

Lewis



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REPLY TO  
ATTN OF: GP

TO: KSI/Scientific & Technical Information Division  
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General  
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,819,299

Government or Corporate Employee : U.S. Government

Supplementary Corporate Source (if applicable) : [Signature]

NASA Patent Case No. : LEW-11,672-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES  NO

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

*Bonnie L. Woerner*

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Enclosure



(NASA-Case-LEW-11672-1)  
PUMP Patent (NASA) 4 P  
MAGNETOCALORIC  
CSCI 13K  
N74-27904

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Unclas  
42821

[54] **MAGNETOCALORIC PUMP**  
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 [73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, Washington, D.C.**  
 [22] Filed: **Nov. 10, 1972**  
 [21] Appl. No.: **305,639**

[52] U.S. Cl. .... **417/52**  
 [51] Int. Cl. .... **F04b 19/24**  
 [58] Field of Search ..... **417/48, 207, 383, 52, 322**

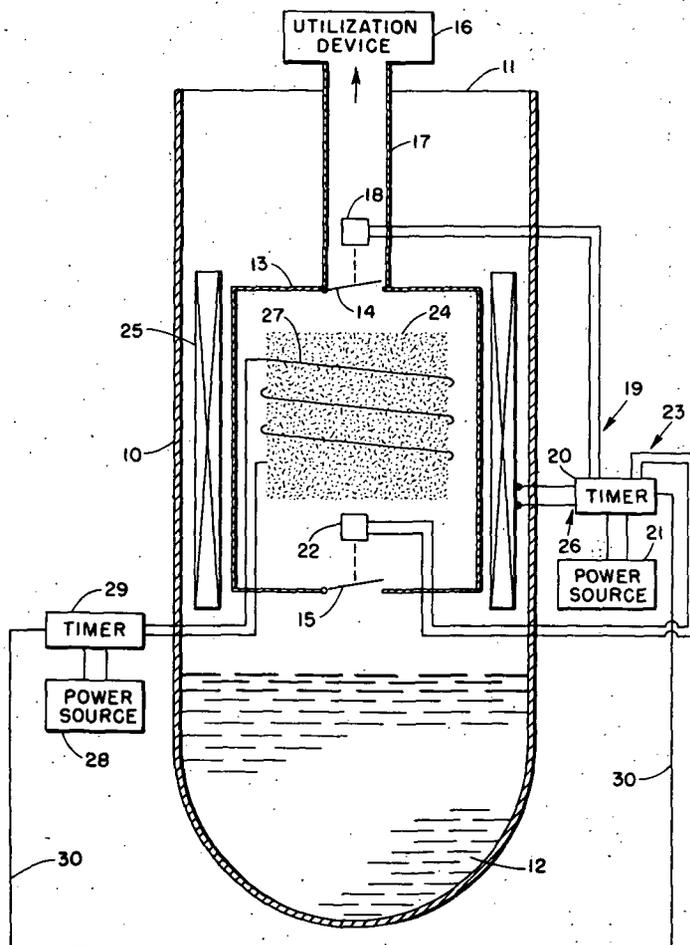
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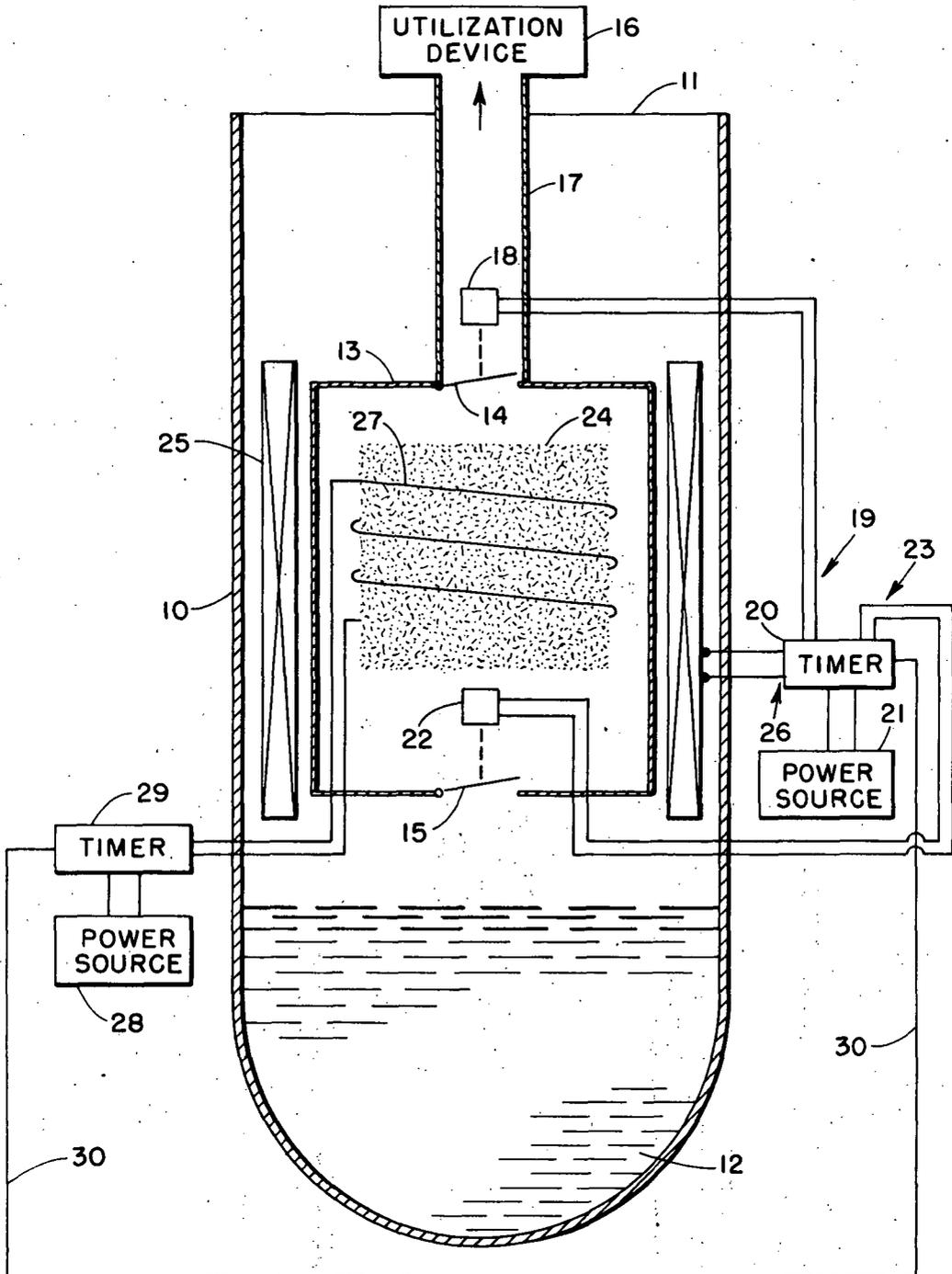
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[57] **ABSTRACT**  
 A pump for fluids is disclosed. A vessel having inlet and outlet valves is disposed in a container having disposed therein a fluid to be pumped and which fluid may be evolved from a liquid in the container below the vessel. A magnetocaloric substance is disposed in the vessel and causes fluid vapor in the vessel to expand and be expelled through the outlet valve when a magnetic field is impressed on a magnetocaloric substance of the type which increases in temperature when subjected to an increasing magnetic field. If the magnetocaloric substance is of a type which increases in temperature when subjected to a decreasing magnetic field, then fluid will be expelled from the vessel when the magnetic field is decreased or terminated. As the substance cools, vapor is drawn in through the inlet valve. The inlet valves may be one-way check valves or may be solenoid valves energized at appropriate times by timing circuits. A timer controlled heating element may also be disposed in the vessel to operate in conjunction with the magnetic field.

18 Claims, 1 Drawing Figure





## MAGNETOCALORIC PUMP

### ORIGIN OF THE INVENTION

This invention was made by an employee of the U.S. Government and may be manufactured or used by or for the Government of The U.S. of America without any payment of royalties thereon or therefor.

### BACKGROUND OF THE INVENTION

This invention relates to pumps and is directed more particularly to a pump for cryogenic fluids.

In addition to transferring fluid from one location to another, pumps are used to cool fluids and particularly cryogenic fluids. An example of this occurs where liquid helium is disposed in a container and which, as a result of evaporation, also contains saturated helium vapor. By pumping saturated vapor out of the container to the atmosphere, cooling of the liquid is effected.

In the prior art, the pumping of fluids has been accomplished by a variety of devices such as mechanical pumps, diffusion pumps, and various other types of cyclic and acyclic sorption pumps. Mechanical and diffusion pumps can cause contamination of the pumped fluid with oil or other substances which cannot be tolerated in many instances, as for example, where the pumped fluid must be of high purity. Furthermore, many of the prior art pumps can operate only above certain temperatures, as for example, normal room temperature, and would be inoperative at a temperature of, for example, 4.0° Kelvin.

Mechanical pumps in general involve moving parts which, of course, make the pump more subject to mechanical failure. The other types of pumps are generally more expensive and complex.

### OBJECTS OF THE INVENTION

It is an object of the invention to provide a fluid pump having a minimum of moving parts.

It is another object of the invention to provide a pump which does not contaminate the fluid being pumped.

Still another object of the invention is to provide a pump which is particularly suitable for pumping extremely cold vapors, for example, as low as 4.0° Kelvin.

Yet another object of the invention is to provide a pump which is specially effective in pumping saturated vapors at a high rate of delivery.

Another object of the invention is to provide a pump for fluids which either expand or contract when heated.

It is a further object of the invention to provide a pump suitable for cooling liquid in a closed container.

### BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a schematic drawing of a magnetocaloric pump embodying the invention.

### DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the single FIGURE, there is shown a suitable container 10 having a closed top 11. Container 10 may be partially filled with a liquid 12 such as helium, nitrogen, hydrogen, or neon, although operation is not restricted to these particular liquids. For example, the pump will also operate when the liquid is water.

Disposed inside container 10 above the liquid 12 is a pump embodying the invention and comprising a suitable vessel 13 having an outlet valve 14 and an inlet valve 15. The outlet valve 14 communicates with a utilization device 16 or with the atmosphere through a conduit 17 which extends through a port in the top 11 of the container 10. Thus, the interior of the vessel 13 is periodically and alternately in communication with the interior of the container 10 and with the utilization device 16 or atmosphere. The valve 14 communicates with the atmosphere when the pump is being used to cool a liquid by expelling saturated vapor, as discussed previously.

Although the valves 14 and 15 are disposed in the top and bottom, respectively, of the vessel 13, it will be understood that the valves may be located at any point in the walls of the vessel 14 provided the communication paths are maintained, that is, the outlet valve 14 is maintained in communication with a utilization device 16 or atmosphere while the inlet valve 15 is maintained in communication with the interior of the chamber 10. Inlet valves 14 and 15 may be simple one-way check valves. However, outlet valve 14 may be of the type having a solenoid 18 energized from a first output 19 of a timer 20 which received electrical power from a power source 21. Likewise, inlet valve 15 may be provided with a solenoid 22 energized from a second output 23 of the timer 20. The timer is preferably programmed to alternately open the valves 14 and 15.

Pumping action is provided by a body of magnetocaloric material 24 disposed in the vessel 13. A magnetocaloric material is one which is either increased or decreased in temperature when subjected to the magnetic field. Examples of such materials are the rare earth elements such as Gd, Dy and Ce, the transition series elements such as Fe, Cr, Ni and Co, and the salts of these two groups. For maximum heat exchange whereby the fluid being pumped is heated and cooled by the magnetocaloric body 24, the body is porous and may be made by sintering, granulating or otherwise providing openings in such magnetocaloric body. To the end that a magnetic field will be applied to the magnetocaloric material 24, a solenoid winding 25 is disposed around the vessel 13. Solenoid 25 is energized from a third output 26 of timer 20. Preferably the magnetic field is supplied by a super-conducting magnet for maximum effectiveness.

To increase the pumping rate and efficiency of the pump a heating element 27 may be disposed around or in the magnetocaloric material. The heating element 27 is energized from a power source 28 by means of a timer 29, the operation of which will be described presently. In order that the heating element 27 will be energized during the time when pumping action is occurring, that is when fluid is being expelled from the vessel 13 by way of the outlet valve 14, a synchronizing lead 30 is connected between timer 29 and timer 20. It will be understood by those skilled in the art, that dependent upon the electrical requirements of solenoid 25, solenoids 18 and 22 and the heater element 27, timers 20 and 29 could be combined in one unit as is also possible with the power sources 21 and 28.

Operation of the magnetocaloric pump will now be described. It will be assumed that the magnetocaloric body 24 has a positive effect, that is, it increases in temperature when subjected to a magnetic field. It will be understood that there are magnetocaloric materials

which have a negative effect and would require the valves 14 and 15 to be opened for conditions under which they would be closed for a material having a positive effect.

Pumping action is initiated by filling the vessel 13 with a fluid to be pumped thus ensuring that the magnetocaloric material 24 is at the same temperature as the fluid. This may be done with the magnetic field either off or on. If the pump is primed with the magnetic field on, a reduction or termination of the magnetic field will cause the magnetic material 24 to cool and the fluid in the vessel 13 will contract drawing in more fluid through the valve 15. If the valve 15 is of the solenoid type the timer 20 will cause the solenoid to be energized to open the valve during the time the fluid is contracting.

To expel the fluid from the vessel 13 the magnetic field is again impressed on the material 24 by supplying or increasing the current to the solenoid winding 25 to cause heating of the material 24. This expands the fluid in the vessel 13 causing it to be expelled through the outlet valve 14 and through the conduit 17 through the utilization device 16. The outlet valve may be of the solenoid type in which case the solenoid 18 is energized by the timer 20 during the period of time that the fluid in the vessel 13 is expanding. The magnetic field is again either terminated or reduced and the cycle is repeated.

As explained previously, the heating element 27 may be energized simultaneously with the solenoid 25 to increase the pumping action by providing additional heat to expand the fluid in the vessel 13 where the fluid is one which expands when heated. There are certain fluids, which contract when heated within certain temperature ranges. An example is water between 0° and 4°C. With such fluids it will be understood that, if the valves 14 and 15 are solenoid types rather than one-way valves, they must be actuated in reversed order to their normal sequence.

The magnetocaloric pump embodying the invention is most effective for pumping saturated vapors. Such vapors have a temperature equal to the boiling point of the liquid 12. If the liquid is helium, for example, the boiling point is -269°C or 4.2°K.

The liquid 12 need not be in the container 10. The requirement for the pump to work is that the inlet valve 15 be in communication with a fluid to be pumped. Thus, a fluid could be supplied to container 10 from a supply of the fluid being pumped. For example, the magnetocaloric pump embodying the invention may be used to pump natural gas. In such an arrangement, the pipe carrying the natural gas and the source of the gas would be the equivalent of the container 11.

It will be understood that changes and modifications may be made to the above-described magnetocaloric pump without departing from the spirit and scope of the invention as set forth in the claims appended hereto.

What is claimed is:

1. A fluid pump comprising a container filled with a substantially nonmagnetic, nonelectro fluid to be pumped;

a vessel disposed in said container;  
 an inlet valve disposed in a wall of said vessel;  
 an outlet valve disposed in a wall of said vessel, said second valve communicating with a port in the wall of said container;  
 a body of magnetocaloric material disposed in said vessel; and  
 means for subjecting said body of magnetocaloric material to a time-wise varying magnetic field to cause alternate expansion and contraction of the fluid.

2. The apparatus of claim 1 and including means for alternately opening said outlet valve and said inlet valve.

3. The apparatus of claim 1 wherein said inlet and outlet valves are one-way check valves.

4. The apparatus of claim 1 wherein said last named means comprises a magnetic winding disposed around said vessel and means for supplying an alternately increasing and decreasing electrical current to said winding.

5. The apparatus of claim 1 wherein said last named means includes a superconducting magnet.

6. The apparatus of claim 1 and including a heating element disposed in said vessel and means for energizing said heating element simultaneously with the expansion of the fluid in said vessel.

7. The apparatus of claim 1 wherein the magnetic field is of such intensity that the temperature of said magnetocaloric material does not rise above the boiling point of said liquid, when said liquid is water.

8. The apparatus of claim 1 wherein said inlet and outlet valves are solenoid type and including a power supply for said solenoid valves and timing means for opening said outlet valve when fluid in said vessel is expanding and for opening said inlet valve when fluid in said vessel is contracting.

9. The apparatus of claim 1 wherein said inlet valve is disposed in a bottom wall of said chamber and said inlet valve is disposed in a top wall.

10. The apparatus of claim 1 wherein said magnetocaloric material is porous.

11. The apparatus of claim 1 wherein said magnetocaloric material is a rare earth.

12. The apparatus of claim 1 wherein said magnetocaloric material is the salt of a rare earth.

13. The apparatus of claim 1 wherein said magnetocaloric material is a transition of element.

14. The apparatus of claim 1 wherein said magnetocaloric material is the salt of a transition element.

15. The apparatus of claim 1 wherein said container is partially filled with a liquid.

16. The apparatus of claim 11 and including means to heat said liquid to a temperature greater than its boiling point temperature.

17. The apparatus of claim 15 wherein said liquid is selected from the group consisting of helium, hydrogen, nitrogen and neon.

18. The apparatus of claim 1 and including receiving means communicating with said port in said container wall to receive fluid expelled from said pump.

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