March 2, 1943. R. E. HARTLINE 2,312,712

FLUID PUMP

Filed April 16, 1941

Fig. 1.

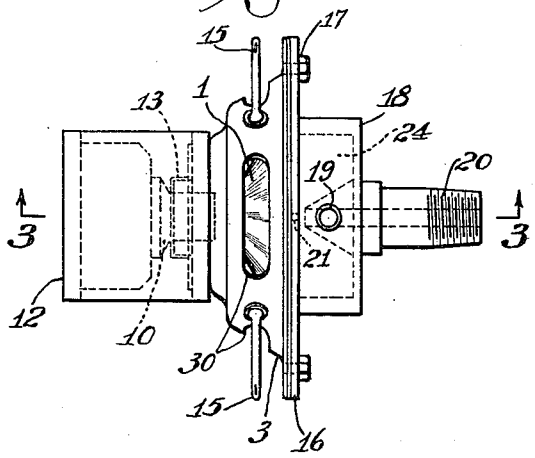



Fig. 2.

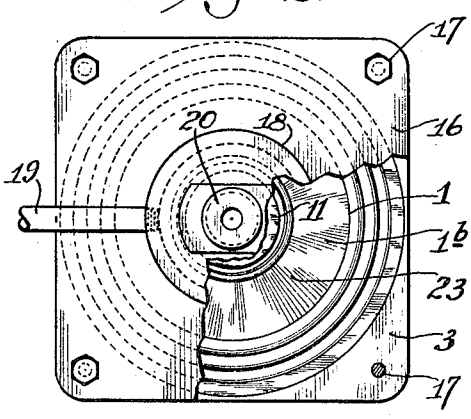



Fig. 3a.

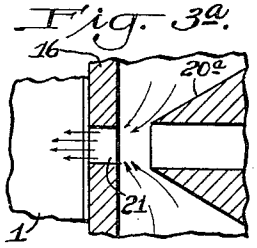



Fig. 3.

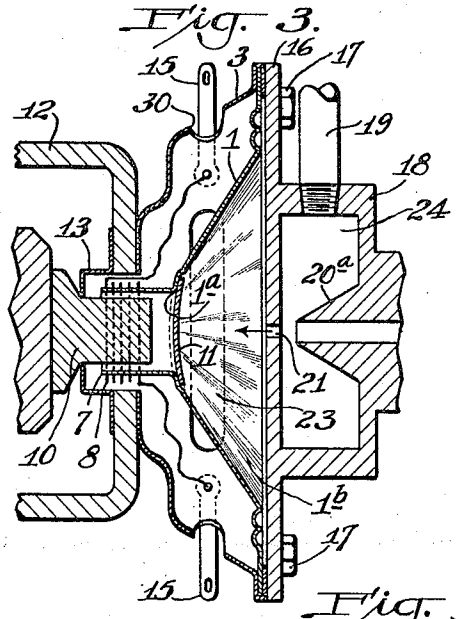



Fig. 4a.

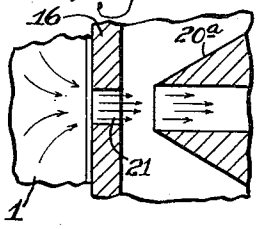



Fig. 4.

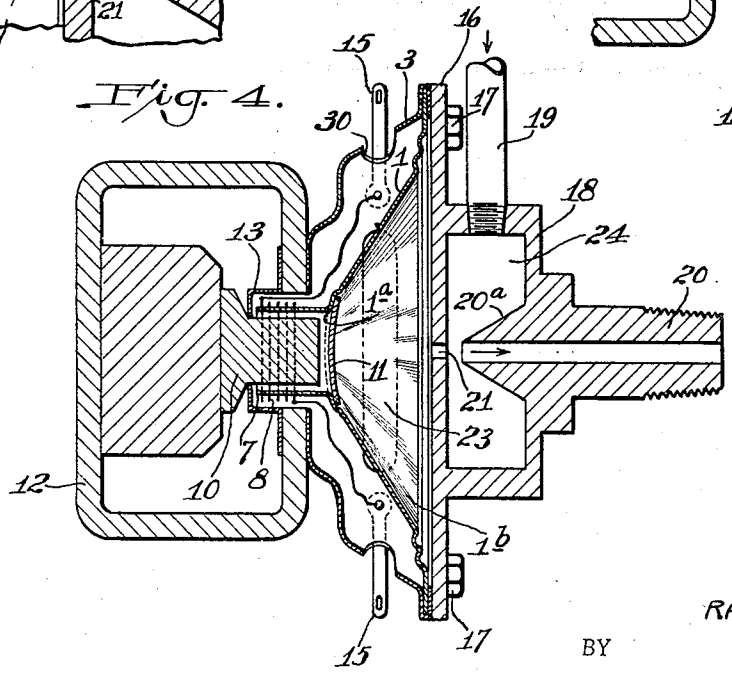
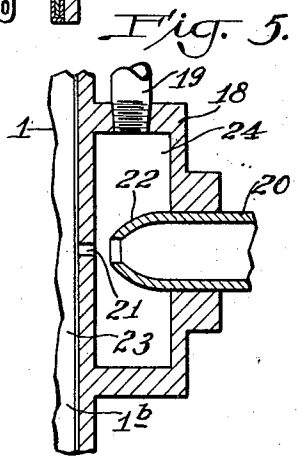



Fig. 5.




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# UNITED STATES PATENT OFFICE

2,312,712

## FLUID PUMP

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Application April 16, 1941, Serial No. 388,766

3 Claims. (Cl. 230—55)

This invention relates to an improvement in a fluid pump and, more particularly, to providing a pump that incorporates a principle of operation which makes it possible to eliminate wearing elements and is especially suitable to move small volumes of fluid.

In providing a pump for any use, it is most desirable to have a pump which is free from mechanical failure, and, obviously, such failure is affected by the number and complexity of moving parts incorporated therein. The constructions of pump, heretofore available, include generally some form of a moving element having bearing surfaces to provide a source of compression or movement of fluid and, in most cases, some form of a valve to control the movement of fluid to and from the moving or compression element and this means also has surfaces subject to wear. Consequently, because of their nature, they each provide a source of wear and probable pump failure and constitute a factor of much importance in the original cost and the cost of operation of the pump.

It is an object of this invention to provide a fluid pump which is simplified in construction, that is, containing less wearing surfaces and fewer parts subject to wear, low in maintenance cost, inexpensive to manufacture and capable of moving a fluid sample such as suitable for supplying a testing or detecting apparatus or instrument.

It is proposed by this invention to accomplish this object by employing an orifice member to confine the product of compression and accelerate the movement of fluid so as to discharge it from the orifice at a velocity sufficient to move fluid at a suitable rate through a conduit. In line with the purpose of this invention, it is preferred to use a moving or compression element such as a magnetically actuated diaphragm positioned on one side of the orifice member and operative to produce a difference in pressure on each side thereof and define two zones of pressure connected only by the orifice in the member. This difference in pressure causes a flow through the orifice from the side of high pressure to that of low pressure and in the embodiment it is followed by a succeeding action of the diaphragm which compresses the fluid to convert the zone of low pressure to that of high pressure. This produces a flow return through the orifice and gives increased velocity to the fluid and the discharge from the orifice is moving at a rate and in a confined condition that it can be discharged directly into a tube acting as the high pressure end of the apparatus. In addition to the effect on the fluid, there is produced also certain results of value in constructing a satisfactory pump for use as will become apparent from a detailed description of the embodiment of the invention. The orifice controls the flow of fluid to the compression member and into the discharge conduit and the diaphragm member can be constructed to eliminate wearing surface so that the whole combination affords a means of providing a pump of long service life and of low initial cost.

The preferred embodiment of this principle of operation is illustrated in the drawing wherein the collector or discharge tube forming the outlet of the pump is positioned in an original high pressure zone on one side of the orifice member and opposite to the zone on the other side that is affected by the moving member, which is an electrically vibrated diaphragm. By this arrangement, fluid is drawn through the orifice from the high pressure side and this action on the fluid causes it to pass in a converging manner from all parts of the instantaneous high pressure zone. Little effect is produced on the fluid previously discharged into the collector tube positioned in alignment with the orifice because of the force of inertia of the moving mass in the tube. By the action of the vibrating or compressing member, the fluid moving into the low pressure zone is compressed to form what becomes an alternate high pressure zone and is effective to cause the movement of fluid within the zone into the orifice to the other or original high pressure side. The fluid efflux from the orifice moves in a substantially straight line path through the space between the orifice edge and the entering end of the collector tube and into the tube to form a high pressure end. Placing such a device in a conduit produces a suction action in one portion of the conduit and a pressure in the other portion of the conduit, the differential depending on the size of parts employed and the rate of actuation.

It is an object of this invention to provide a pumping device and a method of operation which incorporates the principle of employing an orifice member in association with a moving element to produce movement of fluid through a conduit.

A more specific object of this invention is to provide a fluid pump that employs an electrically vibrated diaphragm which in combination with an orifice member is capable of moving

fluid through the orifice in an alternating direction of movement and the orifice being operative to produce a fluid flow that the efflux from the orifice contains such velocity that the flow therefrom moves through space in a straight line direction outward from the orifice to operatively move fluid through a conduit.

Other equally important objects of this invention will become apparent from the preferred embodiment hereinafter described in detail.

In the drawing:

Fig. 1 is a side elevational view of the preferred embodiment;

Fig. 2 is a front elevational view of the embodiment illustrated partly in section to disclose more fully the construction of the pumping or moving element employed;

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 1 and illustrates one portion of the pumping element;

Fig. 3*a* is a diagrammatic view illustrating the fluid flow condition existing in the pump in the instantaneous position illustrated in Fig. 3;

Fig. 4 is a sectional view similar to Fig. 3 and illustrates another position of the pumping element;

Fig. 4*a* is a diagrammatic view illustrating the fluid flow condition existing in the pump in the instantaneous position illustrated in Fig. 4; and

Fig. 5 is a modification of the discharge or collecting conduit illustrated in the embodiment.

In employing the principle of my invention, some form of an orifice member is used and in the event relatively low pressures are involved, the member is to be relatively thin since that is sufficient to cause the desired action and offers little resistance to movement of fluid due to the surface action of the orifice. The member is to be positioned to form pressure zones on each side connected by the orifice and effective to produce flow of fluid through the orifice. These zones are alternately high and low pressure relative to each other by the action of a moving or vibrating element on one side of the member. By this action of alternate flow through the orifice, advantage is taken of the nature of confluence of fluid to the orifice and the discharge from the orifice in producing movement of sufficient extent to produce operative fluid flow.

The apparatus of the embodiment illustrated in the drawing utilizes a vibrating diaphragm, of the radio speaker type, and, in one instance, a 2" diaphragm, used as the moving element and energized by a translating device operating on 60-cycle alternating current delivered about .02 of a cubic foot per minute of gas at about ½" water pressure by the reflow method through the orifice. This diaphragm, in combination with a plate having an orifice of about $\frac{1}{16}$" in diameter and having a discharge tube positioned in alignment and in spaced relation to an orifice and on the side opposite to that of the diaphragm, moves fluid of sufficient volume and at an ample velocity to provide a sample to a gas testing apparatus.

More specifically, and referring to the drawing, this moving or compression element construction consists merely of a vibratory circular diaphragm 1 of suitable material such as a rigid or stiff processed paper mounted on to a rigid frame 3. A sleeve 7 is attached to the diaphragm at its central portion and it carries a conductor coil 8 positioned so as to be influenced by the magnetic field of a permanent magnet 10. Some form of a closure 11 closes the opening 1*a* of the diaphragm to provide a surface suitable for moving fluids. The C-shaped flux conducting metal element 12 provides a means of support for a closure 13, that encloses the electrical mechanism from the atmosphere and permits normal movement of the diaphragm, and for the frame 3 which is attached to another surface. The terminals 15 of the coil are mounted to the frame and are to be connected to a suitable source of pulsating or alternating current for moving or actuating the diaphragm by the reversal of direction or change of intensity of current moving through the coil 8. A feature of this invention resides in the utilization of a vibrating diaphragm to produce a movement of fluid that contains sufficient kinetic energy to produce a confined fluid flow and cause movement of fluid through a conduit.

The orifice member 16, containing an orifice 21, is mounted to the frame 3 of the diaphragm by means of bolts or studs 17 and forms with the inner surface of the diaphragm a pressure zone or chamber 24 on one side of the orifice and member. Preferably, the orifice is in alignment with the center of the diaphragm. The pressure zone or chamber 23 on the other side is formed by means of a housing 18 that is integral with the plate and contains an inlet conduit 19 and an outlet conduit 20. The chamber 23 is affected by movement of the diaphragm through the orifice by the alternate suction and compression of fluid in the chamber 24 and produces the alternate high and low pressure zones on each side of the member. By means of the orifice, the energy supplied to the fluid by movement of the diaphragm creates a flow of some velocity so that the fluid discharged from the orifice is directed into the opening of a receiving tube and produces movement of fluid from the inlet to the outlet of the apparatus.

It is intended to illustrate the principle which I believe to be involved in producing the unidirectional fluid flow resulting from vibrating diaphragm and its influence on the alternate movement of fluid through an orifice. In Figs. 3 and 3*a*, the diaphragm is illustrated in an extreme position comparable to the beginning of the suction stroke in which fluid such as gas or atmosphere entering the inlet conduit is drawn from the high pressure zone existing in the chamber 24 through the orifice into the relatively low pressure zone within the chamber 23. To produce this condition, the diaphragm begins its movement inwardly or towards the C-shaped element and in doing so the fluid contained in the chamber 24 is drawn into the orifice in a converging manner from all parts of the chamber and after moving through the orifice is discharged into the chamber 23. This is specifically illustrated in Fig. 3*a* in which the directional arrows indicate the converging flow of fluid in the chamber 24 and the directed flow or efflux of fluid emerging from the orifice into the chamber 23.

The diaphragm having reached its most inward or other extreme position instantly begins a movement in the opposite direction, Fig. 4, due to the effect of change in intensity of current flow in the coil by reason of the alternating or pulsating source of power that is to be connected to the terminal 15 of the translating device. As the diaphragm moves in this opposite direction, the fluid contained in the one chamber 23 converges towards the orifice such as illustrated in Fig. 4*a* and by reason of the kinetic energy given the fluid and the static energy converted the fluid converges to the orifice. The actuated fluid emerges from the orifice and moves in substan-

tially a straight line path and in a confined condition in the space between the orifice and the inlet to the outlet opening. Positioning the entering surface of the outlet tube 20 in alignment with the orifice and in certain relation thereto, the efflux from the orifice is directed into and received by the conduit.

By the operation or cycle just described, fluid entering the chamber 24 from the inlet 19 is effectively moved into the outlet conduit 20. The inertia contained in the mass moving into the conduit and the velocity of the mass opposes the change in the movement of the diaphragm, such as occurs in the succeeding cycle during the suction stroke, and does not have much effect upon the fluid flow in the conduit except to produce some deceleration of the mass. However, this is ineffective to cause any substantial amount of fluid discharged into the conduit to be reversed in direction of movement so as to flow back into the chamber 24 and at most causes pulsations in the discharge of the apparatus. It has been found that the net flow from the complete cycle of operation is predominantly in a direction from the orifice into the outlet or collector tube 20. In the operative form of the embodiment described relative to the use of a 2" diaphragm, the inlet and outlet openings in the chamber 24 are about $\frac{3}{16}$" in diameter and the plate containing the orifice of about $\frac{1}{16}$" in diameter is of about the same dimension.

In order to reduce the resistance of movement to the orifice as much as possible, the entering portions 20a of the outlet conduit 20 are tapered toward the orifice so as to reduce the amount of resistance and to conform the engaging surfaces to the converging movement of fluid within the chamber. The entering end of the conduit is in spaced relation to the orifice and it is apparent that the amount of this spacing can be readily determined from the principles involved in the invention. It is obviously dependent upon the amount of velocity and energy in the mass discharged from the orifice and that entering the inlet opening 19 into the chamber 24. Also, the rate of movement of the diaphragm will have some effect upon the proximity of the entering end.

For some purposes, it may be advisable to taper the inside surface of the entering end of the outlet conduit or collector tube 20 as is illustrated in Fig. 5 and referring to the inlet portion 22 which has a converging inner surface to the entering end of the conduit. With this construction, the fluid having moved into the conduit continues movement in the same direction because of the minimizing effect the conduit structure produces within the conduit to the drawing action created by movement of the diaphragm in the opposite direction.

While other moving elements may be employed for producing an alternating flow through an orifice, the advantage of the diaphragm and its translating means is the simplicity and few wearing parts existing. This, in combination with the orifice member and collector tube, provides a pump containing only one moving part, that is, the diaphragm, and this is driven magnetically without mechanical contact with any other part of the apparatus. Furthermore, the apparatus in itself is operative to produce a directed fluid flow without the employment of a valve system or single valve means, and this eliminates elements most subject to wear in an ordinary type of pump.

It is to be observed that the embodiment illustrates but one application of the principle of my invention and this embodiment can be modified without departing from my invention such as by arranging the passages in a different fashion to and from the orifice or by positioning the discharge or collector tube in different relations to the moving element such as by positioning the tube on the same side as the moving element. With this arrangement, the tube is to be positioned to receive the efflux from the orifice during what was described in the preferred embodiment as the suction stroke of the diaphragm. It is necessary, however, that some form of a chamber or zone be provided on one side of the orifice plate and effected by a moving element to cause the movement of fluid through the orifice and effect a uni-directional or straight line flow therefrom which can be utilized to produce a flow of sufficient capacity and rate of movement. Actually, the mechanism of the embodiment produces pulses or fluctuating movements of fluid due to the frequency of operation, but because of the frequency of operation the result is a continuous flow and is being used quite successfully for supplying a sample to a gas testing apparatus.

In the commercial construction of vibrating diaphragm, openings 30 are provided in the frame 3 for the purpose of permitting free movement of the diaphragm during its operation.

Although but a single embodiment of the invention has been illustrated and described which discloses fully the principle involved therein, further changes and modifications in form, material, kind and relative arrangement of parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

I claim:

1. A fluid pump comprising a relatively thin plate member having an orifice, an electrically operated conically shaped vibratory diaphragm supported on one side of the member to enclose the orifice, an electrical translating means operatively connected to the diaphragm to transmit vibrating movement to the diaphragm and effect an alternating flow through the orifice, and a collector tube disposed on the opposite side of the member and having an inlet opening in aligned and closely spaced relation to the orifice to receive fluid discharged therefrom.

2. An electrical fluid pump comprising a housing having a relatively thin plate member with an orifice, an electrically operated conically shaped vibrating diaphragm supported on one side of the member to enclose the orifice and provide a chamber, an electrical translating means operatively connected to the diaphragm to transmit vibrating movement to the diaphragm and effect an alternating flow through the orifice, the housing having an inlet opening on the opposite side of the member, and a collector tube disposed on the same side of the member and having an inlet opening in aligned and closely spaced relation to the orifice to receive fluid discharged therefrom, the entering portion of the collector tube having its outer surface converging toward the orifice to provide a passage from the inlet opening to the orifice.

3. An electrical fluid pump comprising a housing having a relatively thin plate member with an orifice, an electrically operated conically shaped vibrating diaphragm supported on one

side of the member to enclose the orifice and provide a chamber, an electrical translating means operatively connected to the diaphragm to transmit vibrating movement to the diaphragm and effect an alternating flow through the orifice, the housing having an inlet opening on the opposite side of the member, and a collector tube disposed on the same side of the member and having an inlet opening in aligned and closely spaced relation to the orifice to receive fluid discharged therefrom, the entering portion of the collector tube having its outer surface converging toward the orifice to provide a passage from the inlet opening to the orifice, and the inner surface of the entering portion converging toward the orifice to restrict movement of fluid from the tube.

RALPH E. HARTLINE.