid of the ring 7. The armature 3, the diaphragm 5, the connecting rod 4, and the structural parts which connect these elements together should be made as light as possible, with a view to reducing the resistance of inertia.

The spring means employed for the vibrating system consist of the conical spring 12 which has a non-linear power-course characteristic, and which bears on the one hand against the end plate 40 of the spindle 16 which is adjustable in the casing cap 13 by means of the hand-wheel 15, and on the other hand against a plate 11 pertaining to the carrier of the diaphragm, in the present instance to the connecting rod 4. Any other type of spring may be employed, such as for example the helical spring 12' shown in Fig. 3. The arrangement of the spring 12 or 12' is such that it constantly strives to restore the moving system into a central position. The spring means employed are tuned exactly or approximately to the frequency of the magnetic attraction of the electromagnet 1, that is to say to the frequency of the alternating current used, or to a higher harmonic thereof. The total mass of the spring means employed, like that of the whole of the vibrating system, should be kept down to a minimum. By raising or lowering of the plate 40 the initial tension of the spring means can be set or adjusted.

The piston diaphragm 5, together with the parts 19, 20, and 22 of the casing, enclose the working chamber 41 of the pump. In the parts 20 and 22 of the casing there are provided the suction valves 36 and the pressure valves 37 of the pump in the form of readily movable flaps covering annular or slotted apertures. The suction valve flaps—and the same applies to the pressure valve flaps—should be as readily movable as possible and preferably so constructed that their natural working frequency is equal to or higher than the vibration frequency of the piston diaphragm 5. The valves 36 and 37 connect the working chamber 41 with the suction chamber 23 and with the pressure chamber 24, respectively, which chambers are provided with the suction pipe connection 24 and delivery pipe connection 25, respectively (the orifices of these pipe connections are indicated in the drawings). The valves are preferably so arranged that the distance from the suction to the pressure valves is as short as possible. It is advisable, as is the case in the example shown in the drawings, to make the valve members in the

form of rubber rings held in position by means of a tension wire 47 and 48, respectively, and adapted to cover over slot apertures.

The suction chamber 23 is delimited at one side by a wall 26 in the form of a diaphragm which can be made of elastic material such as rubber or leather so that the adjoining space 28 may serve as an air receiver or cushion, pressure impacts compensated, and as constant a fluid resistance as possible maintained during pumping. For the same purpose the pressure chamber 21 also possesses a diaphragm-like wall 27 separating it from the air cushion space 29. The diaphragms 26 and 27 take the place of the compressed air receivers otherwise usually employed in conjunction with piston pumps, and offer, as compared with the latter, the advantage that they are well capable of following the high periodicity of the working process of the pump according to the invention in spite of occupying but a very small space. These diaphragms should preferably be exactly or approximately in resonance with the frequency of the vibrating system, which can be effected either by making them of elastic material and adopting suitable dimensioning, or by making them of elastic or non-elastic material and supporting them against adjustable springs. In the form of construction shown in Fig. 1 of the drawings, this purpose is served by the springs 30 and 31 the tension of which can be appropriately set or adjusted with the aid of the hand wheels 32 and 34. In the modified form of construction shown in Fig. 4 no supporting springs are provided, the specific frequency of the diaphragms being in this case brought into harmony with the frequency of the vibrating system solely by suitable dimensioning. With the form of construction shown in Fig. 4 it has proved advisable so to construct or design the casing 44 of the compressed air receiver 29 that, when the pressure increases to a great extent in the chamber 29, the diaphragm 27 bears against this casing 44, with the result that any further increase of pressure causes the mediate vibrating position of the piston diaphragm 5 to become automatically altered, and that in such a manner as to reduce the amount of current taken up by the magnet. As shown in Fig. 4, the portion 44 of the casing may be provided with apertures 45.

The described unit functions in the following manner: If alternating current from the main be fed to the coil 2 of the electromagnet 1 the armature 3 with all the parts connected thereto, and more particularly the piston diaphragm 5, vibrate in beat with the alternating current frequency, and the amplitude of these vibrations will be particularly great when the vibrating system, or at least the spring 12 or 12', is tuned to the frequency of the alternating attraction of the magnetic field. The vibrating piston diaphragm alternately enlarges and diminishes the volume of the working chamber 41, so that given suitable cooperation on the part of the suction valves 36 and of the pressure valves 37, liquid from the suction pipe 24 is forced into the delivery pipe 25. The fluctuations in pressure and/or volume occurring in the liquid outside the working chamber during each cycle are compensated by the diaphragms 26 and 27. At the suction stroke the diaphragm 26 is subjected to tensile strain, and at the pressure stroke the diaphragm 27 is subjected to pressure strain, in both cases towards the left hand side in Fig. 1, so that these diaphragms work alternately so to speak with a temporal phase displacement of 90°. In other words, dur-

ing the suction stroke the diaphragm 27 forces the liquid out, and during the pressure stroke the diaphragm 26 sucks in fresh liquid. The two air cushions or air receivers thus fulfill the function of maintaining the kinetic energy.

If a slighter quantity of liquid be taken from the described pump, under otherwise the same conditions, the pressure in the chamber 21 increases, with the result that the vibrations of the diaphragm 5 or rather of the armature 3 are so influenced that the electromagnet takes up a correspondingly lower amount of current. The operation of the unit thus adapts itself automatically to varying conditions of working. In the extreme case of no liquid at all being taken from the delivery pipe 25 the pump only continues to work until the diaphragm 27 has attained its maximum degree of distension, that is to say bears against the housing 44 in the form of construction shown in Fig. 4 or can not further overcome the counter force of the spring 31 in the form of construction shown in Fig. 1. When this condition has once been reached there remains as the sole yielding element delimiting the liquid the piston diaphragm 5, which in consequence of the high fluid pressure set up in the working chamber becomes forced into its lowermost position in which the armature bears against the suitable counter surfaces on the core of the electromagnet. Since as the construction example given in the drawings shows, the armature and the electromagnet may be so designed that there is no appreciable air gap left when the armature is completely attracted, it will be clear that on the complete shutting down or pronounced throttling of the fluid delivery from the pump the core of the electromagnet will be so closed that this magnet acts, relatively to the alternating current supply, like a choke coil of high inductive resistance and therefore takes up practically no current. It is therefore not necessary with a unit of this nature to switch off the current during relatively short intervals between periods of working. If after such intermission the delivery be allowed to flow again and the pressure falls in the working chamber 41, the armature and the piston diaphragm of the pump become automatically set in motion again, so that the provision of any special liquid container for the starting up of the pump is superfluous.

It has proved advisable to provide special connecting elements between the stationary casing and the vibrating system or assembly for the purpose of preventing or checking deviation of the latter from its prescribed path of movement and more particularly lateral deviation. For this purpose the unit shown in Figs. 1, 1a, 2, and 2a is provided with closely wound helical springs 9 the one end of which is attached to the connecting rod frame 4 of the vibrating system while the other end is attached by means of the screw connection 10 to angle pieces 17 pertaining to the casing or framework of the unit. With the aid of these springs 9 the air gap between the armature and the field magnet can be accurately adjusted and inadmissible alterations in this air gap during the working of the pump avoided.

The pump unit can be erected in any desired manner, either horizontally or vertically. In the described constructional example the pump is supported on the magnet and the latter attached to through carrying members 46.

What I claim is:

1. In combination with a source of alternating electric current, an electromagnet energizable

thereby, an armature reciprocable by said electromagnet, a liquid pump having a liquid conduit and a pumping member arranged to force the liquid through said conduit and connected to said armature for being operated thereby and for constituting therewith an oscillatory unit, spring means operatively associated with said unit so as to cause the same to oscillate under the influence of the attractive force of said electromagnet, and pressure-equalizing means arranged in the said conduit so as to allow the passage of the liquid therethrough unobstructed, said pressure-equalizing means being adapted to prevent excessive rise of pressure in the liquid despite the rapid oscillations of the pumping member.

2. In combination in an electromagnetically driven reciprocating liquid pump, an electromagnet energized by alternating electrical current, an armature actuated by said electromagnet, a liquid conduit including a yielding wall-element adapted to enlarge the liquid volume of said conduit when the volume or pressure of the liquid passed through increases and arranged so as to allow the passage of the liquid through the conduit free and unobstructed, a pumping member arranged to force the liquid through said conduit and connected to said armature to be operated thereby and to constitute therewith an oscillatory unit, and spring means operatively associated with said unit so as to cause the same to oscillate under the influence of the attractive force of said electromagnet.

3. In a device as claimed in claim 2, the feature that the said yielding wall element is oscillatable.

4. In a device as claimed in claim 2, the feature that the said yielding wall element is elastic.

5. An electromagnetically driven, reciprocating, liquid-pump, having, in combination, an electromagnet arranged for energization by an alternating electrical current, an armature actuated by said electromagnet, a pressure conduit for the pumped liquid, said conduit including a yielding oscillatable wall portion adapted to equalize the liquid pressure therein by preventing excessive rise of pressure in the liquid and arranged so as to allow the passage of the liquid through the conduit free and unobstructed, a pumping member of the diaphragm-type arranged to force the liquid into said pressure conduit and connected to said armature for simultaneous reciprocation and for constituting therewith an oscillatory unit, and spring means operatively associated with said unit so as to counteract the attractive force of said electromagnet and to cause thereby said unit to oscillate.

6. An electromagnetically driven reciprocating, liquid-pump, comprising, an electromagnet arranged for energization by an alternating electrical current, an armature actuated by said electromagnet, a pressure conduit and a suction conduit for the pumped liquid, a yielding element in each of said conduits for equalizing the flow of liquid through the pump, a pumping member arranged to force the liquid from the said suction conduit into the said pressure conduit and connected to said armature for being operated thereby and for constituting therewith an oscillatory unit, and spring means operatively associated with said unit so as to cause the same to oscillate under the influence of the attractive force of said electromagnet, the said yielding elements in the conduits being so arranged and constructed as to contribute to maintaining said unit in proper oscillations.

7. In combination with a source of alternating electric current of predetermined frequency, an electromagnet energizable thereby, an armature reciprocable by said electromagnet, a liquid pump comprising a working chamber, a suction conduit and a pressure conduit both connected to said chamber, a yielding oscillatable element in at least one of said conduits for preventing excessive rise of pressure in the liquid, said element being arranged so as to let the passage of liquid through the conduits free and unobstructed, and a pumping member of the diaphragm-type arranged to force the liquid from the suction conduit through the said working chamber into the pressure conduit, said pumping member and said armature being operatively connected with one another so as to constitute together an oscillatory unit, and spring means operatively associated with said unit and adapted to counteract the attractive force of said electromagnet and to impose upon said unit a period of oscillation substantially in tune with the period of energization of the electromagnet.

8. A device as claimed in claim 7 wherein the said yielding oscillatable element is tuned substantially to resonance with the period of oscillation of the said oscillatory unit.

9. In combination in an electromagnetically driven reciprocating liquid pump, an electromagnet energized by alternating electrical current of predetermined frequency, an armature actuated thereby, a suction conduit and a pressure conduit for the liquid to be pumped, a working chamber connecting both conduits, a yielding oscillatable element in at least one of said conduits for preventing excessive rise of pressure in the liquid, said element being so arranged as to allow the passage of liquid through the conduits free and unobstructed, a pumping member arranged to force the liquid from the suction conduit through said working chamber into the pressure conduit, said pumping member being connected to said armature so as to be operated thereby and to constitute therewith an oscillatory unit, and spring means operatively associated with said unit to cause the same to oscillate under the influence of the attractive force of said electromagnet, said unit being so dimensioned and weighed as to have its natural frequency of oscillation substantially in tune with the frequency of energization of the said electromagnet provided the proper mass of pumped liquid contained in the said conduits and in the working chamber and implicated in the oscillatory movement of the pumping member is added to the mass of the said unit.

10. An electromagnetically driven, reciprocating, liquid-pump, comprising electromagnetical means for forming an alternating magnetic field of predetermined frequency, a suction conduit and a pressure conduit containing the liquid to be pumped, a working chamber connecting both conduits, and a number of oscillatable elements which altogether are in tune with the said frequency of the magnetic field, said elements involving a reciprocating pumping unit arranged so as to force the liquid from the said suction conduit through the working chamber into the said pressure conduit under the influence of the said magnetic field, resilient means arranged to counteract the attractive force of said field and to cause thereby the reciprocation of said pumping unit, the body of liquid implicated in the reciprocatory movement of said unit, and in at least one of the said conduits a yielding, pressure-equalizing body adapted to prevent excessive rise of pres-

sure in the liquid despite the rapid oscillations of the pumping unit and arranged so as to allow the passage of the liquid through the conduits free and unobstructed.

11. A liquid pump as claimed in claim 10, wherein the said pumping member is of the diaphragm-type.

12. In a pump as claimed in claim 10, the feature that additionally to the elements recited, there is a further oscillatable element that is substantially in tune with the frequency of the magnetic field, said element including the suction valve of the pump.

13. An electromagnetically driven reciprocating liquid pump having, in combination, an electromagnet comprising a stationary core, a coil arranged thereon for energization by an alternating electrical current of given frequency, and a vibratile armature in position to be attracted by said core upon energization of said coil, said armature and said core being so shaped that the armature forms with the core when fully attracted by the same, a substantially closed magnetic iron circuit, a reciprocating pumping member of the diaphragm-type connected to said armature and forming therewith an oscillatory unit, and restoring spring means connected to said unit so as to counteract the attractive force of the said core upon said armature, said spring means being so tensioned and said unit being so dimensioned and weighed as to impart to the oscillating unit a natural frequency which is substantially out of resonance with the periodic force of attraction of the electromagnet, but only so far out of resonance that the resonance will be restored when the mass of pumped liquid implicated in the oscillating movement of the pumping member is added to the mass of said unit.

14. An electromagnetically driven liquid pump as claimed in claim 13, wherein the said closed magnetic iron circuit is interrupted only by butt joints.

15. In a device as claimed in claim 2, the combination with the said yielding wall-element of spring means arranged for resiliently resisting the deviation of said element from a given position.

16. In a device as claimed in claim 2, abutment means placed in the path of movement of the said yielding wall element for limiting this path.

17. In combination with a source of alternating electric current, an electromagnet energizable thereby, an armature reciprocable by said electromagnet, a liquid pump including a pumping member of the diaphragm-type connected to said armature for being operated thereby and for effecting the suction stroke during the movement of the armature towards the electromagnet, and spring means operatively associated with said armature so as to counteract the attractive force

of the electromagnet thereupon and to cause the armature to oscillate, said pumping member and said armature constituting together an oscillatory unit arranged for free oscillation and for having shifted its center position of oscillation in the direction of the attractive force of said electromagnet and thereby reduced the mean width of the air gap between said armature and said electromagnet with increasing back pressure exerted upon said pumping member by the pumped liquid.

18. In combination in an electromagnetically driven reciprocating liquid pump, an electromagnet comprising a stationary core, a coil arranged thereon for energization by alternating current, and an armature in position to be attracted by said core upon energization of said coil, said armature and said core being so shaped that the armature forms with the core when fully attracted by the same a substantially closed magnetic iron circuit, a pumping member of the diaphragm-type connected to said armature for simultaneous reciprocation, and subjected, at least from time to time, to the pressure of the pumped liquid, said member and armature constituting together an oscillatory unit, and spring means operatively associated with said unit so as to counteract the attractive force of the electromagnet and to cause thereby said unit to oscillate, this latter being arranged for free oscillation without artificial curtailment of its stroke and for having displaced its center position of oscillation in the direction of the attractive force of said core with increasing pressure exerted upon said pumping member by the pumped liquid, this displacement of said center position corresponding automatically to the pump output in such manner that an increase or decrease in the output is accompanied by an increase or decrease, respectively, in the input of electrical energy.

19. In combination with a source of alternating electric current, an electromagnet energizable thereby, an armature reciprocable by said electromagnet, a liquid pump including a pumping member of the diaphragm-type connected to said armature for simultaneous reciprocation, and subjected, at least from time to time, to the influence of a liquid under pressure, said pumping member and said armature constituting together, an oscillatory unit, and spring means operatively associated with said unit so as to counteract the attractive force of said electromagnet and to cause thereby the oscillating of said unit, this latter being arranged for free oscillation without artificial curtailment of its stroke and for oscillating to the full extent of stroke corresponding to the combined action and reaction of the electromagnetic attractive force, of the tension of the spring means, and of the forces exerted upon the pumping member by the pumped liquid.

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