Radial-Electric-Field Piezoelectric Diaphragm Pumps

Displacements are increased in a departure from traditional electrode configurations.

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In a recently invented class of piezoelectric diaphragm pumps, the electrode patterns on the piezoelectric diaphragms are configured so that the electric fields in the diaphragms have symmetrical radial (along-the-surface) components in addition to through-the-thickness components. Previously, it was accepted in the piezoelectric-transducer art that in order to produce the out-of-plane bending displacement of a diaphragm needed for pumping, one must make the electric field asymmetrical through the thickness, typically by means of electrodes placed on only one side of the piezoelectric material. In the present invention, electrodes are placed on both sides and patterned so as to produce substantial radial as well as through-the-thickness components. Moreover, unlike in the prior art, the electric field can be symmetrical through the thickness. Tests have shown in a given diaphragm that an electrode configuration according to this invention produces more displacement than does a conventional one-sided electrode pattern.

The invention admits of numerous variations characterized by various degrees of complexity. Figure 1 is a simplified depiction of a basic version. As in other piezoelectric diaphragm pumps of similar basic design, the prime mover is a piezoelectric diaphragm. Application of a suitable voltage to the electrodes on the diaphragm causes it to undergo out-of-plane bending. The bending displacement pushes a fluid out of, or pulls the fluid into, a chamber bounded partly by the diaphragm. Also as in other diaphragm pumps in general, check valves ensure that the fluid flows only in through one port and only out through another port.

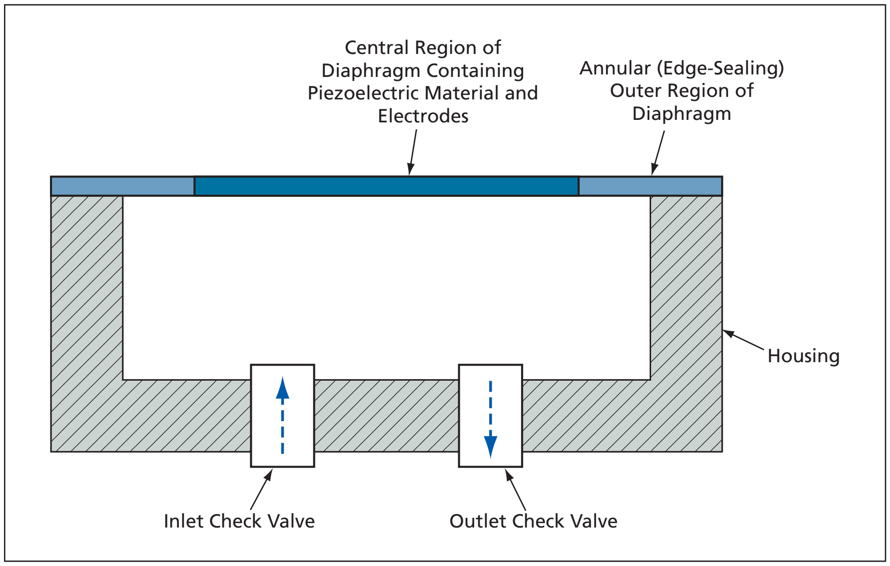

Figure 1. This **Piezoelectric Diaphragm Pump** is similar to other piezoelectric diaphragm pumps, except for the advanced design of the diaphragm.

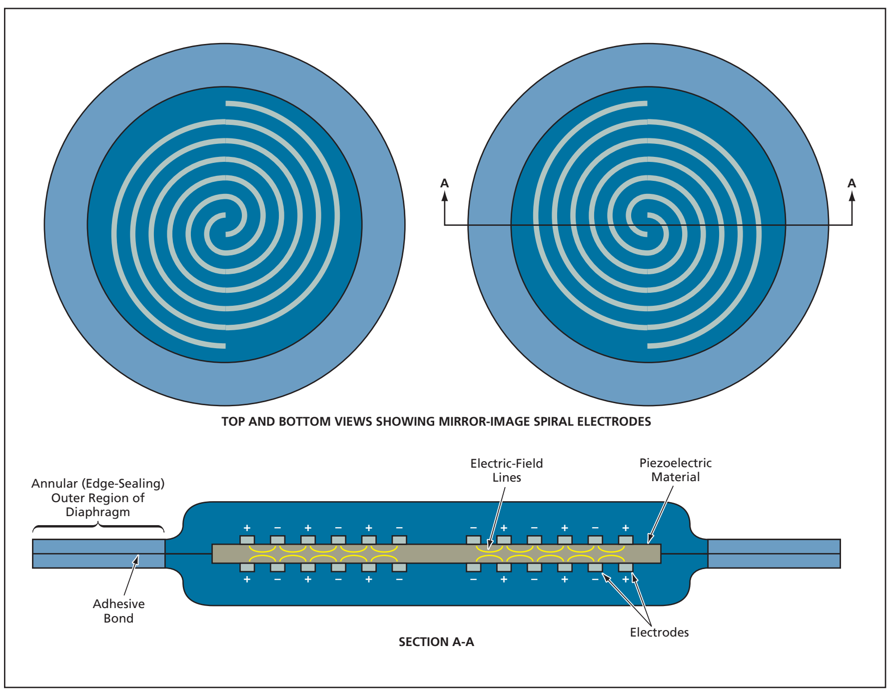

Figure 2. The **Diaphragm** features a central region containing a piezoelectric actuator and an annular outer region for sealing to the housing. The electrode pattern is chosen to ensure that the electric field has a substantial radial component.

Figure 2 shows the diaphragm in more detail. In this case, the diaphragm is circular. The central region of the diaphragm contains the piezoelectric material. There are two centrally located, intercirculating spiral electrodes on the top side of the piezoelectric material and two mirror-image replicas of them on the bottom side. The polarities of the voltages applied to the electrodes are chosen to produce a nearly symmetrical, substantially radial electric field. The piezoelectric material and electrodes are adhesively bonded together and sandwiched between adhesive-coated sheets of a flexible dielectric material, which extends radially outward to form an outer annular region for sealing the diaphragm to the pump housing.

This work was done by Robert G. Bryant and Dennis C. Working of Langley Research Center and Karla Mossi, Nicholas D. Castro, and Poorna Mane of Virginia Commonwealth University. Further information is contained in a TSP (see page 1).
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