

(19)



(11)

EP 2 918 945 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.09.2015 Bulletin 2015/38

(51) Int Cl.:
F24J 3/00 (2006.01)

(21) Application number: **14160593.1**

(22) Date of filing: **18.03.2014**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
 GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
 PL PT RO RS SE SI SK SM TR**
 Designated Extension States:
BA ME

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(30) Priority: **11.03.2014 US 201414204042**

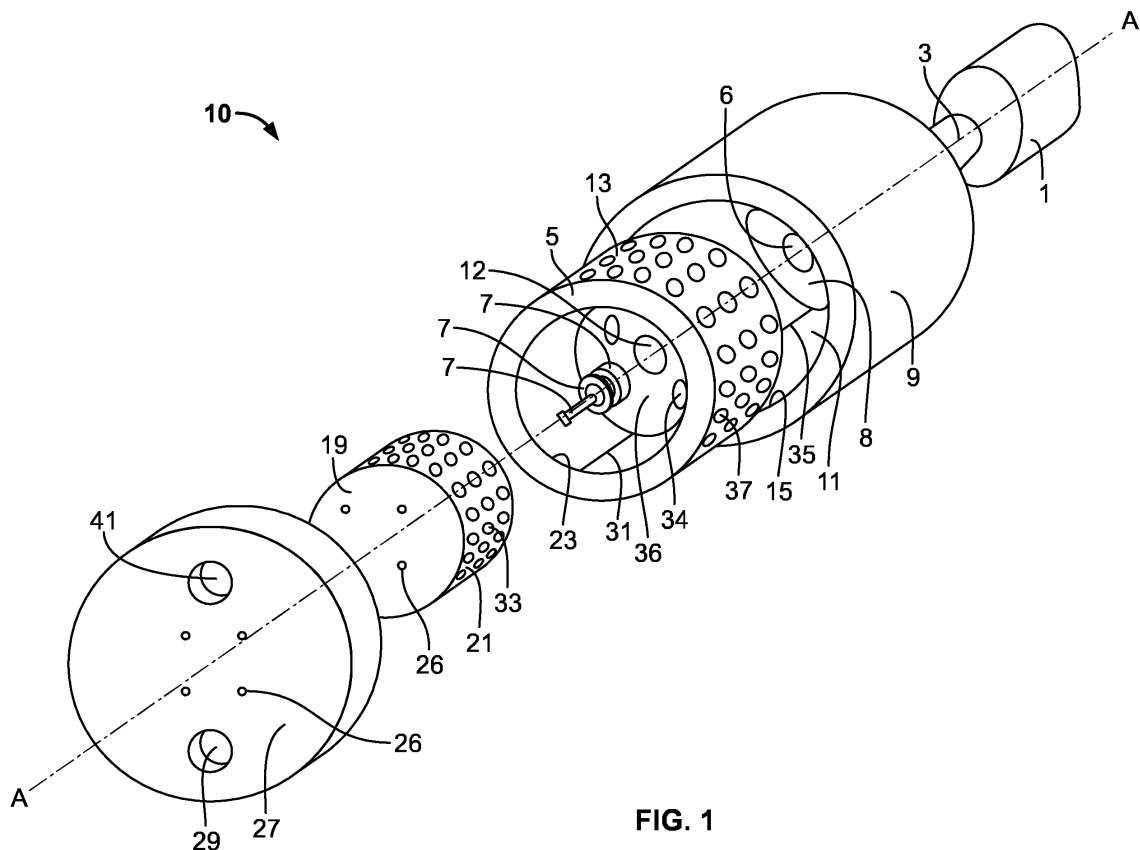
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(54) Method and apparatus for heating liquids

(57) A fluid heating apparatus (10) using cavitation includes a housing (9), an external rotor (5) with cavitation bores (37) in an outer surface thereof, and a motor (1) for rotating the external rotor (5). An inner surface (15)

of the housing (9) is spaced from the outer surface of the external rotor (5) to create a fluid heating zone. The inner surface of the housing is configured with a spiral shape and wave form to enhance the heating of the fluid.

**FIG. 1****EP 2 918 945 A1**

Description

Field of the invention

[0001] The invention relates to a cavitation equipment producing heated liquids, containing at least one engine, a house, the liquid to be heated, and cavernous cavitation body rotating in the liquid to be heated and driven by the engine.

Background Art

[0002] The phenomenon of cavitation to produce heat in liquids such as water is well known in the art.

[0003] An example of a cavitation system using a rotating body for producing heated liquids is presented in United States Patent No. 3,720,372 to Jacobs. Other patented solutions using the cavitation phenomenon to produce heat were developed in 1950s, especially in the United States. A well known patent is United States Patent No. 4,424,797 to Perkins. This patent is a developed and state of the art version of the solutions described in United States Patent No. 2,683,448 to Smith. An improvement was also disclosed in United States Patent No. 4,779,575, also to Perkins.

[0004] Cavitation devices are also described in United States Patent Nos. 5,188,090 and 5,385,298 to Griggs. In these devices, a cylindrical body is placed into the housing of the device, and a cloak is provided with cavitation bores. The liquid to be heated is placed into the cylindrical free space between the rotating body with cavitation bores and the internal cloak of the housing; the pressure and temperature of the liquid increases while the cavitation body is rotating. The Griggs patents are incorporated by reference herein in their entirety.

[0005] Other cavitation devices are disclosed in United States Patent No. 6,164,274 to Giebler, United States Patent No. 6,227,193 to Selivanov, and the Russian patent No. RU 2,262,644. Another approach from a cavitation standpoint is shown in United States Published Patent Application No. 2010/0154772 to Harris. In this approach, the helical loops of the rotating rotor and the internal cloak of the housing jointly result in cavitation heat production, while the rotor is rotating.

[0006] The prior art systems described above have a number of disadvantages, including being inefficient and generating noise. One aim of the invention is to eliminate the disadvantages of the known solutions and the harmful cavitation effects in water heating devices, to improve efficiency, and to reduce cavitation noise.

Summary of the Invention

[0007] One object of the invention is a cavitation apparatus producing heated liquids, containing at least one engine, a housing, liquid to be heated, and one or more cavernous cavitation body rotating in the liquid to be heated and driven by the engine. The invention includes the

procedure for the operation of the equipment. The solution according to the invention advantageously eliminates the otherwise harmful and eroding features of cavitation, while using the generated cavitation heat to heat liquids, primarily water.

[0008] More particularly, the invention is characterized in that a constricting form is installed in the housing, the constricting form contains cavitation steps, and there is a free constricting gap for the liquid to be heated between the constricting form and the cavitation body (2). The method for the use of the cavitation equipment forms also part of the invention.

Brief Description of the Drawings

[0009]

Figure 1 shows a perspective and exploded view of one embodiment of the invention.

Figure 2 shows a top of the apparatus of Figure 1 with portions cut away to show detail.

Figure 3 shows a sectional view along the line III of Figure 2.

Figure 4 shows an enlarged portion of the sectional view in Figure 3.

Figure 5 shows an even more enlarged view of a portion of Figure 4.

Detailed Description of the Invention

[0010] The phenomenon of cavitation and its use in heating liquids is well known in the prior art.

[0011] Cavitation vacuum bubbles are created in the lower pressure parts of liquids, primarily in areas the liquid flows at high speed. The phenomenon is common in central pumps and in the proximity of ship propellers or water turbines, and may extensively erode the rotating propellers and the surface of all materials affected.

[0012] The phenomenon is accompanied by vibration and knocking-like sounds; it distorts the flow pattern, and reduces the efficiency of the associated engine. Irrespective of the material the propeller or turbine blade is made of, cavitation erodes the respective surfaces by literally eating away even the hardest alloys and creating tiny holes and cavities on the surface. The name of the phenomenon is of this origin, as cavitation means the creation of cavities. For the above reasons, cavitation is usually a phenomenon to be eliminated.

[0013] Cavitation vacuum bubbles are generally small, just a few millimeter in size, and the bubbles are generated by a sudden decrease in pressure in high-speed liquid flows between the molecules of the liquid. The bubbles crash when entering highpressure areas, or explode and fill the space evenly with drops, if the pressure of highpressure liquids drops suddenly. Small cavities are created among the drops and drop molecules, creating literally vacuum bubbles. The subsequent crash of such vacuum bubbles is accompanied by a low

crashing noise and light emission. The crashing of large quantities of liquid molecules produces cracking, bouncing, and rumbling noise. When the bubbles crash, the energy stored, which is in the form of significant heat and light energy in the bubbles, is released. The energy spreads at various frequencies and is absorbed by neighboring molecules, thereby increasing their temperature. Put another way, the resulting gas reaches a state where the greater temperature and pressure of the saturated gas breaks the molecular adhesion and the bubbles suddenly will split. The resulting high temperature is absorbed by the surrounding fluid molecules, thus heating the fluid.

[0014] Again, the utilization of this phenomenon to heat liquids has been known for years. However, producing cavitation to heat liquids has been indirectly - e.g. by using rotating bodies run by electric engines - more expensive than heating liquids by using electricity directly. On the other hand, the situation is different, if other economical power sources - e.g. turbine, petrol or diesel engine, etc. - are available anyway. By using such power sources, hot liquids may be produced directly.

[0015] In systems such as shown in the Griggs patents above, circulating a fluid in a closed system at a select high speed and passing through a narrowing channel, the fluid is suddenly introduced into an expanding section (cavitation bores) and the necessary decompression to create cavitations occur.

[0016] Cavitation is generally a detrimental phenomenon due to its destructive characteristics, excessive heat generation, high discharge pressure, and noise. However, the invention is based on the realization that an improved cavitation apparatus can be made by installing a constriction or interference between a rotating cavitation body and the internal surface of a housing containing the body and, optionally, the internal surface of the rotating cavitation body and a secondary and stationary rotor head. In this case, it is ensured that the vacuum bubbles are continuously exploded. By designing the internal of the housing with the interference or constriction, the liquid to be heated surrounds the vacuum bubbles in the bores upon explosion, cavitation noise can be reduced, and the harmful effects of cavitation can be reduced or eliminated.

[0017] The invention, in one aspect is a cavitation apparatus producing heated liquids, containing at least one engine, a housing, the liquid to be heated, a rotating cavitation body rotating in the liquid to be heated and driven by the engine. The engine may be an electric engine, but steam or internal combustion engines, or the rotating shafts of turbines may also be used to drive the cavitation equipment. A stationary rotor head can be placed inside of the rotating cavitation body to form the second liquid heating zone. The invention also includes the method for the operation of the apparatus, which entails broadly supply a fluid, for example water to the apparatus for heating purposes and subsequent use of the heated fluid as would be known in the art. While water is a desired fluid,

the apparatus can be used to heat any fluid if so desired..

[0018] The advantages of the invention are aided by having cavitation bores in the rotating cavitation body and the rotor head, if present. For the rotating cavitation body, its external surface is fitted with cavitation bores, much like found in the Griggs patents. The bores and the chamber between the rotating cavitation body and the surrounding housing forms a first heating cavitation flow zone. In the embodiment using the stationary rotor head, the external surface of the rotor head is also fitted with cavitation bores so as to face an inner surface of the rotating cavitation body, which is then generally ring-shaped. This creates an additional liquid heating cavitation flow zone between the inside of the rotating cavitation body and the rotor head to enhance the heating of the fluid.

[0019] One embodiment of the invention is shown in the Figures 1-5. The apparatus is designated by the reference numeral 10 and includes an external motor 1 is used to rotate a rotating cavitation body or external rotor 5 through a direct drive shaft 3 that includes a shaft seal 7. The shaft 3 extends through an opening 6 in an end 8 of a housing 9 and an opening 12 in the external rotor 6. The external rotor 5 can be rotated at any number of speeds and this depends on the viscosity of the fluid being heated. Typical speeds are from 2500-4000 rpm to generate optimal cavitation of fluid, such speeds similar to those disclosed in the Griggs patents.

[0020] A rotor housing 9 is provided and has no internal bearings. The shaft 3 of the motor 1 extends through the housing 9 and supports the external rotor 5 for rotation. The motor has a longer shaft 3 than normal and internal bearings in the motor to support the balanced external rotor 5 when the shaft 3 extends through housing 1. The housing 1 forms a cavity 11, with the cavity shaped to receive the external rotor 5. In operation, fluid, e.g., water, is introduced into the cavity 11 at a rate for maximum energy release of the fluid during operation of the apparatus. When the external rotor 5 is positioned within the housing, an outer surface 13 of the external rotor 5 faces an inner surface 15 of the housing. A gap 17 exists between these two surface 13 and 15, and this gap 17 becomes one fluid heating zone for the apparatus 10.

[0021] In the embodiment of Figures 1-5, two fluid heating zones exist. This is accomplished by providing a secondary rotor head 19 in a specific rotational pitch or configuration and has similar physical characteristics as the external rotor to enhance the energy in the fluid. An outer surface 21 of the rotor head 19 faces an inner surface 23 of the external rotor 5, with a gap existing therebetween. The gap forms the another fluid heating zone 25 of the apparatus 10.

[0022] A housing cover 27 is also provided. The housing cover 27 mates with the housing 1 using any known fastening technique to form a sealed cavitation chamber that includes the rotor head 19 and the external rotor 5. The rotor head 19 is mounted to the housing cover 27 in any conventional way to create the gap 25 as the second

fluid heating zone between the external or outer surface 21 of the rotor head 19 and the inner surface 23 of the external rotor 5. As an example of the mounting, openings 26 can be used with the appropriate fasteners.

[0023] The materials selected for the external rotor 5 and rotor head 19, and housing 1 and cover 27 are selected for optimal performance & safety. Examples of materials for the housing 1 and cover 27 include polymers, e.g., a polyamide. The external rotor 5 and rotor head 19 can be made from metal materials like aluminum or an alloy thereof or stainless steels.

[0024] The fluid to be heated is introduced to the cavitation apparatus 10 through an intake port 29 located on the housing cover 27. While the position of the intake port 29 can vary, it is preferred to be positioned so that fluid entering the second fluid heating zone 25, see Figure 4, that is between the fixed internal rotor head 19 and the external rotor 5.

[0025] The zone 25 has a generally annular shape, but the width of the gap around the circumference of the rotor head is not uniform. This is accomplished by the shape of the inner surface 23 of the external rotor 5. This surface has a spiral shape, which is illustrated by radial distances, as measured from a central and longitudinal axis A of the apparatus 10. Referring to Figure 3, one radius R3 as measured from a center axial point of the apparatus is such that the radius R3 is less than another radius R4. This difference in radius and spiral shape of the inner surface 23 of the external rotor 5 creates a wave ramp 31. This configuration produces a pressure differential critical for formation of cavitation vacuum bubbles at wave ramp 31.

[0026] The rotor head outer surface 21 is configured with a number of spaced apart cavitation bores 33 of a given depth and circumference. The bores 33 cooperate with the wave ramp 31 and spiral shape of the inner surface 23 of the external rotor 5 to create a continuous and growing vacuum bubble generation in the regular arrangement of the cavitation bores 33 of the rotor head 19. Heat is generated through the cavitation process of the fluid with virtually no destructive impact to the rotor head 19 or the cavitation bores 33. During operation, the external rotor 5 is spinning in a clockwise direction, see Figure 4. The fluid is compressed during the rotation cycle of the external rotor 5 and pressure increases in the fluid heating zone 25 and 17. The entry to the wave ramps 31 and 35 provides an area of expansion that generates a rapid loss of pressure and this pressure reduction permits the forming of the cavitation bubbles and subsequent explosion in the cavitation bores 33 and 37.

[0027] After entering the zone 25, the fluid exits the zone 25 through multiple ports 34 at the rear face 36 of the external rotor 5. This exiting fluid then enters the other fluid heating zone 17 formed in the space between the inside surface 15 of the housing 1 and the outer surface 13 of the external rotor 5. In effect, the fluid is introduced to a secondary cavitation process, which is opposite in direction from a spinning fluid flow direction to the first

cavitation process occurring in the zone 25 between the rotor head outer surface 21 and the inner surface 23 of the external rotor 5.

[0028] The housing 1 is equipped with the similar spiral configuration on the inner surface 15 thereof with a corresponding wave ramp 35 formed by the radial differences shown in Figure 3. That is, the radius R1 is less than radius R2 so as to form the wave ramp 35.

[0029] The external rotor 5 includes cavitation bores 37, like those in the rotor head 19.

[0030] Fluid exiting the second heating zone 25 is introduced into first heating zone 17. The spinning fluid therein is then introduced into the regular arrangement of external rotor cavitation bores 37 in the same fashion as fluid is introduced into the bores 33 in the rotor head 19. What is different between chambers 17 and 25 is the orientation of the wave ramps 31 and 35. The wave ramp 35 is configured oppositely from the wave ramp 31

[0031] Put another way and referring to Figure 3, the spiral of increasing radius moves in the clockwise direction for surface 23 of the external rotor 5, short radius R3 to longer radius R4. For surface 15 of the housing 9, the increasing radius moves in the counterclockwise direction, short radius R1 to longer radius R2. This means that the faces of the wave ramps 31 and 35 are opposite to each other. Referring to Figure 5, the wave ramp 35 has face 39, which is shown with a right angle configuration. However, the face 39 could be angled as well. The spiral configuration insures the maximum vacuum bubble generation and the resulting heat generation bubble explosion. The dual balanced cavitation process of the zone 17 and zone 25 occur simultaneously. Thus, through a single rotational cycle of the motor and external rotor 5, the fluid is processed twice for heating.

[0032] It is also desirable that the wave ramps 31 and 35 be aligned at rest as shown in Figure 3. That is, the wave ramps 31 and 35 are at the 6 o'clock position. Since the housing 1 is fixed and the apparatus would be positioned so that the axis A is horizontal, it is not a problem to have the wave ramp 35 in this position. In order to have the wave ramp 31 of the external rotor 5, which can move due to its motor connection in this position, one way is to have the external rotor 5 balanced by the multiple outlet ports 34 such that the when motor 1 is not providing power, the external rotor 5 returns to the proper start up position in respect to the inner wave ramp 31 and the outer wave ramp 35. With this start up position, maximum heat generation of the fluid within the process is achieved. While the wave ramp position of the external rotor could vary from the 6 o'clock position, even as high as 90 degrees to either side, heating efficiency is lowered when varying from the preferable start up position. It is also preferred that the wave ramps 31 and 35 be at the 6 o'clock position as this facilitates the start up of the apparatus from a priming standpoint (the input 29 is aligned with the wave ramp 31 since the apparatus not only functions as a liquid heating device but also like a pump, drawing liquid in to the apparatus 10 and discharg-

ing it. Varying from the 6 o'clock position towards either the 3 or the 9 o'clock reduces the pressure drop at the ramp and/or reduces the cavitation.

[0033] The fluid being heated then leaves the cavitation apparatus 10 through an outlet port 41 in the cover 9 and into a system tank (not shown) at low pressure (< 1 atmosphere). The heated fluid can be used in any known application that employs a heated fluid.

[0034] The spiral nature of both the internal chamber or zone 17 and external chamber or zone 25 with respective wave ramps 35 and 31 are important in the cavitation process and for reducing or eliminating unwanted side effects. The invention is based on the realization that the objective of having a cavitation fluid heating apparatus without the known problems in prior art cavitation heating apparatus can be obtained by having a constricting form or interference in the zones or chambers 17 and 25 containing the wave ramp 35 between the rotating external rotor outer surface 13 and the inner surface 15 of the housing 9 and same constriction or interference as wave ramp 31 between the rotor head outer surface 21 and the external rotor inner surface 23. By designing the internal surface 15 of the housing 1 and the internal surface 23 of the external rotor 5 this way, it can be continuously ensured that the vacuum bubbles explode. Ensuring by designing the spiral surfaces 15 and 23 that the liquid to be heated surrounds the vacuum bubbles in the bores upon explosion, cavitation noise can be reduced, as well as reducing or eliminating the other harmful effects of cavitation, e.g., erosion of component parts and the like.

[0035] It should be understood that the two chamber or zone design of Figures 1-5 can be modified so that it is only a one chamber design. Thus, the rotor head 6 could be made without the cavitation bores and act only as a conduit to feed liquid to the zone 17 between the housing 1 and the external rotor 5. In yet a further embodiment, the rotor head 6 could be eliminated so that only the external rotor 5 with its cavitation bores 37, the housing 9 with its specially configured inner surface 15, and the appropriate inlet and outlet ports would interact to heat the fluid.

[0036] While a single chamber apparatus provides heated liquid without many of the cavitation-related problems of prior art devices, it is more advantageous to employ the embodiment of Figures 1-5, wherein the external rotor is installed with an fixed rotor head 19, the external surface of which is fitted with additional cavitation bores 33. Together this configuration allows the rotor pump to produce heat energy at a significant increased ratio of energy utilization to consumption, while overcoming the traditional problems of prior systems; such as sonic sound waves (noise), bearing failures, and high discharge pressure energy losses.

[0037] The present invention is directed at releasing heat energy for use in delivering a fluid for heating, and cooling systems, fluid purification and separation, and any fluid processing that require heat to complete pro-

gression. Moreover, the invention, releases the energy through a cavitation process using less power consumption than traditional boiler systems or furnaces. The balanced internal fixed rotor 19, external rotor 5, wave ramps 31 and 35, and coinciding housing 1 and cover 27 provide the unique physical characteristics to produce heat at an increased rate of return of energy consumption while maintaining thermal characteristics.

[0038] The present invention comprises these unique component characteristics in a manner such that the fluid that the heat generated is retained for extended periods of time and thus requires lower cycles of energy consumption.

[0039] The present invention is unique such that the multistage cavitation process is initially completed through a primary cavitation rotor head that is stationary, with the external rotor acting as both a centrifugal source for the initial process and a cavitation element of the second stage. Both the external rotor and rotor housing have wave ramps to enhance the cavitation process. This allows the system to maximize the energy released from the cavitation process, while maintaining a low discharge pressure in so that energy is not lost by changing the state of the fluid to a gas. The present invention configuration is such that the normally associated noise from the cavitation process is minimized and controlled.

[0040] As explained above, the spiral configuration of the surfaces 15 and 23 are an important feature of the invention. This configuration allows for the creation and growth of the vacuum bubbles in the bores 33 and 37. In the bores 33 and 37, the vacuum bubbles are created among the molecules and surrounded by the fluid to be heated. The bubbles do not actually explode but crash, when they reach the wave forms 31 and 35.

[0041] According to the method, the external rotor 5 is placed into the housing 1 and is rotated with the driving engine 1. During rotation, fluid to be heated is injected into the housing 1 through the input 29. With the help of the rotation, continuously growing vacuum bubbles are created among the liquid molecules in the bores 33 of the rotor head 6, if present, and in the bores 37 of the external rotor 5. Once the vacuum bubble reaches the cavitation step 31 or 35, they crash. The fluid to be heated is otherwise continuously flowed through the chambers 25 and 17, with the vacuum bubbles crashing in the expanding liquid after passing the wave ramps 31 and 35. Upon the crash, the liquid molecules, moving in opposite directions, explode. The heat generated during the explosion is absorbed by the surrounding liquid, and the heated liquid is ultimately extracted through the output 41.

[0042] It is the advantage of the cavitation apparatus according to the invention to successfully eliminate or reduce the harmful effects of the cavitation phenomenon by using flow channels designed for the liquid to be heated and by using the procedure for the operation of the equipment.

[0043] Turning back to the embodiments discussed

above, one embodiment of the invention uses a single rotating cavitation body having bores in it, with the bores open to an outer surface of the cavitation body. This cavitation body rotates within a housing and interacts with the cavitation step, which is located on the inside surface of the housing. During this rotation, vacuum bubbles are created in the bores in the rotating body. The bubbles eventually grow such that they are no longer confined to the bores and crash into the cavitation step. This crash causes the liquid molecules to explode, which is the energy release that causes the heating of the water.

[0044] In another embodiment, there are two sets of bores, one on the outer surface of the rotating body and another set of bores on the outer surface of a second and stationary component located within the rotating body. In this dual bore embodiment, the cavitation step or wave form for the bores on the outer surface of the rotating body is on the inner surface of the housing. The cavitation step for the bores on the outer surface of the stationary rotor head are on the inner surface of the rotating body.

[0045] The inventive configuration allows the cavitation apparatus to produce heat energy at a significant increased ratio of energy utilization to consumption, while overcoming the traditional problems of prior systems; such as sonic sound waves (noise), bearing failures, and high discharge pressure energy losses. The present invention, through mechanic means, produces heated water at a 30-70% decreased rate of energy consumption (dependent upon the volume of fluid in the system) through a balanced cavitation furnace.

[0046] Another aspect of the invention is the ability of the apparatus to increase the density of the fluid being heated, e.g., water. Since it is known that less energy is needed to heat denser water, the increase in density of the water helps in increasing the efficiency of the fluid heating process.

[0047] Testing has been performed to monitor the heating effect of the inventive apparatus. This testing involved running the cavitation apparatus using different volumes of water to be heated and monitoring inlet water temperature, the volume of water flow rate, outlet water temperature of the cavitation apparatus, the temperature of the supply water to the apparatus, power of drive motor, electricity consumption, values of power, consumption of electricity power, and ambient temperature. This testing showed high efficiencies in terms of amount of heating done to the water as compared to the power used to run the apparatus.

[0048] As such, an invention has been disclosed in terms of preferred embodiments thereof which fulfills each and every one of the objects of the present invention as set forth above and provides a new and improved fluid heating apparatus using cavitation.

[0049] Of course, various changes, modifications and alterations from the teachings of the present invention may be contemplated by those skilled in the art without departing from the intended spirit and scope thereof. It

is intended that the present invention only be limited by the terms of the appended claim.

5 Claims

1. An apparatus for heating a fluid using cavitation comprising:

10 a housing having an inlet for fluid to be heated and an outlet to discharge the heated fluid from the housing;
a external rotor contained in the housing and adapted to rotate within the housing, the external rotor having a plurality of cavitation bores arranged in an outer surface thereof and the external rotor arranged within the housing to form a fluid heating zone between the outer surface of the external rotor and an inner surface of the housing that faces the outer surface of the external rotor,
20 wherein the inner surface of the housing facing the bore-containing outer surface of the external rotor has a spiral shape and a wave ramp running longitudinally along the inner surface, fluid entering the housing being heated by interaction with the spiral configuration of the inner surface and the wave ramp of the housing, bores in the external rotor, and external rotor rotation.

2. The apparatus of claim 1, further comprising a stationary rotor head, the stationary rotor head mounted in the housing and having an outer surface which faces an inner surface of the external rotor, the outer surface of the stationary rotor head and an inner surface of the external rotor forming a second fluid heating zone, the outer surface of the stationary rotor head including a plurality of cavitation bores therein, the inner surface of the external rotor having a spiral shape and a wave ramp running longitudinally along the inner surface, fluid entering the second fluid heating zone being heated by interaction with the spiral configuration of the inner surface of the external rotor, the wave ramp of the inner surface of the external rotor, bores in the rotor head, and external rotor rotation.

3. The apparatus of claim 1, wherein the cavitation apparatus has a horizontal longitudinal axis and the wave ramp when viewed in a cross section transverse to the horizontal longitudinal axis is at a 6 o'clock position.

4. The apparatus of claim 2, wherein the cavitation apparatus has a horizontal longitudinal axis and each of the wave ramps when viewed in a cross section transverse to the horizontal longitudinal axis is at a 6 o'clock position.

5. The apparatus of claim 1, wherein the wave ramp on the inner surface of the housing has a face formed at a right angle with respect to the inner surface.
6. The apparatus of claim 2, wherein the wave ramp on the inner surface of the housing has a face formed at a right angle with respect to the inner surface of the housing and the wave ramp on the inner surface of the external rotor has a face formed at generally a right angle with respect to the inner surface of the external rotor.
7. A method of heating a fluid using cavitation comprising the steps:
- a) providing the apparatus of claim 1;
 - b) introducing fluid into the inlet;
 - c) rotating the external rotor to heat the fluid, and
 - d) discharging heated fluid from the outlet.
8. The method of claim 6, wherein the fluid is water.
9. A method of heating a fluid using cavitation comprising the steps:
- a) providing the apparatus of claim 2;
 - b) introducing fluid into the inlet;
 - c) rotating the external rotor to heat the fluid, and
 - d) discharging heated fluid from the outlet.
10. The method of claim 8, wherein the fluid is water.

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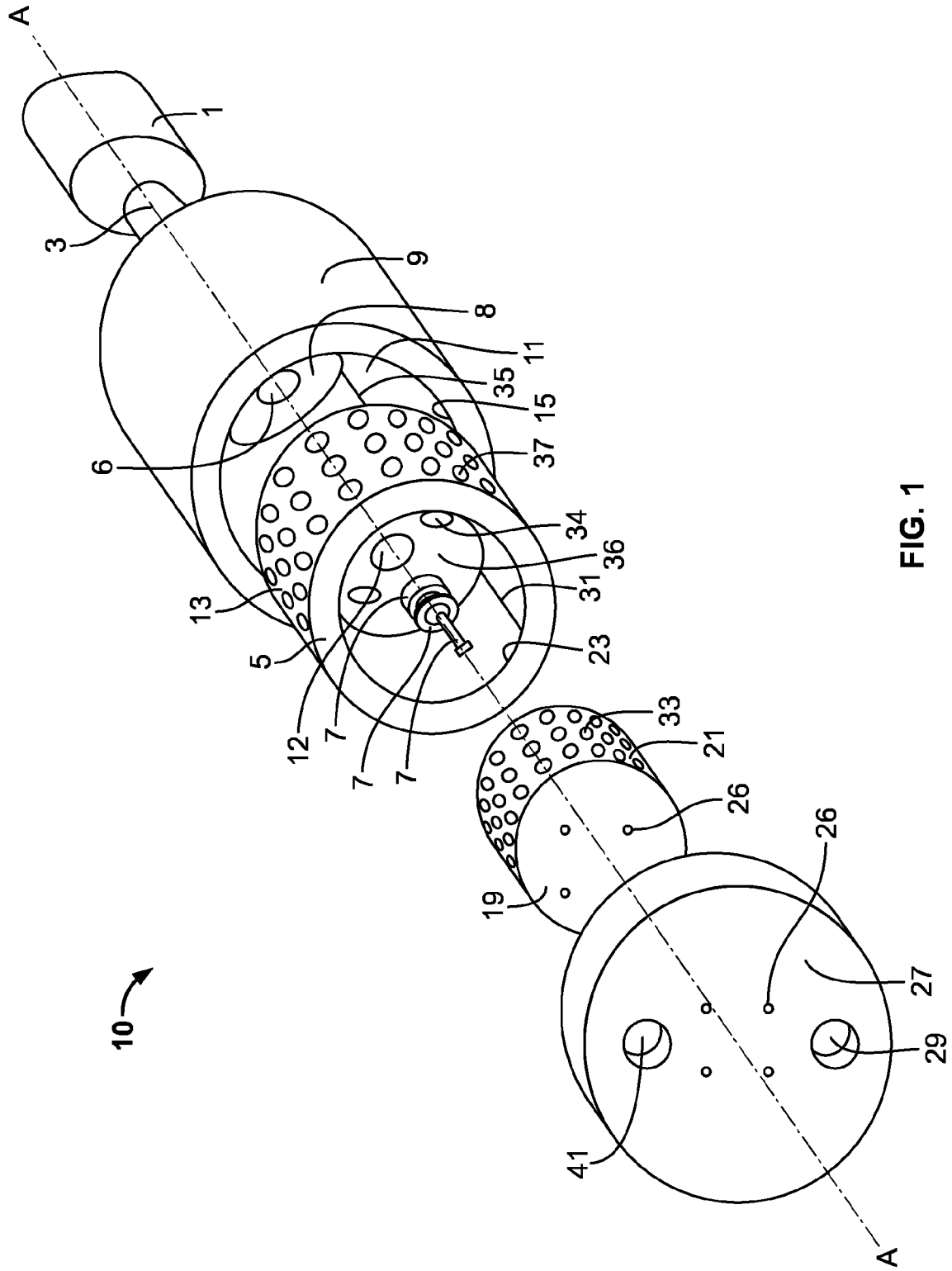
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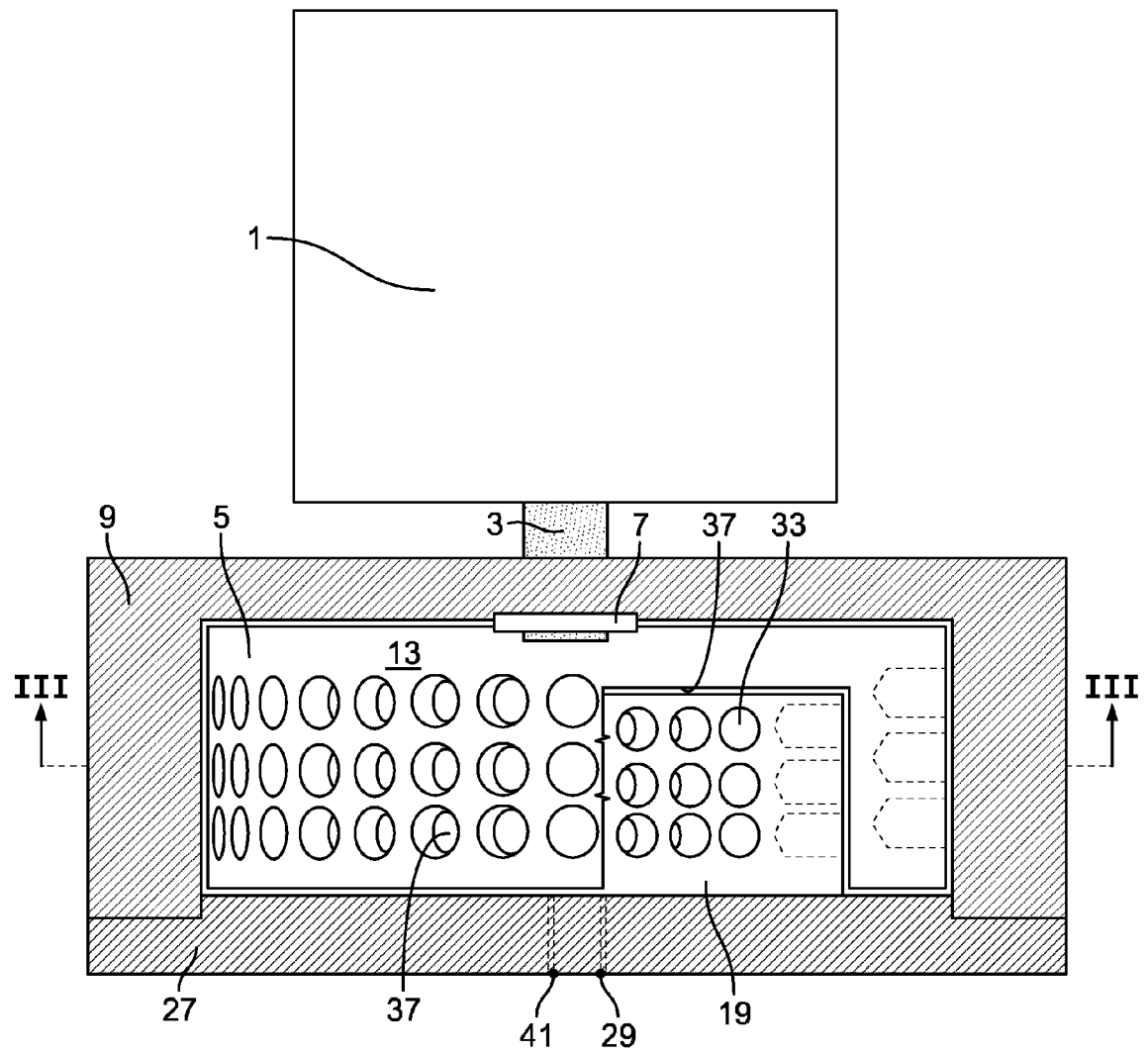


FIG. 2

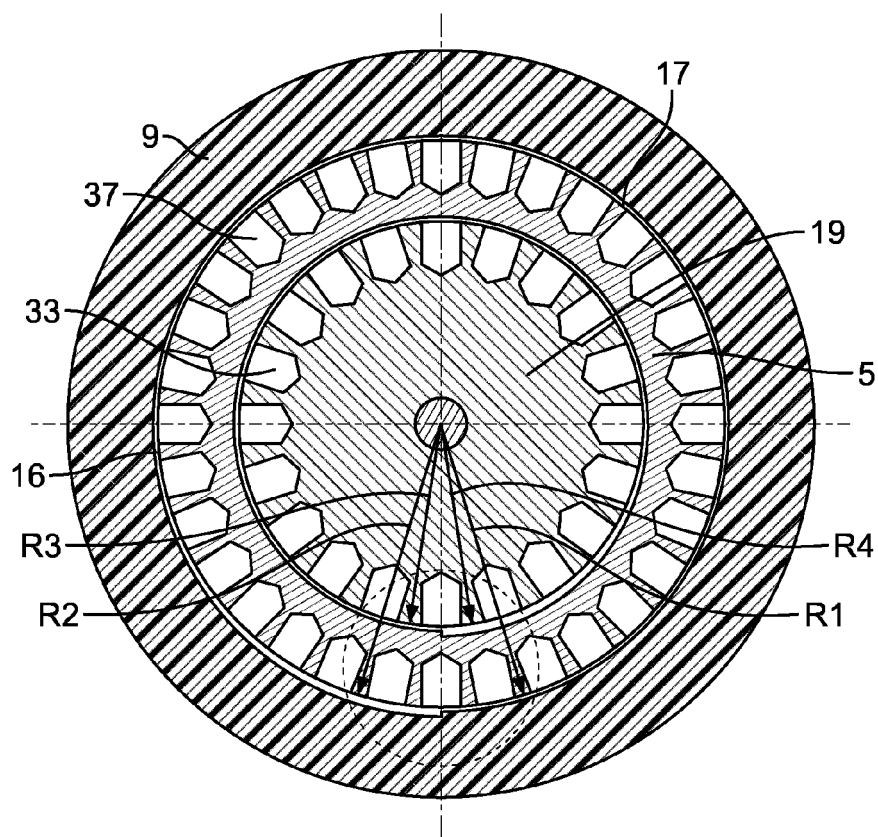


FIG. 3

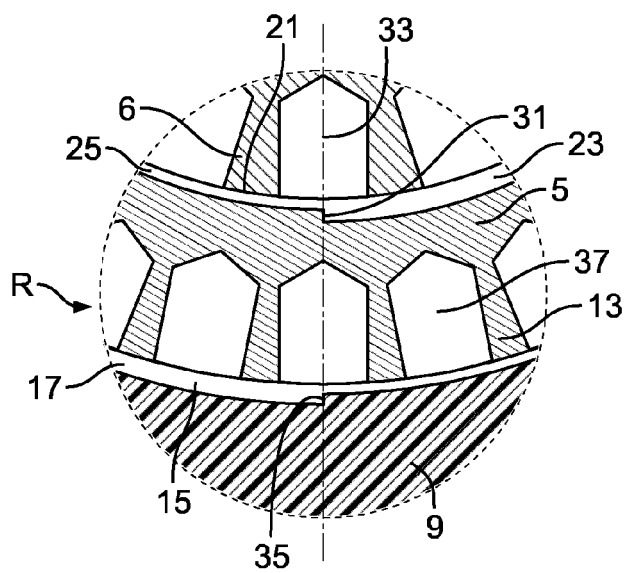


FIG. 4

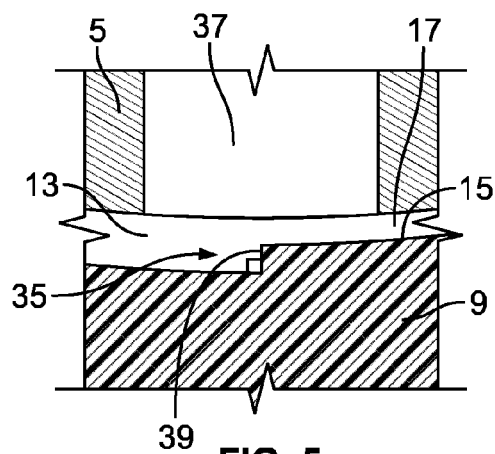


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 14 16 0593

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2012/164322 A1 (FABIAN JOZSEF [HU]) 6 December 2012 (2012-12-06)	1,3-10	INV. F24J3/00
Y	* page 4, line 23 - page 5, line 17; figures 1,2,3,3a * * page 5, line 27 - page 6, line 12; figures 9, 9a * * page 6, line 20 - page 7, line 5; figures 9-11 * * page 1, line 4 - line 10 *	2	
Y	----- KR 101 036 662 B1 (SONG DONG JOO [KR]; KUKBO ENERGY CO LTD [KR]) 25 May 2011 (2011-05-25) * figures 1,2 * -----	2	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F24J
Place of search		Date of completion of the search	Examiner
The Hague		23 July 2015	Mendão, João
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 16 0593

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- US 20100154772 A, Harris **[0005]**