FIG. 2
FIG. 4
Steam output

FIG. 7
FIG. 8
FIG. 10
FIG. 17

High Pressure Water In
APPLICATION

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FOR

LETTERS PATENT OF THE UNITED STATES

FOR

CAVITATION ENGINE

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Attorney Docket: 69935 US
CAVITATION ENGINE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to US Provisional Application No. 62/162,970, filed May 18, 2015, and entitled CAVITATION ENGINE, incorporated herein by reference in its entirety
[0002] The present disclosure relates to cavitation engines. More particularly, the disclosure relates to cavitation engine structures that generate steam from liquid water fed into the engine in a manner that enables improved efficiency to conventional steam generation devices.
BACKGROUND

[0003] Improvement is desired in the construction of engines or the like that generate steam from water fed into the engine. Conventional engines or like devices that convert liquid water to steam are inefficient in terms of their energy use.

[0004] The present disclosure relates to more energy efficient engine structures configured to inject liquid water in a controlled to promote the formation of cavitation bubbles within the injected water, and to impact the injected water onto an impact surface of an impact chamber to crush the cavitation bubbles to generate very high pressure superheated steam that can be used to generate electricity or otherwise harnessed as an energy output.
SUMMARY

[0005] Cavitation engines according to the disclosure are configured to produce high pressure superheated steam from injected liquid water.

[0006] In one aspect, a cavitation engine according to the disclosure includes an impact chamber having an impact surface having a temperature of at least 375 degrees Fahrenheit, and a fluid injector having an outlet positioned to inject hyperbaric liquid water onto the impact surface of the impact chamber at supersonic velocities such that cavitation bubbles are present in the injected water. The outlet of the fluid injector and the impact surface are located relative to one another such that the outlet is spaced a distance from the impact surface of between 0.150 and 0.450 inches and the injected water hits the impact surface at an angle of between 85 and 95 degrees. Impact of the water with the impact surface the crushes the cavitation bubbles in the injected water to generate pressure above 1,000 pounds per square inch and produce superheated steam.

[0007] In another aspect, the cavitation engine according to the disclosure includes a funnel shaped impact chamber having an impact surface having a temperature of at least 375 degrees Fahrenheit, a small diameter opening at a bottom of the impact chamber, and an expansion chamber below the small diameter opening. The engine includes a fluid injector having an outlet positioned adjacent a largest diameter of the impact chamber and located to inject hyperbaric liquid water onto the impact surface of the impact chamber at supersonic velocities such that cavitation bubbles are present in the injected water. The outlet of the fluid injector and the impact surface are located relative to one another such that the outlet is spaced a distance from the impact surface of between 0.150 and 0.450 inches and the injected water hits the impact surface at an angle of between 85 and 95 degrees. The cavitation bubbles in the injected water are crushed by the impact of the injected water onto the impact surface and gases inside the cavitation bubbles rapidly increases in temperature to create superheated steam and pressure. The pressure forces the superheated steam through the small diameter opening of the impact chamber.
brief description of the drawings

[0008] Further advantages of the disclosure are apparent by reference to the detailed description when considered in conjunction with the figures, which are not to scale so as to more clearly show the details, wherein like reference numbers indicate like elements throughout the several views, and wherein:

[0009] FIG. 1 is a perspective view of a cavitation engine according to the disclosure.

[0010] FIG. 2 is a frontal view of the cavitation engine of FIG. 1, with a portion cutaway to show internal details.

[0011] FIG. 3 is a cross-sectional view taken along line A-A of FIG. 2.

[0012] FIG. 4 is a detailed view of a portion of FIG. 3.

[0013] FIG. 5 is a top view of the cavitation engine of FIG. 1.

[0014] FIG. 6 is a bottom view of the cavitation engine of FIG. 1.

[0015] FIG. 7 is a transparent perspective view of the cavitation engine of FIG. 1.

[0016] FIG. 8 is a transparent frontal view of the cavitation engine of FIG. 1.

[0017] FIGS. 9-19 show various cross-sectional and detailed views of the cavitation engine of FIG. 1.

[0018] FIG. 20 is a graph showing operation of a cavitation engine according to the disclosure.
**Detailed Description**

[0019] With reference to the drawings, the disclosure relates to a steam engine, and in particular to a cavitation engine 100. The cavitation engine 100 produces superheated steam by injecting hyperbaric liquid water at supersonic velocities to create cavitation bubbles within the injected water. The water is injected into specially configured, heated impact chambers 102 having impact surfaces 102a configured to crush or collapse the cavitation bubbles.

[0020] It has been discovered that injecting water in a manner that forms cavitation bubbles in the water and impacting the water to crush the cavitation bubbles generates very high pressure superheated steam that can be used to generate electricity or otherwise harnessed as an energy output. The feed water can be ambient temperature, but may be initially heated, but injected as a liquid.

[0021] The impact chamber 102 is advantageously configured to provide a funnel like curvature of the chamber 102 as shown in the drawings that opens towards a fluid injector with the largest dimension closest to the injector. It has been discovered that the described shape and configuration of the impact chamber 102 desirably produces very high water hammer pressure during collision of the water fraction that rapidly crushes the cavitation bubbles.

[0022] The engine 100 and the impact chambers 102 include the following components, as shown in the drawings:

<table>
<thead>
<tr>
<th>Ref. #</th>
<th>Component</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>High pressure fuel rail</td>
</tr>
<tr>
<td>2</td>
<td>Thermocouple probe</td>
</tr>
<tr>
<td>4</td>
<td>Wire to thermocouple probe</td>
</tr>
<tr>
<td>6</td>
<td>Pressure relief valve</td>
</tr>
<tr>
<td>7</td>
<td>Spring for pressure relief valve</td>
</tr>
<tr>
<td>8</td>
<td>Insert for impact chamber 102</td>
</tr>
<tr>
<td>9</td>
<td>Entrance for injector</td>
</tr>
<tr>
<td>12</td>
<td>Piezoelectric injector</td>
</tr>
<tr>
<td>13</td>
<td>Outer shell of impact chamber 102</td>
</tr>
<tr>
<td>14</td>
<td>Pressure regulating plug</td>
</tr>
<tr>
<td>15</td>
<td>Immersion thermocouple probe</td>
</tr>
</tbody>
</table>
Each impact chamber 102 is preferably initially pre-heated to 375 degrees F. Once the engine 100 is operating, the energy supplied for the pre-heating may be ceased, as it has been observed that the temperature of the impact chambers 102 will remain above 375 degrees F due to the operation of the engine 100. For example, the thermocouple probe 2 may be connected to a digital controller for providing the desired pre-heating.

Cavitation will be understood herein to refer to the formation of vapor cavities in a liquid. The vapor cavities are characterized as small liquid-cavitation-free zones in the nature of bubbles or voids that are the consequence of cavitational forces acting upon the liquid. Cavitation occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low. When subjected to higher pressure, as in the case of the cavitation engines according to the disclosure, it has been observed that the voidsimplode or are otherwise crushed and generate an intense shockwave and high pressure.

Thus, it will be understood that engine structures according to the disclosure are configured to receive injected water and to promote cavitation of the injected water to generate very high pressure that can be used to generate electricity or otherwise harnessed as an energy output. That is, the injector 12 injects water in a manner such that bubbles or voids are created in the stream of injected water, referred to herein as cavitation bubbles.

In accordance with the disclosure, and without being bound by theory, it is believed that when the injected water collides with the impact surface 102a of the impact chamber 102, a shock wave occurs and the water is shattered to crush the bubbles and the
water is instantly transformed into superheated steam. That is, the injector 12 operates to form cavitation bubbles in the water and the impact surface 102a cooperate so that cavitation bubbles in the injected water are crushed upon impact of the water with the impact surface 102a.

[0027] Thus, cavitation engines according to the disclosure encompass (1) injecting liquid water in a manner that creates cavitation bubbles, and (2) impacting the water onto an impact surface in a manner that rapidly crushes the cavitation bubbles upon impact. The injected water is desirably substantially saturated with cavitation bubbles. Crushing of the cavitation bubbles in this manner causes the temperature of the gases inside the bubbles to rapidly increase and raise the temperature of the surrounding water and the resulting steam, which creates high pressure superheated steam. The described structures have successfully been operated to inject water in a manner that results in the generation of high pressure superheated steam.

[0028] The superheated steam produced by the collision of the injected liquid water with the impact surface 102a is channeled through a small diameter opening 102b to an enlarged area providing an expansion chamber 102c of the impact chamber 102 (FIG. 13). The pressure relief valve 6 retains the pressure until it exceeds a pre-set spring pressure, at which point the valve 6 permits exit of the pressure which may be routed for further use. For example, the engine 100 may be utilized to power an electric generator or the like.

[0029] For the purpose of example, an uppermost diameter of the impact chamber 102 adjacent the injector 12 is about 1.2 inches. The preferred outside diameter of the small diameter opening for such an impact chamber is 0.150 inches (ratio 0.150/1.2 = 0.125). In addition, it has been observed that it is desirable that the volume of the expansion chamber 102c not exceed the volume of the impact chamber.

[0030] It has been observed that the angle of incidence of the water as it strikes the impact surface 102a and the proximity of the impact surface 102a of the impact chamber 102 to an orifice or outlet 12a of the fluid injector 12 are critical to the functioning of the cavitation engine of the disclosure. The pressure of the water as it is injected and the
orifice size of the outlet 12a also affect the velocity of the injected water. The velocity of the water directly affects the shock wave at the impact surface 102a and the resulting water hammer pressure within the droplet containing the vapor nano bubbles.

[0031] The pressure of the injected water preferably ranges from about 5,000 psi to about 30,000 psi, most preferably about 20,000 psi. Preferred water velocities range from 1,500 meters/second to 2,000 meters/second. In the case of water injected at 20,000 psi, an injector is used having an orifice of 0.005 inches in diameter, and operated to inject pulses of water of 0.295 ml/pulse. Water injected in this manner has a velocity of 1,700 meters/second.

[0032] It has also been discovered that it is desirable that the injection angle of the injector 12a and the angle of the impact surface 102a be configured to cooperate so that the injected water hits the impact surface 102a at an angle \( \theta \) of from about 85 to 95 degrees, and most preferably about 90 degrees (FIG. 18). Thus, for different injectors having a different injection angle, the inclination of the impact surface 102a of the impact chamber 102a is selected so that the injected water hits the impact surface 102a at an angle of about 90 degrees.

[0033] For example, with reference to FIG. 18, there is shown the impact chamber 102 with the injector 12a provided as by a hydraulic injector which injects water at an angle of about 35 degrees. As shown, the impact chamber 102 is thus configured so that the impact surface 102a is at an angle of about 35 degrees so that the injected water represented by line \( W \) hits the impact surface 102a at an angle of about 90 degrees.

[0034] It will be understood that the injected water will be provided in a 360-degree swath and that the impact surface 102a is also a 360-degree surface as it is funnel shaped. However, it will be appreciated that the injected water follows a spray line as represented by the line \( W \) so that the injector 12a is a desired distance from the impact surface 102a as described more fully below.

[0035] In another example, FIG. 19 shows the injector 12a provided as by a Ford piezoelectric diesel fuel injector which injects water at an angle of about 15 degrees.
will be observed, the impact surface 102a is oriented so that the injected water hits the impact surface 102a at an angle of about 90 degrees. As will be observed, the sidewalls of the impact chamber 102 below the impact surface 102 increase in slope to taper the lower end of the chamber 102 to the small diameter opening 102b.

[0036] In regards to the proximity of the outlet of the injector 12 to the impact surface 102a, it will be seen that the injector 12 terminates at the outlet 12a that extends into an upper portion of the impact chamber 102. The outlet 12a is positioned to inject liquid water onto the impact surface 102a. The outlet 12a is desirably located a distance of between about 0.150 - 0.450 inches from the impact surface 102a of the impact chamber 102. This distance of the outlet 12a to the impact surface 102a is represented by the length of the line W in FIGS. 18 and 19.

[0037] It has been observed that greater distances will tend to dissipate the injection stream and the vapor bubbles present in the stream will be lost. It is important that the water injection, which is saturated with cavitation bubbles, impacts the surface with maximum force so that the water hammer pressure crushes the bubbles and releases the energy associated with the bubble collapse.

[0038] It is desirable to maximally collapse these bubbles to obtain the greatest heat energy, which is a function of the cube of the bubble ratio (Radius expanded/Radius collapsed) and product of the pressure ratio. It is believed that this is why the heat observed during operation of the engine is so intense. In this regard, it is believed that an oxyhydrogen covalent separation occurs where temperatures in excess to 3000 degrees C are required to get about 50% disassociation. The impact water hammer pressure drops off exponentially as the distance from the injector orifice increases. The angle of impact also affects the impact pressure. Placing the injector close to the impact surface makes no sense from a combustion engineering view point, but in our case it is important.

[0039] Accordingly, it will be appreciated that the timing, distance and geometry of the impact chamber 102 are critical in desired operation of the engine system and the production of heat. The engine system operates with pressures between about 15000 -
28000 psi. A variety of injector orifice diameters may be used, it being understood that
the pressure and orifice determine the degree of cavitation in the injection stream.

[0040] The timing of the injections also affects the operation of the engine. The water is
desirably injected as discrete pulses. The width of each pulse controls the volume of
water injected. The number of injections per second controls the amount of steam
production per hour in pounds of steam/hour. All of this requires an instant response to
all of the sensors. Accordingly, the impact chamber temperature is controlled to manage
the output steam temperature required by the water prime mover, such as a turbine, rotary
expander, reciprocating steam engine etc. Controlling the volume of steam produced per
second will affect the rotation rate of a steam engine which in turn may be driving a
generator or other device. A computer control system it desirably utilized to monitor and
adjust injection rates and volumes, impact chamber temperatures, generator rpm and
output pressure.

[0041] As noted above, it is believed that cavitation is responsible for the heating which
occurs within the impact chamber. Cavitation occurs within the orifice of the fuel
injector nozzle when the local flow pressure drops below the vapor pressure of the liquid.
As the pressurized and compressed water expands through the orifice the liquid
accelerates. The flow streamlines contract as the liquid ejects from the nozzle and
according to the Bernouilli principle this causes a reduction in the local static pressure
which can become lower than the vapor pressure of the water leading to extensive
cavitation bubble formation. These cavitation bubbles are ejected from the nozzle at
supersonic velocity into the impact chamber. When they collide with the impact surface
102a they are crushed from the pressure.

[0042] Additional cavitation bubbles form as the fluid ejection fraction travels towards
the impact surface 102a as the ambient pressure within the impact chamber is
significantly less than the pressure of the exiting water. The distance from the injector
orifice is critical to the operation of the system and must be between 0.150 and 0.450
inches or the cavitation bubbles will dissipate before hitting the impact chamber wall.
[0043] The water hammer shock wave pressures encountered as the water droplet hits the impact surface 102a can be well in excess of 275 MPa (Mega Pascals). This pressure is more than enough to crush any vapor bubbles which have been formed. The energy released when this phenomena occurs can be in excess of 30,000 degrees K (Kelvin). Since these temperatures are well in excess of that required to obtain molecular hydrogen and oxygen separation in water (temperatures above 3000 degrees C result in 50% molecular separation) a significant portion of the water separates and subsequently combusts releasing heat energy.

[0044] In a preferred embodiment, the engine 100 includes banks of eight impact chambers arrayed together. Without being bound by theory, it is believed that as a result of the crushing of the vapor bubbles, heat is generated via conduction at the point of impact and additional heat is infrared or radiated heat. The use of 310 stainless steel which has a relatively low thermal conductivity for the impact chambers 102 is preferred to absorb the infrared heat. 310 stainless steel at 212 degrees Fahrenheit has a thermal conductivity of 8.0. The 310 stainless steel is also desirable as a material for capturing the radiant heat because it has a relatively low thermal emissivity. Emissivity is a measure of the efficiency in which a surface emits thermal energy. Emissivity is the fraction of energy being emitted relative to that emitted by a thermally black surface having an emissivity value of 1. An emissivity value of 0 represents a perfect thermal mirror. 310 stainless steel treated for furnace service has an emissivity of between about 0.90 to 0.97.

[0045] Ceramic or other insulating material may additionally be used to separate the injector body from the impact chamber to minimize heat loss and to capture heat. The primary loss of heat is through steam exiting from the pressure relief valve. The steam exiting the pressure relief valve is superheat steam and can be used to drive a reciprocating steam engine or a rotary expander type turbine. It has been observed that capture of the radiant heat inside the impact chamber offers significant advantages to the operation of the cavitation engine.
The rotational speed of the steam engine or rotary expander may be controlled as by adjusting the flow of superheat steam from the cavitation engine. This steam output flow is adjusted by varying the injection rate (injections/second) of the individual impact chambers. As additional output power is required, the number of impact chambers used and the injection rate per chamber are varied in real time, according to demand.

A high pressure triplex water pump system may be used to provide high pressure water (> 20,000 psi) to the common rail manifold supplying the fuel/water injectors. The speed of the pump and thus the pressure is regulated by controlling the power flow to a DC electric motor. A control computer monitors the common rail manifold pressure and adjusts the pump speed to maintain this pressure. To minimize power consumption the pump is only run on demand for feedwater to the injectors.

An injector control module is used to supply the 140 V DC power required to fire the piezo type fuel injectors. A central control computer controls the impact chamber electric heaters, the impact chamber injection rate, the feedwater temperature and the cyclical rotation rate of the prime mover (steam engine, steam turbine) driving the power generators.

A cavitation engine according to the disclosure was successfully operated and yielded the pressure results shown in FIG. 20. The engine utilized for the results shown in FIG. 20 utilized a single injector and a single impact chamber. No relief valve was provided and an Omega pressure transducer was utilized to obtain instantaneous pressure readings. Because of the pressures generated, it was difficult to continuously operate the engine due to failure of seals. Thus, tests were kept short (1-2 seconds) while efforts are being made to improve the longevity of the seals.

For the purpose of example, for the operation of the engine for the results shown in FIG. 20, the impact chamber was initially pre-heated to 375 degrees F using an electrical heater, and then power to the heater was turned off once the pre-heating was accomplished. The pre-heated sealed impact chamber and expansion chamber of the engine were under 3 cubic inch, and the freshwater feed water was 160 degrees F. After two seconds of operation, resulting in 10 injections (5 injections per second), the impact
chamber was heated to 575 degrees F and produced pressure of 1,340 PSI. In another test of 3 seconds (5 injections per second), a pressure of 1,950 psi was achieved before the seal failed.

[0051] The results have also been observed to differ based on the salinity of the water. In this regard, it was observed that cavitation increased with seawater (4% salt solution) as compared to fresh water. It is believed that other liquids may be utilized other than water.

[0052] When the injector device is fired pre-heated water is injected at pressures ranging from 20,000 – 25,000 psi. The high pressure drop across the injection nozzle as the water exits to near atmospheric pressure within the impact chamber, tends to accelerate the liquid within the small nozzle holes.

[0053] At the sharp edges inside the nozzle holes, such as the inlet of the nozzle hole, the streamlines are contracted such that the effective cross section of the flow is reduced leading to accelerated velocity of the liquid. According to Bernoulli principle, this causes a reduction in the local static pressure and it can reach values as low as the vapor pressure of the liquid. When the local pressure becomes lower than the vapor pressure of the liquid at local temperatures large numbers of cavitation bubbles form within the injection stream.

[0054] Since the temperature of the ejecting liquid approaches 90 degrees C, the vapor pressure is increased as much as 40 times that of room temperature. This situation further increases the amount of cavitation bubbles forming. Without being bound by theory, it is believed that as the water droplets forming the injection stream travel towards the impact chamber the gas in the cavitation bubbles expands. Upon impact with the chamber wall there is a sudden increase in hydraulic pressure within the droplet due to the water hammer effect. The momentary internal pressures can be on the order of tens of thousands of psi. The collision of the injection droplets with the impact chamber wall causes cavitation bubbles within the droplet to be crushed.
[0055] When the bubbles are forced to a very small diameter by impact, the gas inside the bubble approaches extremely high temperatures, and the bubbles explode and collapse. The temperatures inside these collapsed cavitation bubbles can reach many thousands of degrees K (Kelvin). At these high temperatures the gas becomes a superheated plasma in which the water molecules are reduced to their constituent atomic components less the surrounding electrons. The collective heat from this vast quantity of bubbles can raise the temperature of the surrounding water and resulting steam.

[0056] It has been observed that cavitation engines according to the disclosure have substantially improved efficiency as compared to conventional steam engines, such as conventional external combustion Rankine Cycle steam boilers.

[0057] The foregoing description of preferred embodiments for this disclosure has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments are chosen and described in an effort to provide the best illustrations of the principles of the disclosure and its practical application, and to thereby enable one of ordinary skill in the art to utilize the disclosure in various embodiments and with various modifications as are suited to the particular use contemplated.
THE CAVITATION ENGINE ACCORDING TO THE DISCLOSURE IS FURTHER DESCRIBED BELOW.

1. A cavitation engine configured to produce superheated steam from injected liquid water, the engine comprising:
   
an impact chamber having an impact surface having a temperature of at least 375 degrees Fahrenheit; and

   a fluid injector having an outlet positioned to inject hyperbaric liquid water onto the impact surface of the impact chamber at supersonic velocities such that cavitation bubbles are present in the injected water;

   wherein the outlet of the fluid injector and the impact surface are located relative to one another such that the outlet is spaced a distance from the impact surface of between 0.150 and 0.450 inches and the injected water hits the impact surface at an angle of between 85 and 95 degrees, and

   wherein impact of the water with the impact surface crushes the cavitation bubbles in the injected water to generate pressure above 1,000 pounds per square inch and produce superheated steam.

2. The cavitation engine of claim 1, wherein the injected fluid is injected using injector orifices oriented at such an angle to the impact chamber surface as to produce a nearly perpendicular trajectory.

3. The cavitation engine of claim 1, wherein the impact chamber has a funnel-like curvature opening towards the fluid injector that provides a substantially 90-degree angle of incidence of injected water.

4. The cavitation engine of claim 1, wherein the impact surface is disposed at an angle relative to horizontal of from about 10 degrees to about 45 degrees, and the injector ejects water at an angle such that the injected water hits the impact surface at an angle of about 90 degrees.
5. The cavitation engine of claim 1, wherein the fluid injector injects the water at a pressure of about 20,000 psi or above.

6. The cavitation engine of claim 1, wherein the impact chamber has a volume and includes a small diameter opening at a bottom of the impact chamber and an expansion chamber below the small diameter opening, the expansion chamber having a volume less than the volume of the impact chamber.

7. A cavitation engine configured to produce superheated steam from injected liquid water, the engine comprising:

   a funnel shaped impact chamber having an impact surface having a temperature of at least 375 degrees Fahrenheit, a small diameter opening at a bottom of the impact chamber, and an expansion chamber below the small diameter opening; and
   a fluid injector having an outlet positioned adjacent a largest diameter of the impact chamber and located to inject hyperbaric liquid water onto the impact surface of the impact chamber at supersonic velocities such that cavitation bubbles are present in the injected water;
   wherein the outlet of the fluid injector and the impact surface are located relative to one another such that the outlet is spaced a distance from the impact surface of between 0.150 and 0.450 inches and the injected water hits the impact surface at an angle of between 85 and 95 degrees, and
   wherein the cavitation bubbles in the injected water are crushed by the impact of the injected water onto the impact surface and gases inside the cavitation bubbles rapidly increase in temperature to create superheated steam and pressure, and the pressure forces the superheated steam through the small diameter opening of the impact chamber.
ABSTRACT

A cavitation engine configured to produce superheat steam from injected liquid water. The cavitation engine includes a funnel shaped impact chamber having an impact surface having a temperature of at least 375 degrees Fahrenheit, a small diameter opening at a bottom of the impact chamber, and an expansion chamber below the small diameter opening. The engine includes a fluid injector having an outlet positioned adjacent a largest diameter of the impact chamber and located to inject hyperbaric liquid water onto the impact surface of the impact chamber at supersonic velocities such that cavitation bubbles are present in the injected water. The outlet of the fluid injector and the impact surface are located relative to one another such that the outlet is spaced a distance from the impact surface of between 0.150 and 0.450 inches and the injected water hits the impact surface at an angle of between 85 and 95 degrees. Impact of the water with the impact surface crushes the cavitation bubbles in the injected water to generate pressure above 1,000 pounds per square inch and produce superheated steam.
Application Data Sheet 37 CFR 1.76  Attorney Docket Number  6935.US

Title of Invention  CAVITATION ENGINE

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

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☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

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All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).
Application Data Sheet 37 CFR 1.76

Title of Invention: CAVITATION ENGINE

Attorney Docket Number: 69935.US

Application Number: 69935.US

An Address is being provided for the correspondence Information of this application.

Customer Number: 00408

Email Address: RFOX@LUEDEKA.COM

Application Information:

Title of the Invention: CAVITATION ENGINE

Attorney Docket Number: 69935.US

Small Entity Status Claimed: X

Application Type: Nonprovisional

Subject Matter: Utility

Total Number of Drawing Sheets (if any): 33

Suggested Figure for Publication (if any):

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

<table>
<thead>
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<th>Application number of the previously filed application</th>
<th>Filing date (YYYY-MM-DD)</th>
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Publication Information:

Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Limited Recognition (37 CFR 11.9)

Customer Number: 00408
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This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the “Application Number” field blank.

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Claims benefit of provisional

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX), the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

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Additional Foreign Priority Data may be generated within this form by selecting the Add button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant must opt-out of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is ONLY reviewed and processed with the INITIAL filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. **Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People’s Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. **Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby grants the USPTO authority to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO’s Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

   A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

   B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

   **NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.
Application Data Sheet 37 CFR 1.76  

Attorney Docket Number 69935.US  
Application Number  

Title of Invention  
CAVITATION ENGINE  

Applicant Information:  

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.  

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If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.  

Assignee  
Legal Representative under 35 U.S.C. 117  
Joint Inventor  

Person to whom the inventor is obligated to assign.  
Person who shows sufficient proprietary interest  

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:  

Name of the Deceased or Legally Incapacitated Inventor:  

If the Applicant is an Organization check here.  

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<td></td>
<td>Richard</td>
<td>E.</td>
<td>Aho</td>
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Mailing Address Information For Applicant:  

Address 1  
4170 N.W. 42 Street  
Address 2  

City  
Lauderdale Lakes  
State/Province  
FL  

Country  
US  
Postal Code  
33319  

Phone Number  
Fax Number  

Email Address  

Additional Applicant Data may be generated within this form by selecting the Add button.  

Assignee Information including Non-Applicant Assignee Information:  

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.
## Application Data Sheet 37 CFR 1.76

**Title of Invention**: CAVITATION ENGINE

### Assignee

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Assignee Information" section will appear on the patent application publication as an assignee. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here.  

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### Mailing Address Information For Assignee including Non-Applicant Assignee:

- **Address 1**
- **Address 2**
- **City**
- **State/Province**
- **Country**
- **Postal Code**
- **Phone Number**
- **Fax Number**
- **Email Address**

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

### Signature

**NOTE**: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the “Authorization or Opt-Out of Authorization to Permit Access” section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet must be signed by a patent practitioner if one or more of the applicants is a juristic entity (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, all joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of all joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

**Signature**: /robertofox/  
**Date**: 2016-05-16

**First Name**: Robert O.  
**Last Name**: Fox  
**Registration Number**: 34165

Additional Signature may be generated within this form by selecting the Add button.
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This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.
Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency’s responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.
DECLARATION
As a below named inventor, I declare that this declaration is directed to the patent application entitled

CAVITATION ENGINE

having application serial number ____________ , filed on ____________ (the Application). The Application was made or authorized to be made by me. I believe that I am the original inventor or an original joint inventor of a claimed invention in the Application. I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 USC §1001 by fine or imprisonment of not more than five years, or both. I grant authority to any receiving intellectual property office to provide access to the Application to any other intellectual property office in which an application claiming priority to the Application is filed.

POWER OF ATTORNEY
I appoint the practitioners associated with the customer number, firm, and practitioner named below as my attorney to prosecute this Application and any other applications based thereon and to transact all business in connection therewith, including to make and receive payments, and request that all correspondence be directed to the customer number or addresses below:

Customer number: 00408--> Luedeka Neely Group, P.C.
Law Firm: Luedeka Neely Group, P.C.
Attn: Robert O. Fox
Mail: PO Box 1871, Knoxville TN 37901 US
Email: RFOX@LUEDEKA.COM
Attorney docket: 69935.US

I grant the above-referenced practitioners the power to insert on this document any further information that may be necessary or desirable to comply with the rules of any relevant governmental office for the recordation of this document.

This document ☐ does ☐ does not include an assignment.

ASSIGNMENT
For good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, I do hereby sell, assign, and transfer to:

Richard E. Aho

and its successors, assigns, and legal representatives (collectively referred to as “Assignee”), the entire worldwide right, title and interest in and to any all inventions that are disclosed in the Application, and in and to the Application and all applications that have been or shall be filed based thereon; and in and to all rights of priority resulting from the filing of such applications. The Assignee may apply for and receive Letters Patent in its own name.

I will carry out in good faith the intent and propose of this assignment; execute all patent applications based on this Application; execute all needed documents; communicate to the Assignee all facts known to me relating to the invention and the history thereof; do whatever is necessary to secure and maintain patent protection for the invention and vest title to the invention and all applications and patents thereon in the Assignee. I have not made any assignment or other encumbrance or agreement affecting the rights and property herein conveyed, and I possess the full right to convey such rights and property.

I hereby authorize the attorneys named herein to accept and follow the instructions of the Assignee as to any action to be taken regarding this Application without direct communication between the attorneys and myself. I hereby waive any right to revoke such power of attorney and appoint substitute attorneys, and grant all such powers to the Assignee.
Richard E. Aho
May 19, 2016
Witness signature
Natalia Aho
Witness name

Witness address
1111 East Sunrise
FT LAUDERDALE
FL 33304

Inventor Residence: 4170 N.W. 42 Street, Lauderdale Lakes, FL 33319
Inventor Mailing Address: 4170 N.W. 42 Street, Lauderdale Lakes, FL 33319
Inventor Citizenship: US
SIGNATURE BLOCK FOR INVENTOR

William Walter Mee
5/12/2016

Witness signature
Bryan Cooper

Witness address
1600 South Federal Hwy
Boca Raton, FL 33433

Inventor Residence:
8591 Pioneer Road, West Palm Beach, FL 33411

Inventor Mailing Address:
8591 Pioneer Road, West Palm Beach, FL 33411

Inventor Citizenship:
US
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### Miscellaneous-Filing:

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The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:
- Charge any Additional Fees required under 37 CFR 1.16 (National application filing, search, and examination fees)
- Charge any Additional Fees required under 37 CFR 1.17 (Patent application and reexamination processing fees)
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**Total Files Size (in bytes):** 4410616
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

**New Applications Under 35 U.S.C. 111**
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

**National Stage of an International Application under 35 U.S.C. 371**
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

**New International Application Filed with the USPTO as a Receiving Office**
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.