Sept. 24, 1929. H. C. HAYES 1,729,579

APPARATUS FOR FLUID PROPULSION BY VIBRATORY DIAPHRAGMS

Filed Oct. 23, 1926

Fig. 4.

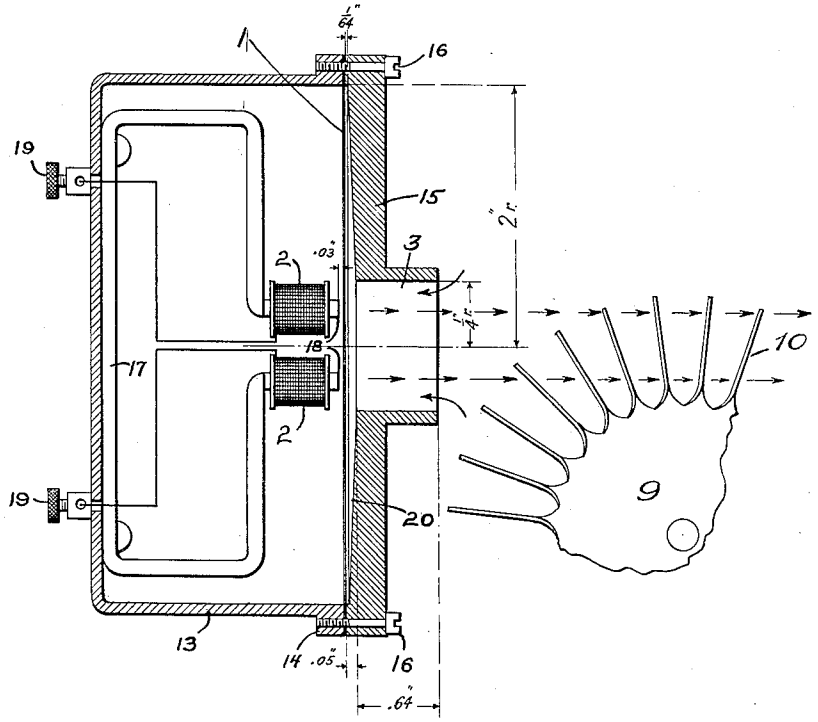


Fig. 1.

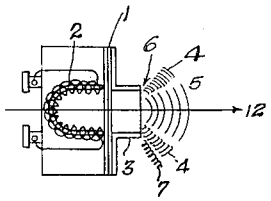


Fig. 2.

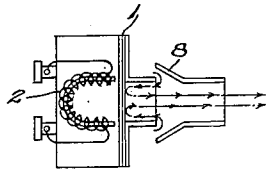
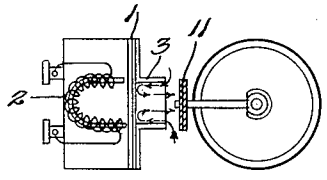


Fig. 3.



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UNITED STATES PATENT OFFICE

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APPARATUS FOR FLUID PROPULSION BY VIBRATORY DIAPHRAGMS

Application filed October 23, 1926. Serial No. 143,776.

(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757)

My invention relates broadly to fluid propulsion by means of vibratory diaphragms.

The object of my invention is to provide a means for imparting kinetic energy to a fluid by means of a vibratory diaphragm, for the production of mechanical work.

My invention consists substantially in the construction, combination and arrangement of parts associated therewith or as will be more fully hereinafter set forth as shown by the accompanying drawings and finally pointed out in the appended claims.

Reference is to be had to the accompanying drawing forming a part of this specification, in which like reference characters indicate corresponding parts throughout the several views and in which:

Figure 1, represents a diagrammatic view of my electromagnetic pump, showing the manner in which I have controlled the output of the energy of the diaphragm when energized by an alternating current,

Figure 2 represents a modification thereof in which I have used a shield to control the flow of fluid through the pump,

Figure 3 shows my device as applied to power generators, and

Figure 4 is a detail sectional view through a small model of my electromagnetic pump showing the detailed construction thereof.

Referring to Figure 1, when the diaphragm 1, is set into motion by a fluctuating or alternating electrical current through coil 2, the portion of the medium in which the instrument is placed and that which is contained within the outlet 3 is forced outwardly from the outlet as the diaphragm 1 moves away from the coil 2 and toward the orifice in the casing. This movement of the diaphragm will hereinafter be termed the pumping stroke of the diaphragm.

When the diaphragm moves toward the coil 2 and away from the outlet 3 a fresh portion of the medium in which the electromagnetic pump is placed is taken into the chamber between the diaphragm and the casing, since the momentum of the fluid which was produced by the pumping stroke of the diaphragm carried that portion of the medium away from the outlet 3. This movement of the diaphragm will hereinafter be termed the intake stroke of the diaphragm.

As the frequency of the current passing through the coil 2 increases there appears a distinct and well defined flow of the medium, having considerable velocity, directed outwardly from the outlet 3.

This effect becomes especially marked when the frequency of the electrical current is equal to the natural free period of the sound generating diaphragm.

This action is diagrammatically shown in Figure 1, wherein the shaded area 5 represents a compressed portion of the medium ejected from the outlet 3 by the motion outward of diaphragm 1. When the diaphragm is then attracted inwardly by the magnet 2, some of the outside medium is drawn back into the sound reproducing chamber to replace that which was expelled. This operation is repeated each time the diaphragm oscillates with the result that as the frequency of the current passing through the coils 2 approaches the resonant frequency of the diaphragm there is produced a rapid series of impulses 5 which are directed outwardly into the medium surrounding the pump and a series of periodical influxes 4 of the medium into the chamber in front of the diaphragm, the two series alternating with each other as the diaphragm moves through its pumping and intake strokes. The line 6 designates the direction of flow of the fluid as it enters the chamber in front of the diaphragm 1, and line 12 designates the outward flow of compressions 5.

Tests carried out on the simple device described, have shown that its efficiency, when the current fluctuations are timed to the natural period of the diaphragm, is unusually high and the effectiveness of the device is largely dependent upon a proper dimensioning of the sound chamber and the outlet.

The applicant has also found that the motion of the medium about the outlet 3 is not a simple inward flow as represented by the vector (6) but is really a vortex ring wherein the direction of whorl is shown by 7. This vortex motion of the medium prevents it from entering the chamber as readily as it

otherwise would and as a result the pumping effectiveness is increased by providing a secondary nozzle, one form of which is shown by numeral 8 in Figure 2.

The outward motion of the medium may be utilized by pivoting before the outlet 3 a wheel 9 carrying vanes 10 about its periphery as shown in Figure 4 or by placing a small turbine wheel 11 in front of the outlet as shown in Figure 5. In either case the wheel will be found to rotate with a speed and vigor entirely unlooked for when the small amount of electrical energy required to operate the electromagnetic pump is considered.

The apparatus shown in Figures 3 and 4 for absorbing the kinetic energy imparted to the fluid by the vibrations of the diaphragm is diagrammatic only as I do not wish to limit myself to the specific devices shown therein since the kinetic energy imparted to the fluid is equally applicable to the propulsion of ships as it is to driving devices actuated by the flow of a fluid impinging upon the moving parts of those devices.

As shown in detail in Figure 4 a small model of the electromagnetic pump consists of a casing 13 against the outer flanged surface 14 of which is clamped the diaphragm 1 by means of a cover or outlet casing 15 which is firmly secured to the casing 13 by means of screws 16 which are threaded into the flange of the casing 13.

Within the casing 13 is mounted a permanent magnet 17 the poles 18 of which extend to points in close proximity to the diaphragm 1 but which are sufficiently removed therefrom that the diaphragm will not touch the poles when in its maximum displacement. Upon each of the poles of the permanent magnet 17 are wound the coils 2 which are supplied with alternating current from the terminals of the electrical system of the pump as indicated at 19.

Between the diaphragm 1 and the interior of the casing 15 I have provided a chamber 20 from which leads the outlet 3. In order that the pump will operate with a maximum efficiency the radius of the outlet 3 and the length of the tube thereof, both theory and practice, indicate that the volume of the outlet must equal the volume displaced by the movement of the diaphragm from one position of maximum displacement to the other position of maximum displacement. This condition is approximated by the equation:

$$2\pi a\left(\frac{R^2}{2}+\frac{a^2}{6}\right)=\pi r^2 L$$

Where R is the radius of the active diaphragm
r is the radius of the outlet
a is the amplitude of the diaphragm
L is the length of the outlet.

In general the amplitude (a) is small with respect to the radius (R) so that the term $\frac{a^2}{6}$ may be neglected as exceedingly small in comparison to the value of $\frac{R^2}{2}$. With such an approximation the simple equation is

$$aR^2=r^2L$$

This simple equation serves with sufficient accuracy to design the electromagnetic pump.

In the model that I have constructed the driving force of the coils 2 is such that the displacement of the diaphragm 1 at its center is 1/100 inch when the coils are energized by an alternating current of a freqency which approximates the resonant frequency of the diaphragm 1 and the radius of the diaphragm is 2 inches. Then the simple equation given above is $1/100\times(2)^2=4/100-r^2L$.

For any value of (r) then the corresponding value of (L) may be determined. Thus assuming (r) $=1/4$ inch, then $L/16=4/100$ or $L=64/100$ of an inch.

These different values have been incorporated in the model as indicated in Figure 6.

Further I do not wish to limit myself to the use of a particular fluid as the principles involved apply in the same way irrespective of the fluid used, the difference lying only in the efficiency of operation which is dependent upon the compressibility and the viscosity of the fluid used.

It will be understood that the above description and accompanying drawings comprehend only the general and preferred embodiment of my invention and that minor detail changes in construction and arrangement of parts may be made within the scope of the appended claims and without sacrificing any of the advantages of my invention.

The invention herein described may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon or therefor.

Having thus described my invention, what I claim is as follows:

1. In a fluid pump, the combination of a casing having an orifice for the ingress and egress of a fluid to and from the casing, a vibratory diaphragm the center of which is adjacent the orifice, and electromagnetic means for producing a displacement of the diaphragm at its resonant frequency, the volume of said orifice computed from the equation

$$2\pi a\left(\frac{R^2}{2}+\frac{a^2}{6}\right)=\pi r^2 L$$

substantially as described.

2. In a fluid pump, the combination of a casing having an orifice for the ingress and egress of a fluid to and from the casing, a vibratory diaphragm the center of which is adjacent the orifice, and electromagnetic means for producing a displacement of the diaphragm at its resonant frequency, the vol-

ume of said orifice computed from the equation:

$$aR^2=r^2L$$

substantially as shown.

3. In a fluid pump, the combination of a casing having a conical interior surface and an orifice at the apex of said conical surface for the ingress and egress of a fluid to and from said casing, a vibratory diaphragm within said casing and forming with said conical surface a conical chamber within said casing, the center of said diaphragm being located along the axis of said orifice, and electromagnetic means for imparting vibrations to said diaphragm to produce a flow of fluid through said orifice.

4. In a fluid pump, the combination of a casing having a conical interior surface and an orifice at the apex of said conical surface for the ingress and egress of a fluid to and from said casing, a vibratory diaphragm within said casing and forming with said conical surface a conical chamber within said casing, the center of said diaphragm being located along the axis of said orifice, and electromagnetic means for imparting vibrations to said diaphragm at its resonant frequency to produce a flow of fluid through said orifice.

5. In a fluid pump, the combination of a casing having a conical interior surface, a diaphragm within said casing and forming with said conical surface a conical chamber within said casing, means for electromagnetically driving said diaphragm and means permitting the ingress and egress of a fluid to and from said conical chamber to produce a directional flow of fluid away from said diaphragm in a line substantially perpendicular thereto.

6. In a fluid pump, the combination of a casing having a conical interior surface, a diaphragm within said casing and forming with said conical surface a conical chamber within said casing, means for electromagnetically driving said diaphragm at its resonant frequency and means for permitting the ingress and egress of fluid to and from said conical chamber to produce a directional flow of fluid away from said diaphragm in a line substantially perpendicular therto, said last mentioned means being aligned substantially along the central axis of said diaphragm.

HARVEY C. HAYES.