

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON, D.C. 20546

REPLY TO  
ATTN OF: GP

JAN 21 1974

TO: KSM/Scientific & Technical Information Division  
Attention: 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. : 3,782,699

Government or Corporate Employee : Government

Supplementary Corporate Source (if applicable) : ~

NASA Patent Case No. : ARC-10,441

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 . . ."

*Elizabeth A. Carter*

Elizabeth A. Carter  
Enclosure

Copy of patent cited above



N74-15126  
 Unclas  
 26242  
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 (NASA-Case-ARC-10441-1) BIMETALLIC FLUID  
 DISPLACEMENT APPARATUS Patent (NASA)  
 CSCI 13K  
 5 p

[54] **BIMETALLIC FLUID DISPLACEMENT APPARATUS**

2,114,567	4/1938	Mercur	415/12
2,659,390	11/1953	MacLea	92/1
3,567,185	3/1971	Ross	259/1
3,690,113	9/1972	Mokadam	62/467

[75] Inventor: **Thomas N. Canning**, Sunnyvale, Calif.

[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**, Washington, D.C.

Primary Examiner—Robert W. Jenkins  
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[22] Filed: **Aug. 11, 1972**

[21] Appl. No.: **280,029**

[57] **ABSTRACT**

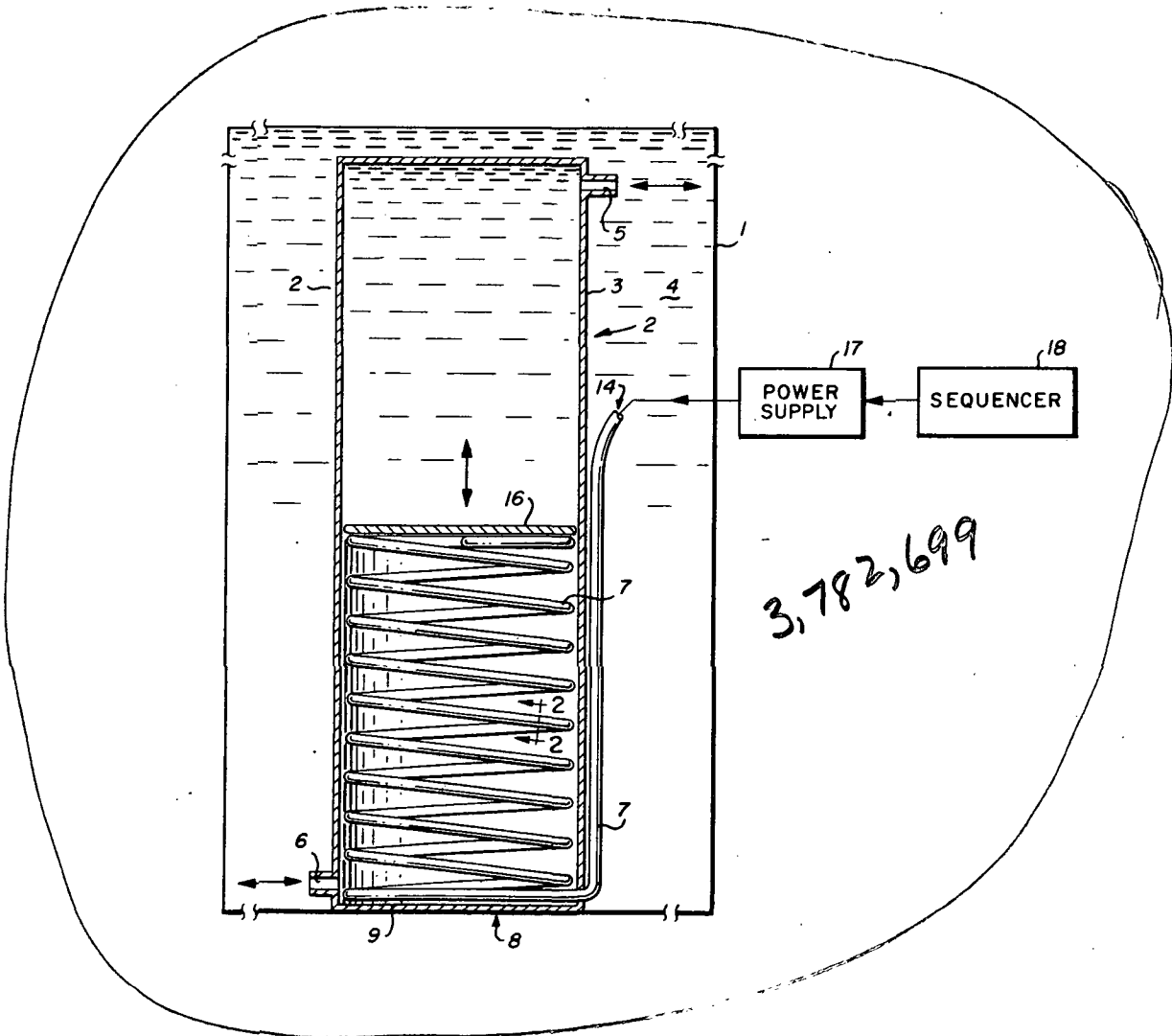
[52] U.S. Cl. .... **259/98, 417/471, 417/470**  
 [51] Int. Cl. .... **B01f 5/12**  
 [58] Field of Search ..... **259/1 R, 95, 97, 259/98, DIG. 30; 62/467; 415/12; 92/1; 417/470, 471**

Stirring and heating of stored gases and liquids is accomplished by using the deformation of a bimetallic structure which deforms significantly when heated. The deformation is used to effect gradual or impulsive motion of a piston, vane, wire, or diaphragm for displacement of the fluid. The heated bimetallic is also employed for heating the stored fluid.

[56] **References Cited**  
**UNITED STATES PATENTS**

2,032,007 2/1936 Fee ..... 92/1

**10 Claims, 5 Drawing Figures**



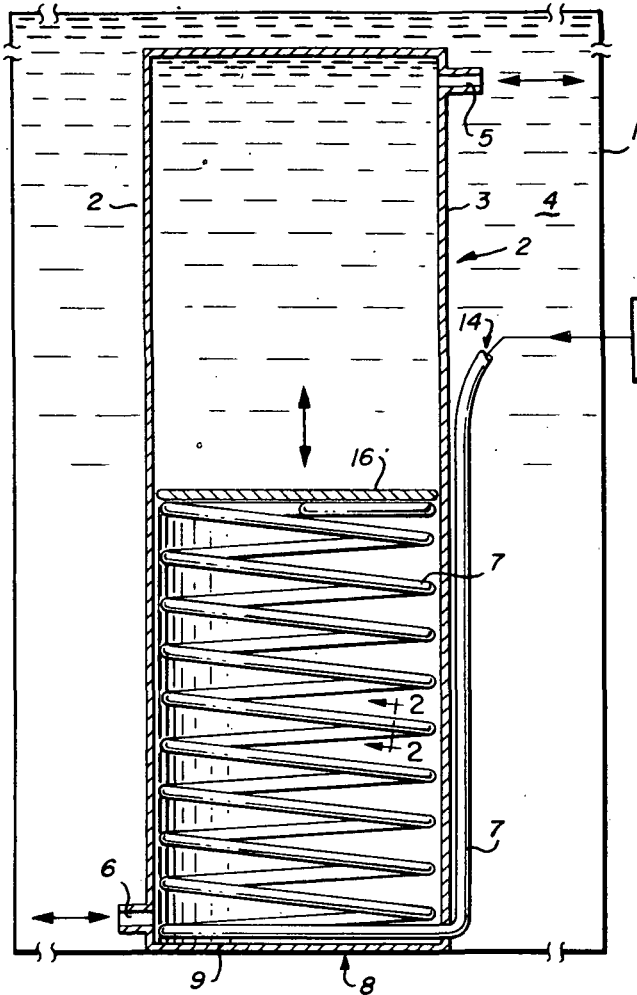


Fig. 1

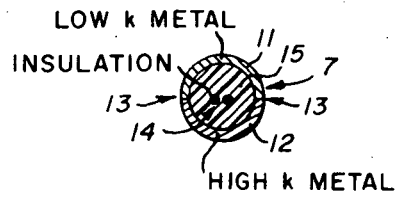
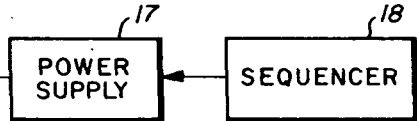


Fig. 2

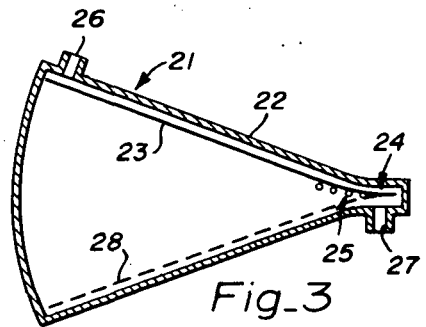


Fig. 3

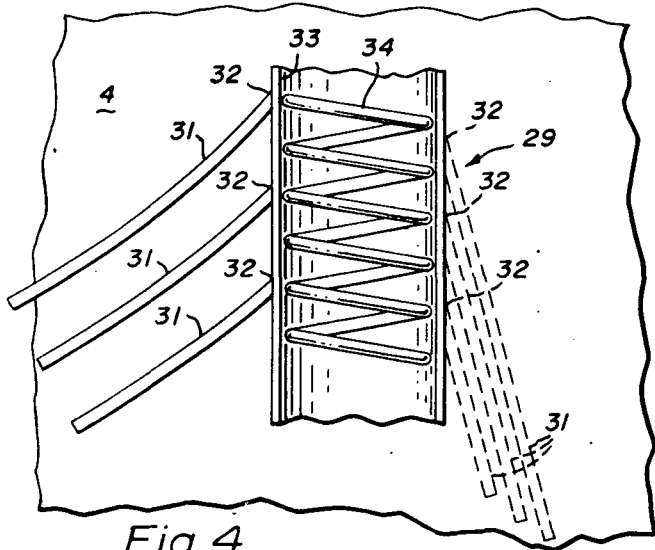


Fig. 4

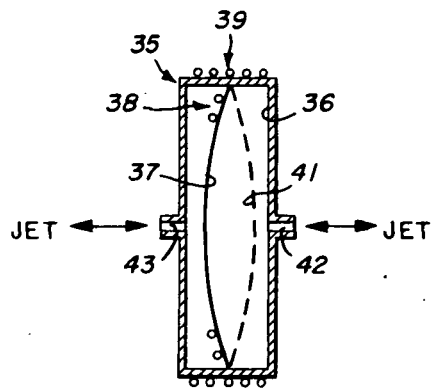


Fig. 5

## BIMETALLIC FLUID DISPLACEMENT APPARATUS

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the government for governmental purposes without the payment of any royalty thereon or therefore.

### BACKGROUND OF THE INVENTION

Heretofore, stored cryogenic gases and liquids have been stirred and heated by separate heaters and motor driven impellers, the combined operation of which produced the desired heating and mixing of the stored cryogenic gases and liquids.

Prior impellers for mixing have generally employed an electrical motor which, heretofore, required hazardous materials and electrical circuits to be installed inside the fluid-storage tanks. Additional disadvantages of the earlier art were excessive complexity, weight and cost of such motorized mixers and electrical heaters. The danger arises from the use of motorized impellers in that incompatible materials were ignitable by sparks from the motor's electrical circuits, particularly when the stored fluid was oxygen.

It is also known from the prior art to use a bimetallic impeller blade in pumps that may change its shape with temperature of the fluid to compensate for changes in viscosity of the fluid being pumped to retain an efficient impeller blade shape. Such a prior art pump is disclosed in U. S. Pat. No. 2,114,567 issued Apr. 19, 1938.

### SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved fluid displacement means particularly useful for stirring and mixing stored cryogenic fluids where natural convection is ineffective.

In one feature of the present invention, stirring of stored fluids is accomplished by heat cycling a bimetallic structure to produce a cyclical deformation of the bimetallic structure to effect a cyclical displacement of the fluid to be mixed or stirred.

In another feature of the present invention, a helical bimetallic member having a piston affixed thereto is heat cycled to produce periodic elongation and contraction of the helical structure for urging the piston to and fro in the stored liquid, thereby producing stirring and mixing of the fluid.

In another feature of the present invention, a bimetallic vane is supported on one end and heat cycled to produce cyclical bending and flexing of the vane for stirring of fluids adjacent said vane.

In another feature of the present invention, a plurality of bimetallic wires or rods are affixed at one end to a support structure and are heat cycled to produce cyclical flexing of the rods for stirring of fluids communicating with said rods or wires.

In another feature of the present invention, a bimetallic disc is heat cycled to produce cyclical impulsive deformation of the disc to impart a stirring motion to fluid communicating with the disc.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view, partly in block diagram form, of fluid storage apparatus incorporating features of the present invention,

FIG. 2 is a sectional view of a portion of the structure of FIG. 1 taken along line 2—2 in the direction of the arrows,

FIG. 3 is a longitudinal sectional view of an alternative bimetallic fluid stirring apparatus of the present invention,

FIG. 4 is a longitudinal sectional view of an alternative fluid stirring apparatus of the present invention, and

FIG. 5 is a longitudinal sectional view of an alternative fluid stirring apparatus of the present invention.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is shown a cryogenic fluid storage tank 1 incorporating a fluid stirring device 2 incorporating features of the present invention. More particularly, the stirring device 2, includes a hollow cylindrical chamber 3 disposed within and in fluid communication with the cryogenic fluid 4 stored within storage tank 1. The volume of the chamber 3 is typically a substantial fraction of that of the tank 1 in which it is installed. In a typical example, the cryogenic fluid 4 is liquified oxygen. Ports 5 and 6 permit passage of the fluid 4 to and fro between the chamber 3 and the tank 1. The bimetallic helix 7, as shown in greater detail in FIG. 2, includes a pair of metallic helices 11 and 12, each of semi-cylindrical cross section. The helices 11 and 12 are disposed in mutually opposed relation and joined together at their mating edges 13 as by welding or a suitable adhesive, to form a composite bimetallic hollow helix 7. An electrical heating element 14 is coaxially disposed in the hollow interior of the bimetallic helix 7 in an electrically insulative relation therefrom via the intermediary of a dielectric insulative filling material 15 as of ceramic.

The upper half 11 of the composite bimetallic helix 7 is made of a material having a lower coefficient of thermal expansion than the lower half 12 such that, upon heating of the helix 7, the bottom half 12 expands more rapidly than the upper half 11 to cause the overall helix 7 to expand axially along the cylindrical housing 2. A metallic disc 16 is affixed to the free end of the bimetallic helix 7 to form a piston 16 for displacing fluid within the housing 2 as the helix expands and contracts. The lower end of the bimetallic helix 7 is affixed to the closed end wall 9 of the housing 3.

At the lower end of the helix 7, the bimetallic member 7 passes through an opening in the housing 2 near its closed end 9 and thence through a suitable fluid tight fitting, not shown, in the wall of the tank 1. A power supply 17 supplies power to the heating element 14 for heating of the bimetallic helix 7. A sequencer 18 causes the power to the heating element 14 to be sequentially applied to produce a cyclical movement of the helix 7 and piston 16. More particularly, during the heating portion of the operating cycle, the helix 7 expands towards the upper end of the housing for displacing fluid within the housing into the tank 1 by way of port 5. Also, as the piston 16 moves toward the upper end of the housing, replacement fluid is drawn in

through the lower port 6 to the region behind the moving piston 16.

Upon termination of the heating cycle the fluid 4 removes heat from the helix 7 via conduction and convection causing the helix to contract and to displace fluid from behind the piston 16 into the tank via port 6. As fluid is exiting port 6, replacement fluid is flowing into the upper portion of the housing 2 via port 5. Thus fluid within the storage tank 1 is being stirred and heated continuously by operation of the stirring device 2.

Referring now to FIG. 3, there is shown an alternative stirring device 21 incorporating features of the present invention. In stirring device 21, the housing 22 is of pie-shaped cross section and elongated in the direction into the paper. A bimetallic vane or flapper 23 is contained within the housing 22. The flapper 23 comprises two sheets of dissimilar metal having dissimilar coefficients of thermal expansion joined together at their abutting faces to form the composite bimetallic flexible vane 23. Vane 23 is fixedly supported along one side edge to the housing 22 at 24 and an electrical heating element 25 is disposed in heat exchanging relation with the vane 23, as by being affixed to one side of the vane 23. Ports 26 and 27 are provided in the housing 22 to provide fluid communication between the housing 22 and the storage tank, not shown, in which the stirring device 21 is immersed.

In the cold position, vane 23 is bent or flexed to the position shown in solid lines. Upon heating of the vane 23, by means of the heating element 25, the metal sheet having the higher coefficient of thermal expansion causes the vane 23 to bend to the dotted position indicated at 28 for expelling fluid from within the housing 22 into the tank 1 via port 27 and into the housing 22 from the tank via port 26. Upon termination of the heating portion of the operating cycle, the vane 23 is cooled by conduction to the fluid and it returns to its cold position expelling fluid through port 26 and drawing in replacement fluid through port 27.

Referring now to FIG. 4 there is shown an alternative stirring device 29 of the present invention. In the stirring device 29, a plurality of bimetallic wires or rods 31 are affixed at their ends 32 to a thermally conductive sleeve 33. An electrical heating coil 34 is disposed within the sleeve 33 in heat exchanging relation therewith for heating the sleeve and the appended bimetallic wires or rods 31.

When the heating element 34 is energized with heating current, the heat thus liberated is conducted through the support sleeve 33 and into the appended wires or rods 31. Upon heating of the bimetallic wires or rods 31 they are caused to flex to the position shown in solid lines and upon termination of the heating cycle the rods or wires 31 are cooled by conduction and retract to their cold position as indicated by the dotted lines.

The transfer of heat into the surrounding fluid is enhanced by the induced motion of the wires or rods 31 through the fluid. In addition the motion of the rods or wires through the fluid produces a stirring motion thereof. The stirring device 29 is preferably immersed in the cryogenic fluid 4 within the storage tank 1.

Referring now to FIG. 5 there is shown an alternative stirring device 35 incorporating features of the present invention. Stirring device 35 includes a hollow cylindrical housing 36 containing a domed bimetallic disc 37

having a heating element 38 directly affixed thereto or affixed to the outside of the housing 36 at 39 such that the heating element is placed in heat exchanging relation with the bimetallic disc 37. In addition, the periphery of the disc 37 is restrained against axial translation within the cylindrical housing 36, however, the periphery of the disc 37 is preferably free to expand and contract slightly in the radial direction.

Upon heating of the bimetallic disc 37, the disc flexes from the cold position, as indicated at 37, to the hot position as indicated by dotted line 41, thereby expelling fluid within the housing 36 through port 42 into the storage tank, not shown. As the fluid is being expelled through port 42, replacement fluid is drawn into the housing 36 via port 43. Upon termination of the heating portion of the operating cycle, the disc 37 is allowed to cool by conduction to the fluid and it returns to its cold position as indicated by solid line 37. Upon its return, the fluid is expelled from housing 36 via port 43 and replacement fluid is drawn into the housing 36 via port 42. The disc 37 imparts a rapid or impulse type motion to the fluid due to the "oil canning" effect of the bimetallic disc 37, thereby obtaining a vigorous stirring motion for the fluid in communication with the stirring device 35.

The advantage of the bimetallic stirring devices of the present invention is that unnecessary rotating machinery and electrical circuits are eliminated and hazardous materials are more easily eliminated from contact with the stored fluid.

What is claimed is:

1. In a fluid displacement apparatus, fluid displacing means for displacing a volume of fluid to produce movement of said fluid, bimetallic means coupled to said fluid displacement means for imparting movement to said fluid displacement means, and heater means disposed in heat exchanging relation with said bimetallic means for heating said bimetallic means for imparting movement to said fluid displacement means.

2. The apparatus of claim 1 including means for cyclically operating said heater to produce cyclical movement of said fluid displacement means.

3. The apparatus of claim 2 including, chamber means for containing a fluid to be stirred, said fluid displacement means being disposed in fluid communication with the fluid in said chamber for stirring the fluid in said chamber in response to cyclical movement of said fluid displacement means.

4. The apparatus of claim 1 wherein said bimetallic means and said fluid displacement means are a common means.

5. The apparatus of claim 4 including, support means affixed to said common means at a support region of said common means for supporting said common means and wherein said bimetallic means flexes about said support region due to the unequal thermal expansion and contraction of said bimetallic means upon heating and cooling of said bimetallic means.

6. The apparatus of claim 1 wherein said bimetallic means comprises a helical structure having a pair of opposed helical portions joined together and being of different coefficients of thermal expansion.

7. The apparatus of claim 6 wherein said fluid displacing means includes a movable wall affixed to a movable end of said bimetallic helical structure.

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8. The apparatus of claim 6 wherein said helical structure is hollow to accommodate said heating means therewithin.

9. The apparatus of claim 1 wherein said bimetallic means includes a bimetallic composite sheet having first and second metallic sheet portions joined together in mutually opposed relation, said first and second

sheets having differing coefficients of thermal expansion.

10. The apparatus of claim 1 wherein said bimetallic means is disposed in heat exchanging relation with the fluid to be displaced for heating the fluid to be displaced.

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