Jan. 20, 1948. M. S. LAGERCRANTZ 2,434,804

PUMPING APPARATUS

Filed March 15, 1945 4 Sheets-Sheet 1

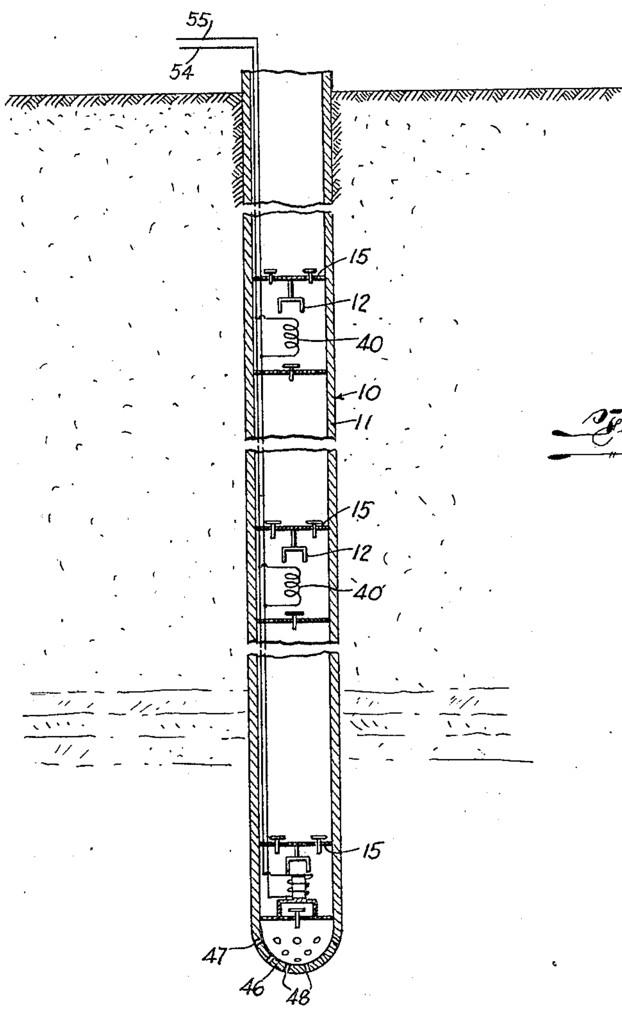

Fig. 1.

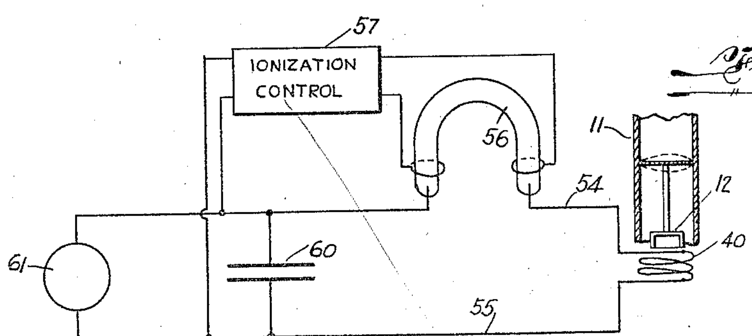

Fig. 2.

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PUMPING APPARATUS

Filed March 15, 1945 4 Sheets-Sheet 2

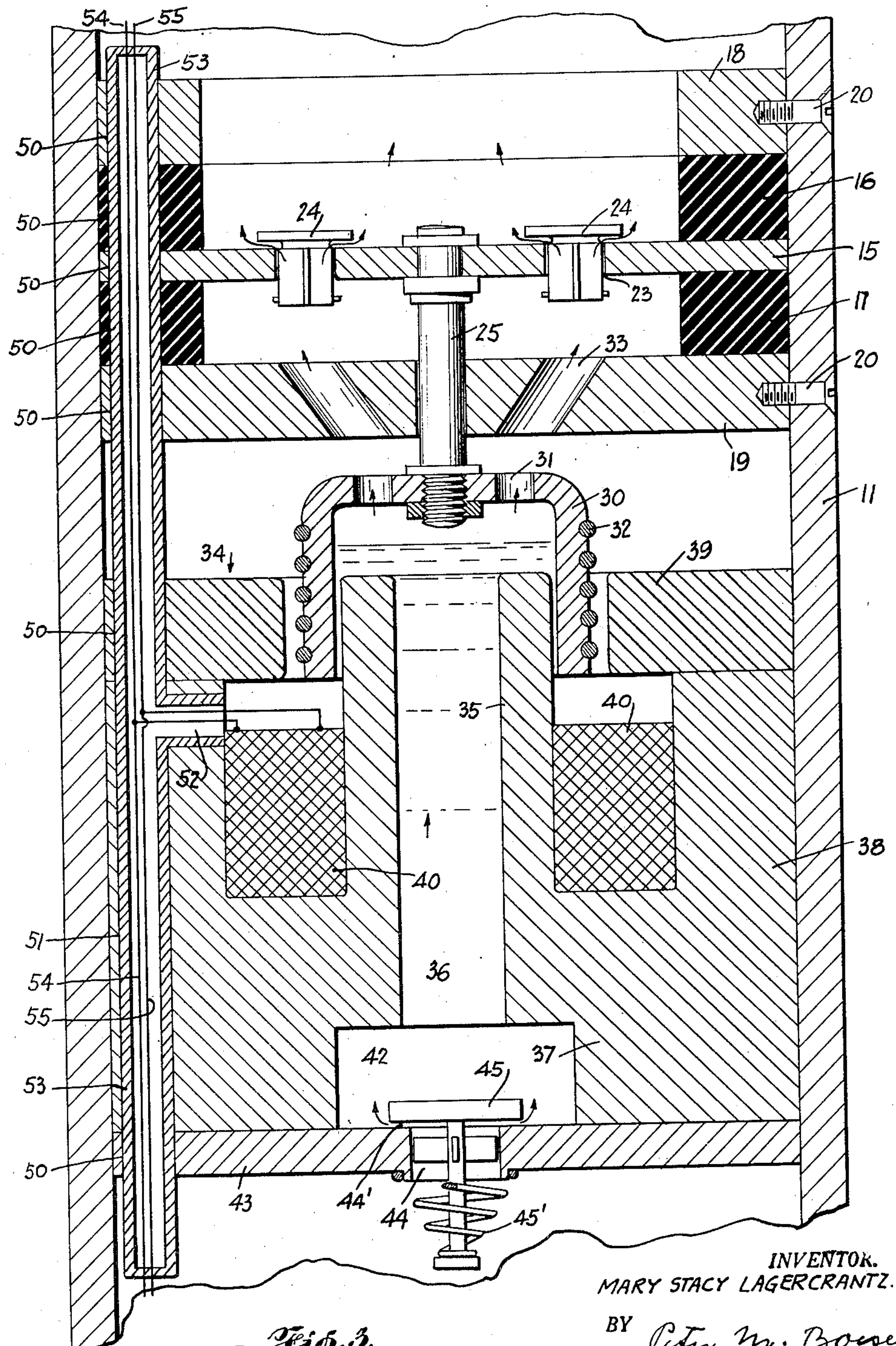

Fig. 3.

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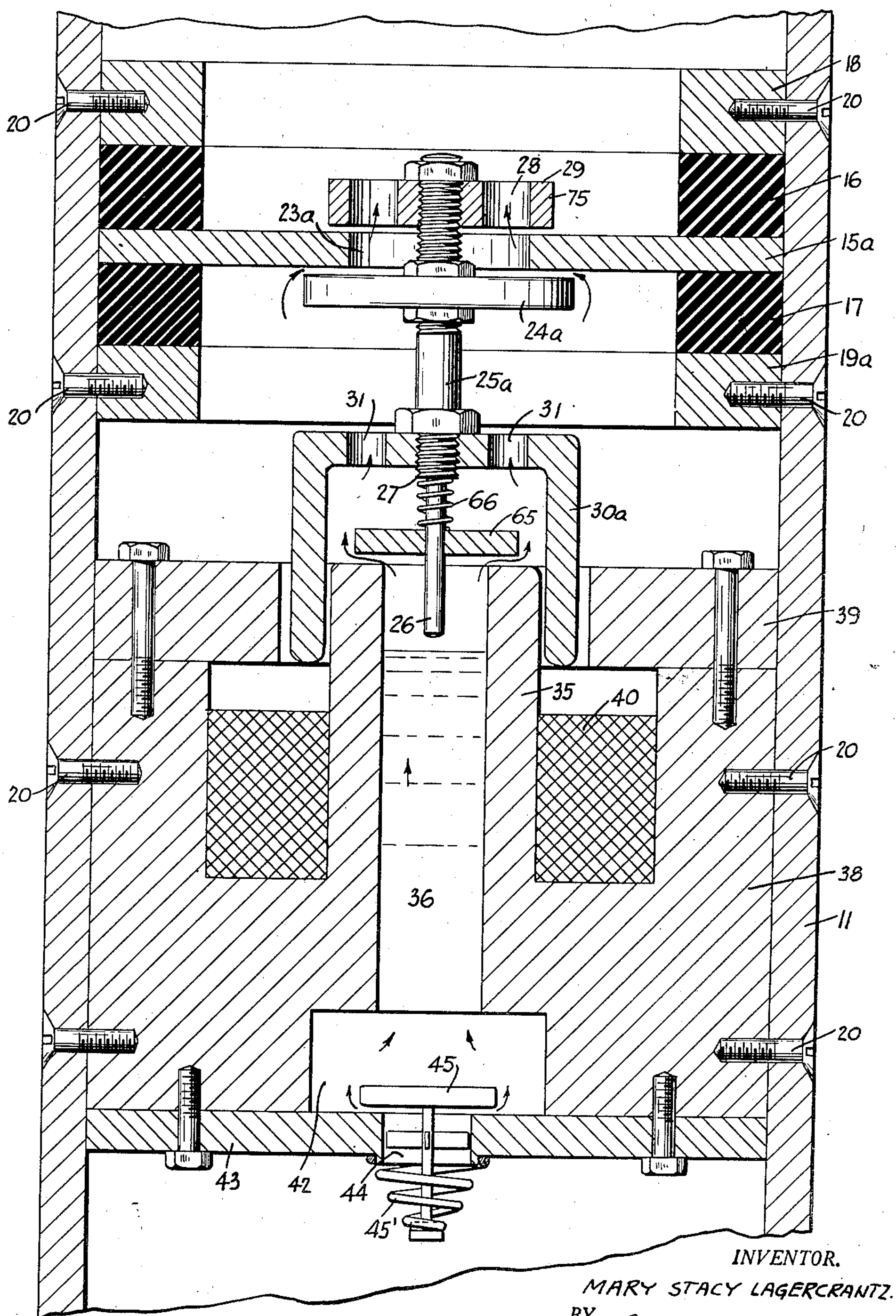

Fig. 4.

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Jan. 20, 1948. M. S. LAGERCRANTZ 2,434,804

PUMPING APPARATUS

Filed March 15, 1945 4 Sheets-Sheet 4

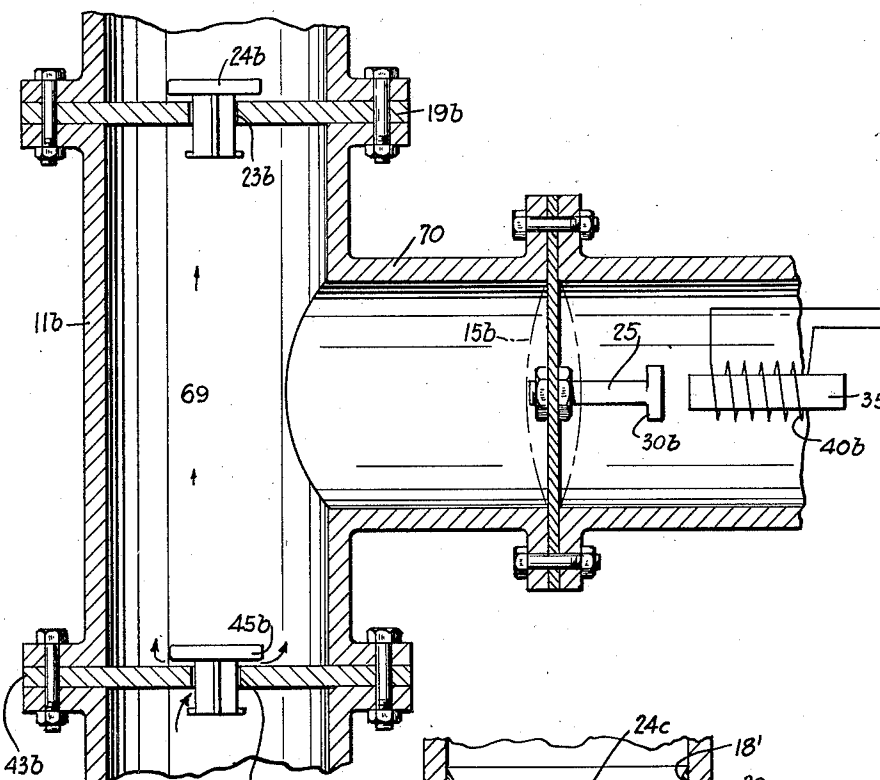

Fig. 5.

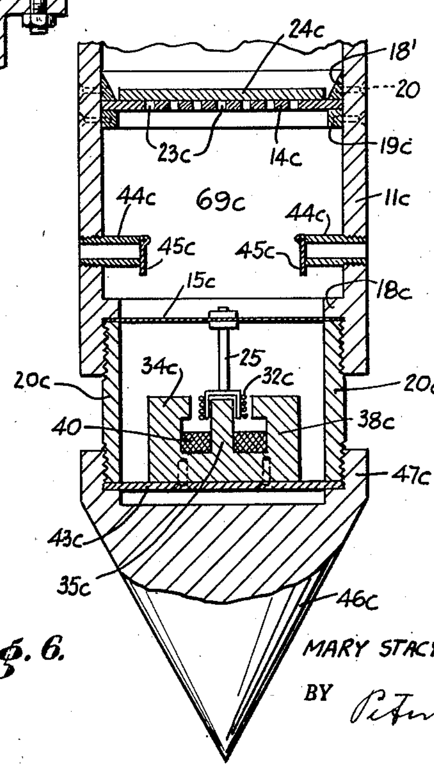

Fig. 6.

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UNITED STATES PATENT OFFICE

2,434,804

PUMPING APPARATUS

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Application March 15, 1945, Serial No. 582,874

11 Claims. (Cl. 103—46)

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This invention relates to new and useful improvements in pumps and water pumping apparatus and more particularly to apparatus and pumps for pumping water from deep wells for irrigation and other purposes, though it may be noted that in most of the claims the invention, which may have a varied mechanical and industrial application is not limited to deep well pumps alone.

Vast areas in so-called deserts or arid lands are exceedingly fertile due to years of accumulation of decayed vegetable and animal matter, since in these areas the rainfall is slight and there has been no washing away of the rich soil. Because of this slight rainfall, these lands are consequently relatively unproductive and support growth of only such vegetation, such as the cacti, the so-called sage brush and perhaps mesquite. Areas near surface streams have been irrigated with exceedingly good results, but the cost of supplying water to the distant regions has heretofore been prohibitive.

However, beneath many of these arid lands there exists a copious supply of ground-water suitable for irrigation, though the water-table may be 300 to 3000 feet below the surface. Heretofore, this ground-water has not been used to any appreciable extent because of the great expense involved in the installation and operation of suitable pumps for bringing said ground-water to the surface.

Objects of the invention are to provide improved pumping apparatus of this kind which may economically raise water distances up to 3000 feet or more with a minimum of outlay for construction, installation and power.

Other objects of the invention are to provide an improved device of this kind which is adaptable for different depths of wells from a minimum to the maximum and which may be driven from usual electrical power sources.

Additional objects of the invention are to effect simplicity and efficiency in such pumping apparatus and to provide an extremely simple pumping apparatus of this kind which is economical, durable, and reliable in operation, and economical to manufacture and install.

Still other objects of the invention will appear as the description proceeds; and while herein details of the invention are described in the specification and some of the claims, the invention as described in some of the broader claims is not limited to these, and many and various changes may be made without departing from the scope of the invention as claimed in the broader claims.

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The inventive features for the accomplishment of these and other objects are shown herein in connection with several forms of pumping apparatus, each of which briefly stated, includes a pipe having pump units spaced therein and each comprising a vibratory diaphragm across the pipe and provided with an upwardly opening valve port. A rod below and operatively connected to the diaphragm carries an inverted cup shaped armature secured on the lower part of the rod and having upper openings therein. The diaphragm is vibrated by a magnet below the armature and has an inner pole received in and spaced from the armature; said inner pole is provided with a passageway therethrough, and in said passageway is disposed an upwardly opening check valve yieldably closing the latter. A transverse wall across the pipe below the magnet has an inlet opening to said passageway. A magnet coil arranged on said inner pole receives current impulses from a suitable current source for causing the magnet to vibrate the armature and consequently the diaphragm, thus causing water to pass upwardly through said passageway, valves and pipe.

In the accompanying drawings, showing by way of example, several of many possible embodiments of the invention:

Figure 1 is a fragmental diagrammatic side elevation, showing one form of the pump in a well.

Figure 2 is a wiring diagram of the electrical connections.

Figure 3 is a detailed fragmental longitudinal vertical sectional view, partly in elevation, showing the pump unit of Figure 1; while

Figures 4, 5, and 6 are fragmental longitudinal vertical sectional views, respectively, showing other forms of the pump units.

The pumps disclosed herein are suitable for a hallow or a deep well 10 (Figure 1) and include a pipe 11, which may also be the wall pipe of the well, if desired. One or more pump units 12 are suitably spaced in the pipe, depending upon the depth of the well.

In the forms of the invention, as shown in Figures 3 and 4, each unit comprises a diaphragm 15 or 15a of resilient or stiff metal or material, disposed transversely substantially across the interior of the pipe and held in place by a pair of resilient rings 16, 17 of rubber or other suitable elastic material; said rings respectively engage against the inner face of the pipe and the upper and lower peripheral marginal faces of the diaphragm and are held in place by a pair of mounting rings 18, 19a, as shown in Figure 4, or a ring 18 and perforated wall 19, as shown in Figure 3; said rings 18 and 19a or the wall 19 are secured to the inner face of the pipe by screws 20 and respectively engage against the outer transverse faces of the resilient rings 16, 17 for holding the latter in resilient engagement with the diaphragm, so that said diaphragm may vibrate longitudinally of and within the pipe. If the diaphragm is of resilient material, it may be held in place by non-resilient rings.

In the form of the invention shown in Figure 3, the diaphragm 15 is provided with valve ports 23, closed by upwardly open check valves 24; a reciprocatory rod 25 is secured to the diaphragm axially below the latter and carries at its lower end an inverted cup-shaped armature 30 of magnetic material, having openings 31 in the upper wall thereof, said armature being surrounded by heavy helical or annular conductor or conductors 32.

The intermediate transverse wall 19 disposed across the pipe between the diaphragm 15 and armature 30 is perforated with passage openings 33 substantially alined with the openings 31 in the armature wall and said valve ports 23.

Means are disposed in the pipe for actuating the armature and comprise a magnet generally designated as 34, spaced from the diaphragm and having a central vertical core forming an inner magnet pole 35 received in the lower open end of the armature 30, said pole being provided with a vertical water passageway 36 therethrough. The lower portion of the magnet is developed radially outwardly as a yoke 37; the outer periphery of said yoke being developed upwardly as a tubular pole 38 spaced from the central core and secured to the inner face of the walls of the pipe 11. An annular pole piece 39 is secured on the top face of said pole 38 and against the face of the pipe 11. A primary coil 40 is disposed around the lower part of said inner pole 35.

The lower end of the passageway 36 through the magnet core 35 is of enlarged diameter to form a cavity 42; a transverse wall 43 across the pipe is integrally secured to the lower face of the magnet and has a central valve opening 44 surrounded by a valve seat 44′ below said cavity and adapted to receive an upwardly opening lower check valve 45 yieldably closed by the spring 45′ and permitting a flow of water only upwardly through said passageway.

A cup-shaped finishing piece 46, shown in Figure 1 is secured on the lower end of the pipe just beneath the lowest pump unit and is provided with lateral and lower perforations 47, 48, thus forming an inlet chamber communicating with the lower valve opening.

Alined bores 50, 51, adjacent and longitudinal to the pipe 11, pass through said diaphragm 15 or 15a, rings 16, 17, 18, wall 19, pole pieces 39, and pole 38, and also through the transverse wall 43 of the intermediate pump units; the bore 51 in the pole has a lateral branch 52 extending to the coil 40. An insulated bushing 53 lining said bores and branch, receives insulating conductors 54, 55, extending from the top of the well through said bushings, in a water-tight manner and communicating with the ends of said coil 40.

Means for supplying pulsating or alternating current to the conductors 54, 55 comprise a condenser 60, as shown in Figure 2, a source 61 of direct current for charging the condensers, means for selectively conducting current from the condenser to the respective conductors 54, 55, including a mercury discharge tube, high voltage switch 56 interposed between the side of the condenser and the conductor 54, and an ionization control 57 connected to the source and passing to the ends of the tube, for periodically ionizing the contents of the tube to permit a flow of current therethrough, whereby the condenser may periodically discharge current through the coil of the magnet. Sixty alternations or pulsations per second are satisfactory and 25 to 200 cycles may be used. Where pumping loads are relatively light, the conductors may be connected directly to a commercial source of alternating current. Said alternating or pulsating current causes an induced current around the skirt of the armature 30 and in said conductors 32, thereby causing the armature and magnet intermittently to attract each other and consequently to draw the diaphragm toward the magnet 34. Upward movement of the armature raises the diaphragm, thus drawing water in through the water passageway 36 of the magnet core, giving the water upward momentum in the passageway, while the lower check valve opens to allow passage of the water upwardly. Movement of the diaphragm downward meets the upwardly moving water, incidentally causing the upper check valve to open, while the lower check valve is closed; the diaphragm pressing upon the water, thus adds to said upward momentum an upward force whereby further to push water up through the openings 31 and 33 and the valve ports 23, and similarly through other units to flow out at the upper part of the pipe 11.

In the form of the invention, as shown in Figure 4, the diaphragm mounting, the magnet and the valve 45 are similar to those shown in Figure 3, but the diaphragm 15a is in this modification provided with a large central valve port 23a, while the reciprocatory rod 25a is disposed in the pipe substantially in axial alinement therewith and loosely passing through said port 23a, said rod has a reduced diameter at its lower end portion 26 forming a downwardly facing shoulder 27. A valve disk 24a, large enough to close the port, is adjustably secured transversely on said rod 25a below the diaphragm, and an intra-marginally open spider member 75 is secured transversely on the rod above the diaphragm and has a peripheral portion 29 of said spider member disposed over the upper marginal structure of the port 23a. The distance between the spider member 75 and valve disk 24a is slightly greater than the thickness of the diaphragm, so that when the rod and disk are lowered relative to the diaphragm, a flow of water may pass between the diaphragm and valve disk up through the port 23a and the openings 28 in the spider member, subsequently further lowering of the rod 25a depresses the diaphragm.

In Figure 4 the inverted cup-shaped armature 30a secured coaxially on the rod near the lower end thereof is of magnetic material, but has not an additional conductor 32 around it, as in Figure 3. The armature 30a has large openings in its end wall, as shown in Figures 3 and 4.

The pump shown in Figure 4 has in addition to the inlet valve 45, as shown in Figure 3, a valve disk 65 loosely received on the lower reduced end portion 26 of said road 25a and resting on the top face of the core 35 for closing the passageway 36. A helical spring 66 on said reduced end portion is compressed between the disk 65 and shoulder 27.

The magnet coil 40, shown in Figure 4, is supplied with current as in Figure 3, and the operation is practically the same. Upward movement of the armature **30***a* closes the upward valve disk **24***a*, thereby raising the diaphragm and thus draws water in through the water passageway **36** and openings **31**, giving the water upward momentum in the passageway, incidentally the check valves **45** and **65** open against action of their springs. Movement of the armature downward opens the disk valve **24***a*, while the check valves **45** and **65** tend to close the diaphragm pressing upon the water, thus adding to said upward momentum an upward force, pushing water up through the valve port **23***a* of the diaphragm and through the openings **28** in the spider member **75**. The general effect of the operation is practically the same as in the pump, shown in Figure 3.

The pump illustrated in Figure 5 is shown in combination with a pipe **11***b*, having transverse walls **19***b* and **43***b*, forming therewith a pump chamber **69** with which communicates a branch conduit **70**, having a vibratory diaphragm **15***b* disposed thereacross for pressing upon and retracting from the water in the pump chamber. Said walls are respectively provided with valve openings **23***b*, **44***b*, receiving outwardly and inwardly opening valves **24***b*, **45***b*. An armature **30***b* in the outer part of said conduit is connected by a rod **25** to the diaphragm. A suitable magnet **35***b* is mounted so as to have a pole adjacent to the armature and is provided with a magnet coil **40***b* connected in any suitable manner to a current source supplying current impulses to said coil. As will be obvious, outward movement of the magnet draws water in through the valve opening **44***b*, while inward movement of the diaphragm forces the water out through the opening **23***b*.

The pump illustrated in Figure 6 is shown in combination with a pipe **11***c*, having a transverse wall **14***c* disposed across said pipe near the lower part of the latter and provided with a large number of valve ports **23***c* scattered all across the wall **14***c* and closed by a large disk valve **24***c* resting on said wall and covering the ports and most of the wall. Retaining rings **18'** and **19***c* are secured against the pipe and the upper and lower marginal faces of the wall **14***c* for holding the latter in place.

A retaining flange **18***c* is provided in the pipe some distance below the wall **14***c* and a resilient diaphragm **15***c* is disposed across the pipe against the lower face of said flange **18***c* to form with said wall a pump chamber **69***c*. The pipe **11***c* is internally threaded below the diaphragm, and a short internally threaded pipe section **20***c* is screwed into said pipe against the diaphragm to hold the latter in place.

Threaded bushings **44***c* passing through the sides of the chamber have threaded engagement with the pipe and project radially into the chamber, forming on the inner end of the bushing valve seats adapted to receive inlet check valves **45***c*.

A reciprocatory axial rod **25** below the diaphragm and secured to the latter carries an armature coil **32***c* of conducting material secured coaxially on the lower part of the rod and adapted to be attracted by a magnet **34***c* below the diaphragm, said magnet having a central pole **35***c* in the armature coil. The magnet **34***c* has a lower yoke, the outer periphery of which is developed upwardly as a tubular pole **38***c*, spaced from the central pole and adapted to receive the magnet coil **40**.

A lower transverse wall **43***c* is disposed across the lower face of the pipe section **20***c* to which the magnet **34***c* is secured, said lower wall being held in place by a downwardly pointed finishing piece **46***c*, having an inwardly threaded and upwardly pointed peripheral flange **47***c* screwed on to the lower end of the short pipe section **20***c* and serving as an entering piece, whereby the entire pipe may be forced into the ground to make a driven well.

A source of current as in Figures 1 and 2 is suitably connected to the coil **40** for causing the magnet to vibrate the armature and diaphragm; the vibratory movement of the armature and diaphragm causes water to flow through the inlet bushings **44***c* and into the chamber **69***c* and then up through the valve ports **23***c* of the top wall; the said bushings being longer than their diameter, in order to provide a narrow passageway alined with the path of the water passing therethrough for increasing the velocity and momentum of said water, thus forcing the water upward. When the pump, as shown in Figure 6, is to be operated against relatively low heads of water, the valves **45***c* may be omitted.

It is obvious that slight changes may be made in the form, construction and arrangement of the several parts, as shown, within the scope of the appended claims, without departing from the spirit of my invention, and I do not, therefore, wish to limit myself to the exact construction and arrangement shown and described herein.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. A pump, comprising structure forming a chamber, a vibratory diaphragm for pressing upon and retracting from water in said chamber, the latter being provided with inlet and outlet passages, an armature connected to the diaphragm, an electromagnet adjacent thereto and means supplying current to the magnet, said means comprising conductors connected to the magnet coil, a condenser and a source of direct current for charging the same, means for selectively conducting current from said condenser to the respective conductors and including a discharge tube high voltage switch, interposed between a side of the condenser and one of the conductors, and an ionization control for periodically ionizing the contents of the tube to permit a flow of current therethrough, whereby the condenser may be periodically discharged through the coil of the magnet.

2. A pump comprising a pipe, pump units spaced in said pipe, and comprising a vibratory diaphragm across the pipe, and provided with an upwardly opening valve port, a rod below the diaphragm and operatively connected to the latter, an inverted cup-shaped armature secured on said rod and having an upper opening, a magnet disposed below the diaphragm and having an inner pole in the armature aud provided with a passageway therethrough, an upwardly opening check valve closing said passageway, a transverse wall across the pipe and having an opening to said passageway, a magnet coil on said inner pole, and a current source means supplying current impulses to said coil.

3. A pump as claimed in claim 2 and wherein the current supplying means comprises conductors connected to the magnet coil, a condenser and source of direct current for charging the

same, means for selectively conducting current from the condenser to the respective conductors and including a discharge tube high voltage switch, interposed between a side of the condenser and one of the conductors, and an ionization control for periodically ionizing the contents of the tube to permit a flow of current therethrough, whereby the condenser may be periodically discharged through the coil of the magnet.

4. A pump as claimed in claim 2 and having alined openings in said diaphragm, outer pole, and the lower wall of the intermediate pump units, the bore in the outer pole having a branch to said coil, insulated conductors from the top of the well passing through said alined openings in a water-tight manner to said coil, said source of current being connected to said conductors for causing the magnet to vibrate the armature and the diaphragm, upward movement of the armature closing the upper valve disk and giving upward momentum to the water in the passageway, movement of the armature downward for opening the valve disk, while the lower check valve is closed, thus forcing water up through the valve port.

5. A pump as claimed in claim 2 and comprising a finishing piece on the lower end of the pipe and being provided with perforations and forming an inlet chamber for the lower central valve opening.

6. A pump comprising a pipe, a vibratory diaphragm across the pipe and provided with a valve port, a rod below the diaphragm and passing through the port, a valve disk for closing the port on said rod below the diaphragm, a member mounted on the rod above the diaphragm and having parts disposed over the marginal structure of the port, the distance between said member and disk being slightly greater than the thickness of the diaphragm, an inverted cup-shaped armature on the lower part of the rod and having upper openings in its end wall, a magnet below the diaphragm having a central pole disposed in the armature and provided with a passageway therethrough, a downwardly pressed valve disk loosely received on the lower end of the rod and closing said passageway, the magnet having a lower yoke, the outer periphery of the latter being developed upwardly as an outer tubular pole spaced from the central pole, an insulated coil around said central pole, a wall across the pipe and lower face of the magnet and having a central valve opening, an upwardly opening lower check valve over said opening, and means supplying pulsating current to the coil.

7. A pump comprising a pipe, a wall disposed across the lower part of the pipe and provided with valve ports, a disk valve resting on said ports and on the greater part of the wall, rings secured against the pipe and upper and lower wall margins, a flange in the pipe spaced below said wall, a resilient diaphragm across the pipe against the lower face of the flange and forming a pump chamber with said wall, a short pipe securing the pipe against the diaphragm, bushings projecting radially through the pipe into the chamber, and provided with inlet check valves, a rod below and secured to the diaphragm, a conducting armature coil on the lower part of the rod, a lower wall across the lower part of said pipe section, a magnet on said lower wall having a pole in said coil, a magnet coil on said pole, and a source of pulsating current connected to said magnet coil.

8. A pump as claimed in claim 7, and wherein said bushings are longer than their diameter and providing a narrow passageway in and substantially alined with the path of the water passing therethrough for increasing the velocity and momentum of the water.

9. A pump as claimed in claim 7 and comprising a downwardly pointed finishing piece, having an inwardly threaded upwardly pointed peripheral flange screwed on the lower end of the short pipe section and serving as an entering piece, whereby the pump may be inserted in the ground to make a driven well.

10. A pump comprising a pipe having transverse walls to form a chamber, a branch conduit communicating with said chamber, a vibratory diaphragm across said conduit for pressing upon and retracting from the water in the chamber, inwardly and outwardly opening valves in said walls respectively communicating with the chamber, an armature in said conduit and connected to the diaphragm, a magnet mounted to have a pole adjacent the armature, a magnet coil in said pole, and means for supplying current impulses to said coil.

11. A pulsating pump comprising a pipe, a wall disposed across the lower part of the pipe and provided with valve ports, a disk valve resting on said ports and most of the wall, a flange in the pipe spaced below said wall, a diaphragm mounted to be subjected to pulsation and across the pipe against the lower face of the flange, and forming with said wall a pump chamber, a short pipe secured in the pipe against the diaphragm, conduit means for communication from the exterior of the pump to the chamber, and provided with inlet check valves; a rod below the diaphragm and secured to the latter for pulsating said diaphragm, an armature on the lower part of the rod, a lower wall across the lower part of said pipe section, a magnet on said lower wall, a magnet coil on said magnet, and a source of pulsating current connected to said magnet coil for causing the magnet to pulsate the armature and diaphragm, whereby pulsations of said armature and diaphragm will cause water to pulsate and flow through the inlet valves into the chamber and then up through the valve ports of the top wall.

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