June 19, 1962 C. E. FRICK 3,039,272

FLUID ACTUATING DEVICE

Original Filed Nov. 13, 1958

Fig. 1.

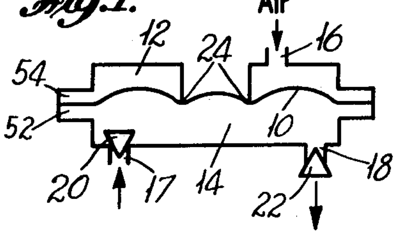
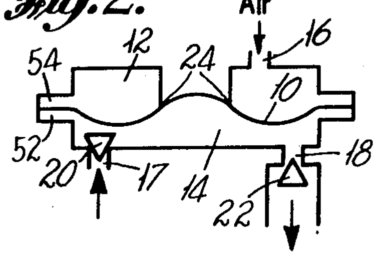


Fig. 2.



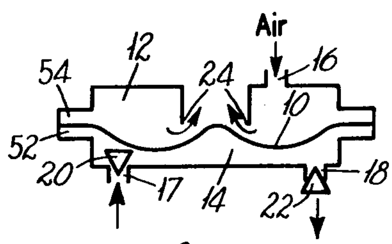


Fig. 3.

Fig. 4.

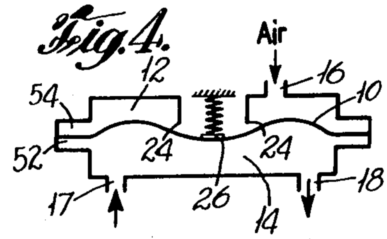


Fig. 5.

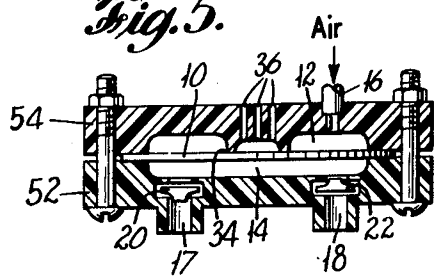


Fig. 6.

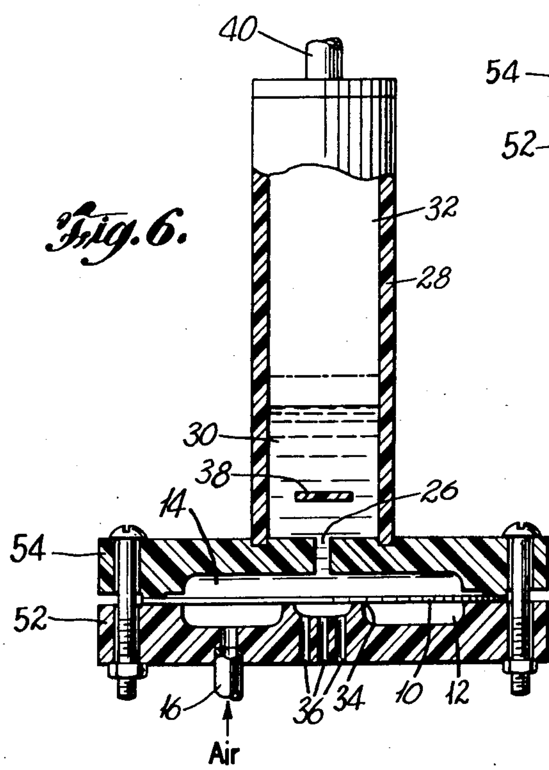
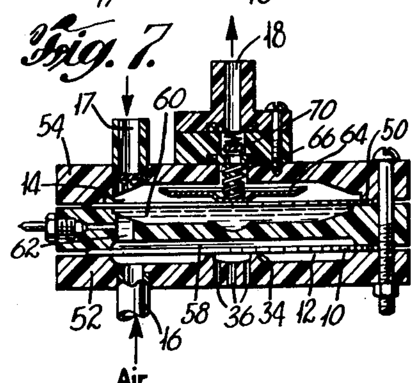


Fig. 7.



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FLUID ACTUATING DEVICE

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Original application Nov. 13, 1958, Ser. No. 773,741, now Patent No. 3,016,840, dated Jan. 16, 1962. Divided and this application Sept. 18, 1961, Ser. No. 138,974
2 Claims. (Cl. 60—62.6)

This invention relates to a diaphragm operated fluid actuating device, and is a divisional application of my copending application Serial No. 773,741, filed November 13, 1958, now Patent No. 3,016,840.

It is a primary object of this invention to provide an improved pumping or pulsing device operated by fluid means. Another object is to provide such a device having a minimum of moving parts and capable of continuous unattended operation. Other objects, features and advantages will be apparent from the following description, appended claims, and the attached drawings wherein:

FIGS. 1 through 3 are schematic diagrams showing the operation of a pump embodying the novel features of the invention;

FIG. 4 is a schematic diagram of a modified version of the pump of FIGS. 1–3;

FIG. 5 is a sectional elevational view of a pumping device embodying the novel features of the invention;

FIG. 6 is a sectional elevational view of a pulsing device embodying the novel features of the invention;

FIG. 7 is a sectional elevational view of a modified pumping device embodying the novel features of the invention.

The above objects are attained by providing a fluid actuating device comprising body member means having first chamber means adapted to receive an actuating fluid and second chamber means adapted to receive an actuated fluid. Flexible diaphragm means are provided for separating the two chambers. Actuating fluid inlet means are provided for continuously supplying pressurized actuating fluid to the first chamber means to flex the diaphragm. Actuating fluid outlet means are provided in contacting relationship with the diaphragm means during a portion of its flexure to alternately present an open and closed outlet passage to the pressurized actuating fluid. The diaphragm is thereby caused to pulse and periodically displace a portion of the actuated fluid from the second chamber means.

With more particular reference to the embodiment of FIGS. 1–3, a flexible diaphragm **10** is shown separating an annular actuating fluid chamber **12** and an actuated fluid chamber **14**. Actuated fluid inlet port **17** and outlet port **18** are provided with standard fluid check valves **20** and **22**. As shown in FIG. 1, positive inlet pressure of the pumped fluid is exerted against diaphragm **10**, pushing the diaphragm against actuating fluid exhaust port **24** causing it to close. An actuating fluid such as compressed air is admitted continuously through port **16**. As pressure on the upper side of diaphragm **10** builds up, the diaphragm begins to bulge as shown in FIG. 2, thereby driving fluid out through port **18**. The pressure of the actuated fluid keeps exhaust port **24** closed until diaphragm **10** is bulged far enough to pull free as shown in FIG. 3. The accumulated air, or other driving fluid, is thereupon vented and diaphragm **10** once again closes exhaust port **24** so that the cycle may be repeated.

It will be readily apparent that the greater the exhaust port area in relation to a given diaphragm size, the more the remaining diaphragm area must flex in order to pull the vented area free from the exhaust port edge. At the same time, however, the working area of the diaphragm

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is proportionately reduced. A smaller exhaust port area leaves a larger diaphragm working area but reduces the amount of diaphragm pull necessary to open the exhaust port. Consequently, a stiff diaphragm would tend to vent prematurely with a resulting decrease in displacement per stroke and might also cause erratic pulsing. The proper ratio for maximum pumping efficiency depends on a number of variable factors including diaphragm stiffness, inlet and outlet operating pressures, viscosity of fluids involved, etc. and must be determined for each application.

FIG. 4 illustrates a pump similar in construction to that of FIGS. 1–3 except that spring-loaded follower **26** has been added. Follower **26** delays exhaust port sealing until the diaphragms has flexed past center toward the driving side, thus increasing the displacement per stroke. This also makes it possible to enlarge the ratio of diaphragm area to exhaust port area for a given size and type of pump.

FIG. 5 is a cross-section of a pump utilizing applicant's invention. This pump is similar to that shown in FIGS. 1 through 3 with the manner of construction more accurately shown. The relief valve is seen to consist of a circular ridge **34** and multiple discharge ports **36**. This construction has been found to minimize diaphragm damage encountered when the exhaust port construction of FIGS. 1 through 3 is followed literally.

FIG. 6 is a cross-section of a device utilizing applicant's invention but for the purposes of pulsing rather than pumping. The actuating side of this device is similar to the pump of FIGS. 1–3 and 5. The actuated side, however, differs in that a single outlet **26** is provided and surrounded by enclosed cylinder **28**. In practice, a diaphragm loading liquid **30** is added to the device which will pulse as the diaphragm moves. This fluid may, in turn, pulse a second fluid that is part of an external system. Thus, fluid **30** may be mercury and secondary fluid **32** may be air, for example. This combination has been found useful as a pressure pulse source to operate the gas scrubber of an automatic Orsat analysis apparatus.

As an example of the invention, a pump of the type shown in FIG. 5 was machined from plastic. The two body halves were bolted together so as to clamp the diaphragm about its circumference. The diaphragm employed was cut from a .041 inch thick sheet of a single ply rubber-like gasket material (Garlock 7430) and was 9 inches in diameter. The "active" diaphragm diameter and the diameter of the actuating fluid (air) chamber **12** was 8¼ inches. The exhaust port was centered in the fluid chamber and the mean diameter of circular ridge **34** was 2¼ inches resulting in a diaphragm to exhaust port area ratio of 13.46 to 1.0. Chamber **14** had a diameter substantially equal to that of chamber **12** and had a depth of 5⁄16 inch. Chamber **14** was provided with inlet and outlet ports having diameters of ½ inch, each. Simple plastic check valves **20** of standard construction were provided. This pump was operated using a standard 20 p.s.i. compressed air source throttled through a standard valve fitting. The device pumped water at the rate of approximately 2 gallons per minute from an inlet head of 12 inches to an outlet head of 40 inches.

As a further example of the invention, a pulsing device, similar to that of FIG. 6 was constructed. With respect to the air side of the diaphragm, this device was identical to that described in the above example although somewhat smaller. In the other section, however, a single outlet orifice **26** of .144 inch diameter was provided. Cylinder **28**, having an internal diameter of one inch, was provided surrounding the outlet port. The chamber **14**, orifice **26**, and a part of cylinder **28** were filled with mercury. By adjusting the flow of air through inlet **16**, this column was caused to pulse at a rate of approximately 30 times per minute with a vertical displacement in the cylinder of approximately 5/16 inch. Outlet orifice 26 is a major factor in determining pulse frequency of this device. The other factors are: the physical nature of the filling liquid 30, such as its viscosity and specific gravity; the liquid head of filling liquid; back pressure of driven device; inertia or other time factor of driven device; and pressure and flow rate of the actuating fluid.

Baffle 38 over orifice 26 deflects the high velocity stream of fluid 30 and prevents its breaking the surface of the pool of liquid, splashing against outlet port 40 and possibly being carried out of the actuator.

Applicant has discovered that the pump of his invention as illustrated in FIG. 5 may be successfully operated under many circumstances utilizing an inlet check valve 20 only and dispensing with outlet check valve 22. Operation in this manner depends upon imparting to the actuated fluid such a velocity through port 18 and its associated outlet tubing that the inlet port 17 can refill chamber 14 by the time the outlet stream stops moving. Such operation is most successful when the ratio of inlet port area to outlet port area is increased over that employed when two check valves are used. As an example of this method of operation, a 5-inch diameter pump was constructed having an actuated fluid chamber diameter of 3 9/16 inches, an inlet check valve port diameter of 3/4 inch, and a outlet port diameter of 3/8 inch. Actuating chamber 12 was 3 9/16 inches in diameter and contained an exhaust port 34 having a diameter of 1 1/4 inches. This unit pumped two gallons per minute of water against a 40 inch head with an inlet head of 8 inches and a 20 p.s.i. air supply.

FIG. 7 illustrates another embodiment of the invention. It will be seen that two diaphragms, 10 and 50, are employed. Both the actuating fluid side 52 and the actuated fluid side 54 of the pump are generally similar to the corresponding portions of the devices illustrated in FIGS. 1–5. The primary difference between this pump and the others will be seen to lie in the use of the two diaphragms separated by a diaphragm loading fluid contained in cavities 58 and 60 which communicate with each other through diaphragm loading fluid orifice 62. The diaphragm loading fluid is pressurized by means of a spring 66 through pressure disc 64 and seal diaphragm 50. The frequency of this pump is controlled primarily by the rate of flow of loading fluid through orifice 62. It is to be noted that in this embodiment the actuated fluid plays no essential part in the pump operation as all regulating and loading functions are carried out by the loading fluid and loading pressure is supplied by spring 64 rather than by gravity. This device is capable of pumping either gases or liquids with an appropriate choice of check valves. In the embodiment of FIG. 7, outlet check valve 70 is spring loaded so as to maintain a relatively high positive pressure in the outlet circuit.

As an example of the device of FIG. 7, a 5 inch diameter pump was constructed having an actuating fluid chamber 12 with a diameter of 3 9/16 inches, and an exhaust port 34 diameter of 1 inch. The actuated fluid chamber 14 was of the same size and was provided with an inlet check valve port 17 and an outlet check valve port 18 having a diameter of 3/8 inch each. A 20 p.s.i. actuating air source was utilized and the device operated at a frequency of approximately 360 pulses a minute. A maximum inlet vacuum of 2 inches of mercury was obtained. Air was pumped from atmospheric pressure to a maximum outlet pressure of 8.5 p.s.i. at zero flow. When pumping from atmosphere to 4 p.s.i., a flow rate of 8.12 cc. per minute was obtained.

One possible use of this pump would be as an explosion-proof atmospheric sampling device for hazardous locations. It would be possible to maintain the sampling lines at positive pressure to minimize contamination due to leaks.

One of the novel features of applicant's invention is the fact that the diaphragm serves as its own relief valve. It will be readily apparent that the actual construction details of applicant's device may vary widely from those disclosed herein. For example, relief valve 24, shown in the drawings as centered within the body of the device may, in actuality, be located in any position so long as it may be contacted by the diaphragm. An offset location may be advantageous under certain circumstances. Similarly, although the device as illustrated is circular, the novel principles of the invention apply equally well to other shapes.

It will also be apparent that the body of the device may be constructed of any desired material. Composition of the diaphragm may similarly be varied over a wide range of materials, the only requirement being that the diaphragm be capable of a certain amount of flexure. Check valves, also, may be made in any manner whereby one-way fluid flow is provided.

What is claimed is:

1. A fluid pulsing device comprising a hollow body member means, flexible diaphragm means sealably connected with in said body member means and forming with said body member means first and second chambers, said first chamber adapted to receive an actuating fluid and disposed opposite said second chamber, said second chamber directly connecting to receptacle means through an orifice, said receptacle means adapted to contain an actuated fluid and positioned above and opposite said second chamber, said second chamber adapted to be filled with said actuated fluid, actuating fluid inlet means in said body member communicating with said first chamber and adapted to supply pressurized actuating fluid to said first chamber, actuating fluid outlet means in said body member means communicating with said first chamber, said diaphragm means normally positioned to close said actuating fluid outlet means but yieldable when the pressure of said actuating fluid reaches a predetermined value to flex and thereby move to a position opening said outlet means to release a portion of said actuating fluid whereby said diaphragm means is caused to return to its normal position closing said outlet means, the motion of said diaphragm means causing actuated fluid in said receptacle means to pulse periodically.

2. The apparatus of claim 1 wherein a baffle member is disposed within said receptacle means directly above said orifice to prevent disruption of the surface of said actuated fluid.

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