US 20150316047A1

(19) **United States**

(12) **Patent Application Publication**

Forejt

(10) **Pub. No.: US 2015/0316047 A1**

(43) **Pub. Date: Nov. 5, 2015**

(54) **FLUID PUMP HAVING MATERIAL DISPLACEABLE RESPONSIVE TO ELECTRICAL ENERGY**

(71) Applicant: **Texas Instruments Incorporated**, Dallas, TX (US)

(72) Inventor: **Brett Earl Forejt**, Richardson, TX (US)

(21) Appl. No.: **14/714,929**

(22) Filed: **May 18, 2015**

Related U.S. Application Data

(60) Provisional application No. 61/986,345, filed on Apr. 30, 2014.

Publication Classification

(51) **Int. Cl.**

F04B 43/04 (2006.01)

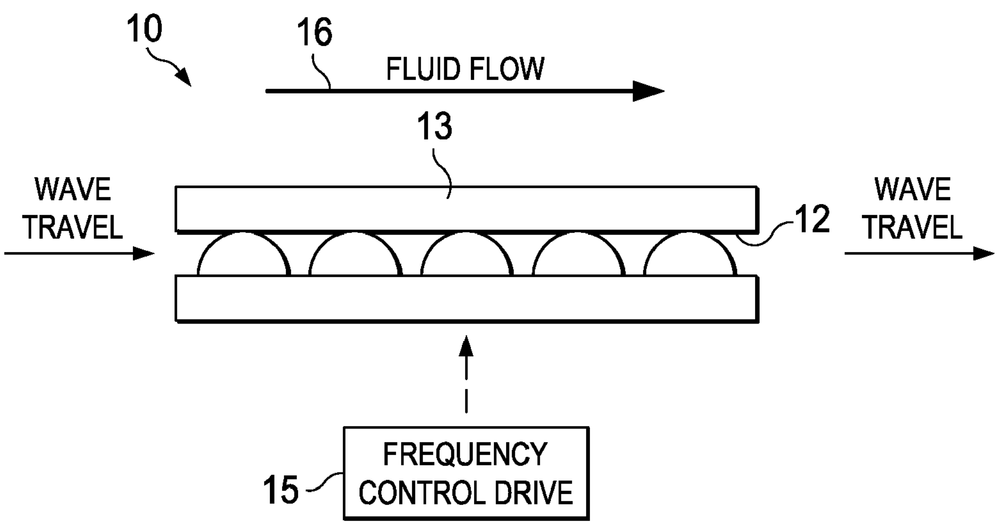
F04B 45/047 (2006.01)

(52) **U.S. Cl.**

CPC ***F04B 43/046*** (2013.01); ***F04B 45/047*** (2013.01)

(57) **ABSTRACT**

A fluid pump apparatus includes a conduit, a material supported on and surrounded by the conduit, and an electrical energy source coupled to the material and configured to apply electrical energy to the material. The material is physically displaced relative to the conduit in response to the electrical energy. The conduit is configured to receive therein a fluid that is physically displaced relative to the conduit in response to the physical displacement of the material.



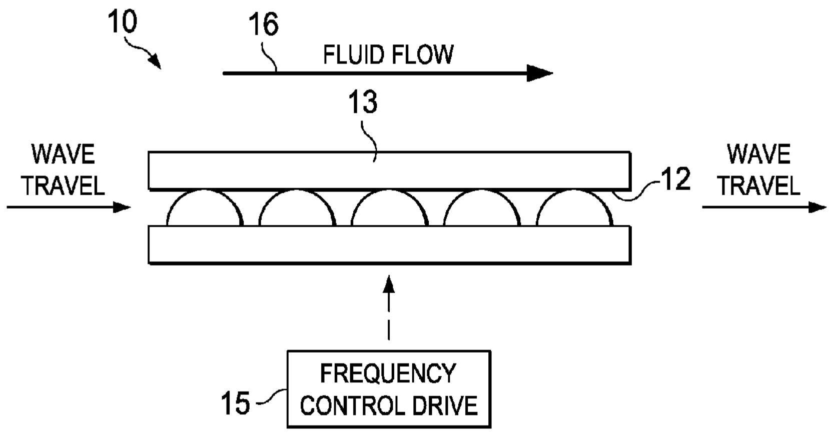


FIG. 1

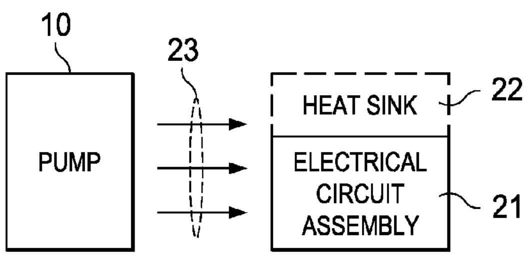


FIG. 2

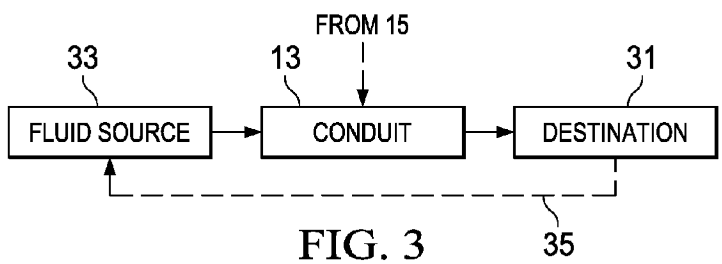


FIG. 3

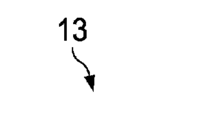


FIG. 4

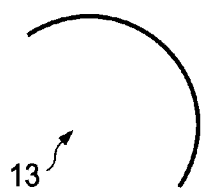


FIG. 5

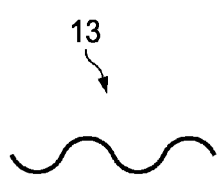


FIG. 6

FLUID PUMP HAVING MATERIAL DISPLACEABLE RESPONSIVE TO ELECTRICAL ENERGY

FIELD

[0001] The present work relates generally to fluid pumps and, more particularly, to inaudible fluid pumps that support multiple configurations.

BACKGROUND

[0002] Increased computation capability and functionality in mobile electronic devices has highlighted the need for cooling solutions. Typically some type of mechanical fan assembly is employed to move the air and provide necessary cooling. One conventional solution is referred to as “DCJ” or dual cooling jet technology. This technology uses piezo-electric (PZE) materials to create a ‘bellows’ effect that pulls and pushes air to create an air flow. A DCJ “bellows” is only a few millimeters thick, making DCJ useful in a variety of installation environments, and highly preferred for portable electronic devices. However, to achieve significant air flow, DCJ must run near the resonant frequencies of the PZE material. Disadvantageously, the resonant frequencies are in the 100-200 Hz range, causing the bellows to behave like a speaker, producing loudly audible noise.

[0003] It is desirable in view of the foregoing to provide for a cooling solution that has wide applicability, including mobile electronic devices, that does not produce audible noise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** diagrammatically illustrates a fluid pump according to example embodiments of the present work.

[0005] FIG. **2** diagrammatically illustrates an electrical apparatus according to example embodiments of the present work.

[0006] FIG. **3** diagrammatically illustrates a fluid system according to example embodiments of the present work.

[0007] FIGS. **4-6** are diagrammatic plan views of the conduit of FIGS. **1-3** according to example embodiments of the present work.

DETAILED DESCRIPTION

[0008] Example embodiments of the present work exploit a principle used in conventional PZE motors, resulting in a quiet cooling solution with wide applicability. Some conventional PZE motors have a ring of PZE material on which a traveling wave is created by application of electrical energy. The traveling wave manifests as displacements of PZE material that contact an adjacent frictional ring such that the traveling wave imparts to the frictional ring a rotational force that causes the frictional ring to rotate. Such PZE motors are typically used, for example, in industrial applications and in camera autofocus mechanisms. The PZE material is electrically excited at approximately 60 kHz, which is well out of the audible range.

[0009] As shown diagrammatically in FIG. **1**, example embodiments of the present work provide a fluid pump **10** that includes a strip of PZE material disposed in a channel **12** defined within a conduit **13**. The PZE material is supported on one side of the conduit (i.e., one side of the channel). In some embodiments, the width of the PZE strip and the size of the channel are such that, when the PZE material is excited in response to electrical energy applied by a frequency control drive **15**, the PZE material is displaced relative to the conduit **13**, and crosses the channel **12** to contact (or nearly contact) the other side of the conduit **13** and substantially block the channel **12**. If the PZE material is excited at around 60 kHz, the displaced PZE material forms a traveling wave that travels along the length of the conduit **13**, so that fluid in the conduit **13** is propelled through the channel **12** along the length of the conduit **13**.

[0010] FIG. **1** shows a plurality of convex portions that each represents displaced PZE material forming part of the traveling wave. The PZE material is supported on one side (bottom in the FIG. **1** example) of the conduit **13**, and the convex portions contact (or nearly contact) the other side (top in the FIG. **1** example) of the conduit **13**. This substantially eliminates fluid flow between the conduit **13** and the (contacting or nearly contacting) convex portions of PZE material. Thus, as the convex portions travel through the conduit **13** from end to end (left to right in FIG. **1**), they push the fluid in the travel direction of the traveling wave, resulting in fluid flow in the desired direction, as shown at **16**.

[0011] In some embodiments, the conduit **13** is constructed from an electrically conductive material to which the PZE material readily adheres. Such materials are well known to workers in the art. In some embodiments, the outer surface of conduit **13** is clad with an insulating material. In some embodiments, the conduit **13** is structured as a tube with an annular cross-sectional profile. In various embodiments, the conduit **13** has an approximately circular cross-sectional profile, and the channel **12** has a diameter that ranges from 1 mm to 10 mm. Various embodiments of the conduit have various cross-sectional profiles.

[0012] In some embodiments, the PZE material, when not energized, substantially blocks the channel **12**. In this case, when energy from frequency control drive **15** displaces the PZE material, the convex portions shown in FIG. **1** represent the un-displaced PZE material, and the displaced PZE material creates a traveling wave of “pockets” between the convex portions. The traveling wave of pockets produces a vacuum pump type of operation.

[0013] In the example of FIG. **1**, both ends of the conduit **13** are open, such that fluid surrounding the conduit **13** enters at one end of the conduit **13**, is propelled through the channel **12**, and exits the other end of the conduit **13**. In some embodiments, however, one end of the conduit **13** is arranged in fluid communication with a fluid source, for example, a fluid supply reservoir, such that fluid is drawn from the source into the conduit **13**, and propelled through the channel **12** to exit the other, open end of the conduit **13**.

[0014] FIG. **2** diagrammatically illustrates an electrical apparatus (e.g., a mobile electronic device in some embodiments) according to example embodiments of the present work. The fluid pump **10** of FIG. **1** is arranged to propel a coolant fluid (for example, ambient air surrounding the pump **10**), shown at **23**, across an electrical circuit assembly **21**, at locations proximate the assembly **21**, to cool its constituent electrical circuitry. The constituent circuitry of the assembly **21** performs a desired function of the apparatus. As shown by broken line, some embodiments use conventional techniques to mount a heat sink **22** in thermal contact with the electrical circuit assembly **21**, and the coolant fluid at **23** is propelled across the heat sink **22**. It will be appreciated that the coolant fluid, as propelled by the fluid pump **10**, effects convection transfer of heat away from locations proximate the electrical circuit assembly **21**. It will also be appreciated that the electrical circuit assembly **21** is merely an example. In various embodiments, the electrical circuit assembly **21** is replaced by various targets that benefit from cooling.

[0015] In still further embodiments, the pump **10** provides pressurized fluid for various applications where such is required. Automotive applications and medical applications (where the fluid may, for example, include a medication) are but two categories among numerous other examples that will be familiar to workers in the art. FIG. **3** diagrammatically illustrates such a fluid system according to example embodiments of the present work. The conduit **13** of pump **10** is arranged to provide fluid flow to a destination **31** that utilizes pressurized fluid. One end of conduit **13** is arranged in fluid communication with a source of fluid (e.g., a reservoir in some embodiments) shown generally at **33**, and the other end of conduit **13** is arranged in fluid communication with the destination **31**. In some embodiments, the destination **31** is a mechanical assembly that requires pressurized fluid for mechanical operation. In some medical application embodiments, the destination **31** is, for example, a living patient (e.g., human or animal). As shown by broken line, some embodiments provide a return fluid path **35** from the destination **31** to the fluid source **33**.

[0016] In various embodiments, the conduit **13** has various configurations in its longitudinal direction (proceeding generally left-to-right in FIG. **1**) to accommodate a variety of applications. Some general examples of longitudinal configurations of the conduit **13** are shown in the diagrammatic plan views of FIGS. **4**-**6**. FIG. **4** shows a straight line configuration, FIG. **5** shows a simple curved configuration, and FIG. **6** shows a more complex curved configuration. The complex curve example shown in FIG. **6** is also referred to herein generally as a "serpentine" configuration. It will be appreciated that the possible longitudinal configurations are virtually without limit.

[0017] Any of the general examples of two-dimensional shapes shown in FIGS. **3**-**5** may be either planar or non-planar relative to the third dimension. Any configuration that is non-planar in the third dimension may have any desired non-planar configuration in that third dimension, for example, curved, serpentine, etc. As an illustrative example, a conduit having a three-dimensional spiral configuration is a specific instance of a two-dimensional serpentine configuration that has a serpentine configuration in the third dimension also. It will be appreciated that the possible three-dimensional configurations of the conduit **13** are virtually without limit.

[0018] Various embodiments use various commercially available materials instead of PZE material. Examples include electro-active polymers and so-called 'artificial muscle'. More generally, any material that experiences physical displacement in response to application of electrical energy (e.g., electric field, magnetic field, electric current, etc.) may be used instead of the PZE material.

[0019] Because the fluid pump according to example embodiments of the present work is operated at an ultrasonic frequency (e.g., 60 kHz), its operation is inaudible. Because the conduit **13** may have virtually any desired shape and size, the pump **10** is useful in myriad applications.

[0020] Although example embodiments of the present work have been described above in detail, this does not limit the scope of the work, which can be practiced in a variety of embodiments.

What is claimed is:

1. A fluid pump apparatus, comprising:

a conduit;

a material supported on and surrounded by said conduit; and

an electrical energy source coupled to said material and configured to apply electrical energy to said material, wherein said material is physically displaced relative to said conduit in response to said electrical energy;

wherein said conduit is configured to receive therein a fluid that is physically displaced relative to said conduit in response to the physical displacement of said material.

2. The apparatus of claim **1**, wherein the electrical energy produces a traveling wave in said material, and said fluid flows in a direction of travel of the traveling wave.

3. The apparatus of claim **2**, wherein said conduit has a curved configuration.

4. The apparatus of claim **3**, wherein said curved configuration is approximately planar.

5. The apparatus of claim **3**, wherein said curved configuration is non-planar.

6. The apparatus of claim **5**, wherein said non-planar curved configuration is a spiral configuration.

7. The apparatus of claim **1**, wherein said fluid is a coolant.

8. The apparatus of claim **7**, wherein said fluid is air.

9. The apparatus of claim **1**, wherein said material is a piezoelectric material.

10. The apparatus of claim **1**, wherein said material is an electro-active polymer material.

11. The apparatus of claim **1**, wherein said fluid includes a medication.

12. An electrical apparatus, comprising:

electrical circuitry that performs a desired function; and

a pump arranged to propel a fluid to a location proximate said electrical circuitry, wherein said fluid effects transfer of heat away from said location, said pump including a conduit, a material supported on and surrounded by said conduit, and an electrical energy source coupled to said material and configured to apply electrical energy to said material, wherein said material is physically displaced relative to said conduit in response to said electrical energy, wherein said conduit is configured to receive said fluid therein, and wherein said fluid is physically displaced relative to said conduit in response to the physical displacement of said material.

13. The apparatus of claim **12**, wherein the electrical energy produces a traveling wave in said material, and said fluid flows in a direction of travel of the traveling wave.

14. The apparatus of claim **12**, wherein said fluid is air, and wherein the air effects said transfer of heat by convection.

15. The apparatus of claim **14**, including a heat sink thermally coupled to said electrical circuitry and disposed at said location proximate said electrical circuitry, wherein said pump is configured to propel the air across said heat sink.

16. The apparatus of claim **12**, wherein said material is a piezoelectric material.

17. The apparatus of claim **12**, wherein said material is an electro-active polymer material.

18. A fluid system, comprising:

a fluid source;

a destination that requires pressurized fluid; and

a pump arranged in fluid communication with said destination and said fluid source, said pump configured to provide pressurized fluid to said destination, said pump including a conduit, a material supported on and surrounded by said conduit, and an electrical energy source coupled to said material and configured to apply electrical energy to said material, wherein said material is physically displaced relative to said conduit in response to said electrical energy, and wherein fluid from said fluid source is received within said conduit and physically displaced relative to said conduit in response to the physical displacement of said material.

19. The system of claim **18**, wherein said fluid source is a fluid reservoir.

20. The system of claim **18**, wherein said destination includes a mechanical assembly that requires pressurized fluid for mechanical operation.

* * * * *