A diaphragm pump for pumping a fluid, includes a flexible diaphragm which contains magnetically hard or soft particles and is actuated by an electromagnetic actuator. The diaphragm pump having a housing having an interior space containing two pump chambers which are separated by the diaphragm, and in that the diaphragm is actuated by two opposite electromagnetic actuators.
DIAPHRAGM PUMP FOR PUMPING A FLUID

[0001] This application claims priority to German Patent Application DE 102007014709.2-15, filed Mar. 23, 2007, which is incorporated by reference herein.

[0002] The present invention relates to a diaphragm pump for pumping a fluid, including a flexible diaphragm which contains magnetically hard or soft particles and is actuated by an electromagnetic actuator.

[0003] When fluids need to be pumped, whether liquids or gases, it is preferred to use diaphragm pumps in cases where the pumped fluid is aggressive. The diaphragms used may be actuated either mechanically or electromagnetically. Such pumps may be used, inter alia, in fuel tank venting systems for combustion engines.

BACKGROUND

[0004] German Patent Document DE 40 32 555 A1 relates to electromagnetically actuated hydraulic pumps of different construction. The described pumps include a magnetostrictively actuated diaphragm pump, the diaphragm of which is reciprocated by an electromagnetically operated actuator and a return spring.

[0005] Another diaphragm pump is described in US 2004/0265150 A1. The pump disclosed therein uses a diaphragm which contains magnetic particles and is actuated by an electromagnet. The curvature produced in the diaphragm by the electromagnet can be used to pass a fluid through a housing adjacent to the diaphragm.

[0006] The diaphragm pumps discussed hereinabove may be used, for example, in a fuel tank venting system for combustion engines, such as is described in DE 196 50 517 C2.

SUMMARY OF THE INVENTION

[0007] It is an object of the present invention to provide a diaphragm pump that is simple in construction, easy to manufacture, and is capable of providing a high delivery rate. The diaphragm pump is intended to be used preferably for metering liquids or gases. A particular application is in the pumping of fuel vapors.

[0008] The diaphragm pump of the present invention includes a housing containing two pump chambers which are separated by the diaphragm. The selected diaphragm is a highly flexible diaphragm containing magnetically hard or soft particles. The diaphragm itself is actuated by two opposite electromagnetic actuators. By using two pump chambers and associated electromagnetic actuators, a high flow rate is achieved for the fluid to be pumped. The actuators themselves are provided by electromagnetic coils. It is advantageous to operate the coils at resonance; the resonant frequency being in the range from 10 to 100 Hz. The diaphragm itself is disposed axially centrally in the housing.

[0009] All chambers are provided with inlet and outlet valves. These valves may preferably take the form of check valves. Valves of this type permit fluid flow in one direction only. The flow of fluid is assisted by an additional chamber connected to the two aforementioned pump chambers in the flow direction of the fluid being pumped. The valve provided at the outlet of the additional chamber remains closed when the coils are de-energized, thus preventing reversal of flow.

[0010] Particularly advantageously, the diaphragm is at least partially formed from a formed plastic material. This material allows the production of a diaphragm which is particularly flexible. The diaphragm may be provided with magnetically soft and/or hard particles. Preferred are particles having a diameter of ≦ 100 μm. The content by weight of the magnetically soft particles should be 50 to 90% of the total weight of the diaphragm.

[0011] According to one aspect of the present invention, the diaphragm has plate-shaped ends. The rims of said plates are flexible and are used as covers for the inlet and outlet openings at the end walls of the chambers. This eliminates the need for separate valves, because the rims cover the inlet and outlet openings in the manner of a non-return flap so as to prevent backflow of the fluid. To this end, the plate located at the end wall containing the inlet for the fluid is placed against the inner surface of the end wall, while the plate located at the end wall containing the outlet for the fluid is disposed against the outer surface of the end wall. Moreover, the diaphragm is provided with an extension which extends through the additional chamber, and the end face of which covers the outlet opening of the additional chamber.

Brief Description of Drawings

[0013] The operation of the diaphragm pump is schematically illustrated in the accompanying drawing, in which:

[0014] FIG. 1 is a view showing the diaphragm pump in an idle state;

[0015] FIG. 2 and FIG. 3 are views illustrating the curved shape assumed by the diaphragm during pumping.

Detailed Description

[0016] FIG. 1 shows two electromagnetic coils 2 and 3 which are disposed in a housing 1 (not specifically shown) and are surrounded by magnetic circuit 4 and 5. Housing 1 has an interior space 7 which is enclosed by an inner housing wall 6. Diaphragm 8 divides interior space 7 into two pump chambers 9 and 10. Each chamber 9, 10 is provided with inlet valves 11 and 12 and outlet valves 13 and 14. A supply line 15 for the fluid to be pumped is connected to inlet valves 11 and 12 of chambers 9 and 10. An additional chamber 16 is connected to pump chambers 9 and 10 in the flow direction of the fluid being pumped. Outlet 17 of aforementioned additional chamber 16 has a valve 18 which is closed when coils 2, 3 are de-energized.

[0017] In the present case, diaphragm 8 is made entirely from a foamed plastic material and is provided with magnetically soft particles in an amount of about 70% by weight of the total weight of diaphragm 8. The ends of diaphragm 8 are configured in the shape of a plate. As can be seen from FIGS. 2 and 3, rims 20 and 21 (in FIG. 2) and rims 22 and 23 (in FIG. 3) clear the openings at valves 12 and 14 and at valves 11 and 14, respectively, so that a corresponding flow is produced by the pumping action of the diaphragm, as indicated by the arrows, when coils 2 and 3 are energized, as indicated by dotted lines 24 and 25. Diaphragm 8 is disposed axially centrally in the interior space 7 of the housing. During operation of coils 2, 3, especially when they operate at resonant frequency, diaphragm 8 is reciprocated, as a result of which the liquid or gas is forced out of chamber 9 while in the other
chamber 10, the liquid or gas is drawn in, or vice versa, as illustrated in FIG. 3. At the inlet side, the plate 30 of diaphragm 8 bears against the inner surface of end wall 26, while plate 31 bears against the outer surface of end wall 27. The positive and negative pressures produced in chambers 9 and 10 cause rims 21 and 23 of plate 27 to be pressed outwardly, and rims 20 and 22 of plate 30 to be drawn inwardly. At its center, diaphragm 8 has a cushion 32 attached thereto on each side thereof, said cushions providing for early engagement against magnetic circuit 4, 5. It is also advantageous for diaphragm 8 to have an extension 33 which extends through additional chamber 16 and which, in the de-energized state shown in FIG. 1, covers outlet opening 18 of additional chamber 16, whereas during the pumping operation, it clears opening 18, as illustrated in FIGS. 2 and 3.

What is claimed is:

1. A diaphragm pump for pumping a fluid, comprising:
   a flexible diaphragm containing magnetically hard or soft particles and is actuated by an electromagnetic actuator;
   housing having an interior space containing two pump chambers separated by the diaphragm; and
   two opposite electromagnetic actuators actuating the diaphragm.

2. The diaphragm pump as recited in claim 1, wherein the actuators include electromagnetic coils.

3. The diaphragm pump as recited in claim 2, wherein the coils are operated at a resonant frequency; the resonant frequency being in the range from 10 to 100 Hz.

4. The diaphragm pump as recited in claim 1, wherein the diaphragm is disposed axially centrally in the housing.

5. The diaphragm pump as recited in claim 1, wherein an additional chamber is connected to the pump chambers in a flow direction of the fluid being pumped.

6. The diaphragm pump as recited in claim 1, wherein the pump chambers are each provided with inlet and outlet valves.

7. The diaphragm pump as recited in claim 6, wherein the inlet and outlet valves are check valves.

8. The diaphragm pump as recited in claim 5, further comprising a valve provided at an outlet of the additional chamber, the valve being closed when the coils are de-energized.

9. The diaphragm pump as recited in claim 1, wherein the diaphragm is at least partially formed from a formed plastic material.

10. The diaphragm pump as recited in claim 1, wherein the diaphragm is provided with magnetically soft and hard particles.

11. The diaphragm pump as recited in claim 1, wherein the magnetic particles have a diameter of ≤100 μm.

12. The diaphragm pump as recited in claim 1, wherein the content by weight of the magnetically soft particles is 50 to 90% of the total weight of the diaphragm.

13. The diaphragm pump as recited in claim 1, wherein one end of the diaphragm are configured in the shape of plates.

14. The diaphragm pump as recited in claim 13, wherein one end of the plates are flexible and are used as covers for inlet and outlet openings at axial end walls of the chambers.

15. The diaphragm pump as recited in claim 14, wherein the plate located at the end wall containing the inlet for the fluid bears against the inner surface of the end wall, while the plate located at the end wall containing the outlet for the fluid bears against the outer surface of the end wall.

16. The diaphragm pump as recited in claim 5, wherein the diaphragm has an extension extending through the additional chamber, and the end face of which covers an outlet opening of the additional chamber.

17. The diaphragm pump as recited in claim 1, wherein the foamed plastic is resistant to chemicals, particularly to engine fuels.

18. The diaphragm pump as recited in claim 17, wherein the foamed plastic is a butadiene-acrylonitrile rubber (NBR) or a vinylidene fluoride-hexafluoropropylene rubber (FPM) or an FKM or optimized PU.

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