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3,606,592

FLUID PUMP

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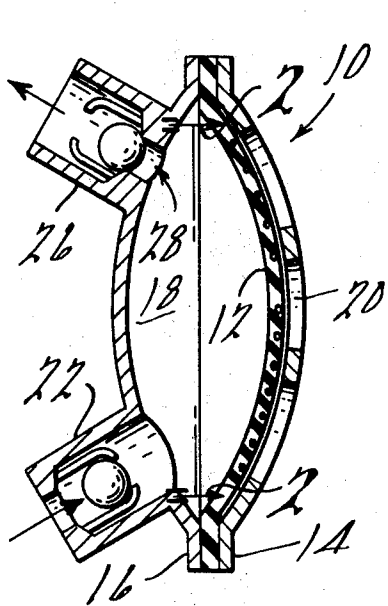


Fig. 1.

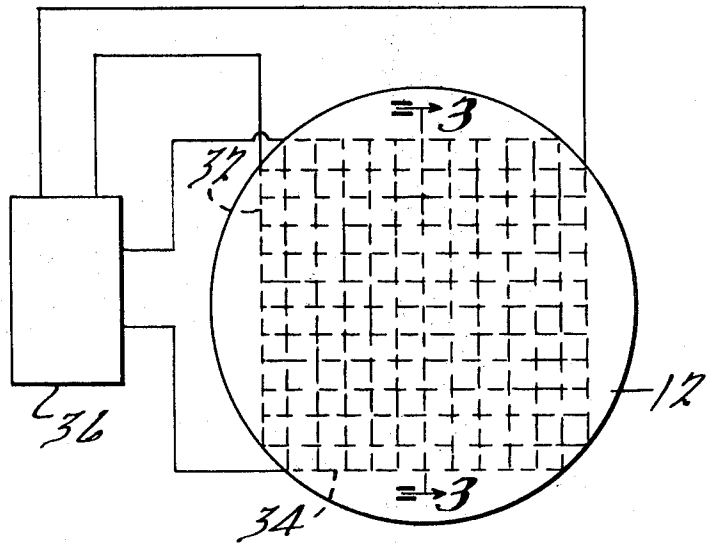


Fig. 2.

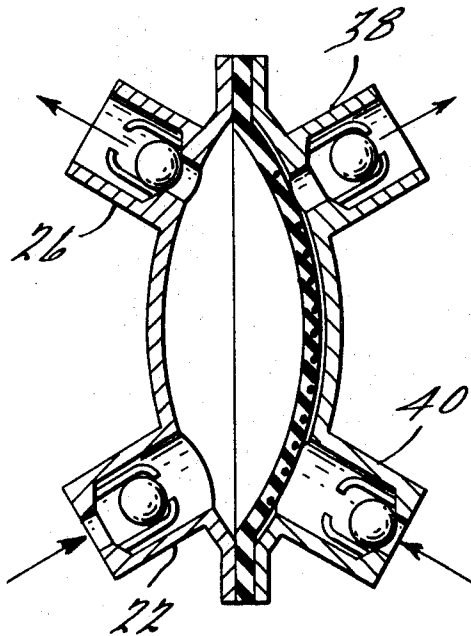


Fig. 4.

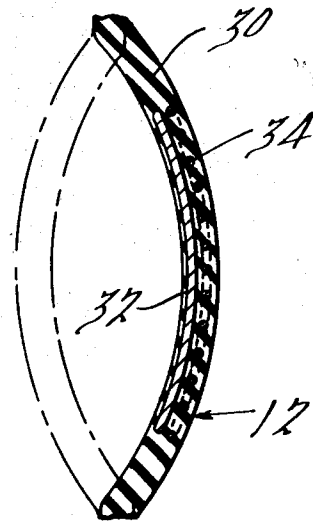


Fig. 3.

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FLUID PUMP

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6 Claims

ABSTRACT OF THE DISCLOSURE

A displacement element for a fluid pump comprised of opposed, connected members of a memory heat treatable material such as 55-Nitinol with an electrical control circuit used to alternately cause each of the members to assume its memory heat treated configuration, thereby causing cyclical movement of the members. This movement is utilized to create the pumping action by embedding these elements in a diaphragm element to create a diaphragm pump.

BACKGROUND OF THE INVENTION

The great need for a practical artificial heart and the resulting widespread research and development efforts expended towards providing for this need has made clear the special design requirements necessary in order for any such device to be successful.

These requirements include compactness, simplicity, reliability, and the ability to operate efficiently on a minimum power input.

In providing these requirements, it would be desirable to have a direct and efficient conversion of electrical or thermal energy to mechanical energy with a minimum of mechanical parts. Prior art pumps have included those having piezoelectric diaphragms, in which a piezoelectric ceramic material such as barium titanate is alternately pulsed to provide a direct mechanical output. While satisfactory for some applications, these devices suffer from the drawback of relatively low displacements of the piezoelectric material, leading to high power consumption, poor efficiencies, and complexity of design in the power circuit and valving, hence rendering such devices unsatisfactory for artificial heart or cardiac assist applications.

Hence, it is an object of the present invention to provide a displaceable element arrangement for pump applications which directly converts electrical or thermal energy into a mechanical output with a minimum number of parts.

SUMMARY OF THE INVENTION

This object and others which will become apparent upon a reading of the following specification and claims are accomplished by providing a pumping member including a pair of interconnected members of a memory heat treatable material such as 55-Nitinol, heat treated in opposed configurations so that causing these members to alternately assume their heat treated configuration will provide a cyclical displacement of the pumping member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a pump utilizing the pumping member according to the present invention.

FIG. 2 is a front elevation of the pumping member shown in FIG. 1, together with a schematic representation of the electrical control circuit.

FIG. 3 is a view of the section created by cutting plane 3-3 in FIG. 2.

FIG. 4 is a sectional view of a double acting pump incorporating a pumping member according to the present invention.

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DETAILED DESCRIPTION

In the following detailed description, certain specific terminology will be employed for the sake of clarity and a specific embodiment and application will be described in order to provide a complete understanding of the invention, but it is to be understood that the invention is not so limited, and may be practiced in a variety of forms and embodiments.

Referring to the drawings, and particularly FIG. 1, a diaphragm type pump 10 is shown utilizing a displacement element pumping member according to the present invention as the diaphragm 12. The diaphragm 12 is secured between housing members 14, 16 to divide the space formed by the members 14, 16 into a pair of chambers 18, 20. Movement of the diaphragm 12 to increase the volume of chamber 18 draws fluid into the inlet 22 via check valve 24. Fluid is prevented from reentering the chamber 18 from the outlet 26 by means of the check valve 28.

Movement of the diaphragm 12 so as to reduce the volume of the chamber 18 causes fluid contained therein to be advanced through the outlet 26 via check valve 28, being prevented from backing out the inlet 22 by the action of the check valve 24.

As shown in FIGS. 2 and 3, the diaphragm 12 is comprised of a flexible rubber or plastic body 30 having embedded therein grids 32, 34 of wire or strip elements extending transversely to each other.

The material of which these grids are formed is of a material having a heat treat memory, such as 55-Nitinol.

55-Nitinol is the generic name given to a group of alloys having 53-57 percent nickel with the remainder titanium.

This material has the characteristic above referred to: a mechanical heat treat memory.

55-Nitinol, if constrained to have a particular shape while heat treated above a certain temperature (approximately 900° F.) will return to this configuration with considerable force, even if being plastically deformed in the interim, upon being heated to a certain temperature which may vary, depending on the composition of the alloy from -60° F. to +300° F.

The straining to an intermediate shape differing from the memory heat treat shape, giving the restorative heat treat (RHT), and cooling to ambient temperatures is referred to as the Strain-Heat-Cool cycle (SHC) and may be repeated over and over on the order of millions of cycles, which is the basic mechanism relied on in the present invention.

The precise behavioral characteristics of the displacement members will vary with the composition, temperature, and percent of strain, and in providing an actual design, all of these factors must be considered in arriving at the specific performance characteristic desired.

These characteristics have been established to a considerable extent and details thereof are contained in numerous patents and applications including the following U.S. patents: 3,174,851 (basic composition of matter patent), 3,351,463; 3,352,650; 3,352,722; 3,391,882; 3,403,238; 3,416,342. Publications include Materials and Processes for the 70's, "Investigations of the Unique Memory Properties of 55-Nitinol Alloy," Proceedings of the 15 National SAMPE Symposium and Exhibition, Apr. 29-May 1, 1969, pp. 265-274; "A Summary of Recent Research on the Nitinol Alloys and Their Potential Application in Ocean Engineering," Ocean Engineering, 1, 105-120 (1968).

Inasmuch as the details of these characteristics do not in themselves form a part of the present invention and are well known and available to the public as indicated by

the above references, it is not felt necessary to include data on these in detail.

The grids 32, 34 are given memory heat treats so as to have opposing configurations. That is, in the position shown in FIG. 3, one of the grids is in its memory heat treat configuration while the other is deformed out of its memory heat treat configuration, while conversely, in the diaphragm position shown in phantom in FIG. 3, the other of the grids is in its memory heat treat configuration while the one grid is deformed out of its memory heat treat configuration.

As shown schematically in FIG. 2, a power supply unit 36 is shown, which alternately and successively supplies electrical power to the grids 32 and 34. This electrical power is selected to be of a sufficient level to cause the grid supplied to be raised to or above its RHT temperature, thus causing the grid supplied to assume its memory heat treat configuration.

If the grid so supplied is in a deformed condition at the moment it reaches its RHT temperature, it will snap back with considerable force. This action has a two-fold effect: movement of the diaphragm causes the pumping action to take place; and the other grid by means of the driving connection therebetween formed by the rubber sheet 30 is deformed out of its MHT configuration. Upon the application of the electrical energy to the grid so deformed, the diaphragm will then snap back to its original position, while deforming again the other grid which has then cooled below its RHT temperature and so on.

The movement of the fluid through the unit will tend to prevent the temperature of the grids from building up beyond their respective RHT temperatures. This RHT temperature is selected to be well above ambient conditions so that the electrical energy must be applied in order to cause the respective grids to assume their MHT configurations.

The grid sizes, the power levels, and frequency of the pulses, the insulating needs between the grids and the other specific details of design will vary with the particular composition of the grid material, the operating temperature involved, the performance characteristics required, the fluid to be pumped, the mechanical strain induced by the diaphragm's movement, the properties of the diaphragm sheet 30, and a number of other factors. Hence, in arriving at a specific design, all of these factors must be considered, and by applying general engineering principles, their effect on the design characteristics may be foreseen and a desired performance provided.

This basic arrangement may be extended to a great number of other pump configurations and installations as shown in FIG. 4, which illustrates a double acting pump, which advances fluid from a second inlet 40 to a second outlet 42 on the back stroke of the diaphragm.

Of course, in-line, circulating, ganged, etc., pump installations in a variety of environments are possible in this same context.

Similarly, the particular configuration of the opposed members 32, 34 may be varied as required, as leaf, strip

or other forms are well within the scope of the present invention.

In this same context, other applications of the opposed member mechanism are possible in which the large displacement, direct energy conversion characteristic may be used to advantage.

From the above description, it can be appreciated that an extremely simple, effective, and reliable displacement device suitable for artificial heart and cardiac assist device applications has been provided, without the need for complex mechanisms.

What is claimed is:

1. A fluid pump comprising:

a housing member defining a pumping chamber;

a displacement element disposed in said chamber including a first member having a memory configuration to which it may be controllably restored; a second member having a memory configuration to which it may be controllably restored; means drivingly connecting said first and second members so that when either of said elements is in its memory configuration the other is distorted out of its memory configuration, control means alternately causing said first and second members to tend to assume their memory configurations to cause said displacement element to alternately move to a position corresponding to each of said member's memory configurations;

means for creating a pumping action through said chamber in response to said movement of said displacement element, whereby a pumping action may be created by said control means.

2. The pump of claim 1 wherein said first and second members are of a memory heat treatable material and wherein each of said control means restores said memory configurations by heating each of said members to its restorative temperature.

3. The pump of claim 2 further including a plurality of each of such first and second members and wherein said means drivingly connecting said plurality of first and second members includes a diaphragm member and means embedding said plurality of first and second members in said diaphragm member.

4. The pump of claim 3 wherein said plurality of first and second members extend transversely to each other.

5. The pump of claim 2 wherein said first and second members are composed of 55-Nitinol.

6. The pump of claim 2 wherein said first and second members are composed of an alloy having 53-57 percent by weight of nickel with the remainder titanium.

References Cited

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