Nov. 17, 1953 A. RYBA 2,659,310

ELECTROMAGNETIC PUMPING DEVICE FOR PUMPING FLUIDS

Filed Sept. 2, 1950

2 Sheets-Sheet 1

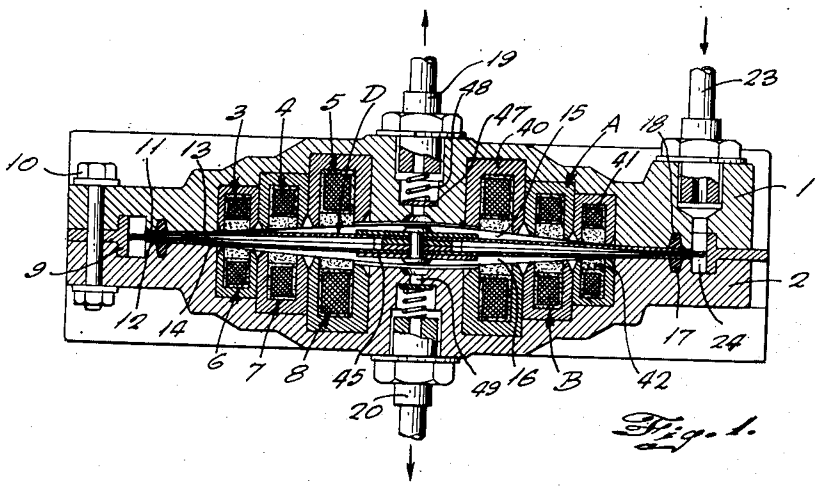

Fig. 1.

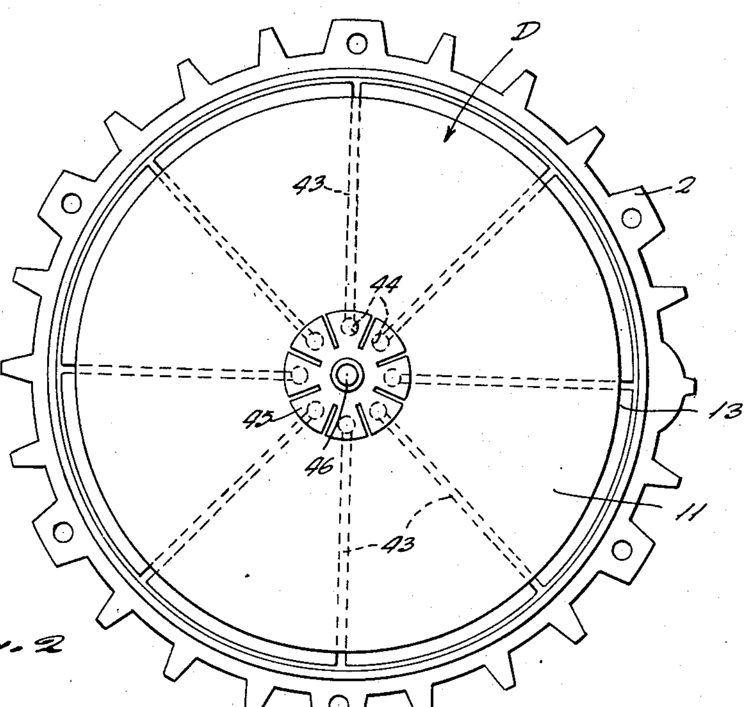

Fig. 2

INVENTOR.
ANTON RYBA
BY Andrew L. D. Hay
ATTORNEY

Nov. 17, 1953

A. RYBA

2,659,310

ELECTROMAGNETIC PUMPING DEVICE FOR PUMPING FLUIDS

Filed Sept. 2, 1950

2 Sheets-Sheet 2

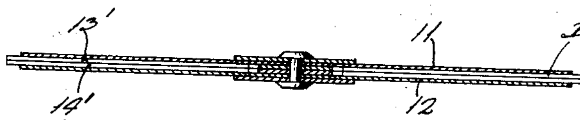

Fig. 3.

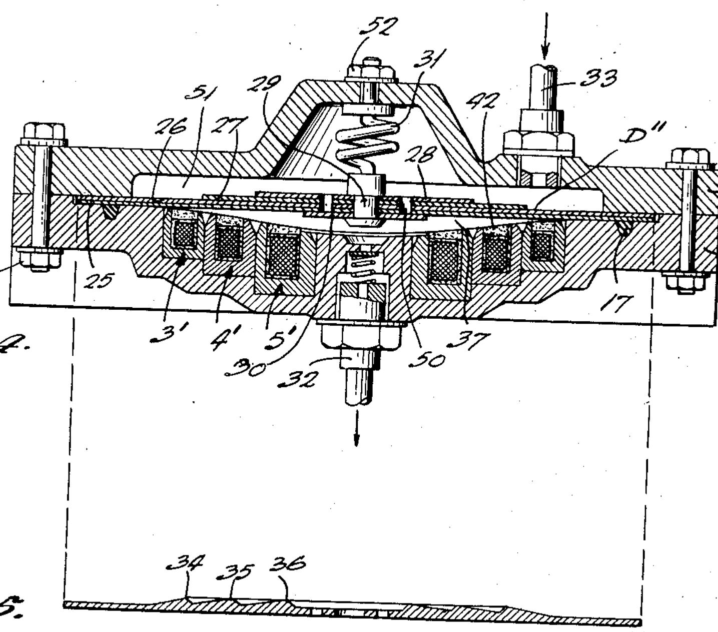

Fig. 4.

Fig. 5.

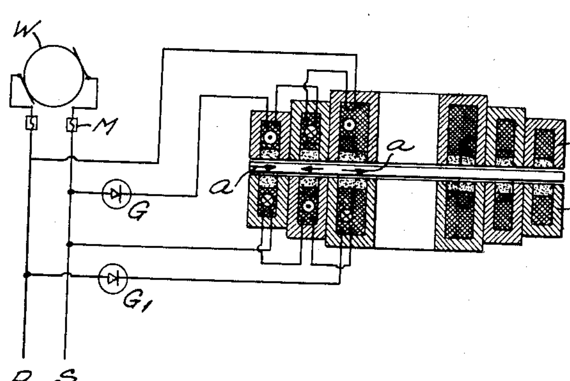

Fig. 6.

INVENTOR.
ANTON RYBA
BY Friedrich E. Hanz
ATTORNEY.

Patented Nov. 17, 1953

2,659,310

UNITED STATES PATENT OFFICE

2,659,310

ELECTROMAGNETIC PUMPING DEVICE FOR PUMPING FLUIDS

Anton Ryba, Bolzano, Italy

Application September 2, 1950, Serial No. 182,982

11 Claims. (Cl. 103—53)

1

This invention relates to electromagnetic pumping devices for pumping a gaseous or liquid fluid either with or without increase in pressure.

In particular, the present invention relates to an electromagnetic pumping device or compressor of the type in which electromagnetic means comprising a plurality of concentric magnetic circuits each including exciting coil means and core material and forming one or two substantially continuous surfaces are disposed within a housing. Each of the said surfaces may be inwardly curved to form a shallow bowl. The concentric circuits coact with armature means in form of a flexible diaphragm which is supported along its periphery in the housing in a position facing the continuous surface or surfaces and forms together with each adjacent continuous surface a pumping chamber. Electric means are provided for energizing the said concentric circuits intermittently so as to cause the diaphragm to oscillate thereby intermittently varying the capacity of the pumping chamber or chambers. Each pumping chamber communicates with fluid admission means and fluid discharge means. The fluid admission means admit fluid into the respective chamber upon oscillation of the diaphragm in one direction and the fluid discharge means discharge fluid from the respective chamber upon oscillatory movement of the diaphragm in opposite direction.

Electromagnetic pumping means of this type are more fully described in my co-pending application Ser. No. 46,377 filed on August 27, 1948 now issued as Patent 2,630,760 on March 10, 1953.

With electromagnetic pumping device of the general type, above referred to, the most favorable distribution of the magnetomotive forces affecting the oscillations of the armature and, hence, the efficiency of the pumping device offers considerable difficulties by reason of the variance in the airgap between the diaphragm and the individual concentric circuits of the electromagnetic means.

Accordingly, one of the objects of the present invention is to provide means by which the most favorable distribution of the magnetomotive forces across the radial width of the electromagnetic means and the armature means and, hence, across the width of the pumping chamber or chambers can be efficiently and conveniently attained.

Another object of the invention is to provide means by which magnetomotive forces affecting the oscillations of the armature means are gradually or step by step increased toward the center of the armature means. This has the advantage of counterbalancing the increase of the air gap

2

between the oscillating armature means and the adjacent continuous surface or surfaces toward the center of the armature means. As will be obvious, the larger sections of the air gap require larger magnetomotive forces.

Other and further objects, features and advantages of the invention will be pointed out hereinafter and set forth in the appointed claims forming part of the application.

In the accompanying drawing several now preferred embodiments of the invention are shown by way of illustration and not by way of limitation.

In the drawing:

Fig. 1 is a cross-sectional view of an electromagnetic pumping device according to the invention.

Fig. 2 is a plan view of Fig. 1 after removal of the top portion of the pumping device.

Fig. 3 is a cross-sectional detail view of a modification of the armature means of the device.

Fig. 4 is a cross-sectional view of a modification of an electromagnetic pumping device according to the invention.

Fig. 5 is a cross-sectional detail view of another modification of the armature means for a pumping device according to the invention, and

Fig. 6 is a diagrammatic circuit system for the electromagnetic means of a pumping device according to the invention.

Referring first in detail to the embodiment shown on Figs. 1 and 2, the electromagnetic pumping device according to these figures is shown as a double acting pump for pumping liquid or gas. It comprises two casing or housing halves **1** and **2** housing the electromagnetic means of the device. These electromagnetic means are shown as comprising an upper set A and a lower set B of concentric magnet members. Three members generally designated by **3**, **4**, **5** and **6**, **7**, **8** are shown for each set. Each of said members comprises an annular iron core **40** of substantially U-shaped cross-section. The annular cores may be ring-shaped, polygonal or otherwise shaped. They may be secured to the respective casing half by any suitable means such as rivets. The exciting coils **41** of the magnet members are inserted in the open grooves of the cores and are embedded therein in a mass of an insulation material **42** of a type becoming very hard when dry. This insulation mass together with the pole faces of the cores forms a substantially continuous smooth surface in form of a substantially concavely curved shallow bowl as can be clearly seen on Fig. 1. This figure also shows that the shanks of the cores are tapered toward the pole faces to provide for the greatest possible flux density of the magnetic fields at or near the pole faces.

The two halves 1 and 2 of the casing or housing are joined by any suitable means such as bolts and nuts 10.

The armature means, generally designated by D, are inserted between the two halves of the casing facing the two sets A and B of the electromagnetic means. The armature means are shown in form of a flexible diaphragm which may comprise a single disc or be composed of several thin discs or laminae. There are shown two outer full or cover discs 11 and 12 made of ferromagnetic or other magnetizable material and two inner or filling discs 13 and 14 which may or may not be made of magnetizable material. The inner discs 13 and 14 are each provided with a plurality of radially spaced slots 43 each in registry with one of holes 44 in the cover discs. A slotted valve plate 45 of comparatively rigid material is fastened by means of a rivet 46 to the outside of each cover plate. As can best be seen on Fig. 2, the slots of valve plates 45 form a plurality of fingers each covering one of the holes 44. As will be more fully explained later on, plates 45 together with holes 44 form valves. Rivet 46 is preferably unround to prevent rotation of valve plates 45 relative to holes 44.

The diaphragm disc is held along its periphery between the halves of the casing and is centered in the casing by means of a centering ring 9. Two sealing rings 17 and 18 serve to prevent seepage between the casing halves and the outside of cover plates 11 and 12.

As can best be seen on Fig. 1, the peripheral edge of the diaphragm is extended into an annular channel 24 thereby permitting fluid to flow from channel 24 into slots 43. Channel 24 communicates with an inlet flange 23 which should be visualized as being connected to a supply of fluid to be pumped.

The diaphragm forms together with each adjacent continuous surface a pumping chamber 15 and 16 respectively. Chamber 15 connects with a discharge valve 19 and chamber 16 with a discharge valve 20. Each discharge valve comprises a valve plate 47 pressed by a spring 48 against a valve seat. The valve plates, when seated, close a bore 49 leading into the respective pumping chamber.

According to the invention, the magneto-motive forces generated by the magnetic circuits increase toward the center of the pumping device. As can be clearly seen on Fig. 1, the individual concentric circuits have successively increasing iron cores and also larger exciting coils for the purpose of providing increasing magnetomotive forces required by reason of the increase of the airgap toward the center of the device.

The thickness of the diaphragm is also preferably increased toward the center of the diaphragm, either gradually or step by step. As shown on Fig. 1, the thickness of the inner or filling discs 13 and 14 is gradually or uniformly increased toward the center. The increase in the thickness of the diaphragm is preferably selected according to the dimensions and magnetomotive properties of the magnetic circuit faced by a respective zone of the diaphragm.

The use of a diaphragm thus varying in thickness has the advantage that the swinging or oscillating masses can be reduced to a minimum and that the iron losses can also be kept at a minimum.

The electric connections for energizing the magnetic circuits of the sets A and B respectively can be so made that all the members of the two sets are alternately and intermittently energized or that the individual coils of each set are successively energized. The connections of the individual coils in each set of magnetic circuits may also be so made that the direction of current is reversed in the coils of adjacent annular cores and that the direction of the current flow in the corresponding exciting coils of the upper set and in the lower set of magnet members is opposite. As a result, the magnetization of the diaphragm during the alternate excitation of the upper and lower set is not reversed and the iron losses of the diaphragm are thus reduced.

Suitable connections are shown in Fig. 6. The arrows *a* indicate the direction of the magnetic flux for each annular core element, and the marks in the coils (circle with point and circle with cross) indicate the direction of current in the respective coil.

In the diagram, A is the upper and B is the lower set of magnet members; a single phase alternating current generator is designated by W; G and G_1 indicate the rectifiers in the one phase net; R and S are the main lines from the generator; and M are cut-out fuses.

The operation of the double acting pumping device or compressor, as hereinbefore described, is as follows:

When the compressor is connected to a circuit system according to Fig. 6, the rectifiers (each group of coils must be connected to a rectifier) G and G_1 let each pass one half wave of the alternating current. Accordingly, during each half period the lower and upper set of magnetic circuits are alternately excited so that the magnetic attraction forces thus created pull the diaphragm alternately into opposite directions. Consequently, the diaphragm is flexed toward the curved surface of the excited set of magnet members. At the same time a partial vacuum is formed in the pumping chamber bounded by the opposite face of the diaphragm so that gas or liquid is sucked through the annular channel 24, the radial slots 43 of the filling discs 13 and 14 and the temporarily uncovered openings 44. The other plate, of course, remains pressed against the diaphragm. As a result, fluid is sucked into the respective pumping chamber. If the other pumping chamber has been previously filled with fluid, this fluid will press the respective valve plate 47 away from its seat so that the fluid is discharged through the respective discharge valve 19 or 20. The same cycle is repeated when the other set of magnetic circuits is subsequently energized.

Let it be assumed that the upper set of magnetic circuits is excited. Then, the outer marginal zone of the diaphragm is first attracted since the air gap is smallest in this zone. As a result, the compression of fluid in the respective pumping chamber begins and the air gap is gradually reduced from the exterior toward the center as the deflection of the diaphragm progresses. By reason of the hereinabove described increase of the available magnetomotive forces toward the center, the diaphragm will be flexed rapidly and forcefully toward the respective curved surface and hug the same closely thereby insuring a powerful intake and discharge action.

In certain instances, the use of a diaphragm having a uniform thickness in connection with magnetic circuits increasing in magnetomotive force toward the center is practical and advisable.

Fig. 3 shows a diaphragm D' of uniform thickness composed of cover discs 11 and 12 and inner discs 13' and 14' of uniform thickness. The thickness of the diaphragm should be selected according to the requirements of the largest magnetic circuit shown as the magnet member 5 of Fig. 1.

Fig. 4 shows a single acting electromagnetic pumping device or compressor according to the invention which is based upon the same principle as the previously described pump. The electromagnetic means of the pumping device according to Fig. 4 comprise only one set of magnetic circuits 3', 4' and 5' increasing in size and, hence, magnetomotive force. The members forming the circuits are fitted in the two halves A' and B' of the casing. The pole faces of the magnet members again form together with the insulation mass 42 a continuous substantially concavely curved surface. This curved surface together with a diaphragm generally designated by D'' forms the single pumping chamber 37 of the device. The diaphragm comprises a full cover plate 25 and several slotted plates 26, 27 and 28. A valve plate 30 is fastened to cover plate 25 and forms together with holes 50 valves as has been described in connection with Figs. 1 and 2.

As will be noted, plates 26, 27 and 28 have different diameters so that the total thickness of the diaphragm is increased toward the center of the diaphragm. It will be evident that the effect of the magnet members of the circuits increasing toward the center in dimensions and of the diaphragm increasing in thickness toward the center is the same as has been described in connection with Figs. 1 and 2. The face of the diaphragm opposite to the pumping chamber 37 bounds a chamber 51 corresponding in function to annular channel 24. Chamber 51 communicates with an inlet flange 33 corresponding in function to inlet flange 23. The pumping chamber 37 communicates with a discharge valve 32 which in design and function is similar to valve 19 or 20. The diaphragm is engaged by one end of a spring 31 which is fastened to the diaphragm by means of a rivet or screw 29 also serving to secure the valve plate 30 to cover plate 25. The other end of the spring is secured to casing half A' by means of a nut 52.

Spring 31 is so loaded that it will pull back the diaphragm into the position shown on Fig. 4 after the magnet members 3', 4' and 5' become deenergized. In other words, the spring performs substantially the same function as the second set of magnet members provide in a double acting compressor.

The electric connections of the device may be as previously described or any other electric connections suitable for the purpose and well known in the art may be employed.

The operation of the pump according to Fig. 4 will be obvious from the previous description.

Fig. 5 shows an arrangement in which the increasing thickness of the diaphragm is obtained by providing concentric ribs or reinforcements 34, 35 and 36 disposed in accordance with the positions of the individual magnetic circuits.

It will be obvious that the effect will be substantially the same whether the reinforcements of the diaphragm are provided on one side only or symmetrically on both sides. Furthermore,

the effect is approximately the same with a step by step and a gradual or uniform increase in the thickness of the diaphragm.

A symmetric distribution of the reinforcements on both sides of the diaphragm is preferable for double acting pumps while one sided reinforcements appear to be more suitable for single acting pumping devices.

The curvature of the continuous surface formed by the magnetic circuits is preferably selected in accordance with the deflections of the diaphragm to avoid the retention of local airgaps.

With a single acting pump according to Fig. 4, the surface of the pumping chamber 37 formed by the magnetic circuits can also be made plane in which case the necessary suction space is formed by lifting the diaphragm vertically to its plane.

The number of concentric magnetic circuits can be freely selected within a wide range. The diaphragm can be kept the lighter the more concentric magnetic circuits are provided.

While the invention has been described in detail with respect to certain now preferred examples and embodiments of the invention it will be understood by those skilled in the art after understanding the invention, that various changes and modifications may be made without departing from the spirit and scope of the invention and it is intended, therefore, to cover all such changes and modifications in the appended claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In an electromagnetically actuated pumping device for pumping a fluid, in combination a housing, an electromagnetic means comprising a plurality of ring shaped magnetic circuit means disposed within the housing in concentric arrangement, the said ring-shaped circuit means forming at least one substantially continuous surface, each of said circuit means including exciting coil means and ferromagnetic core means, the said individual circuit means when energized generating differently strong magneto-motive forces, armature means in form of a flexible diaphragm, the said diaphragm being supported along its periphery within the housing and positioned to form a pumping chamber between the diaphragm and each adjacent continuous surface, electric means for intermittently energizing said concentric magnetic circuit means so as to cause the diaphragm to oscillate thereby varying the capacity of each pumping chamber, said concentric circuit means, when magnetized, attracting adjacent corresponding zones of the diaphragm, fluid admission means arranged to communicate with each pumping chamber and to admit fluid into a chamber upon an oscillatory movement of the diaphragm in one direction, and fluid discharge means arranged to communicate with each pumping chamber to discharge fluid from a chamber upon an oscillatory movement of the diaphragm in opposite direction.

2. In an electromagnetically actuated pumping device for pumping a fluid, in combination a housing, electromagnetic means comprising a plurality of ring shaped magnetic circuit means disposed within the housing in concentric arrangement, the said ring-shaped circuit means forming at least one substantially continuous surface, each of said circuit means including exciting coil means and ferromagnetic core

means, the coil means and the core means in the individual circuit means being different one from another as to their electric and magnetic properties respectively so that the individual circuit means when energized produce magneto-motive forces different in strength, armature means in form of a flexible diaphragm, the said diaphragm being supported along its periphery within the housing and positioned to form a pumping chamber between the diaphragm and each adjacent continuous surface, electric means for intermittently energizing said concentric magnetic circuit means so as to cause the diaphragm to oscillate thereby varying the capacity of each pumping chamber, said concentric circuit means, when magnetized, attracting corresponding adjacent zones of the diaphragm, fluid admission means arranged to communicate with each pumping chamber and to admit fluid into a chamber upon an oscillatory movement of the diaphragm in one direction, and fluid discharge means arranged to communicate with each pumping chamber to discharge fluid from a chamber upon an oscillatory movement of the diaphragm in opposite direction.

3. A pumping device according to claim 1, wherein the said coil means and the said core means included in the individual magnetic circuit means when energized generate magneto-motive forces increasing in strength toward the center of the electromagnetic means.

4. A pumping device according to claim 2, wherein the said coil means and the said core means included in the individual magnetic circuit means are different one from another as to ampere turns and cross-section of the core means, the ampere turns and the cross-sections in individual circuit means increasing from the outer circuit means toward the inner circuit means.

5. In an electromagnetically actuated pumping device for pumping a fluid, in combination a housing, electromagnetic means comprising a plurality of ring shaped magnetic circuit means disposed within the housing in concentric arrangement, the said ring-shaped circuit means forming at least one substantially continuous surface, each of said circuit means including exciting coil means and ferromagnetic core means, the said coil means and the said core means in the individual circuits being different one from another as to their electric and magnetic properties respectively so that the individual circuit means when energized produce magneto-motive forces different in strength, armature means in form of a flexible diaphragm having zones different in cross-sectional thickness, each of said differently thick diaphragm zones being positioned adjacent to one of said concentric magnetic circuit means, the said diaphragm being supported along its periphery within the housing and positioned to form a pumping chamber between the diaphragm and each continuous surface, electric means for intermittently energizing said concentric ring-shaped circuit means so as to cause the diaphragm to oscillate thereby varying the capacity of each pumping chamber, said concentric circuit means, when magnetized, attracting corresponding adjacent zones of the diaphragm, fluid admission means arranged to communicate with each pumping chamber and to admit fluid into a chamber upon an oscillatory movement of the diaphragm in one direction, and fluid discharge means arranged to communicate with each pumping chamber and to discharge fluid from a chamber upon an oscillatory movement of the diaphragm in opposite direction.

6. A pumping device according to claim 5, wherein the thickness of the diaphragm zones is increased toward the center thereof.

7. A pumping device according to claim 5, wherein said diaphragm zones are concentrically arranged and gradually increase in thickness toward the center of the diaphragm, each of said concentric diaphragm zones facing a respective one of said concentric magnetic circuit means.

8. A pumping device according to claim 5, wherein the said concentric diaphragm zones increase in thickness step by step toward the center of the diaphragm.

9. A pumping device according to claim 1, wherein each continuous surface formed by said circuit means is substantially concavely curved relative to the adjacent side of the armature means.

10. A pumping device according to claim 1, wherein the said electromagnetic means comprise two sets of the said concentric magnetic circuit means, each of said sets forming a continuous surface, said two surfaces facing each other spaced apart, and wherein said diaphragm increases in cross-sectional thickness toward its center and is disposed between said two surfaces to form two pumping chambers therewith, the said surfaces being substantially concavely curved relative to the respective adjacent side of the diaphragm.

11. In an electromagnetically actuated pumping device for pumping a fluid, in combination a housing, electromagnetic means comprising a plurality of ring shaped magnetic circuit means disposed within the housing in concentric arrangement, the said ring-shaped circuit means forming a substantially continuous surface, each of said circuit means including exciting coil means and ferromagnetic core means, the said coil means and the said core means in the individual circuit means being different one from another as to their electric and magnetic properties respectively so that the individual circuit means when energized produce magneto-motive forces different in strength, armature means in form of a flexible circular diaphragm, the said diaphragm being supported along its periphery within the housing and positioned to form a pumping chamber defined by the diaphragm and the continuous surface, electric means for intermittently energizing said concentric magnetic circuit means so as to cause the diaphragm to oscillate thereby varying the capacity of the pumping chamber, said concentric circuit means, when magnetized, attracting adjacent corresponding zones of the diaphragm, fluid admission means arranged to communicate with the pumping chamber and to admit fluid into the chamber upon an oscillatory movement of the diaphragm in one direction, and fluid discharge means arranged to communicate with the pumping chamber to discharge fluid therefrom upon an oscillatory movement of the diaphragm in opposite direction.

ANTON RYBA.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,380,442	Trumble ----------	June 7, 1921