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(71) Applicant and

(72) Inventor: **HAASE, Richard, Alan** [US/US]; 4402 Ringrose Drive, Missouri City, TX 77459 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **SMAARDYK, John** [US/US]; 2331 River Rock Trail, Kingwood, TX 77345 (US). **NEWSOM, Frank** [US/US]; 11606 Louetta Road, Houston, TX 77070 (US).

(74) Common Representative: **HAASE, Richard, Alan**; 4402 Ringrose Drive, Missouri City, TX 77459 (US).

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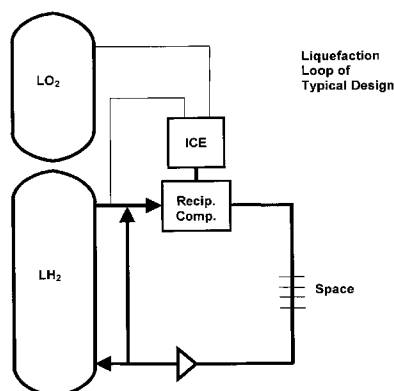
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(54) Title: SPACE ENGINE INCLUDING THE HAASE CYCLE WITH ENERGY RECOVERY COOLING

Space Engine Including The Haase Cycle with Energy Recovery Cooling



(57) Abstract: The instant invention relates to improved methods, systems, processes and apparatus (means) for the combustion of hydrogen (H_2) with oxygen (O_2), wherein the H_2 and O_2 are obtained from at least one storage tank or obtained by electrolysis of water (H_2O). The instant invention is based upon the chemistry of H_2O incorporating H_2 as the fuel and O_2 as the oxidizer. The instant invention relates to combustion, wherein the thermodynamics of the Otto Cycle are improved providing improved combustion efficiency and power output, thereby producing the Haase Cycle. The instant invention relates to means of liquefaction unit for the storage of said H_2 and/or of said O_2 in applications which are at an altitude above the surface of the earth (space applications). Finally, the instant invention relates to applications of producing mechanical or electrical energy, as well as improved H_2 and/or O_2 storage in space applications.

PATENT SPECIFICATION

TITLE: SPACE ENGINE INCLUDING THE HAASE CYCLE WITH
ENERGY RECOVERY COOLING

INVENTORS: RICHARD A. HAASE, JOHN SMAARDYK AND FRANK NEWSOM

Related Application Data

This application claims priority on U.S. Provisional Application 61/004,326 filed
November 26, 2007.

BACKGROUND OF THE INVENTION**Field of the Invention**

The instant invention relates to improved methods, systems, processes and apparatus for
the combustion of hydrogen (H_2) with oxygen (O_2), wherein the H_2 and O_2 are obtained from at
least one storage tank or obtained by electrolysis of water (H_2O). The instant invention is based
upon the chemistry of H_2O incorporating H_2 as the fuel and O_2 as the oxidizer. The instant
invention does not require a hydrocarbon fuel source. H_2O is the primary product of
combustion while in many embodiments of the instant invention, H_2O is separated into H_2 and
 O_2 , thereby making H_2O an efficient method of storing fuel and oxidizer, e.g. potential energy.

Applications of the instant invention include: furnaces, combustion engines, internal
combustion engines, turbine combustion engines, heating or any combustion engine, method, system
or apparatus wherein mechanical, electrical or heat energy is created. The instant invention contains
embodiments wherein Nitrogen (N_2) and Argon (Ar) are partially or totally removed from the fuel
mixture to improve the energy output of combustion.

The discovered instant invention comprises improved combustion thermodynamics, thereby
significantly improving the power and efficiency of combustion. Further, the discovered instant
invention relates to improved combustion wherein H_2O is added to the combustion chamber, thereby
utilizing H_2O during combustion as a heat sink, as well as the resultant steam energy as an energy
source. The discovered instant invention incorporates embodiments wherein the steam produced by
combustion: 1) maintains the power output of combustion, 2) provides method(s) of energy transfer,
3) provides an efficient method of energy recycle, 4) provides power through steam, and 5) cools the

combustion chamber. Steam presents a potential (reusable) energy source, both from the available kinetic and the available heat energy, as well as the conversion of the steam into H_2 and O_2 .

The discovered instant invention relates to generating electricity (electrical energy). Two means of generating electricity are discovered. The first places a steam turbine in the exhaust of a combustion engine of the instant invention, wherein said steam turbine is driven by steam produced in combustion, and wherein said steam turbine turns a generator (the term generator is used herein to define either a generator, an alternator or a dynamo); and wherein at least a portion of said steam energy is converted into said electricity. The second places a generator to receive the mechanical rotating energy output of a combustion engine of the instant invention, wherein at least a portion of said mechanical rotating energy is converted by the generator into electricity.

The instant invention relates to combustion, wherein the thermodynamics of the Otto Cycle are improved providing improved combustion efficiency and power output, thereby producing the Haase Cycle.

The instant invention relates to the combustion of H_2 with O_2 , wherein said combustion powers a liquefaction unit for the storage of said H_2 and/or of said O_2 .

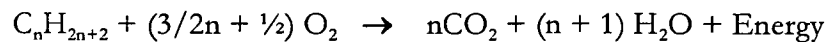
Finally, the instant invention relates to applications of producing mechanical or electrical energy, as well as improved hydrogen and/or oxygen storage in applications which at an altitude above the surface of the earth.

Background of the Invention

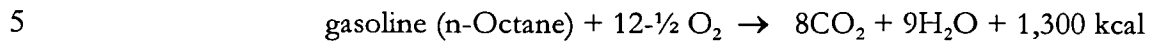
Mankind, has over the centuries, developed many forms of energy, along with many forms of transportation. In the modern economy, energy is needed to literally "fuel" the economy. Energy heats homes, factories and offices, provides electrical power, powers manufacturing facilities, and provides for the transportation of goods and of people. During the 19'th and 20'th centuries, mankind developed fossil fuels into reliable and inexpensive energy sources. Today, fossil fuels are used in transportation, manufacturing, electricity generation and heating. This use has caused the combustion products from fossil fuels to be a major source of air and H_2O pollution.

Fossil fuels (hydrocarbons) are used as a fuel along with air as an oxidant to generate combustion energy. Hydrocarbons are either: petroleum distillates such as gasoline, diesel, fuel oil, jet fuel and kerosene; fermentation distillates such as methanol and ethanol; or natural products such as methane, ethane, propane, butane, coal and wood. However, excess hydrocarbon combustion interferes with nature. The products of hydrocarbon combustion were thought to work in concert with nature's O_2 -carbon cycle, wherein CO_2 is recycled by plant life

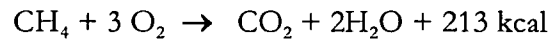
photosynthesis back into O₂. However, excess CO₂, e.g. excess combustion, upsets the environment. The combustion of a hydrocarbon can be approximated by:



More specifically, for gasoline (2, 2, 4 trimethyl pentane or n-Octane):



And, for natural gas (methane):



10 So, oxides of carbon (CO_x, CO and/or CO₂) are produced by the combustion of fossil fuels. It is generally believed among scientists that global warming is a result of a buildup of CO_x in the Earth's atmosphere. While photosynthesis will naturally turn CO₂ back into O₂, man-made production of CO₂ in combination with significant deforestation have left earth's plant life incapable of converting enough of manmade CO₂ back into O₂. This is while CO, an incomplete combustion by-product, is toxic to all human, animal and plant life.

15 In addition, hydrocarbon combustion with air creates NO_x (NO, NO₂ and NO₃); NO_x retards photosynthesis, while being toxic to all human, animal and plant life. This is while the formation of NO_x is endothermic, thereby lessening combustion efficiency. Once formed, NO_x further reacts with O₂ in the air to form ozone (O₃). O₃ is toxic to all human, animal and plant life. O₃ does protect the earth in the upper atmosphere from harmful U/V radiation; however, at the surface, O₃ is toxic to all life.

20 There have been many previous attempts to produce a combustion engine that would operate with H₂ as the fuel and air as the oxidant. Those attempts had as difficulties: higher combustion temperatures, reduced available torque, increased NO_x formation, a lack of H₂ storage capacity, excessive heat and cost of operation. Jet propulsion applications with H₂ as the fuel have had as difficulties: high combustion temperatures, lack of available thrust and a low altitude ceiling, thereby limiting jet propulsion use to kerosene. This is while, as compared to kerosene, H₂ has about
25 three times the available combustion energy per pound.

Previous and current attempts to produce a fuel cell that would operate on H₂ and air or O₂, as well as on a hydrocarbon and air demonstrate limitations. The capital investment to power output ratio for fuel cells is 300 to 500 percent of that for traditional hydrocarbon combustion.
30 The available power and/or torque to engine mass available from a fuel cell are much lower than that of a combustion engine. Also, the maintenance requirement of fuel cells is 100 to 300 percent of that for a combustion engine.

Prior to this instant invention, previous work in the Water Combustion Technology (WCT) and the Haase Cycle is referenced herein in U.S. Application 10/790,316, PCT/US 03/11250, PCT/US 03/41719 and PCT/US06/048057.

Previous work to develop a combustion engine prior to the WCT and the Haase Cycle that would operate on fuel(s) other than hydrocarbon(s) is referenced herein in US 2,406,605; US 3,459,953; US 3,884,262; US 3,939,806; US 3,982,878; US 4,167,919; US 4,308,844; US 4,440,545; US 4,599,865; US 4,841,731; US 5,775,091; US 5,293,857; US 5,388,395; US 5,782,081; US 5,775,091; US 5,899,072; US 5,924,287; US 6,212,876; US 6,290,184; and US 6,698,183. The closest work to this instant invention is US 4,841,731 and US 6,289,666 B 1. While each of these patents present improvements in combustion technology, each leaves issues that have left the commercialization of such a combustion engine impractical.

Combustion Engine Thermodynamics – Much has been much done mechanically and chemically to combat the environmental issues associated with hydrocarbon combustion. Often, industrial facilities are outfitted with expensive scrubber systems whenever the politics demand installation and/or the business supports installation. As another example, the internal combustion engine has been enhanced significantly to make the engine more fuel efficient and environmentally friendly. However, even with enhancement, the internal combustion engine is only approximately 20 percent efficient and the gas turbine/steam turbine system is only approximately 20 to 40 percent efficient. The internal combustion engine loses as a percentage of available energy fuel value: 1) approximately 35 percent in the exhaust, 2) approximately 35 percent in cooling, 3) approximately 9 percent in friction, and 4) approximately 3 percent due to combustion performance, leaving the engine approximately less than 20 percent efficient.

An internal combustion engine produces power to perform work as a result of a complex series of interactions among “*Billions and billions* of molecules on a microscopic scale.” (quoting Carl Sagan) Thermodynamics is a branch of engineering, chemistry and physics that allows one to reduce this chaotic process to a relatively simple system based on the behavior of these molecules in the aggregate or, in other words, on a macroscopic scale.

For example, each molecule of a gas flies around with a speed that is a function of its particular temperature. Thermodynamics allows one to assign a single temperature to an entire volume of gas molecules based on the average temperature of all the molecules. Other macroscopic variables used to describe the behavior of a gas are the pressure within the enclosing container, the volume of the container and the number of molecules of gas present. The relationship between these variables can be approximated by the ideal gas law:

$$PV = nRT$$

where P , V and T are the absolute pressure, volume and absolute temperature, respectively. N (n) is the number of moles of gas (1 mole = 6.023×10^{23} molecules) and R is the universal gas constant (0.0821 liter-atmosphere/mole-K).

There are three basic laws of thermodynamics. The first, called the zeroth, law states that if object A is in thermal equilibrium with object B and object B is in thermal equilibrium with object C then object A and object C will also be in thermal equilibrium. This law is the basis of thermometry in which a thermometer can be used to compare the temperature of one object with another.

The next law, which is called the first law in the traditional numbering scheme, states that the change in the internal energy of a system is equal to the sum of the heat transferred from the system, the entropy transferred from the system and the amount of work done by the system. In other words, any thermal energy transferred into a system can be used to change the internal energy of that system (by changing its temperature) or to perform external work. This is a statement of the law of conservation of energy for thermal processes.

The final law, the second, essentially says that any heat engine cannot convert all of the energy put in to it to useful work. There will always be some waste heat left over.

A system's temperature is a measure of its internal energy. If heat is added to a volume of gas molecules and the system does not perform any external work the relationship between the heat added and the temperature can be described by:

$$Q = nC_V \Delta T \quad \text{or} \quad Q = nC_P \Delta T,$$

wherein: Q is the amount of heat transferred, n is the number of moles of gas present, ΔT is the temperature change, and C_V as well as C_P are called the specific heat at constant volume and the specific heat at constant pressure, respectively, which depend on the type of gas. The first equation applies if the process takes place without a change in volume (a constant volume or isochoric process) and the second equation applies if the process takes places at constant pressure (a constant pressure or isobaric process).

The work done by a system can be found by multiplying the component of the force exerted in the direction of motion times the distance moved. For more complex systems where the force may not be constant the work can be calculated using calculus by integrating the following equation:

$$dW = Fdx,$$

wherein: dW is the increment of work, F is force and dx is the incremental distance moved. For a machine consisting of a piston in a closed cylinder the force exerted against the piston is given by the product of the pressure in the cylinder, P , and the area of the piston, A , e.g.

$$dW = PAdx .$$

Note that the term Adx is just the amount the volume of the closed cylinder changes when the piston moves a distance dx so the equation can be rewritten as:

$$dW = PdV .$$

In order to integrate this equation it is necessary to know the relationship between pressure and volume for the process. Such relationships can be displayed on a P-V diagram which is a plot with P as the vertical axis and V as the horizontal axis. There are a number of standard P-V processes illustrated on Figure 2. The solid black line represents an isothermal expansion from 1 liter to 5 liters. The equation describing this curve is the ideal gas law:

$$PV = nRT ,$$

wherein: P is the absolute pressure, V the volume, n is the number of moles of gas present, R is the universal gas constant and T is the absolute temperature. Isothermal means that the temperature is constant during the process. The work done by the system during the expansion can be calculated by integrating the work equation with the P replaced by a function of V from the governing ideal gas law:

$$W = \int PdV = nRT \int_1^5 \frac{1}{V} dV .$$

Notice that this integral represents the area on the P-V diagram that lies under the isothermal curve.

The gray curve represents an adiabatic expansion from 1 to 5 liters. Adiabatic means that no heat is transferred during the process. Notice that the adiabatic curve is steeper than the isothermal curve. The relationship between pressure and volume for an adiabatic curve is given by the following equation:

$$PV^\gamma = \text{constant}$$

where, γ is the ratio of specific heat at constant pressure to the specific heat at constant volume (C_p/C_v) for the contained gas with a typical value of 1.4 for the types of gases involved in gasoline combustion engines. Generally, an isothermal process occurs slowly so heat can be transferred into or out of the system to maintain the constant temperature. An adiabatic process, by contrast, generally occurs rapidly so heat does not have a chance to flow.

The dotted black line describes an isobaric (constant pressure) process. The work done during this process is simply:

$$W = P \times (V_f - V_i)$$

The final dotted grey line represents an isochoric (constant volume) process. Since the area under this curve is zero no work is done.

Figure 3 represents a cyclic process for a theoretical system called a Carnot engine. Path a to b is an isothermal compression at 400K. Path b to c is an adiabatic compression. Path c to d is an isothermal expansion at 600K and d back to a is an adiabatic expansion. The four paths define a closed path in P-V space. The enclosed area is the net work performed by the engine for each completed cycle around the clockwise path described. If the path had been in the counter clockwise direction the net work would have been negative.

Figure 4 presents the Otto Cycle, which approximates the operation of a gasoline-powered internal combustion engine. Path a to b represents the intake stroke during which the air-fuel mixture is drawn into the cylinder as the piston moves outward. This process occurs at roughly atmospheric pressure (assuming a normally aspirated engine). Next, the intake valve closes and the piston moves inward compressing the mixture along the path from b to c. This is an adiabatic process since it happens fairly quickly. Work is done on the gas and its internal energy increases.

At the end of the compression stroke the mixture is ignited and the pressure increases rapidly along the path from c to d. This process happens very quickly and is essentially a nearly pure isochoric (constant volume) process. No work is done during this process so the heat of combustion goes entirely into raising the internal energy of the constituent gases. The power stroke is next and is an adiabatic expansion from d to e. During this process the system does external work and the internal energy decreases. At the end of the power stroke the exhaust valve is opened and the exhaust gases escape very quickly in what is essentially another isochoric process moving along path e to b. Finally, the piston again moves inward forcing out the remaining exhaust gases at atmospheric pressure along the path b to a. And the cycle repeats...

The net work performed by the Otto Engine is given by the area enclosed by the four paths b to c to d to e to b. The work done during the intake and exhaust strokes (the areas under paths a to b and b to a) cancel each other.

A Hypothetical Gasoline Engine - Let us consider the following hypothetical gasoline engine in order to put some actual numbers to the Otto cycle described previously. Let us have 6 cylinders with 100 mm bore and 78.9 mm stroke and a compression ration of 10; then:

1. Compression

During the compression stroke:

$$\text{Engine displacement} = \pi \cdot \left(\frac{\text{bore}}{2} \right)^2 \cdot (\text{stroke}) \cdot (\# \text{ of cyls.})$$

$$\text{Displacement per cylinder} = \pi \cdot (50 \text{ mm})^2 \cdot (78.9 \text{ mm}) = 620 \text{ cm}^3 \quad (0.62 \text{ l})$$

$$\text{Compression ratio} = c.r. = \frac{\text{displacement} + \text{dead space}}{\text{dead space}}$$

5 The dead space (volume remaining when the piston is fully inserted) can be calculated from the following equation:

$$c.r. = 10.0 = \frac{620 + d.s.}{d.s.} \rightarrow 69 \text{ mm}^3 \quad (0.069 \text{ l})$$

For simplicity, $0.069 \text{ L} \approx 0.070 \text{ L}$ for the dead space.

10 The number of moles of gas (air and gasoline vapor) in the cylinder at the beginning of the compression stroke from the ideal gas law.

$$n = \frac{P \cdot V}{n \cdot R}$$

$$n = \frac{(1.0 \text{ atm}) \cdot (0.69 \text{ l})}{(0.0821 \text{ l} \cdot \text{atm} / \text{mole} \cdot \text{K}) \cdot (300 \text{ K})} = 0.0280 \text{ moles}$$

15 The pressure in the cylinder at the end of the compression stroke (P, V) can be calculated from the pressure and volume at the beginning of the compression stroke (P_0 , V_0) as follows:

$$P \cdot V^\gamma = \text{constant} = P_0 \cdot V_0^\gamma$$

$$P = P_0 \cdot \left(\frac{V_0}{V} \right)^\gamma$$

$$P = (1.0 \text{ atm}) \cdot \left(\frac{0.690 \text{ l}}{0.070 \text{ l}} \right)^{1.4} = 24.6 \text{ atm}$$

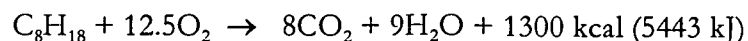
The temperature after compression is given by the ideal gas law:

$$T = \frac{PV}{nR} = \frac{(24.6 \text{ atm}) \cdot (0.070 \text{ l})}{(0.028 \text{ moles}) \cdot (0.0821 \text{ l} \cdot \text{atm} / \text{mole} \cdot \text{K})} = 749 \text{ K}$$

The resulting curve is shown in Figure 5.

20 2. Combustion

The chemical reaction between gasoline and air can be simplified as follows:



Just prior to combustion there are 0.0280 moles of gas present in the cylinder. This gas is a mixture of gasoline vapor, O_2 and N_2 . The O_2 and N_2 came from air which is approximately 21% O_2 and 79% N_2 . The ratio of gasoline vapor to O_2 is given in the above equation. So a single equation can relate the relative amounts of all three gases present. If x represents the number of moles of air in the cylinder, then:

$$\text{moles of } N_2 = 0.79 \cdot x$$

$$\text{moles of } O_2 = 0.21 \cdot x$$

$$\text{moles of } C_8H_{18} = \frac{1}{12.5} \cdot 0.21 \cdot x$$

The total number of moles is 0.0280 so x can be determined from the following equation:

$$\frac{1}{12.5} \cdot (0.21) \cdot x + (0.21) \cdot x + (0.79) \cdot x = 0.0280 \text{ moles}$$

The result is 0.0275 moles of air. Inserting this value of x in the previous series of equations yields: 0.0005 moles of C_8H_{18} , 0.0058 moles of O_2 and 0.0218 moles of N_2 . From the chemical equation describing the combustion of gasoline and the number of moles of reactants we can calculate the number of moles of each of the reaction products. Each 12.5 moles of O_2 produces 8 moles of CO_2 and 9 moles of H_2O .

$$(0.0058 \text{ moles } O_2) \cdot \frac{8 \text{ moles } CO_2}{12.5 \text{ moles } O_2} = 0.0037 \text{ moles } CO_2$$

$$(0.0058 \text{ moles } O_2) \cdot \frac{9 \text{ moles } H_2O}{12.5 \text{ moles } O_2} = 0.0042 \text{ moles } H_2O$$

Since one mole of gasoline reacting with O_2 yields 5443 kJ, the above reaction of 0.0005 moles will yield 2.5 kJ of energy. No work is done during this process so the first law of thermodynamics requires this energy to be stored as internal energy of the reaction products which will raise their temperatures in proportion to the number of moles present and the specific heats of each gas. The heat capacities (in this case the molar-specific heats at constant volume) and number of moles (from the above formula) are as follows:

Gas	Number of Moles	Heat Capacity	Units
N_2	0.0218	25.8	J/mole-K
CO_2	0.0037	40.8	J/mole-K
H_2O	0.0042	37.0	J/mole-K

The temperature rise can then be calculated using the following equation:

$$Q = n_{N_2} \cdot C_{V,N_2} \cdot \Delta T + n_{CO_2} \cdot C_{V,CO_2} \cdot \Delta T + n_{H_2O} \cdot C_{V,H_2O} \cdot \Delta T$$

Rearranging the equation to solve for ΔT and inserting appropriate values:

$$\Delta T = \frac{Q}{\left(n_{N_2} \cdot C_{V,N_2} + n_{CO_2} \cdot C_{V,CO_2} + n_{H_2O} \cdot C_{V,H_2O}\right)}$$

$$\Delta T = \frac{2.5 \text{ kJ}}{(0.02176 \cdot 25.8 + 0.00368 \cdot 40.8 + 0.00414 \cdot 37.0)} = 2891 \text{ K}$$

$$T = 749 \text{ K} + 2891 \text{ K} = 3640 \text{ K}$$

The pressure at the end of combustion can be calculated using the ideal gas law:

$$Pressure = \frac{n \cdot R \cdot T}{V}$$

$$Pressure = \frac{(0.02958 \text{ moles}) \cdot (0.0821 \text{ l} \cdot \text{atm} / \text{mole} \cdot \text{K}) \cdot (3640 \text{ K})}{0.070 \text{ l}} = 126.3 \text{ atm} \quad (1856 \text{ psi})$$

The increase in pressure from 24.6 atm to 126.3 atm, at C_v , is plotted in Figure 5.

3. Expansion

Having computed the pressure at the beginning of the expansion stroke (and knowing the volume) it is possible to calculate the pressure as a function of volume during the adiabatic expansion:

$$P = P_0 \cdot \left(\frac{V_0}{V}\right)^\gamma$$

$$P = (126.3 \text{ atm}) \cdot \left(\frac{0.070 \text{ l}}{V}\right)^{1.4}$$

This line is plotted in the grey line on the P-V diagram.

4. Exhaust

The exhaust stroke is plotted in Figure 5.

5. Work Performed

Work is only done by (or on) the system during the adiabatic processes (when the piston is actually moving) which can be calculated as follows:

$$W = \int P \cdot dV$$

$$P \cdot V^\gamma = P_0 \cdot V_0^\gamma$$

$$W = \int P_0 \left(\frac{V_0}{V}\right)^\gamma \cdot dV$$

$$W = \frac{P_0 \cdot V}{1 - \gamma} \left(\frac{V_0}{V}\right)^\gamma \bigg|_{V_i}^{V_f}$$

Values for evaluating this integral are:

Parameter	Compression	Expansion	Units
P_0	1.0	126.3	atm ¹
$V_0 (V_i)$	0.690	0.070	L ²
V_f	0.070	0.690	L
Work	-2.58	13.25	L-atm

1 – atm = atmosphere of pressure; 2 – L = Liter of volume

The work done during the expansion is 13.25 L-atm and the work done during the compression is –2.58 L-atm. The net work performed during each cycle is 10.67 L-atm (1.08 kJ).

6. Total horsepower

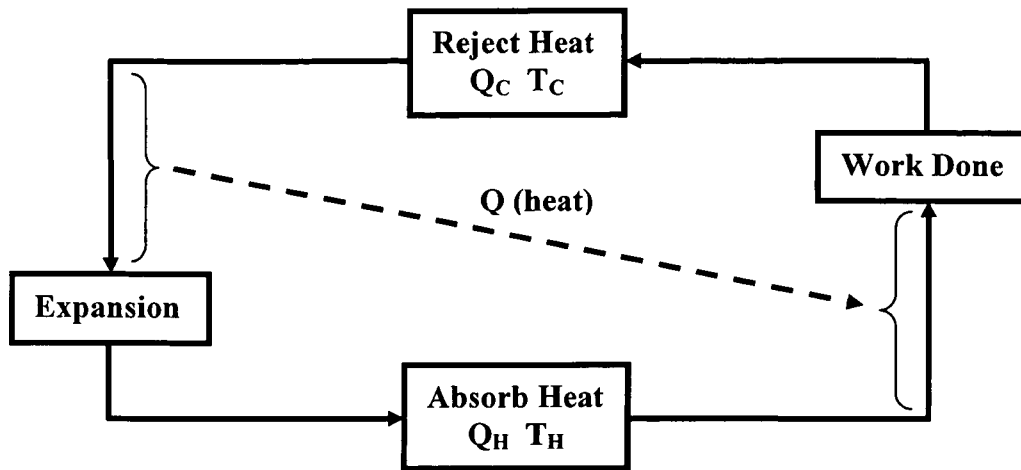
For a typical automobile traveling at 60 MPH the engine speed is approximately 3000 rpm or 50 revolutions per second. Since a four stroke cylinder has a power stroke only every other revolution it will be firing at a rate of 25 power strokes per second. A six-cylinder engine will have 150 power strokes per second. Thus, the total power will be:

$$(150 \text{ power strokes} / \text{sec}) \cdot (1.08 \text{ kJ} / \text{stroke}) / 0.746 \text{ kW} / \text{hp} = 217 \text{ hp}$$

However, there are a whole host of effects that take this energy away such as friction, inefficient combustion, heat losses, entropy losses and accelerating inertial masses. This can easily take up 80 to 85% of the power leaving only about 35 to 45 hp delivered to the rear wheels (at 60 MPH).

Liquefaction - Liquefaction incorporates cryogenic refrigeration, wherein there are many known methods of cryogenic refrigeration. A good reference of cryogenic refrigeration methods and processes known in the art would be “Cryogenic Engineering,” written by Thomas M. Flynn and printed by Dekker. As written by Flynn, “cryogenic refrigeration and liquefaction are the same processes, except liquefaction takes off a portion of the refrigerated liquid which must be made up, wherein refrigeration all of the liquid is recycled. All of the methods and processes of refrigeration and liquefaction are based upon the same basic refrigeration principals, as depicted in Flow Diagram 1.

As written by Flynn, there are many ways to combine the few components of work (compression), rejecting heat, expansion and absorbing heat. There exist in the art many methods and processes of cryogenic refrigeration, all of which can be adapted for cryogenic liquefaction. A listing of those refrigeration cycles would include: Joule Thompson, Sterling, Brayton, Claude, Linde, Hampson, Postle, Ericsson, Gifford-McMahon and Vuilleumier. As written by Flynn, “There are as many ways to combine these few components as there are engineers to combine them.” (It is important to note, as is known in the art, that H₂ has a negative Joule-Thompson coefficient until temperatures of approximately 350 R or less are obtained.)



Flow Diagram 1

While it is well known in the chemical industry that the cryogenic distillation of air into O₂, N₂ and Ar₂, cryogenic distillation is the most economical pathway to produce these elemental diatomic gases. Previous work performed to separate air into its components is herein referenced in US 4,112,875; US 5,245,832; US 5,976,273; US 6,048,509; US 6,082,136; US 6,298,668 and US 6,333,445.

Steam Conversion - The discovered instant invention relates to producing H₂ from steam, since steam is the physical state of the H₂O product from combustion. Previous work in this field has focused on refinery or power plant exhaust gases; none of that work discusses the separation of steam back into H₂. Previous work performed to utilize the products of hydrocarbon combustion from an internal combustion engine can be referenced in US 4,003,343. Previous work in corrosion is in the direction of preventing corrosion instead of encouraging corrosion, yet is herein referenced in US 6,315,876, US 6,320,395, US 6,331,243, US 6,346,188, US 6,348,143 and US 6,358,397.

Electrolysis - The discovered instant invention relates to electro-chemically converting H₂O into O₂ and H₂. While there have been improvements in the technology of electrolysis and there have been many attempts to incorporate electrolysis with a combustion engine, wherein the hydrocarbon fuel is supplemented by H₂ produced by electrolysis, there has been no work with electrolysis to fuel a combustion engine wherein electrolysis is a significant source of O₂ and H₂. Previous work in electrolysis as electrolysis relate to combustion systems is herein referenced in US 6,336,430, US 6,338,786, US 6,361,893, US 6,365,026, US 20 6,635,032 and US 4,003,035.

Electricity - The discovered instant invention relates to the production of electricity. The mechanical energy to turn a generator (again, a generator means a generator, alternator or dynamo) is produced by the instant invention. This is while the steam energy for a steam driven generator

may be produced by the instant invention; instant invention exhaust steam energy may drive a steam turbine, thereby turning a generator to create an electrical current.

The discovered instant invention presents a combustion turbine, wherein the exhaust gas is at least primarily if not totally H_2O . While there has been much work in the design of steam turbines, in all cases steam for the steam turbine is generated by heat transfer, wherein said heat for heat transfer is created by nuclear fission or hydrocarbon combustion. Previous work in steam turbine generation technology and exhaust turbine technology is herein referenced in: US 6,100,600, US 6,305,901, US 6,332,754, US 6,341,941, US 6,345,952, US 4,003,035, US 6,298,651, US 6,354,798, US 6,357,235, US 6,358,004 and US 6,363,710, the closest being US 4,094,148 and US 6,286,315 B1.

The discovered instant invention relates to photovoltaic means to create electricity, wherein said electricity is used in electrolysis to create at least one of H_2 and O_2 from H_2O , and wherein said H_2 and/or said O_2 is used as a fuel in said instant invention. There are many means of photovoltaics, as is known in the art. There are many means wherein a photovoltaic cell may be used to create electricity for the electrolytic separation of H_2O into H_2 and O_2 . Previous work in photovoltaic cells in relation to the production of H_2 is herein referenced in: US 5,797,997, US 5,900,330, US 5,986,206, US 6,075,203, US 6,128,903, US 6,166,397, US 6,172,296, US 6,211,643, US 6,214,636, US 6,279,321, US 6,372,978, US 6,459,231, US 6,471,834, US 6,489,553, US 25 6,503,648, US 6,508,929, US 6,515,219 and US 6,515,283.

H_2O Treatment Chemistry - The discovered instant invention relates to methods of controlling corrosion, scale and deposition in H_2O applications. U.S. Patent No. 4,209,398 issued to Li, et al., on June 24, 1980, referenced herein, presents a process for treating H_2O to inhibit formation of scale and deposits on surfaces in contact with the H_2O and to minimize corrosion of the surfaces. The Li, et al. process comprises mixing in the H_2O an effective amount of H_2O soluble polymer containing a structural unit that is derived from a monomer having an ethylenically unsaturated bond and having one or more carboxyl radicals, at least a part of said carboxyl radicals being modified, and one or more corrosion inhibitor compounds selected from the group consisting of inorganic phosphoric acids and H_2O soluble salts thereof, organic phosphoric acids and H_2O soluble salts thereof, organic phosphoric acid esters and H_2O - soluble salts thereof and polyvalent metal salts, capable of being dissociated to polyvalent metal ions in H_2O .

U.S. Patent No. 4,442,009 issued to O'Leary, et al., on April 10, 1984, referenced herein, presents a method for controlling scale formed from H_2O soluble calcium, magnesium and iron impurities contained in boiler H_2O . The method comprises adding to the H_2O a chelant and

H₂O soluble salts thereof, a H₂O soluble phosphate salt and a H₂O soluble poly methacrylic acid or H₂O soluble salt thereof.

U.S. Patent No. 4,631,131 issued to Cuisia, et al., on December 23, 1986, referenced herein, presents a method for inhibiting formation of scale in an aqueous steam generating boiler system. Said method comprises a chemical treatment consisting essentially of adding to the H₂O in the boiler system scale-inhibiting amounts of a composition comprising a copolymer of maleic acid and alkyl sulfonic acid or a H₂O soluble salt thereof; hydroxyl ethylidene, 1-diphosphic acid or a H₂O soluble salt thereof and a H₂O soluble sodium phosphate hardness precipitating agent.

U.S. Patent No. 4,640,793 issued to Persinski, et al., on February 3, 1987, referenced herein, presents an admixture, and its use in inhibiting scale and corrosion in aqueous systems, comprising: (a) a H₂O soluble polymer having a weight average molecular weight of less than 25,000 comprising an unsaturated carboxylic acid and an unsaturated sulfonic acid, or their salts, having a ratio of 1:20 to 20:1, and (b) at least one compound selected from the group consisting of H₂O soluble polycarboxylates, phosphonates, phosphates, polyphosphates, metal salts and sulfonates. The Persinski patent presents chemical combinations which prevent scale and corrosion.

The instant invention relates to methods of storing hydrogen; as hydrogen is a preferred fuel in applications beyond the surface of the Earth, herein after referred to as Space Applications. Hydrogen is preferred as compared to a hydrocarbon in Space Applications; as, hydrogen has near 3 times the available combustion energy per pound as compared to any hydrocarbon; this is while all hydrocarbons have a freezing point which is much higher than hydrogen, and while the temperature in most Space Applications is near 5 to 250 K. As an example, the lightest hydrocarbon, methane, which has the lowest freezing point of any hydrocarbon has a freezing point of 91 K (1 atm), which is in stark contrast to hydrogen, which has a freezing point of 3 K (1 atm). This is while hydrogen has a significant vapor pressure, even at 5 K.

Applicant attended the NASA Exploration Systems Mission Directorate (ESMD) Technology Exchange Conference in Galveston, Texas on 11/14 – 15, 2007, wherein hydrogen boil-off and required fuel cell cleanliness in a dust environment were presented as significant challenges to future space flight to the Moon and Mars, e.g. Project Constellation. It was presented by NASA that the Apollo Program after launch lost near 6 - 10 percent of stored H₂ in a matter of days; said loss was due to H₂ vapor pressure, e.g. H₂ boil-off; this is while lift-off costs are in the range of \$10,000 to \$25,000 per pound. As of the filing of the instant invention, Applicant is efforting work with propulsion and cryogenic storage engineers at NASA to further application of the instant invention in Constellation.

SUMMARY OF THE INVENTION

A primary object of the invention is to devise effective, efficient and economically feasible combustion methods, processes, systems and apparatus in Space Applications, wherein engine power, effectiveness and efficiency are improved.

5 Another object of the invention is to devise effective, efficient and economically feasible combustion means in Space Applications for an internal combustion engine.

Another object still of the invention is to devise effective, efficient and economically feasible combustion means in Space Applications for a turbine combustion engine.

10 Still another object of the invention is to devise effective, efficient and economically feasible combustion means in Space Applications for electrical energy generation.

Further, another object of the invention is to devise effective, efficient and economically feasible means of fuel and oxidizer storage in Space Applications.

15 Still further yet, another object of the invention is to devise effective, efficient and economically feasible combustion means in Space Applications that include H_2 and O_2 , wherein the temperature of combustion is controlled so that economical materials of construction for a combustion engine can be used.

Still further yet also, another object of the invention is to devise effective, efficient and economically feasible combustion means in Space Applications that include H_2 and O_2 , wherein the temperature of combustion is not controlled with a water jacket cooling system.

20 Additional objects and advantages of the invention will be set forth in part in a description which follows and in part will be obvious from the description, or may be learned by practice of the invention.

The instant invention manages energy much more efficiently than the traditional combustion engine, which operates with hydrocarbons and air. This is especially the case with respect to the internal combustion engine (ICE). ICE, generally, loses approximately 60 to 85 percent of available combustion energy in: heat losses from the engine, engine exhaust gases and unused mechanical energy. In contrast, the instant invention recaptures significant energy losses by converting lost energy (enthalpy, entropy and mechanical energy) into potential energy and internal energy. The instant invention generates additional power by utilizing the power of steam to increase engine efficiency while using H_2O and the release of said steam to cool the engine. It is further discovered that this instant invention provides the thermodynamic capability to improve combustion efficiency while providing improved engine performance, wherein said improved engine performance relates to both the produced engine power and the available power produced per cubic inch of engine displacement.

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The discovered instant invention utilizes the energy of combustion of H_2 fuel with O_2 as the oxidizer. The combustion of H_2 with O_2 provides a combustion envelope having attributes which are somewhat different than those for any hydrocarbon. In comparison and contrast, the auto-ignition (combustion without a spark) temperature of H_2 is $585^\circ C$, while that of methane and propane is 540 and $487^\circ C$, respectively. The combustion envelope, by volume, for H_2 in air is near $4 - 75\%$ (air is near $20\% O_2$), while that of methane and propane is near $5.3 - 15\%$ and $2.1 - 9.5\%$, respectively. The explosive regions for H_2 and methane are $13 - 59\%$ and $6.3 - 14\%$, respectively. It has, therefore, been discovered in the instant invention that H_2 provides a combustion envelope which allows for a cooling of combustion and of combustion exhaust gases in the combustion chamber, wherein said combustion envelope is not available with a hydrocarbon.

The combustion product of H_2 and O_2 is H_2O . This combustion reaction is somewhat similar to that of hydrocarbon combustion; however, carbon and nitrogen (from air) are removed from the reaction. The combustion of H_2 with O_2 produces H_2O , which is in stark contrast to the combustion of fossil fuels which produce in addition to H_2O oxides of carbon (CO_x) oxides of N_2 (NO_x) and whenever the hydrocarbon is contaminated with S, oxides of sulfur (SO_x).

The discovered instant invention uses the first and second laws of thermodynamics as an asset. In contrast, hydrocarbon combustion technologies have the first and second laws of thermodynamics as a liability. Specifically:

$$\text{Combustion Energy} = \text{Available Work} + \text{Combustion Losses} + \text{Friction Energy Losses} + \text{Enthalpy Losses} + \text{Entropy Losses} + \text{Potential Energy},$$

which can be rewritten as:

$$\text{Combustion Energy} = \text{Available Work} + \text{Combustion Losses} + \text{Friction Energy Losses} + \text{Heat and Cooling losses} + \text{Exhaust losses} + \text{Potential Energy},$$

And, in the case of most hydrocarbon combustion systems:

$$\text{Combustion Energy} = (15 - 20\%) + (1 - 5\%) + (5 - 15\%) + \approx 35\% + \approx 35\% + 0,$$

leaving only about 15 to 20 % of combustion energy available for work.

In comparison and contrast the discovered instant invention preferably operates with an insulated combustion chamber or engine block and a recycling of exhaust gas energy, thereby redefining the thermodynamics of combustion to be approximated by:

$$\text{Combustion Energy (100\%)} = \text{Available Work} + \text{Friction Energy Losses} + \text{Recycled Energy Losses} + \text{Potential Energy}$$

Therefore, $100\% = (15 \text{ to } 20 \%) + (1 - 5 \%) + (5 - 15 \%) + (5 - 40\%) + \text{Potential Energy}$. And, Potential Energy = 25 - 75 % excluding recycle losses, thereby producing a final engine efficiency of approximately 40 to 90 % by incorporating the available potential energy of recycle. A preferred energy flow diagram for the instant invention is depicted in Figure 6.

5 The instant invention preferably adds H_2O to the combustion chamber, preferably as low steam, at least once during at least one cycle to cool the engine, thereby creating higher pressure steam, and thereby further powering the engine. It is a preferred embodiment of the instant invention within an internal combustion engine to have at least one cycle wherein no fuel (H_2) or oxidizer (O_2) is added to the combustion chamber, wherein H_2O , preferably as steam, is added,
10 wherein the heat of the combustion chamber is transferred into said H_2O thereby cooling said combustion chamber and providing power due to the steam energy created by said heat transfer to said H_2O . It is a preferred embodiment of the instant invention within a turbine to add H_2O as either a low pressure gas (steam) or as a liquid (H_2O) to at least one of the combustion chamber and the steam turbine, wherein the heat of at least one of the combustion chamber and the combustion
15 product (steam) is transferred into said H_2O thereby cooling said combustion chamber and providing power due to the steam energy created by said heat transfer. The capability of the instant invention to provide further power and cooling by the addition of H_2O in at least one cycle other than the combustion cycle in an internal combustion engine or to provide further power and cooling by the addition of H_2O to at least one location in a turbine is herein defined as "Energy Recovery Cooling".

20 Further, instant invention power capability is enhanced by the discovered capability of the instant invention to provide at least one of fuel (H_2) and of oxidizer (O_2) to combustion under pressure. This discovered capability of the instant invention provides a significant power capability which is not practical in a hydrocarbon air induction combustion system. Specifically, a hydrocarbon air induction combustion system must increase rpm to increase power; as, the combustion chemistry within each
25 revolution is limited by the availability of oxidizer, O_2 , in air at atmospheric pressure. In contrast, the discovered instant invention can provide O_2 , as well as H_2 , to combustion under pressure.

The discovered instant invention in a preferred embodiment stores H_2 in a cryogenic state, wherein said cryogenic capability is preferably provided by a liquefaction means powered by an engine of the instant invention. It is it most preferred to store said cryogenic H_2 below its Joule Thompson
30 Curve, thereby causing said H_2 to have a positive Joule Thompson coefficient (JtC) in order to provide further chilling and/or liquefaction of said H_2 . While significantly improving the storage energy per unit volume, chilled or liquefied, H_2 provides a discovered capability to provide H_2 to combustion under pressure. As the discovered instant invention is preferred to provide to combustion under pressure at least one of H_2 and of O_2 , the discovered instant invention presents an engine which can

increase power or available work about independent of rpm, as well as increase power or work directly dependant upon rpm. This discovered capability of the instant invention presents an engine which has a torque curve which is at least partially independent of rpm, or on a diagram of torque vs. rpm, the capability of a vertical or near vertical torque curve or the capability of a torque curve wherein at least one portion of the torque curve is about vertical, e.g. vertical torque curve.

Further yet still, the discovered instant invention in yet another embodiment improves the previously known Otto cycle by the addition of H_2O , preferably as steam, to the combustion chamber during exhaust, thereby cooling the engine during exhaust prior to the next cycle. This addition of water during exhaust has the instant invention the capability of increasing available work, $P \times V$.

Further still yet, as the discovered instant invention in still yet another preferred embodiment can operate "in diesel fashion" due to the auto-ignition temperature of H_2 , which is near $585^\circ C$; the discovered instant invention has the capability to further manage the cycle by the addition of either H_2 (fuel) or O_2 (oxidizer) during combustion. This discovered capability of the instant invention provides the ability of "a slow burn" during the power or expansion portion of the cycle. This slow burn capability of the instant invention is herein termed the "Newsom burn".

And further still yet, as the discovered instant invention has the capability of managing engine power by H_2O addition to cool the engine during the exhaust stroke and/or a cooling cycle, as well as the capability of providing at least one of H_2 and O_2 to combustion during power generation (in the case of an ICE, this would be the power stroke and in the case of a turbine this would be anytime during the combustion of fuel); therefore, the discovered instant invention has the capability of significantly managing and/or manipulating the work (P-V) curves of an engine such that instant invention can manipulate the net work output for each engine cycle relative to conventional internal combustion engines which operate from the Otto Cycle. This capability of managing engine power is depicted in Figures 7 and 8, wherein Figure 7 depicts the preferred embodiment of a two cycle version and Figure 8 depicts a preferred embodiment of a four cycle version; this instant invention variant to the Otto cycle incorporating at least one of: H_2O cooling during exhaust, H_2O cooling during at least one additional cycle and diesel like "slow burn" during power is defined in the instant invention defines a new combustion cycle termed the "Haase Cycle".

Finally, the instant invention has been discovered to provide means of liquefaction for H_2 and/or O_2 storage. In Space Applications, it is of high importance to maintain H_2 fuel mass; this is when H_2 fuel and O_2 oxidizer have significant vapor pressure. As depicted in Figure 18, the instant invention provides means, e.g. method, system process and apparatus, to control H_2 fuel mass storage by means of liquefaction of H_2 vapor from H_2 fuel storage using available H_2 fuel and

available O₂ oxidizer to power an engine of the instant invention, wherein said engine powers at least one compressor for liquefaction of at least one of H₂ fuel and/or O₂ oxidizer.

Brief Description of the Drawings

A better understanding of the present invention can be obtained when the following descriptions of the preferred embodiments are considered in conjunction with the following drawings, in which:

Figure 1 illustrates a legend for Figures 2 through 20.

Figure 2 illustrates a graphical representation of various thermodynamic processes as functions of pressure and volume

Figure 3 illustrates a graphical representation of the work, pressure – volume, diagram of a Carnot Cycle.

Figure 4 illustrates a graphical representation of the work, pressure – volume, diagram for an Otto Cycle.

Figure 5 illustrates a graphical representation of the work, pressure – volume, diagram for an Atypical Gasoline Engine.

Figure 6 illustrates in block diagram form the preferred embodiment of the instant invention as the instant invention applies to ICE.

Figure 7 illustrates a graphical representation of the work, pressure – volume, diagram for a 2 cycle variant of the Haase Cycle.

Figure 8 illustrates a graphical representation of the work, pressure – volume, diagram for a 4 cycle variant of the Haase Cycle.

Figure 9 illustrates a graphical representation of the work, pressure – volume, diagram for a 4 cycle variant of the instant invention.

Figure 10 presents a computer result of a Model, wherein $T_0 = 100$ K, the moles of H₂O range from 0.084 to 0.2521 and the moles of H₂ range from 0.005 to 0.016.

Figure 11 presents a computer result of said Model, wherein $T_0 = 200$ K, the moles of H₂O range from 0.042 to 0.126 and the moles of H₂ range from 0.005 to 0.016.

Figure 12 presents a computer result of said Model, wherein $T_0 = 300$ K, the moles of H₂O range from 0.028 to 0.084 and the moles of H₂ range from 0.005 to 0.016.

Figure 13 presents a computer result of said Model, wherein $T_0 = 400$ K, the moles of H₂O range from 0.021 to 0.063 and the moles of H₂ range from 0.005 to 0.016.

Figure 14 presents a computer result of said Model, wherein $T_0 = 300$ K, the moles of H₂O range from 0.028 to 0.084 and the moles of H₂ range from 0.010 to 0.050.

Figure 15 presents a computer result of said Model, wherein $T_0 = 300\text{ K}$, the moles of H_2O range from 0.028 to 0.084 and the moles of H_2 range from 0.060 to 0.100.

Figure 16 presents a computer result of said Model, wherein $T_0 = 300\text{ K}$, the moles of H_2O range from 0.000 to 0.020 and the moles of H_2 range from 0.060 to 0.10.

Figure 17 presents a computer result of said Model, wherein $T_0 = 300\text{ K}$, the moles of H_2O range from 0.100 to 0.0200 and the moles of H_2 range from 0.060 to 0.010.

Figure 18 presents a flow diagram of the instant invention operating in the configuration of an internal combustion engine. Within figure 18 are depicted two exhaust valves from each of said combustion chamber(s). It is an embodiment to operate the instant invention wherein each combustion chamber exhaust sends steam to a steam turbine, wherein said steam turbine turns at least one of a generator and an alternator, wherein the electricity created by said generator and/or said alternator is sent to an electrolysis unit, wherein the H_2O in said electrolysis unit comprise condensate from the combustion of H_2 and O_2 in said combustion chamber, wherein said electrolysis unit converts said H_2O into H_2 and O_2 for use in said combustion chamber. It is preferred to operate the instant invention wherein the combustion chamber exhaust sends steam to a condenser, wherein the water from said condenser is at least partially used in said combustion chamber. It is most preferred to operate the instant invention wherein the combustion chamber at least partially sends steam to a steam turbine, wherein said steam turbine turns at least one of a generator and an alternator, wherein the electricity created by said generator and/or said alternator is sent to an electrolysis unit, wherein the H_2O in said electrolysis unit comprises condensate from the combustion of H_2 and O_2 in said combustion chamber, wherein said electrolysis unit converts said condensate into H_2 and O_2 for use in said combustion chamber, and wherein steam is at least partially sent to a condenser, wherein the H_2O from said condenser is used in said combustion chamber.

Figure 19 presents a flow diagram of the instant invention operating in the configuration of a steam turbine electrical power plant. It is to be understood that the H_2 fuel and the O_2 oxidizer for combustion in the steam turbine electrical power plant may be obtained from either storage of H_2 and/or O_2 , or creation of H_2 and/or O_2 from the electrolysis of water. In Space Applications, electrolysis of water is preferably performed with electrical energy obtained from photovoltaic cells or steam energy obtained from nuclear reaction.

Figure 20 presents a flow diagram of the instant invention operating means as liquefaction for H_2 storage. It is to be understood that the same liquefaction means can be utilized for O_2 storage.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The timing of the instant invention is significant since humankind is preparing to travel to the Moon and to Mars. Timing of the instant invention is significant as a means is needed to improve H₂ and/or O₂ storage for extended space flight. Timing of the instant invention is significant as a means is needed to provide power to liquefaction means as a means to improve H₂ and/or O₂ storage for extended space flight. Timing of the instant invention is significant as travel to other planets by humanity requires improved power/engine mass ratios in order to improve the effectiveness of payloads to other worlds.

The instant invention utilizes the combustion of H₂ with O₂ to create energy. It is preferred that the methods, process, systems and apparatus of the instant invention produce at least one selected from a list consisting of: rotating mechanical energy, power, torque, and any combination therein. The instant invention utilizes H₂O and/or the environmental temperature within a space application to cool the engine; H₂O is preferably added to the combustion chamber, while utilizing the steam (hot gaseous H₂O) produced during combustion and/or during cooling as a means of energy recycle and/or energy conservation by converting at least a portion of said steam energy into potential energy (fuel) for the instant invention. The combustion chamber is defined herein as a volume wherein combustion takes place or wherein the products of combustion create at least one of: energy, power, torque and any combination therein. Said recycled potential energy is to be at least one of O₂ and H₂.

It is a preferred embodiment that combustion is at least one of: internal combustion, open flame (heating) combustion and turbine combustion, as these applications are known in the art of combustion science.

The Haase Cycle (Depicted in Figures 7 and 8) – It is most preferred that the instant invention combust as a fuel H₂ with O₂ as the oxidant.

It is preferred that the instant invention be insulated to minimize enthalpy losses from the engine block. It is most preferred that the combustion chamber be insulated. It is most preferred that each combustion chamber be insulated, wherein there is at least one combustion chamber. It is preferred that the instant invention operate wherein H₂O is added to the combustion chamber in order to cool and/or manage the temperature of the instant invention combustion chamber and/or engine block. It is most preferred that the instant invention operate wherein H₂O is added to the combustion chamber during at least one of the expansion portion of the cycle and the exhaust portion of the cycle (or at a point in the expansion or exhaust portion of combustion in the case of a turbine) in order to cool and/or manage the temperature of said instant invention. It is most preferred that said H₂O

addition to combustion provide a reduction in combustion temperature to a temperature lower than that which would be obtained without the addition of H_2O to combustion. It is most preferred that said H_2O addition to combustion expands at least one of: the P-V relationship, work, power, energy, torque, and any combination therein available from said instant invention.

5 It has been learned and is preferred in the instant invention that at least one selected from a list consisting of: reducing operating pressure, expanding P-V relationship, increasing available work, increasing available power, increasing available energy and any combination therein, can be performed by operating the instant invention with a Newsom burn. It is most preferred to operate the instant invention, wherein at least one of the H_2 and the O_2 is added
10 during the generation of power (in the case of an internal combustion engine this would be defined as the power stroke). Further, due to the auto-ignition temperature of H_2 , which is approximately 585 ° C, it is most preferred to operate the instant invention without a spark or ignition device; such operation is defined herein defined as “diesel-like fashion.”

It is preferred to operate the instant invention with the addition of H_2O to the combustion
15 chamber during the exhaust stroke and/or to operate in diesel like fashion. It is most preferred to operate the instant invention in the configuration of an internal combustion engine, as is known in the art, wherein the instant invention operates with 2 cycles, as depicted in Figure 7. It is preferred to operate instant invention in the configuration of an internal combustion engine, as is known in the art, wherein the number of cycles is 4, as depicted in Figure 8.

20 It is most preferred that operation of the instant invention be in either diesel like fashion or in diesel like fashion with a slow burn situation by the addition of at least one of H_2 and O_2 , thereby creating a Newsom burn. It is preferred to operate the instant invention wherein at least one of H_2 and O_2 is added to the combustion chamber at a pressure of greater than about 0.1 atmosphere (1 atmosphere being 14.67 psia). It is preferred to operate the instant invention wherein at least one of H_2
25 and O_2 is added to the combustion chamber at a pressure of greater than about 1.0 atmosphere.

Energy Recovery Cooling – It is an embodiment to perform cooling of the combustion chamber of the instant invention wherein H_2O in the form of at least one of a liquid and a gas is added to the combustion chamber at a time before or after combustion. In the case of a turbine, as a turbine spins
30 within a housing comprising 360° and the flame of the combustion chamber is located within at least one point of said 360° of said combustion housing, said H_2O is preferably to be added to at least one point of said 360° of said combustion housing and in such an amount that said H_2O cannot extinguish combustion flame. In the case of an internal combustion engine, it is preferred that said H_2O be added to the combustion chamber during a cycle in which combustion does not occur, thereby cooling said

combustion chamber with said H_2O . (A cycle is herein defined as movement of the piston from top dead center (TDC) to full available piston displacement within the combustion cylinder and returning to TDC.) It is preferred to add said H_2O to the combustion chamber in an internal combustion engine during a cycle in which combustion does not occur; the latent heat of vaporization of H_2O is about 41 kJ/mole, as compared to the heat capacity of steam which is only about 34 J/(mole °K). It is most preferred to add said H_2O to the combustion chamber in an internal combustion engine during a cycle in which combustion does not occur for a number of cycles until a temperature within said combustion chamber is obtained; after which, a combustion cycle is repeated with H_2 and O_2 .

It is preferred that H_2O added to the combustion cylinder of an internal combustion engine be added as near the beginning of the cycle (TDC) as is practical. As is revealed in the instant invention in examples 10 to 23, the available work from steam and the available cooling from adiabatic expansion of steam is directly related to the amount of adiabatic expansion of said steam in combination with the beginning temperature of said steam and the amount of said steam. It is preferred that there be at least one cycle in which H_2O is added to the combustion chamber of an internal combustion engine. The number of cycles adding H_2O to the combustion chamber of an internal combustion engine prior to the next combustion cycle is limited by the available enthalpy (measured as temperature) in the combustion chamber from the previous combustion cycle and the cooling effect of steam during adiabatic expansion of said steam. Depending on the beginning temperature, the amount of H_2O converted to steam and the amount of adiabatic expansion, it is an embodiment that there a number of cycles of Energy Recovery Cooling, wherein said number can be from 1 to 20. It is preferred that H_2O is added to the combustion chamber during at least one cycle or operating time wherein combustion is not performed and the H_2O absorbs enthalpy from the combustion chamber, thereby creating steam energy and cooling the combustion chamber.

It is an embodiment that the materials of construction of the combustion chamber have a high heat transfer coefficient, such as that which is available with metals. Energy Recovery Cooling is most effective when the energy contained within the combustion chamber is easily transferred to the H_2O , thereby creating steam energy. It is an embodiment that the materials of construction of the combustion chamber have a relatively high heat capacity, such as that which is available with metals. As the combustion chamber of the internal combustion engine is inherently inefficient losing near 50 to 80 percent of the energy of combustion to heat and exhaust gases, Energy Recovery Cooling can most effectively improve engine power and efficiency when combustion heat energy, enthalpy, from the previous combustion cycle is stored within the material(s) of construction of the combustion chamber.

Engine Efficiency - The instant invention utilizes electro-chemical pathways to convert H_2O into O_2 and H_2 , wherein the electrical energy for these pathways is obtained from at least one of: cooling the engine, exhaust gas energy, combustion output mechanical energy, photovoltaic energy and the energy of air or H_2O motion. Given that the efficiency of most combustion engines (especially the internal combustion engine) is only approximately 15 to 25 percent (near 20 percent), the instant invention can significantly increase engine efficiency.

It is discovered that the theoretical limit of efficiency for the discovered WCT is approximately limited to the available enthalpy recovery during Energy Recovery Cooling minus friction losses. This theoretical limit presents that the theoretical efficiency limit of the instant invention to be near approximately 60 - 90 percent.

Liquefaction - While liquefaction is commonly used in the chemical industry, liquefaction has not previously been used in Space Application(s), most notably in rocket fuel for rocket propulsion.

It is preferred to power a liquefaction unit with at least one of rotational mechanical energy and electricity. It is preferred that at least a portion of said rotational mechanical energy and/or electricity be generated by an engine of the instant invention. It is preferred that at least a portion of said rotational mechanical energy or electricity be generated by an engine of the instant invention, wherein combustion is cooled by the addition of H_2O to the combustion chamber. It is preferred to perform liquefaction upon at least one of the H_2 and O_2 storage tanks in rocket propulsion with the liquefaction unit located on the rocket.

Cryogenic Storage of H_2 and/or O_2 - It is a preferred embodiment to store at least one of O_2 and H_2 at a temperature of less than $0^\circ C$, herein referred to as cryogenic O_2 and cryogenic H_2 , respectively. It is preferred that said cryogenic O_2 and/or cryogenic H_2 be stored with a refrigeration and/or liquefaction loop. It is preferred that said refrigeration and/or liquefaction loop be powered by the stored cryogenic H_2 and O_2 . It is most preferred that said cryogenic O_2 and/or cryogenic H_2 be stored as a liquid or plasma.

Gel - It is preferred to improve the handling of H_2 by creating a H_2 gel. Said H_2 gel is to be formed by the inclusion of at least one selected from a list consisting of: H_2O , O_2 and methane in said H_2 , wherein said H_2 is in a cryogenic state such that said inclusion is in a frozen crystalline state, thereby causing said H_2 and inclusion to form and behave as a gel. It is preferred to improve the handling of O_2 by creating an O_2 gel. Said O_2 gel is to be formed by the inclusion of at least one selected from a list consisting of: H_2O , and methane in said O_2 , wherein said O_2 is in

a cryogenic state such that said inclusion is in a frozen crystalline state, thereby causing said O₂ and inclusion to behave as a gel.

Insulation – It is preferred to insulate an engine of the instant invention. It is preferred to insulate an engine of the instant invention, wherein said engine is cooled by the addition of H₂O to the combustion chamber.

It is most preferred that said insulation be that as is known in the art. It is preferred that said insulation be located around each combustion chamber to thereby minimize the use of high temperature materials in construction of the instant invention. In the case of an ICE, it is preferred that each combustion chamber (most likely of cylinder type design) be insulated with insulation materials as known in the art of insulation. In the case of an ICE, it is preferred that each combustion chamber (most likely of cylinder type design) be insulated with insulation materials as known in the art of insulation, wherein said insulation materials slow the rate of heat transfer from said combustion chamber via a shape of insulation material which is cylindrical and which surrounds said combustion chamber. In the case of an ICE, it is preferred that each combustion chamber (most likely of cylinder type design) be insulated with insulation materials as known in the art of insulation, wherein the piston contains a layer of insulation to reduce the rate of heat transfer from the combustion chamber into the block of the engine. In the case of an ICE, it is preferred that each combustion chamber (most likely of cylinder type design) be insulated with insulation materials as known in the art of insulation, wherein the head components of said ICE comprise a layer of insulation to reduce the rate of heat transfer from the combustion chamber to said head components or to the surrounding environment. In the case of an ICE, it is preferred that each combustion chamber (most likely of cylinder type design) be insulated with insulation materials as known in the art of insulation, wherein said ICE is cool externally to the touch. In the case of an ICE, it is preferred that each combustion chamber (most likely of cylinder type design) be insulated with insulation materials as are known in the art of insulation, wherein said ICE is externally cool to the touch, wherein the external surface temperature of said ICE is at least about less than 150 ° F. In the case of a turbine, it is preferred that each combustion chamber (most likely of cylinder type design) be insulated with insulation materials as are known in the art of insulation.

It is preferred that ceramic materials are used. A ceramic material is herein defined as a compound comprising at least one metal, other than iron, which forms a crystalline structure, wherein said crystalline structure is formed by heat.

Steam Conversion – It is preferred to convert exhaust gas H₂O, steam, into H₂ utilizing corrosion to chemically convert the steam to H₂. Said corrosion is to utilize the O₂ in the steam to convert at least

one metal to its metal oxide, while releasing H_2 . It is most preferred to produce an electromotive potential in at least one metal to drive the corrosion process for the at least one metal to its metal oxide, while producing H_2 . It is most preferred that said electromotive potential be anodic.

5 **Electrolysis** – It is preferred to electro-chemically convert exhaust gas H_2O into O_2 and H_2 . It is to be understood that under the best of engineered circumstances, the electrical energy required by electrolysis to convert H_2O into O_2 and H_2 will be greater than the energy obtained by the combustion of O_2 and H_2 . However, electrolysis allows for significant improvements in the thermodynamic efficiency of combustion by reclaiming energy which would otherwise be lost.

10 As the installation of a steam turbine in the engine exhaust will create a back pressure situation to the engine, thereby lessening engine power and efficiency, it is preferred that the instant invention include a condenser, thereby evacuating the combustion chamber and minimizing combustion chamber pressure prior to the next combustion cycle. It is most preferred that the condenser for steam exiting the steam turbine and the condenser for the steam evacuating the combustion chamber be the
15 same condenser. It is an embodiment that the condenser for steam exiting the steam turbine be separate from the condenser for the steam evacuating the combustion chamber. It is preferred that make-up H_2O to the instant invention be added to at least one of said condenser(s). It is preferred that the H_2O added to the combustion chamber comprise H_2O from said condenser(s). It is preferred that at least a portion of the H_2O in said condenser(s) be transferred to an electrolysis unit. It is preferred
20 that the H_2O in said electrolysis unit be converted to H_2 and O_2 by electrolysis. It is preferred that at least a portion of said H_2 be used as a fuel in said combustion chamber. It is preferred that at least a portion of said O_2 be used as an oxidizer in said combustion chamber. It is most preferred that the electrical energy of said electrolysis unit be obtained from at least one of an alternator and a generator wherein the power to turn said at least one of an alternator and a generator be obtained from at least
25 one selected from a list consisting of: a steam turbine turned by the exhaust gases (steam) from the combustion chamber(s), a drive shaft turned by the combustion chambers, moving wind energy, moving H_2O energy, and any combination therein.

30 **Electrolysis Electrical Energy** – It is preferred to obtain the electrical energy for electrolysis from at least one method selected from a list consisting of: rotating mechanical energy turning a generator, exhaust gas steam energy turning turbine which turns a generator, light energy via a photovoltaic cell, wind energy (moving air) turning a turbine which turns an electrical generator, and nuclear energy creating steam which turns a turbine which turns a generator, and any combination therein. It is most preferred that said rotating mechanical energy comprise rotating

mechanical energy created by an engine using H_2 as a fuel and O_2 as an oxidizer. It is most preferred that said rotating mechanical energy comprise rotating mechanical energy created by an engine using H_2 as a fuel and O_2 as an oxidizer, wherein said engine is cooled by the addition of H_2O to the combustion chamber.

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Potential Energy/Fuel Generation – It is most preferred that at least a portion of the H_2 and/or O_2 from the electrolysis of H_2O be used in an engine using H_2 as a fuel and O_2 as an oxidizer. It is most preferred that at least a portion of the H_2 and/or O_2 from the electrolysis of H_2O be used in an engine using H_2 as a fuel and O_2 as an oxidizer, wherein said engine is cooled by the addition of H_2O to the combustion chamber.

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Electricity Generation – It is preferred to generate electrical energy, wherein said electrical energy (electricity) is created from a generator, wherein said generator is turned by rotating mechanical energy, wherein said rotating mechanical energy is created by an engine using H_2 as a fuel and O_2 as an oxidizer. It is preferred to generate electricity, wherein said electricity is created from a generator, wherein said generator is turned by rotating mechanical energy, wherein said rotating mechanical energy is created by an engine using H_2 as a fuel and O_2 as an oxidizer, wherein said engine is cooled by the addition of H_2O to the combustion chamber.

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It is a preferred embodiment that said rotating mechanical rotating energy enter a transmission, wherein said transmission engage in a manner that is inversely proportional to the torque and/or work load of the engine, wherein said transmission output mechanical rotating energy turn said generator to create said electrical energy. Said transmission is to be as is known in the art. It is most preferred that said transmission engage a flywheel capable of storing rotational kinetic energy, wherein said flywheel turns said generator.

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It is preferred to generate electricity, wherein said electricity is created from a generator, wherein said generator is turned by a steam turbine, wherein said steam turbine is turned by steam, wherein said steam is created by an engine using H_2 as a fuel and O_2 as an oxidizer. It is preferred to generate electricity, wherein said electricity is created from a generator, wherein said generator is turned by a steam turbine, wherein said steam turbine is turned by steam, wherein said steam is created by an engine using H_2 as a fuel and O_2 as an oxidizer, wherein said engine is cooled by the addition of H_2O to the combustion chamber. It is preferred that said steam turbine(s) be in such a configuration that said steam be the exhaust of said engine. It is preferred that said steam energy be converted into rotational mechanical energy via a turbine to turn said

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generator. It is most preferred that there be at least one steam turbine and that said steam turbine(s) create mechanical energy to turn at least one of said generator(s).

It is preferred to generate electricity by the energy of light using photovoltaic cells, wherein said electricity is used to electrochemically convert H_2O into H_2 and O_2 , and wherein at least one of said H_2 and O_2 is used in the combustion chamber of the instant invention.

It is preferred to generate electricity by nuclear means, wherein said nuclear means is defined herein as the generation of heat energy generated from the radioactive decay of at least one element or the generation of He from H_2 , wherein said heat energy is used to create steam energy, wherein said steam energy is used to turn at least one steam turbine, and wherein said steam turbine turns at least one generator to create said electricity. It is preferred that said electricity is used to electrochemically convert H_2O into H_2 and O_2 , wherein at least one of said H_2 and O_2 is used in the combustion chamber of the instant invention.

It is preferred to generate electricity, wherein said electricity is generated by at least one selected from a list consisting of: photovoltaic cells, moving air, moving H_2O , nuclear means and any combination therein, wherein said electricity is at least partially utilized in an electrolysis unit to convert H_2O to H_2 and O_2 , and wherein at least a portion of at least one of said H_2 and O_2 is used in the combustion chamber of the instant invention.

H_2O Chemistry - H_2O is the most efficient and economical method of storing O_2 and/or H_2 . Electrolysis is the most preferred method of converting H_2O into combustible H_2 and O_2 . Electrolysis is best performed with a dissolved electrolyte in the H_2O ; the dissolved electrolyte, most preferably a salt, will improve conductivity in the H_2O , thereby reducing the required electrical energy to perform electrolysis. It is an embodiment to perform electrolysis upon H_2O that contains an electrolyte. It is preferred to perform electrolysis upon H_2O that contains a salt. It is most preferred to perform electrolysis upon H_2O that contains polyelectrolytes.

However, many dissolved cation(s) and anion(s) combination(s) can precipitate over time reducing the efficiency of electrolysis. Further, as temperature is increased, hard H_2O contaminants may precipitate; therefore, it is preferred to add a dispersant to the H_2O to prevent scale.

Dispersants are low molecular weight polymers, usually organic acids having a molecular weight of less than 25,000 and preferably less than 10,000. Dispersants are normally polyelectrolytes. Dispersant chemistry is based upon carboxylic chemistry, as well as alkyl sulfate, alkyl sulfite and alkyl sulfide chemistry; it is the oxygen (O) atom that creates the dispersion, wherein O takes its form in the molecule as a carboxylic moiety and/or a sulfoxy moiety. Dispersants that can be used in the instant invention which contain the carboxyl moiety comprise at least one selected from a list consisting of:

acrylic polymers, acrylic acid, polymers of acrylic acid, methacrylic acid, maleic acid, fumaric acid, itaconic acid, crotonic acid, cinnamic acid, vinyl benzoic acid, any polymers of these acids and any combination therein. Dispersants that can be used in the instant invention contain the alkyl sulfoxy or allyl sulfoxy moieties include any alkyl or allyl compound, comprise at least one selected from a list consisting of: SO, SO₂, SO₃ and any combination therein. Due to the many ways in which an organic molecule can be designed to contain the carboxyl moiety and/or the sulfoxy moiety, it is an embodiment that any H₂O soluble organic compound containing at least one of a carboxylic moiety and/or a sulfoxy moiety may be added to the H₂O in the instant invention. (This is with the knowledge that not all dispersants have equivalent dispersing properties. Acrylic polymers exhibit very good dispersion properties, thereby limiting the deposition of H₂O soluble salts and are most preferred embodiments as a dispersant. The limitation in the use of a dispersant is in the H₂O solubility of the dispersant in combination with its carboxylic nature and/or sulfoxy nature.)

H₂O is inherently corrosive to metals. H₂O naturally oxidizes metals, some with a greater oxidation rate than others. To minimize corrosion, it is preferred that the H₂O have a pH of equal to or greater than 7.5, wherein the alkalinity of the pH is obtained from the hydroxyl anion. Further, to prevent corrosion or deposition of H₂O deposits on steam turbines, it is preferred to add a corrosion inhibitor to the H₂O. It is an embodiment to utilize nitrogen (N) containing corrosion inhibitors, such as hydrazine, as is known in the art of H₂O treatment.

While corrosion inhibitors are added to H₂O to prevent corrosion, a chelant is preferred to both prevent corrosion and complex, as well as prevent the deposition of, a cation, including hardness and heavy metals. A chelant or a chelating agent is a compound having or forming a heterocyclic ring wherein at least two kinds of atoms are joined in a ring. Chelating is forming a heterocyclic ring compound by joining a chelating agent to a metal ion. Most chelants are polyelectrolytes. It is a preferred embodiment to use a chelant in the H₂O and or the steam to control mineral deposition. It is preferred to add to the H₂O and/or the steam at least one selected from a list consisting of a: phosphate, phosphate polymer, phosphate monomer and any combination thereof. Said phosphate polymers consist of, but are not limited to, phosphoric acid esters, metaphosphates, hexametaphosphates, pyrophosphates and/or any combination thereof. Phosphate polymers are particularly effective in dispersing magnesium silicate, magnesium hydroxide and calcium phosphates. Phosphate polymers are particularly effective at corrosion control. With proper selection of a polymer, along with maintaining an adequate polymer concentration level, the surface charge on particle(s) can be favorably altered. In addition to changing the surface charge, polymers also function by distorting crystal growth.

Operating Pressure Management – An engine recycling exhaust gas energy has the potential to develop unintended operating situations, wherein the operating pressure becomes greater than the design pressure of the equipment employed; any such situation can be a significant safety issue. And, regardless of a safety situation, the recycling of exhaust gas energy from an engine which may operate in a situation of changing exhaust gas conditions, comprises a situation wherein the pressure of said exhaust gas should be managed in order to protect equipment and manage equipment operation. Operating pressure management is to include a pressure management device, herein termed a pressure control device, which may include any type of pressure controller and/or pressure relief device as is known in the art of managing gas pressure. Such devices can include, yet are not limited to: a pressure control valve, a pressure control loop including a valve, a relief valve, a rupture disc and any combination therein. It is an embodiment to provide a pressure control device to an engine using H_2 as a fuel and O_2 as an oxidizer. It is an embodiment to provide a pressure control device to an engine using H_2 as a fuel and O_2 as an oxidizer, wherein said engine is cooled by the addition of H_2O to the combustion chamber. It is an embodiment to provide a pressure control device to an engine using H_2 as a fuel with air as the oxidizer, wherein said air is in excess over that required to perform combustion to limit NO_x formation. It is a preferred embodiment to provide a pressure control device to an engine using H_2 as a fuel and O_2 as an oxidizer, wherein the exhaust gas of said engine comprises steam, and wherein said steam turns a steam turbine. It is a preferred embodiment to provide a pressure control device to an engine using H_2 as a fuel and O_2 as an oxidizer, wherein said engine is cooled by the addition of H_2O to the combustion chamber, wherein the exhaust gas of said engine comprises steam, and wherein said steam turns a steam turbine.

Engine, H_2O and Lubricant Heating – In Space Applications, as the ambient temperature is often below the freezing point of water and of an engine lubricant, it is preferred to provide a means of heating to at least one of: any engine block, engine water and engine lubricant. It is most preferred that said means of heating be accomplished by a heating element powered by a fuel cell and/or of combustion heat energy obtained from the instant invention. It is most preferred that said fuel cell be powered by H_2 and O_2 . It is most preferred that said fuel cell provide said means of heating via a resistive wire type of heating element, as is known in the art. It is most preferred that at least one of said engine block, said engine H_2O and said engine lubricant be insulated from ambient temperature. It is most preferred that said fuel cell be a fuel cell as is known in the art.

Apparatus - Referring to Figure 6, a combustion engine is symbolically shown for receiving as fuel H_2 and as an oxidizer O_2 . Said combustion engine may be of any type, wherein combustion is performed

to generate at least one of: mechanical torque, heat, thrust, electricity and/or any combination therein. It is preferred that said H_2 to the combustion chamber is to have a flow. O_2 flowing to the combustion chamber is to have a flow. There is to be means to measure said H_2 flow and a means to measure said O_2 flow, such that a proportional signal in relation to said flows is sent to a controller from each of said H_2 flow measuring device and said O_2 flow measuring device. H_2 flowing to the combustion chamber is to have at least one flow control valve. O_2 flowing to the combustion chamber is to have at least one flow control valve. Each flow measuring device is to create a flow signal. A controller is to have as input said H_2 flow signal and said O_2 flow signal. Said controller is to receive an input signal from an external source indicating the combustion setpoint. Said controller is to compare said combustion setpoint to said H_2 flow signal and/or to said engine rpm, sending a proportional signal to said H_2 flow control valve that is in proportion to the difference in said combustion setpoint and the said flow signal, thereby proportioning said H_2 flow control valve. The controller is to compare said O_2 flow signal to an H_2 ratio setpoint, providing a proportional signal to said O_2 flow control valve, wherein said H_2 flow and said O_2 flow are such that the molar ratio of H_2 to O_2 is approximately 2:1.

To conserve energy, it is most preferred that said H_2 flow control valve(s) consist of a two staged system of flow control valves. The first H_2 flow control valve is to control recycled H_2 to the combustion chamber, The first H_2 control valve is preferably to be downstream of generated H_2 and downstream of H_2 storage to control H_2 flow to the combustion chamber. The second H_2 flow control valve is to feed stored H_2 to the combustion chamber. The second H_2 flow control valve is preferably to remain closed until the first H_2 flow control valve is near approximately 100 % open (thereby assuring about full usage of generated H_2 prior usage of stored H_2) at which time the second H_2 flow control valve will begin proportion by the controller according to the H_2 setpoint flow control signal. It is also preferred that a recycle H_2 control valve be placed to control the recycle of H_2 to H_2 storage. Said recycle H_2 control valve is to be proportional to the first H_2 control valve position near 100% closed. It is preferred that said controller proportion said recycle H_2 control valve in relation to the first H_2 control valve near a 0 position or 100% closed.

To conserve energy, it is preferred that said O_2 flow control valve(s) consist of a two staged system of flow control valves. The first O_2 flow control valve, downstream of generated O_2 and downstream of H_2 storage is preferably to control H_2 flow to the combustion chamber. The second H_2 flow control valve is to feed stored O_2 to the combustion chamber. The second H_2 flow control valve is to remain closed until the first O_2 flow control valve is near approximately 100 % open (thereby assuring full usage of generated O_2 prior usage of stored O_2) at which time the second O_2 flow control valve will begin proportioned by the controller according to the H_2 setpoint flow control signal. It is also preferred that a recycle O_2 control valve be placed to control

the recycle of O_2 to O_2 storage. Said recycle O_2 control valve is to be proportional to the first O_2 control valve position near 100% closed. It is preferred that said controller proportion said recycle O_2 control valve in relation to the first O_2 control valve near a 0 position or 100% closed.

It is preferred that said combustion comprise an available H_2O flow to said combustion chamber(s), herein termed as combustion H_2O . It is preferred that a temperature measurement device have a means of measuring combustion temperature or approximating combustion temperature. It is preferred that there is a means to measure said combustion H_2O flow. It is preferred that there is a means to indicate engine rpm. It is preferred to send a signal to a controller from each of said combustion H_2O flow measuring device and said combustion temperature measuring device. Said controller is to have as input previous said H_2 flow signal, said engine rpm, said combustion H_2O flow signal and said combustion temperature signal. It is preferred that said controller have a hot temperature setpoint, a warm temperature setpoint, an engine rpm setpoint and an H_2/H_2O ratio setpoint. It is most preferred that said controller compare said H_2 flow signal and said combustion H_2O flow signal to said H_2/H_2O ratio setpoint in combination with comparing said engine rpm signal to said engine rpm setpoint, temperature signal to said warm temperature setpoint, said hot temperature setpoint and provide a proportional signal to said combustion H_2O flow control valve and to said coolant flow control valve.

In the case wherein said temperature signal is less than said warm temperature setpoint, and less than said hot temperature setpoint, it is preferred that said controller send a signal to said combustion H_2O flow control valve to close said combustion H_2O flow control valve.

In the case wherein said H_2/H_2O ratio is about greater than said H_2/H_2O ratio setpoint and said temperature signal is about equal to or greater than said warm temperature setpoint, less than said hot temperature setpoint and engine rpm signal is greater than said engine rpm setpoint, it is preferred that said controller send a signal to said combustion H_2O flow control valve, wherein said signal is proportional to the difference between said measured temperature signal and the warm temperature setpoint, thereby proportioning said combustion H_2O flow control valve.

In the case wherein said H_2/H_2O ratio is about greater than said H_2/H_2O ratio setpoint and said temperature signal is greater than said warm temperature setpoint and equal to or greater than said hot temperature setpoint, it is preferred that said controller send a signal to: close the combustion H_2O flow control valve; and send a signal to said H_2 flow control valve, thereby closing said H_2 flow control valve; and send a signal to said O_2 flow control valve, thereby closing said O_2 flow control valve.

It is most preferred that the engine operate at a temperature between said warm temperature setpoint and said coolant temperature setpoint. It is preferred that energy not leave

the engine via engine coolant. It is most preferred that required engine cooling be performed by the addition of combustion H_2O to the combustion chamber(s).

Materials of construction for the engine are to be those as known in the art for each application as said application is otherwise performed in the subject art. For example, various composite and metal alloys are known and used as materials for use at cryogenic temperatures. Various composite, ceramic and metal alloys are known and used as materials for use at operating temperatures of over 500 °F. Various ceramic materials can be conductive, perform at operating temperatures of over 2,000 °F, act as an insulator, act as a semiconductor and/or perform other functions. Various iron compositions and alloys are known for their performance in combustion engines that operate approximately in the 200 to 1,000 °F range. Titanium and titanium alloys are known to operate over 2,000 and 3,000 °F. Tantalum and tungsten are known to operate well over 3,000 °F. It is preferred to have at least a portion of the construction of the engine contain an alloy composition wherein at least one of a period 4, period 5 and/or a period 6 heavy metal is used, as that metal(s) is known in the art to perform individually or to combine in an alloy to limit corrosion and/or perform in a cryogenic temperature application and/or perform in a temperature application over 1,000 °F. While aluminum is lightweight and can perform in limited structural applications, aluminum is temperature limited. Due to the operating temperatures involved in the instant invention, thermoplastic materials are not preferred unless the application of use takes into account the glass transition temperature and the softening temperature of the thermoplastic material.

Example 1 presents the Otto Cycle modified for the instant invention engine in an internal combustion application. Examples 2 through 9 present results obtained via a computer model of the WCT engine developed according the presentation and results within Example 1. Said computer model was prepared with an Excel spreadsheet program, incorporating graphing capabilities. Said computer model was prepared incorporating the thermodynamic properties of H_2 , O_2 and H_2O , along with the thermodynamic relationships presented in Example 1.

Example 1 - An Excel Spreadsheet Computer Model has been prepared for the instant invention. Said Model is the product of this example in the instant invention, the results of which are presented in Examples 2 through 9.

Operation of the instant invention is approximated by the cycling of a 4 stroke internal combustion engine as depicted in Figure 9, wherein path a to b presents an intake stroke during which a H_2O vapor-fuel-oxidizer mixture is drawn into the combustion chamber as the piston moves outward. Next, the intake valve closes, wherein the piston moves inward thereby compressing the H_2O

vapor, fuel and oxidizer mixture; this is depicted to be along the path from point "0" to point "1". This is process is about adiabatic since it occurs rapidly.

At approximately near the end of the compression stroke, the mixture is ignited and the pressure increases rapidly along the path from point 1 to point 2. This process happens very quickly, thereby being nearly a pure isochoric (constant volume) process.

The power stroke is next, wherein the power stroke is about an adiabatic expansion from point 2 to point 3. At the end of the power stroke, the exhaust valve is opened, wherein the exhaust gases escape in an approximately isochoric process moving along the path from point 3 to point 4.

Finally, the piston again moves inward, thereby forcing exhaust gases out of the combustion chamber along the path b to a. And the cycle repeats...

As net work is the product of pressure and volume, the net work performed is approximated by the area enclosed by the four path points: 0 to 1, 1 to 2, 2 to 3, and 3 to 4. The work done during the intake and exhaust strokes (the areas under paths a to b and b to a) cancel each other.

In this example, the instant invention comprises:

Number of cylinders	6	
Bore	100.0	mm
Stroke	78.9	mm
Compression ratio	10	

Compression -

$$\text{Engine displacement} = \pi \cdot \left(\frac{\text{bore}}{2} \right)^2 \cdot (\text{stroke}) \cdot (\# \text{ of cyls.})$$

$$\text{Displacement per cylinder} = \pi \cdot (50 \text{ mm})^2 \cdot (78.9 \text{ mm}) = 620 \text{ cm}^3 \quad (0.62 \text{ l})$$

$$\text{Compression ratio} = c.r. = \frac{\text{displacement} + \text{dead space}}{\text{dead space}}$$

The dead space (volume remaining when the piston is fully inserted) can be calculated from:

$$c.r. = 10.0 = \frac{620 + d.s.}{d.s.} \rightarrow 69 \text{ mm}^3 \quad (0.069 \text{ l})$$

For simplicity we'll approximate 0.070 L for the dead space.

In this example, it is assumed that the intake mixture consists of H₂O vapor, oxidizer (O₂) and fuel (H₂). It is an embodiment that the intake mixture comprises H₂O vapor, wherein the oxidizer could be injected at any point during at least one of the compression stroke and the power stroke. Similarly, it is also an embodiment that the fuel could be injected at any point during at least one of the compression stroke and the power stroke. In this example it is assumed and is a preferred embodiment that the pressure at the beginning of the compression stroke is about 1 atmosphere. It is a most preferred embodiment that the pressure at the beginning of the compression stroke is greater than

about 1 atmosphere. It is an embodiment that the pressure at the beginning of the compression stroke is about less than 1 atmosphere.

Again, in this example the embodiment comprising an intake mixture consists of H₂O vapor, O₂ and H₂ at 1 atmosphere pressure is depicted. In this depiction we can approximate the number of moles of H₂O vapor, fuel and O₂ in the cylinder at the beginning of the compression stroke from the ideal gas law.

$$n = \frac{P \cdot V}{R \cdot T}$$

$$n = \frac{(1.0 \text{ atm}) \cdot (0.69 \text{ l})}{(0.0821 \text{ l} \cdot \text{atm} / \text{mole} \cdot \text{K}) \cdot (300 \text{ K})} = 0.0280 \text{ moles}$$

And, the pressure in the cylinder at the end of the compression stroke can be approximate by:

$$P \cdot V^\gamma = \text{constant} = P_0 \cdot V_0^\gamma$$

$$P = P_0 \cdot \left(\frac{V_0}{V} \right)^\gamma$$

$$P = (1.0 \text{ atm}) \cdot \left(\frac{0.690 \text{ l}}{0.070 \text{ l}} \right)^{1.4} = 24.6 \text{ atm}$$

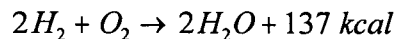
The temperature in the combustion chamber at the end of compression can be approximated by:

$$T = \frac{P \cdot V}{n \cdot R}$$

$$T = \frac{(24.6 \text{ atm}) \cdot (0.070 \text{ l})}{(0.0280 \text{ moles}) \cdot (0.0821 \text{ l} \cdot \text{atm} / \text{mole} \cdot \text{K})} \quad \text{with the resulting curve in Figure 9.}$$

$$T = 749.1 \text{ K}$$

Combustion - The chemical reaction between H₂ and O₂ can be approximated by:



In this example, it is assumed that near 0.0280 moles of H₂, O₂ and H₂O are in the cylinder (for this example, knowing that there may be more or less); it is further assumed that the gas mixture comprises about 18% O₂, 36% H₂ and 46% H₂O vapor (for this example, knowing that there may be more or less of each, except it is most preferred that the H₂ be about near twice the concentration of the O₂). It is an embodiment that these percentages may be varied as needed; however, it is most preferred that the molar concentration of H₂ be about near twice the molar concentration of the O₂. Therefore, in this example the combustion chamber comprises about 0.0050 moles of O₂ along with 0.0100 moles of H₂; and, assuming near complete combustion, said near 0.0050 moles of O₂ and said near 0.0100 moles of H₂ should yield about 2.87 kJ of energy. And, since about no work is done during combustion, the first law of

thermodynamics requires that said 2.87 kJ be retained as internal energy of the reaction products which will raise their temperatures in proportion to the number of moles present and the specific heat of the gas. For H₂O is about: 0.0280 moles with a heat capacity of about 36.2 J/mole-K.

The temperature rise is then approximated by:

$$\Delta T = Q / (n_{H_2O} \cdot C_{H_2O})$$

$$\Delta T = 2.87 \text{ kJ} / (0.0280 \cdot 36.2) = 2831 \text{ K}$$

Since the temperature at the start of the combustion was estimated near 749.1 K, the final temperature following combustion is about 749.1 K + 2831 K or 3580 K. Having an approximation of the temperature rise, the final pressure is approximated from the ideal gas law and the total number of moles of gases present:

$$Pressure = \frac{(0.0280 \text{ moles}) \cdot (0.0821 \text{ l-atm/mole-K}) \cdot (3580 \text{ K})}{0.070 \text{ l}} = 117.6 \text{ atm} \quad (1728 \text{ psi})$$

The increase in pressure from 24.6 atm to 117.6 atm is near constant volume and is depicted as the vertical line from point 1 to point 2 on the P-V diagram of Figure 9.

Expansion - Having approximated the pressure at the beginning of the expansion stroke (and knowing the volume) it is possible to approximate the pressure as a function of volume during the expansion:

$$P = P_0 \cdot \left(\frac{V_0}{V} \right)^\gamma$$

$$P = (117.6 \text{ atm}) \cdot \left(\frac{0.070 \text{ l}}{V} \right)^{1.4}$$

This line is depicted as the line from point 2 to point 3 on the P-V diagram, Figure 9.

Exhaust - The exhaust stroke is depicted from point 3 to point 0 on the P-V diagram of Figure 9.

Work Performed - Work is only done by (or on) the system during the adiabatic processes

which can be approximated as follows:

$$W = \int P \cdot dV$$

$$P \cdot V^\gamma = P_0 \cdot V_0$$

$$W = \int P_0 \left(\frac{V_0}{V} \right)^\gamma \cdot dV \quad , \text{ where}$$

$$W = \frac{P_0 \cdot V \left(\frac{V_0}{V} \right)^\gamma}{1 - \gamma} \bigg|_{V_i}^{V_f}$$

Parameter	Compression	Expansion	Units
P_0	1.0	117.6	atm
$V_0 (V_i)$	0.690	0.070	liters
V_f	0.070	0.690	liters
Work	-2.42	12.35	l-atm

Therefore, the net work performed during each cycle is 12.35-2.42 L-atm, 9.93 L-atm (1.006 kJ).

Total horsepower - For a typical automobile running at 60 MPH the engine speed is approximately 3000 rpm is near 50 revolutions per second (this approximation can be modified for alternate rpm situations given alternate transmission situations). Since in a 4 stroke engine a cylinder has a power stroke only every other revolution, it will be firing at a rate of 25 power strokes per second. A six-cylinder engine will then have 150 power strokes per second. Thus, the total power will be near

$$(150 \text{ power strokes} / \text{sec}) \cdot (1.006 \text{ kJ} / \text{stroke}) / 0.746 \text{ kW} / \text{hp} = 202 \text{ hp}$$

And, in a 2 stroke engine near twice the power is produced per second; therefore, a reduction of near 50% would be required in the combination of at least one of: fuel and oxidizer, rpm, the number of cylinders or some combination therein. However, there are a whole host of effects that take this energy away such as less-than-ideal volumetric efficiency, friction, inefficient combustion, extraneous heat losses, and accelerating inertial masses. This can easily take up 75 to 85% of the power leaving only about 30 to 50 hp delivered to the rear wheels (at 60 MPH).

Torque and power – It is an embodiment of this instant invention that the amount of oxidizer (O_2) and fuel (H_2) admitted to the combustion chamber can be varied independently of the speed of the engine. Further, the amount of oxidizer is not limited by a fixed percentage of inert gases. Therefore, in the instant invention there is a preferred embodiment to change at least one of torque and power independent of engine speed. It is a preferred embodiment that the instant invention comprise the capability of a near vertical torque curve at a given rpm, wherein said torque curve is depicted as a function of engine rpm.

Example 2 - Utilizing a computer model developed from the information developed in Example 1, and written into an Excel spreadsheet program, Figure 10 presents results wherein $T_0 = 100 \text{ K}$, and within each stroke the moles of H_2 range from 0.005 to 0.016 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.084 to 0.252.

Example 3 - Utilizing the computer model developed in Example 1, and written into an Excel spreadsheet program, Figure 11 presents results wherein $T_0 = 200 \text{ K}$, and within each stroke the moles

of H_2 range from 0.005 to 0.016 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.042 to 0.126.

Example 4 - Utilizing the computer model developed in Example 1, and written into an Excel spreadsheet program, Figure 12 presents results wherein $T_0 = 300\text{ K}$, and within each stroke the moles of H_2 range from 0.005 to 0.016 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.028 to 0.084.

Example 5 - Utilizing the computer model developed in Example 1, and written into an Excel spreadsheet program, Figure 13 presents results wherein $T_0 = 400\text{ K}$, and within each stroke the moles of H_2 range from 0.005 to 0.016 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.021 to 0.063.

Example 6 - Utilizing the computer model developed in Example 1, and written into an Excel spreadsheet program, Figure 14 presents results wherein $T_0 = 300\text{ K}$, and within each stroke the moles of H_2 range from 0.010 to 0.050 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.028 to 0.084.

Example 7 - Utilizing the computer model developed in Example 1, and written into an Excel spreadsheet program, Figure 15 presents results wherein $T_0 = 300\text{ K}$, and within each stroke the moles of H_2 range from 0.060 to 0.100 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.028 to 0.084.

Example 8 - Utilizing the computer model developed in Example 1, and written into an Excel spreadsheet program, Figure 16 presents results wherein $T_0 = 300\text{ K}$, and within each stroke the moles of H_2 range from 0.060 to 0.100 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.000 to 0.020.

Example 9 - Utilizing the computer model developed in Example 1, and written into an Excel spreadsheet program, Figure 17 presents results wherein $T_0 = 300\text{ K}$, and within each stroke the moles of H_2 range from 0.060 to 0.100 along with the moles of O_2 in a stoichiometric relationship to those of H_2 , and the moles of H_2O vary from 0.100 to 0.200.

An additional computer model is developed for Examples 10 through 23 wherein the adiabatic expansion of steam is estimated using the adiabatic relationship:

$$W = \int P \cdot dV$$

$$P \cdot V^\gamma = P_0 \cdot V_0$$

$$W = \int P_0 \left(\frac{V_0}{V} \right)^\gamma \cdot dV$$

$$W = \frac{P_0 \cdot V \left(\frac{V_0}{V} \right)^\gamma}{1 - \gamma} \Bigg|_{V_i}^{V_f}$$

And the final temperature is estimated using the ideal gas law:

$$PV = nRT, \text{ wherein } R = 0.0821 \text{ (L} \cdot \text{atm)/(mole} \cdot \text{K)}$$

In each of examples 10 through 23 a molar amount of H₂O, as indicated, is heated to the indicated initial temperature from the heat of the combustion chamber to form steam, wherein said heat of the combustion chamber is enthalpy from the combustion of H₂ and O₂, wherein the indicated initial temperature and the indicated initial pressure is prior to adiabatic expansion, and wherein: the work performed, the final pressure and the final temperature are after adiabatic expansion of the steam. In the instant invention it is an embodiment to add H₂O to the combustion chamber after the combustion of H₂ and O₂ to cool the combustion chamber, wherein said H₂O is in the form of a liquid and/or a low pressure gas at a molar ratio of about 1:0.1 to about 1:12 of H₂:H₂O; it is most preferred that said molar ratio be about 1:6 to about 1:10; and, it is most preferred that said molar ratio be 1:8.

Examples 10 - 13

Moles of H ₂ O		0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01
Initial Temp	K	500	500	500	500	500	500	500	500
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	46.9	41.1	35.2	29.3	23.5	17.6	11.7	5.9
Work	L-atm	4.9	4.3	3.7	3.1	2.5	1.9	1.2	0.6
Heat	cal	860.4	752.9	645.3	537.8	430.2	322.7	215.1	107.6
	L-atm	35.4	31.0	26.6	22.1	17.7	13.3	8.9	4.4
Delta T	K	172.1	150.6	129.1	107.6	86.0	64.5	43.0	21.5
Final pressure	atm	18.68	16.34	14.01	11.67	9.34	7.00	4.67	2.33
Final Temp	K	199	199	199	199	199	199	199	199

Moles of H ₂ O		0.08	0.07	0.06	0.05	0.04	0.03	0.02	0.01
Initial Temp	K	773	773	773	773	773	773	773	773
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	72.5	63.5	54.4	45.3	36.3	27.2	18.1	9.1
Work	l-atm	7.6	6.7	5.7	4.8	3.8	2.9	1.9	1.0
Heat	cal	1057.0	924.8	792.7	660.6	528.5	396.4	264.2	132.1
	l-atm	43.5	38.1	32.6	27.2	21.7	16.3	10.9	5.4
Delta T	K	211.4	185.0	158.5	132.1	105.7	79.3	52.8	26.4
Final pressure	atm	28.87	25.27	21.66	18.05	14.44	10.83	7.22	3.61
Final Temp	K	308	308	308	308	308	308	308	308

Moles of H ₂ O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	500	500	500	500	500	500	500	500
Initial volume	L	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	469.1	205.3	117.3	73.3	46.9	29.3	16.8	7.3
Work	L-atm	49.4	34.1	23.5	15.7	9.9	5.7	2.7	0.9
Heat	cal	8604.0	7528.5	6453.0	5377.5	4302.0	3226.5	2151.0	1075.5
	L-atm	354.1	309.8	265.6	221.3	177.0	132.8	88.5	44.3
Delta T	K	1720.8	1505.7	1290.6	1075.5	860.4	645.3	430.2	215.1
Final pressure	atm	18.68	21.56	21.74	20.32	17.78	14.34	10.17	5.36
Final Temp	K	199	263	309	347	379	408	434	457

Moles of H ₂ O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	773	773	773	773	773	773	773	773
Initial volume	L	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	725.3	317.3	181.3	113.3	72.5	45.3	25.9	11.3
Work	L-atm	76.4	52.7	36.4	24.3	15.4	8.8	4.2	1.4
Heat	Cal	10569.6	9248.4	7927.2	6606.0	5284.8	3963.6	2642.4	1321.2
	L-atm	435.0	380.6	326.2	271.9	217.5	163.1	108.7	54.4
Delta T	K	2113.9	1849.7	1585.4	1321.2	1057.0	792.7	528.5	264.2
Final pressure	atm	28.87	33.34	33.61	31.42	27.48	22.17	15.72	8.29
Final Temp	K	308	406	478	536	586	630	670	707

Examples 14 - 17

Moles of H ₂ O		0.08	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Initial Temp	K	773	773	773	773	773	773	773	773
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Initial pressure	atm	72.5	72.5	54.4	45.3	36.3	27.2	18.1	9.1
Work	L-atm	8.1	8.1	6.1	5.1	4.1	3.0	2.0	1.0
Heat	cal	1057.0	1057.0	792.7	660.6	528.5	396.4	264.2	132.1
	L-atm	43.5	43.5	32.6	27.2	21.7	16.3	10.9	5.4
Delta T	K	211.4	211.4	158.5	132.1	105.7	79.3	52.8	26.4
Final pressure	atm	2.03	2.03	1.52	1.27	1.02	0.76	0.51	0.25
Final Temp	K	278	278	278	278	278	278	278	278

Moles of H ₂ O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	773	773	773	773	773	773	773	773
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Initial pressure	atm	725.3	634.6	544.0	453.3	362.6	272.0	181.3	90.7
Work	L-atm	81.2	71.1	60.9	50.8	40.6	30.5	20.3	10.2
Heat	cal	10569.6	9248.4	7927.2	6606.0	5284.8	3963.6	2642.4	1321.2
	L-atm	435.0	380.6	326.2	271.9	217.5	163.1	108.7	54.4
Delta T	K	2113.9	1849.7	1585.4	1321.2	1057.0	792.7	528.5	264.2
Final pressure	atm	20.31	17.77	15.23	12.69	10.16	7.62	5.08	2.54
Final temp	K	278	278	278	278	278	278	278	278

Moles of H ₂ O		0.08	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Initial Temp	K	773	773	773	773	773	773	773	773
Initial volume	L	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	14.5	14.5	10.9	9.1	7.3	5.4	3.6	1.8
Work	L-atm	3.1	3.1	2.3	1.9	1.5	1.2	0.8	0.4
Heat	cal	1057.0	1057.0	792.7	660.6	528.5	396.4	264.2	132.1
	L-atm	43.5	43.5	32.6	27.2	21.7	16.3	10.9	5.4
Delta T	K	211.4	211.4	158.5	132.1	105.7	79.3	52.8	26.4
Final pressure	atm	5.50	5.50	4.12	3.44	2.75	2.06	1.37	0.69
Final Temp	K	586	586	586	586	586	586	586	586

Moles of H ₂ O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	773	773	773	773	773	773	773	773
Initial volume	L	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	145.1	126.9	108.8	90.7	72.5	54.4	36.3	18.1
Work	L-atm	30.7	26.9	23.1	19.2	15.4	11.5	7.7	3.8
Heat	cal	10569.6	9248.4	7927.2	6606.0	5284.8	3963.6	2642.4	1321.2
	L-atm	435.0	380.6	326.2	271.9	217.5	163.1	108.7	54.4
Delta T	K	2113.9	1849.7	1585.4	1321.2	1057.0	792.7	528.5	264.2
Final pressure	atm	54.97	48.10	41.23	34.35	27.48	20.61	13.74	6.87
Final Temp	K	586	586	586	586	586	586	586	586

Examples 18 - 21

Moles of H ₂ O		0.08	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Initial Temp	K	1000	1000	1000	1000	1000	1000	1000	1000
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Initial pressure	atm	93.8	93.8	70.4	58.6	46.9	35.2	23.5	11.7
Work	L-atm	11.5	11.5	8.6	7.2	5.7	4.3	2.9	1.4
Heat	cal	1220.4	1220.4	915.3	762.8	610.2	457.7	305.1	152.6
	L-atm	50.2	50.2	37.7	31.4	25.1	18.8	12.6	6.3
Delta T	K	244.1	244.1	183.1	152.6	122.0	91.5	61.0	30.5
Final pressure	atm	1.42	1.42	1.06	0.88	0.71	0.53	0.35	0.18
Final temp	K	302	302	302	302	302	302	302	302

Moles of H ₂ O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	1000	1000	1000	1000	1000	1000	1000	1000
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Initial pressure	atm	938.3	821.0	703.7	586.4	469.1	351.9	234.6	117.3
Work	L-atm	118.4	103.6	88.8	74.0	59.2	44.4	29.6	14.8
Heat	cal	12204.0	10678.5	9153.0	7627.5	6102.0	4576.5	3051.0	1525.5
	L-atm	502.2	439.4	376.7	313.9	251.1	188.3	125.6	62.8
Delta T	K	2440.8	2135.7	1830.6	1525.5	1220.4	915.3	610.2	305.1
Final pressure	atm	10.79	9.44	8.09	6.74	5.39	4.04	2.70	1.35
Final Temp	K	279	279	279	279	279	279	279	279

Moles of H ₂ O		0.08	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Initial Temp	K	2000	2000	2000	2000	2000	2000	2000	2000
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Initial pressure	atm	187.7	187.7	140.7	117.3	93.8	70.4	46.9	23.5
Work	L-atm	28.3	28.3	21.2	17.7	14.1	10.6	7.1	3.5
Heat	cal	1940.4	1940.4	1455.3	1212.8	970.2	727.7	485.1	242.6
	L-atm	79.9	79.9	59.9	49.9	39.9	29.9	20.0	10.0
Delta T	K	388.1	388.1	291.1	242.6	194.0	145.5	97.0	48.5
Final pressure	Atm	0.19	0.19	0.14	0.12	0.09	0.07	0.05	0.02
Final temp	K	277	277	277	277	277	277	277	277

Moles of H ₂ O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	2000	2000	2000	2000	2000	2000	2000	2000
Initial volume	L	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Final volume	L	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
Initial pressure	atm	1876.6	1642.0	1407.4	1172.9	938.3	703.7	469.1	234.6
Work	L-atm	282.9	247.5	212.2	176.8	141.5	106.1	70.7	35.4
Heat	cal	19404.0	16978.5	14553.0	12127.5	9702.0	7276.5	4851.0	2425.5
	L-atm	798.5	698.7	598.9	499.1	399.3	299.4	199.6	99.8
Delta T	K	3880.8	3395.7	2910.6	2425.5	1940.4	1455.3	970.2	485.1
Final pressure	atm	1.86	1.62	1.39	1.16	0.93	0.70	0.46	0.23
Final temp	K	277	277	277	277	277	277	277	277

Examples 22 - 23

Moles of H ₂ O		0.08	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Initial Temp	K	400	400	400	400	400	400	400	400
Initial volume	L	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	8.8	8.8	6.6	5.5	4.4	3.3	2.2	1.1
Work	L-atm	1.9	1.9	1.4	1.2	0.9	0.7	0.5	0.2
Heat	cal	788.4	788.4	591.3	492.8	394.2	295.7	197.1	98.6
	L-atm	32.4	32.4	24.3	20.3	16.2	12.2	8.1	4.1
Delta T	K	157.7	157.7	118.3	98.6	78.8	59.1	39.4	19.7
Final pressure	atm	2.67	2.67	2.01	1.67	1.34	1.00	0.67	0.33
Final temp	K	285	285	285	285	285	285	285	285

Moles of H ₂ O		0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
Initial Temp	K	400	400	400	400	400	400	400	400
Initial volume	L	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Final volume	L	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Initial pressure	atm	87.6	76.6	65.7	54.7	43.8	32.8	21.9	10.9
Work	L-atm	18.9	16.5	14.2	11.8	9.4	7.1	4.7	2.4
Heat	cal	7884.0	6898.5	5913.0	4927.5	3942.0	2956.5	1971.0	985.5
	L-atm	324.4	283.9	243.3	202.8	162.2	121.7	81.1	40.6
Delta T	K	1576.8	1379.7	1182.6	985.5	788.4	591.3	394.2	197.1
Final pressure	atm	26.74	23.40	20.06	16.71	13.37	10.03	6.69	3.34
Final temp	K	285	285	285	285	285	285	285	285

5

Certain objects are set forth above and made apparent from the foregoing description. However, since certain changes may be made in the above description without departing from the

scope of the invention, it is intended that all matters contained in the foregoing description shall be interpreted as illustrative only of the principles of the invention and not in a limiting sense. With respect to the above description, it is to be realized that any descriptions, drawings and examples deemed readily apparent and obvious to one skilled in the art and all equivalent relationships to those described in the specification are intended to be encompassed by the present invention.

Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention. It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention, which, as a matter of language, might be said to fall in between.

WE CLAIM:

1. An engine comprising a combustion chamber, wherein
H₂ is combusted with O₂ in said combustion chamber,
wherein the engine performs the combustion with at least one selected from a list
consisting of:
H₂O added to said combustion chamber during combustion;
H₂O added to said combustion chamber during at least one cycle wherein
combustion is not performed;
the combustion chamber is cooled by an environmental temperature within a
space application; and
any combination therein, and wherein
at least a part of said H₂ and said O₂ is provided to said combustion chamber from
at least one of:
a storage tank, and
electrolysis of water powered by at least one of a photovoltaic cell and generator(s)
turned by steam energy obtained from nuclear reaction.
2. The engine of claim 1, wherein said engine is used in a space application.
3. The engine of claim 1, wherein at least one of: block of said engine, said H₂O, and
lubricant for said engine is at least partially heated with a heating element.
4. The engine of claim 1, wherein said engine comprises 2 cycles.
5. The engine of claim 1, wherein said engine comprises 4 or more cycles.
6. The engine of claim 1, wherein said H₂ is at least partially a gel.
7. The engine of claim 1, wherein said O₂ is at least partially a gel.
8. The engine of claim 1, further comprising a vertical Torque Curve.
9. The engine of claim 1, further comprising a Newsom burn.

10. The engine of claim 1, wherein at least one of said H_2 and said O_2 is added to said combustion chamber at a pressure of greater than about 0.1 atmosphere.

11. The engine of claim 1, wherein at least one of said H_2 and said O_2 is added to said combustion chamber at a pressure of greater than about 1.0 atmosphere.

12. The engine of claim 1, wherein the use of said engine comprises transportation or power generation.

13. The engine of claim 1, wherein electricity is generated by at least one selected from a list consisting of: photovoltaic cell(s), a generator, alternator or dynamo turned by steam energy obtained from nuclear means and any combination therein, wherein

said electricity is at least partially utilized in an electrolysis unit to convert H_2O to H_2 and O_2 , and wherein

at least a portion of at least one of the H_2 and the O_2 is said H_2 or said O_2 .

14. The engine of claim 1, wherein said engine creates at least one selected from a list consisting of: rotating mechanical energy, torque and power.

15. The engine of claim 14, wherein said rotating mechanical energy turns an alternator, generator or dynamo to create electricity.

16. The engine of claim 14, wherein said mechanical rotating energy enters a transmission, wherein

said transmission engages in a manner that is inversely proportional to at least one of the torque and work load on said engine, and wherein

said transmission output mechanical rotating energy turns an alternator or a generator to create electricity.

17. The engine of claim 16, wherein said transmission engage a flywheel capable of storing rotational kinetic energy, wherein

said flywheel turns said alternator or generator.

18. The engine of claim 1, wherein said engine produces steam.

19. The engine of claim 18, wherein at least a portion of said steam turns a steam turbine, and wherein
the steam turbine turns an alternator, generator or dynamo to create electricity.

5 20. The engine of claim 15, 16 or 19, wherein at least a portion of said electricity is used in an electrolysis unit, wherein
said electrolysis unit converts H_2O to H_2 and O_2 , wherein
at least a portion of at least one of the H_2 and the O_2 is said H_2 or said O_2 .

10 21. The engine of claim 18, wherein at least a portion of said steam is converted in a unit to H_2 by the corrosion of at least one metal.

22. The engine of claim 21, wherein the conversion of said steam into said H_2 is increased by an electrical current in said metal(s).

15 23. The engine of claim 21 or 22, wherein said H_2 is at least partially used in said combustion chamber.

20 24. The engine of claim 1 or 18, wherein at least a portion of at least one of said combustion chamber and said engine is insulated.

25 25. The engine of claim 1, wherein at least one of O_2 and H_2 is stored in at least one of a cooled gas state and a liquid state by a liquefaction unit.

26. The engine of claim 25, wherein the compressor(s) for at least one of cooling and/or liquefaction is powered by at least one selected from a list consisting of said engine and steam from said engine.

30 27. The engine of claim 1, wherein at least one of combustion heat energy and engine exhaust energy is used in a unit to heat at least one of a gas and a liquid.

28. The engine of claim 27, wherein at least one of the gas is air and the liquid is H_2O .

35 29. The engine of claim 1, wherein said engine is at least one of an internal combustion engine and a turbine.

30. The engine of claim 29, wherein said engine comprises Energy Recovery Cooling.

31. The engine of claim 1, 4, 5 or 29, wherein at least one of:

the material(s) of construction of said combustion chamber comprise a heat capacity capable of storing heat from the previous combustion as enthalpy for the transfer from said combustion chamber to said H₂O; and

the material(s) of construction of said combustion chamber comprise a heat transfer coefficient capable of transferring heat from the previous combustion within the material(s) of said combustion chamber to said H₂O.

32. The engine of claim 18, wherein at least a portion of at least one said steam and the H₂O exiting said engine is transferred to a condenser.

33. The engine of claim 32, wherein at least a portion of the H₂O from said condenser is said H₂O.

34. The engine of claim 33, wherein at least a portion of the H₂O from said condenser is used in an electrolysis unit, wherein

said electrolysis unit converts at least a portion of said H₂O into H₂ and O₂, and wherein

at least a portion of said H₂ or O₂ is said H₂ or O₂.

35. The engine of claim 19, wherein at least a portion of at least one of the steam and the condensed H₂O exiting said turbine is transferred to a condenser.

36. The engine of claim 35, wherein at least a portion of the condensed H₂O from said condenser is said H₂O.

37. The engine of claim 35, wherein at least a portion of the condensed H₂O from said condenser is used in an electrolysis unit, wherein

the electrolysis unit converts at least a portion of the H₂O into H₂ and O₂, and wherein

at least a portion of the H₂ or the O₂ is said H₂ or O₂.

38. The engine of claim 34 or 37, wherein the electricity for said electrolysis unit is at least partially obtained from the turning of at least one of a generator, an alternator and a dynamo, and wherein

said at least one generator, alternator and dynamo is turned by the energy of at least one selected from a listing consisting of: steam turbine turned by the exhaust gases (steam) from said combustion chamber(s), drive shaft turned by the energy created in said combustion chamber(s), steam from nuclear power, and any combination therein.

39. The engine of claim 1, 4, 5 and 18, further comprising at least one pressure control device.

40. The engine of claim 1, 4, 5, 13, 20, 35 or 37, wherein at least one selected from a list consisting of a: corrosion inhibitor, chelant, dispersant, electrolyte and any combination therein is added to said H₂O.

41. A method of performing combustion comprising a chamber for combustion, wherein

H₂ and O₂ are combusted in said chamber, wherein

at least one selected from a list consisting of:

H₂O is added to said chamber during combustion;

H₂O is added to said chamber during at least one cycle wherein combustion is not performed;

the combustion chamber is cooled by an environmental temperature within a space application; and

any combination therein, wherein

said H₂ and said O₂ are provided to said chamber from at least one of:

a storage tank, and

electrolysis of water powered by at least one of a photovoltaic cell and generator(s) turned by steam energy obtained from nuclear means.

42. The method of claim 41, wherein said method is used in a Space Application.

43. The method of claim 41, wherein at least one of: said method, H₂O for said method and lubricant for said method is at least partially heated with a heating element.

44. The method of claim 41, wherein said method comprises 2 cycles.

45. The method of claim 41, wherein said method comprises 4 or more cycles.

46. The method of claim 41, wherein said H₂ is at least partially a gel.

47. The method of claim 41, wherein said O₂ is at least partially a gel.

48. The method of claim 41, further comprising a vertical Torque Curve.

49. The method of claim 41, further comprising a Newsom burn.

50. The method of claim 41, wherein at least one of said H₂ and said O₂ is added to said chamber at a pressure of greater than about 0.1 atmosphere.

51. The method of claim 41, wherein at least one of said H₂ and said O₂ is added to said chamber at a pressure of greater than about 1.0 atmosphere.

52. The method of claim 41, wherein said method further comprises transportation or power generation.

53. The method of claim 41, further generating electricity by at least one selected from a list consisting of: photovoltaics, steam turbine/nuclear means, and any combination therein, wherein said electricity at least partially performs electrolysis to convert H₂O to H₂ and O₂, and wherein at least a portion of at least one of the H₂ and the O₂ is used in said combustion chamber.

54. The method of claim 41, wherein said method creates at least one selected from a list consisting of: rotating mechanical energy, torque and power.

55. The method of claim 54, wherein said rotating mechanical energy is used to turn an alternator, generator or dynamo, and wherein said alternator, generator or dynamo creates electricity.

56. The method of claim 54, further comprising a transmission, wherein
said mechanical rotating energy from said method enters the transmission, wherein
said transmission engages in a manner that is inversely proportional to at least one
of the torque and work load, and wherein

5 said transmission output mechanical rotating energy turns an alternator or a
generator to create electricity.

57. The method of claim 56, further comprising a flywheel capable of storing
rotational kinetic energy, wherein

10 said flywheel turns said alternator or generator.

58. The method of claim 41, wherein said method produces steam.

59. The method of claim 58, further comprising a steam turbine, wherein
15 at least a portion of said steam produced by combustion turns the steam turbine,
and wherein
the steam turbine turns an alternator, generator or dynamo to create electricity.

60. The method of claim 55, 56 or 59, further comprising an electrolysis unit, wherein
20 at least a portion of said electricity is used in the electrolysis unit, wherein
said electrolysis unit converts H_2O to H_2 and O_2 , and wherein
at least a portion of at least one of the H_2 and the O_2 is used in said combustion
method.

61. The method of claim 59, further comprising at least one metal, wherein
25 at least a portion of said steam is converted into H_2 by the corrosion said metal(s).

62. The method of claim 61, further comprising an electrical current in said metal(s),
wherein
30 said steam conversion is increased by said electrical current.

63. The method of claim 61 or 62, wherein said H_2 is at least partially used in said
combustion method.

64. The method of claim 41, wherein said method comprises insulation of the combustion chamber.

65. The method of claim 41, further comprising liquefaction, wherein
at least one of O_2 and H_2 is stored in the state of a cooled gas or liquid.

66. The method of claim 65, further comprising compression,
wherein said compression performs cooling and/or liquefaction of at least one of
said O_2 and said H_2 , and wherein
said compression is powered by at least one selected from a list consisting of: said
method and steam from said method.

67. The method of claim 41, wherein the energy of said method heats at least one of a
gas and a liquid.

68. The method of claim 67, wherein at least one of the gas is air and the liquid is H_2O .

69. The method of claim 41, wherein said method comprises at least one of internal
combustion and turbine.

70. The method of claim 69, wherein said method further comprises Energy Recovery
Cooling.

71. The method of claim 41, 45, 56 or 69, wherein at least one of:
the material(s) of construction of said combustion chamber comprise a heat capacity
capable of storing heat from the previous combustion as enthalpy for the transfer from said
combustion chamber to said H_2O ; and

the material(s) of construction of said combustion chamber comprise a heat transfer
coefficient capable of transferring heat from the previous combustion within the material(s) of said
combustion chamber to said H_2O .

72. The method of claim 58, further comprising a condenser, wherein
at least a portion of at least one of said steam and the H_2O exiting said chamber is
transferred to the condenser.

73. The method of claim 72, wherein at least a portion of the H_2O is transferred from said condenser to said chamber.

74. The method of claim 73, further comprising electrolysis, wherein
at least a portion of the H_2O from said condenser is used in electrolysis, wherein
said electrolysis converts at least a portion of said H_2O into H_2 and O_2 , and wherein
at least a portion of the H_2 or O_2 is used in said combustion method.

75. The method of claim 59, further comprising a condenser, wherein
at least a portion of at least one of the steam and the H_2O exiting said turbine is
transferred to the condenser.

76. The method of claim 75, wherein at least a portion of the H_2O is transferred from said condenser to said combustion chamber.

77. The method of claim 76, further comprising electrolysis, wherein
at least a portion of the H_2O from said condenser is used in electrolysis, wherein
electrolysis converts at least a portion of the H_2O into H_2 and O_2 , and wherein
at least a portion of the H_2 or the O_2 is used in said combustion method.

78. The method of claim 74 or 77, further comprising at least one of a generator, an
alternator and a dynamo, wherein
the electricity for said electrolysis is created in at least one of said generator, alternator
and dynamo, and wherein

the energy to turn the generator, alternator or dynamo is obtained from at least one
selected from a listing consisting of: steam from said combustion method, said combustion
method, moving wind energy, moving H_2O energy, and any combination therein.

79. The method of claim 41, 44 or 45, further comprising at least one pressure control
device.

80. The method of claim 41, 44, 45, 60 or 76, wherein at least one selected from a list
consisting of a: corrosion inhibitor, chelant, dispersant, electrolyte and any combination therein is
added to said H_2O .

81. An apparatus performing combustion of H_2 and O_2 , the apparatus comprising,
- a. a fuel device comprising:
 - i. a source of H_2 , a H_2 source flow control valve and a H_2 source flow sensing device sensing H_2 source flow sending a H_2 source flow signal proportional to H_2 source flow to a controller;
 - ii. a source comprising O_2 , an O_2 source flow control valve and an O_2 source flow sensing device sensing O_2 source flow sending an O_2 source flow signal proportional to O_2 source flow to a controller; and
 - b. a control device comprising at least one controller having a setpoint for the ratio of H_2 to O_2 ; and receiving:
 - iii. said proportional flow signal for source O_2 and H_2 , and
 - iv. an external combustion signal set point; while
 - v. comparing said combustion signal setpoint to said H_2 source flow signal, sending a signal to the H_2 source flow control valve in proportion to the difference in said H_2 source flow signal to said combustion signal setpoint, thereby proportioning said H_2 source flow control valve; and
 - vi. comparing said H_2 source flow signal and said O_2 source flow signal to the H_2 to O_2 ratio setpoint, sending a signal to the O_2 source flow control valve, thereby proportioning the O_2 source flow control valve.
82. An apparatus performing combustion of H_2 and O_2 , the apparatus comprising:
- a. a coolant device comprising:
 - i. an rpm measurement device sensing rpm of said apparatus sending a signal proportional to rpm to a controller;
 - ii. a temperature measurement device measuring at least one of combustion temperature and said apparatus temperature sending a temperature signal in proportion to said combustion temperature or said apparatus temperature to a controller;
 - iii. a source of combustion H_2O flow to the combustion chamber of said apparatus, a combustion H_2O source flow control valve and a combustion H_2O source flow sensing device sensing combustion

H₂O source flow sending a combustion H₂O source flow signal proportional to combustion H₂O source flow to a controller;

- b. a combustion control device;
- c. a cooling control device comprising at least one controller having a setpoint for:

- iv. the ratio of H₂ to combustion H₂O,

- v. rpm,

- vi. cool temperature

- vii. warm temperature, and

- viii. hot temperature;.

while receiving:

- ix. said rpm signal,

- x. said proportional temperature signal, and

- xi. said combustion H₂O flow signal,

comparing said rpm signal to said rpm setpoint, said temperature signal to said cool temperature setpoint, said warm temperature setpoint and said hot temperature setpoint, such that:

- xii. in the case wherein said temperature signal is less than said warm temperature setpoint and less than said hot temperature setpoint, sending a signal to said combustion H₂O source flow control valve to close said combustion H₂O source flow control valve.

- xiii. in the case wherein said temperature signal is equal to or greater than said warm temperature setpoint, less than said hot temperature setpoint and said rpm signal greater than said rpm setpoint, obtain a difference between said temperature signal and said warm temperature setpoint, sending a signal in proportion to the difference between said temperature signal and said warm temperature setpoint, which obtains a H₂ to combustion H₂O ratio that is greater than said H₂ to combustion H₂O ratio setpoint, thereby sending a signal to said combustion H₂O source flow valve proportioning said combustion H₂O source flow control valve.

- xiv. in the case wherein said temperature signal is greater than said warm temperature setpoint and equal to or greater than said hot temperature setpoint, sending a signal in proportion to the difference between said

temperature signal and said coolant temperature setpoint to said combustion H₂O source flow control valve closing said combustion H₂O source flow control valve; and sending a signal to said combustion controller.

5

83. An apparatus performing liquefaction of H₂ or of O₂, comprising an engine powering a compressor for said liquefaction, said engine comprising a combustion chamber, wherein
- 10 a portion of said H₂ is combusted with O₂, or
a portion of said O₂ is combusted with H₂, wherein
at least one selected from a list consisting of:

H₂O is added to the combustion chamber during a combustion cycle;

H₂O is added to the combustion chamber during at least one cycle wherein combustion is not performed;

15

the combustion chamber is cooled by an environmental temperature within a space application; and

any combination therein.

84. The apparatus of claim 83, wherein
- 20 at least one of said H₂ and said O₂ are each obtained from a storage tank.

85. The apparatus of claim 83, wherein
- 25 at least one of said H₂ and said O₂ are obtained from electrolysis, wherein the electricity for said electrolysis is obtained from at least one of:
photovoltaic cells and
generator(s) turned by steam energy obtained from generator(s) turned by steam energy obtained from nuclear reaction.

86. The apparatus of claim 83, wherein said apparatus is used in a Space Application.

30

87. The apparatus of claim 83, wherein at least one of: block of said apparatus, said H₂O and lubricant for said apparatus are at least partially heated.

88. The apparatus of claim 83, wherein said engine comprises 2 cycles.

89. The apparatus of claim 83, wherein said engine comprises 4 or more cycles.

90. The apparatus of claim 83, wherein said H₂ is at least partially a gel.

91. The apparatus of claim 83, wherein said O₂ is at least partially a gel.

92. The apparatus of claim 83, further comprising a vertical Torque Curve.

93. The apparatus of claim 83, further comprising a Newsom burn.

94. The apparatus of claim 83, wherein at least one of said H₂ and said O₂ is added to said chamber at a pressure of greater than about 0.1 atmosphere.

95. The apparatus of claim 83, wherein at least one of said H₂ and said O₂ is added to said chamber at a pressure of greater than about 1.0 atmosphere.

96. A method of performing liquefaction of H₂ or of O₂, comprising
a means of powering said liquefaction, comprising
a chamber of combustion, wherein
a portion of said H₂ is combusted with O₂, or
a portion of said O₂ is combusted with H₂, wherein
said means of powering said liquefaction performs combustion with at least one
selected from a list consisting of:

H₂O added to said chamber of combustion during a combustion cycle;
H₂O added to said chamber of combustion during at least one cycle or operating
time wherein combustion is not performed;
the combustion chamber is cooled by an environmental temperature within a
space application; and
any combination therein.

97. The method of claim 96, wherein
at least one of said H₂ and said O₂ are obtained from a tank storing said H₂ and said
O₂.

98. The method of claim 96, wherein

at least one of said H₂ and said O₂ are obtained from electrolysis means, wherein the electricity for said electrolysis means is obtained from at least one of: photovoltaics; and generator(s) turned by steam energy obtained from nuclear means.

5

99. The method of claim 96, wherein said method is a Space Application.

100. The method of claim 96, wherein at least one of: said means of powering liquefaction, said H₂O and lubricant for said means of powering liquefaction is at least partially heated.

10

101. The method of claim 96, wherein said means of powering liquefaction comprises 2 cycles.

15

102. The method of claim 96, wherein said means of powering liquefaction comprises 4 or more cycles.

103. The method of claim 96, wherein said H₂ is at least partially a gel.

104. The method of claim 96, wherein said O₂ is at least partially a gel.

20

105. The method of claim 96, further comprising a vertical Torque Curve.

106. The method of claim 96, further comprising a Newsom burn.

25

107. The method of claim 96, wherein at least one of said H₂ and said O₂ is added to said chamber at a pressure of greater than about 0.1 atmosphere.

108. The method of claim 96, wherein at least one of said H₂ and said O₂ is added to said combustion chamber at a pressure of greater than about 1.0 atmosphere.

30

Space Engine Including The Haase Cycle with Energy Recovery Cooling

Figure 1
Legend

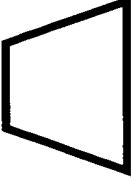
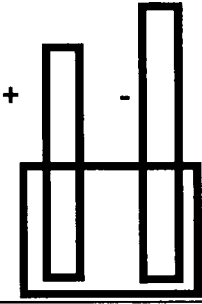
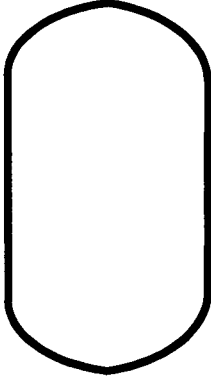
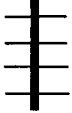
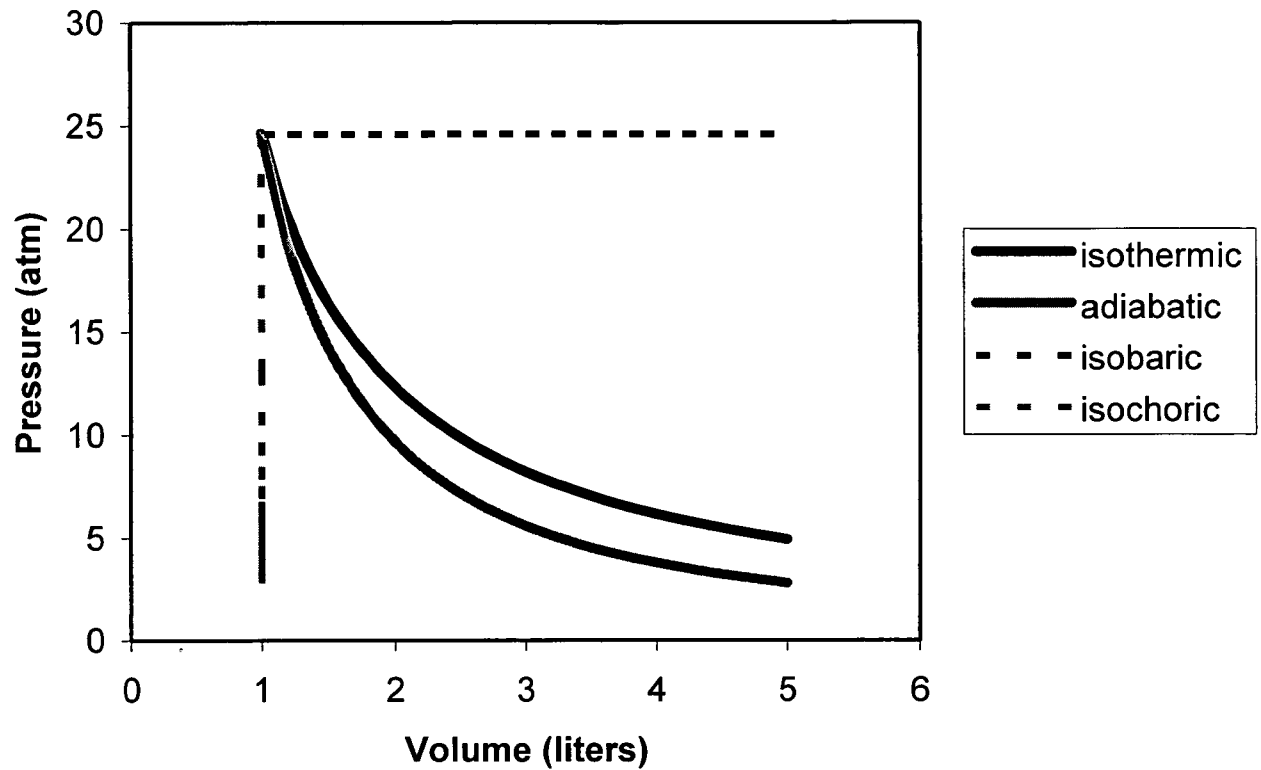
Symbol	Equipment	Equipment Description
	Steam Turbine Steam Turbine Engine Creates Mechanical Energy	Design as is known in the art. Steam turbine is to create mechanical energy, which turns an electrical generator to generate electricity.
	Equipment Designation	Design as is known in the art, unless otherwise specified.
	Process or Energy Flow	As is known in the art, unless otherwise specified.
	Electrolysis Unit	Design as is known in the art.
	Cryogenic Storage Tank	Liquid (L) H ₂ or O ₂ Design as is known in the art.
	Joule Thompson Expansion Device	Design as is known in the art.
	Heat Discharge Device	Design as is known in the art.

Figure 2

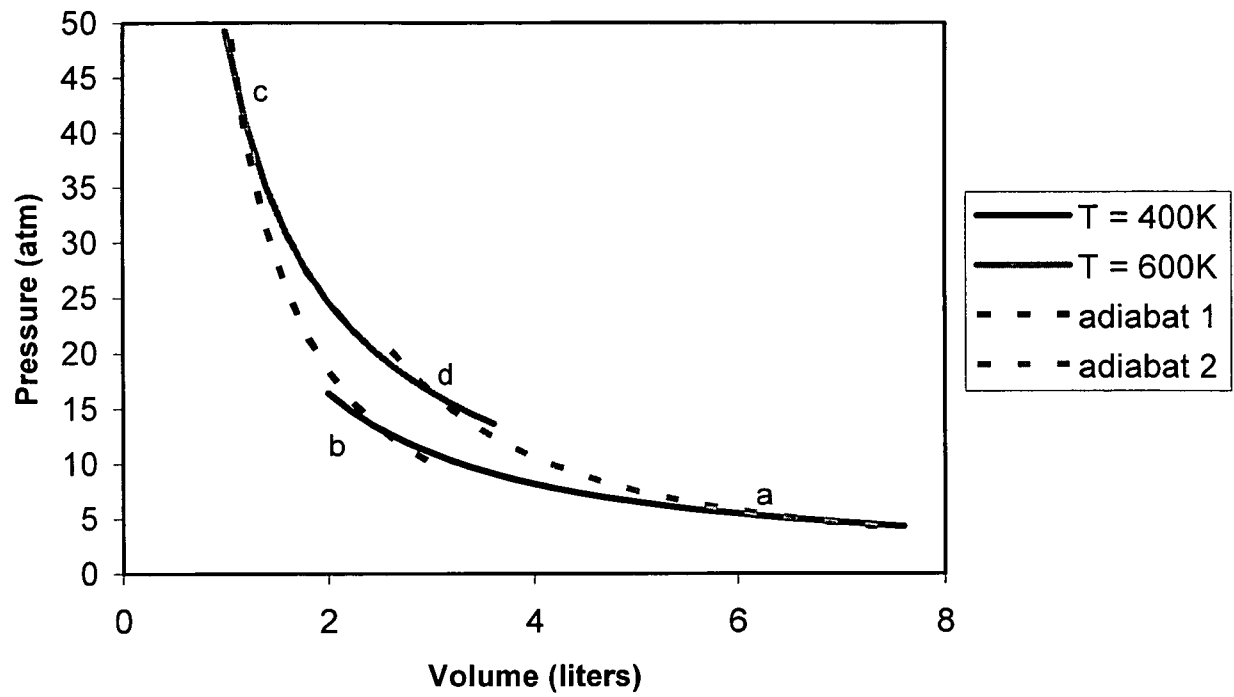
P-V Diagram



Space Engine Including The Haase Cycle with Energy Recovery Cooling

Figure 3

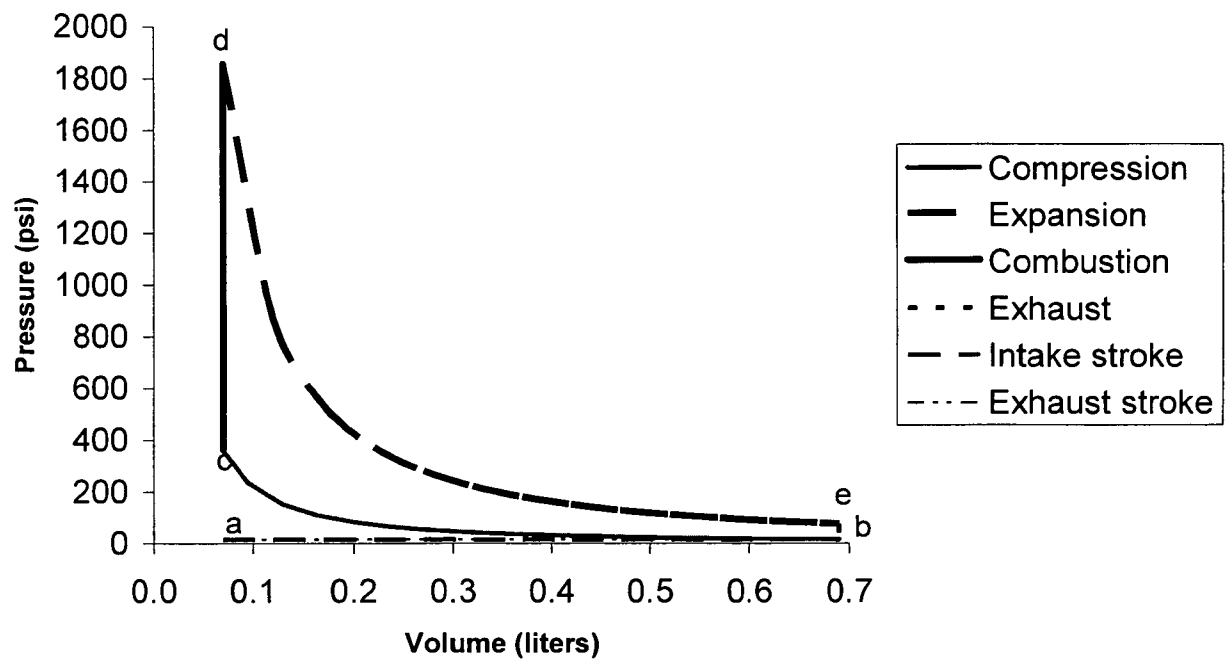
Carnot Cycle



Space Engine Including The Haase Cycle with Energy Recovery Cooling

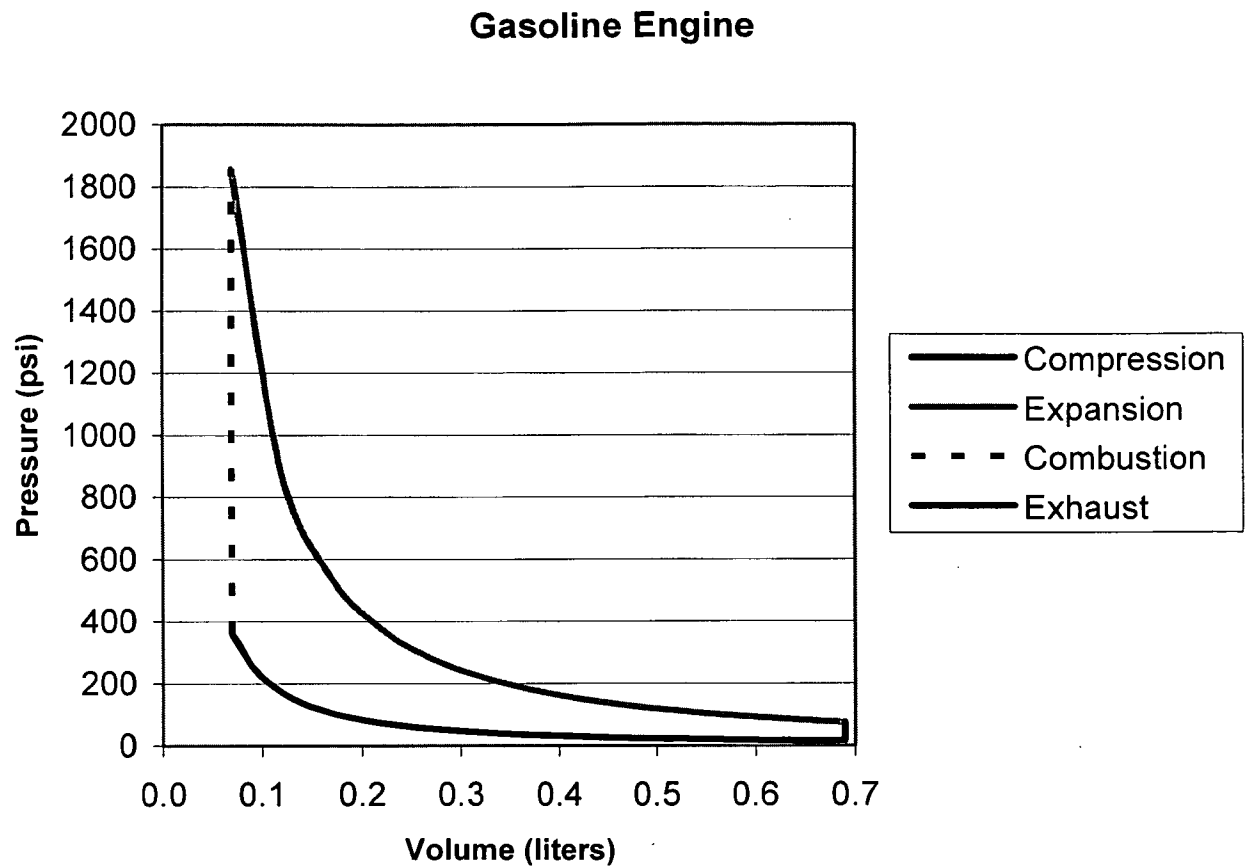
Figure 4

Otto Cycle



Space Engine Including The Haase Cycle with Energy Recovery Cooling

Figure 5



Space Engine Including The Haase Cycle with Energy Recovery Cooling

Figure 6

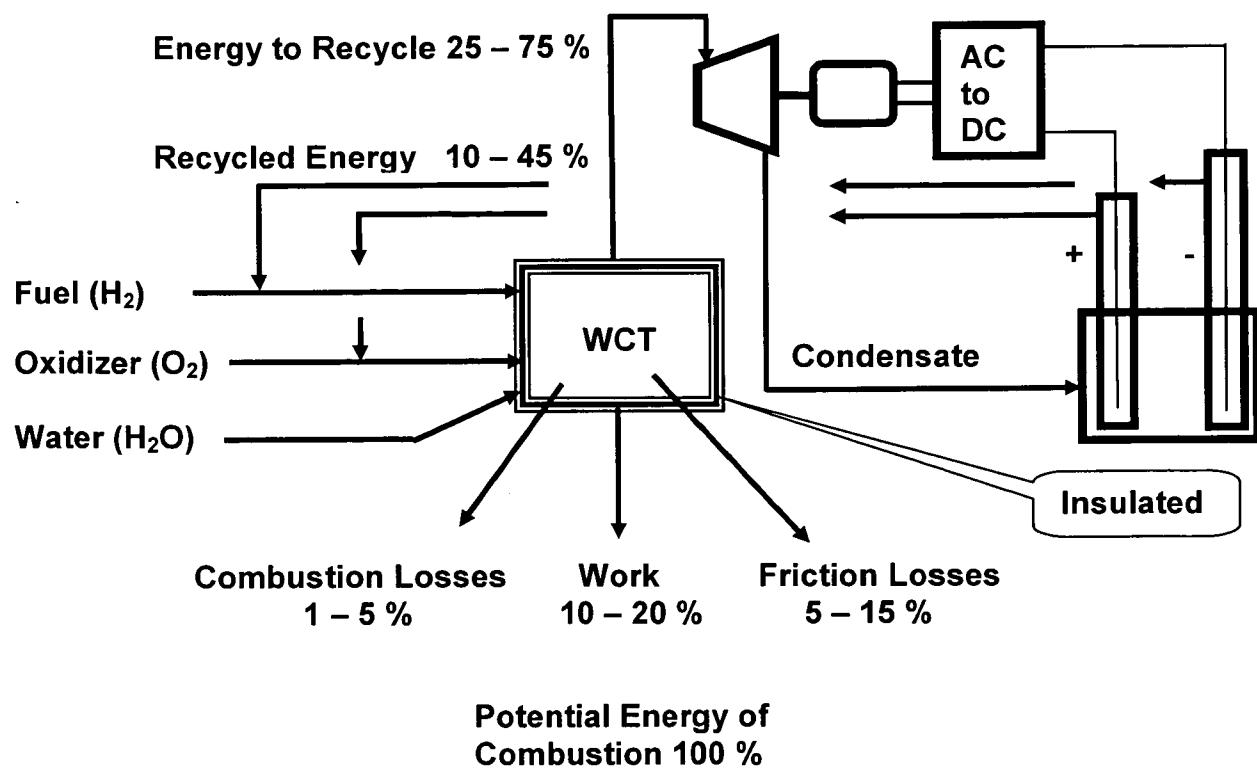
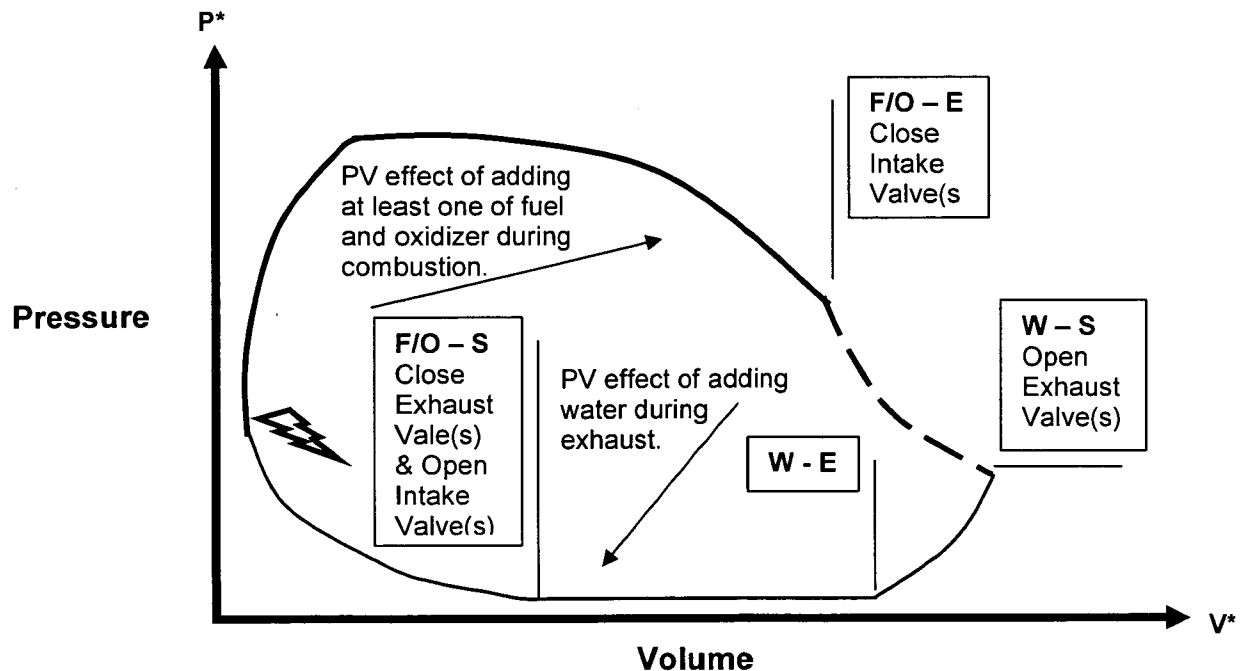


Figure 7 Haase Cycle



Work = P X V

Piston (Volume) Expansion

Piston (Volume) Contraction

Combustion

— — — · **Expansion (Past Combustion)**

———— Cooling/Exhaust Stroke and Intake Stroke



Point of Ignition (Spark or Spontaneous w.r.t. Temperature)

F/O

Point of Fuel or Oxidizer Addition; S = Start, E = End

W

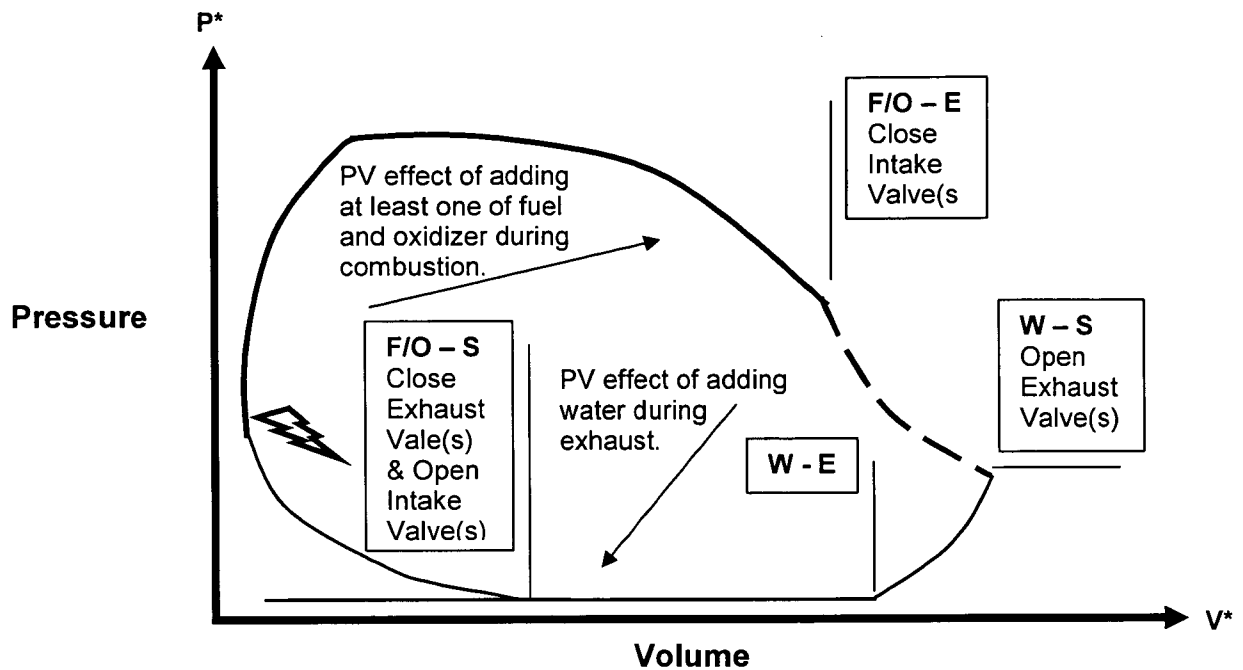
Point of Water Addition; S = Start, E = End

P* and **V*** are limited by the physical constraints of the engine, wherein said physical constraints comprise at least one selected from a list consisting of: material selection, combustion chamber design and engine stress design.

Available Work Area – shape and volume dependant upon physical constraints (P^* and V^*), fuel timing and amount, oxidizer timing and water added, as well as ignition and exhaust timing.

Space Engine Including The Haase Cycle with Energy Recovery Cooling

Figure 8
The Haase Cycle



$$\text{Work} = P \times V$$

Piston (Volume) Expansion

Piston (Volume) Contraction

————— Combustion, Power Stroke

- - - - - Expansion (Past Combustion)

————— Cooling/Exhaust Stroke and Intake Stroke



Point of Ignition (Spark or Spontaneous w.r.t. Temperature)



Point of Fuel or Oxidizer Addition; S = Start, E = End



Point of Water Addition; S = Start, E = End

P^* and V^* are limited by the physical constraints of the engine, wherein said physical constraints comprise at least one selected from a list consisting of: material selection, combustion chamber design and engine stress design.

Available Work Area – shape and volume dependant upon physical constraints (P^* and V^*), fuel timing and amount, oxidizer timing and water added, as well as ignition and exhaust timing.

Space Engine Including The Haase Cycle with Energy Recovery Cooling

Figure 9

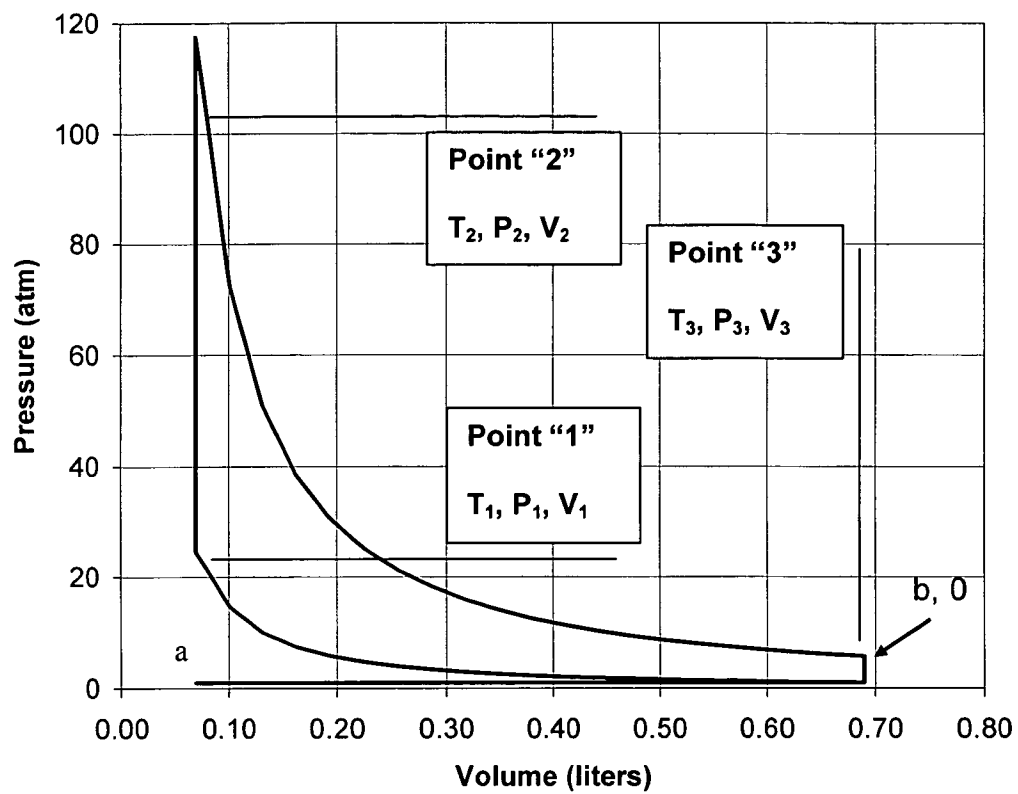


Figure 10

C.R. = 10		D.S. = 0.069 Liter		Vo = 0.69 Liter		To = 100 K		Compression				Combustion				Expansion				Output			
Ps	atm	n (H2O)	n (H2)	moles	moles	Po	atm	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W 0->1	W 2->3	net work	l-atm	net work	kJ	HP
1	1	0.0840	0.00523	1.09	1.33	23.2	212	1.50	454	667	70.8	2.8	265	7.35	4.50	0.456	92						
1	1	0.0840	0.00871	1.16	1.33	24.7	214	2.50	728	943	104.0	4.1	375	10.80	7.79	0.789	159						
1	1	0.0840	0.0122	1.22	1.33	26.3	216	3.50	983	1199	137.3	5.5	477	14.26	11.08	1.123	226						
1	1	0.0840	0.0157	1.28	1.34	27.8	218	4.51	1221	1438	170.7	6.8	573	17.73	14.39	1.457	293						
2	2	0.1681	0.00523	2.09	1.32	44.1	211	1.50	234	445	91.7	3.7	177	9.52	4.06	0.412	83						
2	2	0.1681	0.00871	2.16	1.33	45.6	212	2.50	382	594	124.9	5.0	236	12.97	7.35	0.744	150						
2	2	0.1681	0.0122	2.22	1.33	47.2	213	3.50	525	738	158.2	6.3	294	16.43	10.65	1.078	217						
2	2	0.1681	0.0157	2.28	1.33	48.7	214	4.51	663	876	191.6	7.6	349	19.90	13.95	1.413	284						
3	3	0.2521	0.00523	3.09	1.32	65.0	210	1.50	158	368	112.6	4.5	146	11.69	3.62	0.367	74						
3	3	0.2521	0.00871	3.16	1.32	66.5	211	2.50	259	470	145.8	5.8	187	15.14	6.91	0.700	141						
3	3	0.2521	0.0122	3.22	1.33	68.1	212	3.50	358	570	179.1	7.1	227	18.60	10.21	1.034	208						
3	3	0.2521	0.0157	3.28	1.33	69.6	212	4.51	455	667	212.5	8.5	266	22.07	13.51	1.369	275						

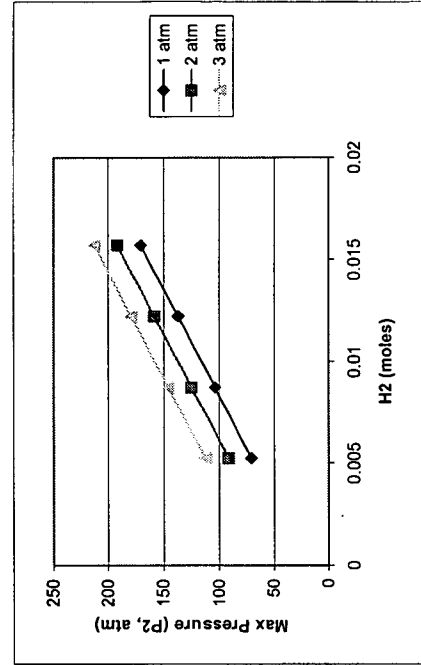
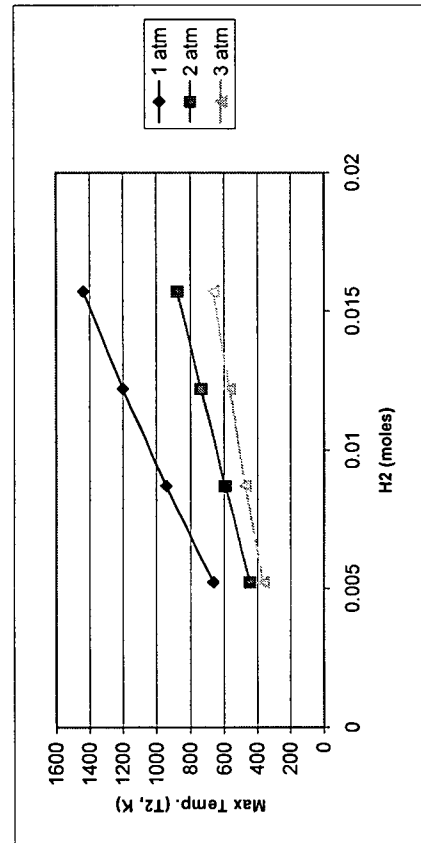


Figure 11

C.R. = 10				D.S. = 0.069 Liter				Vo = 0.69 Liter				To = 200 K				
Ps	n (H2O)	n (H2)	Po	Compression			Combustion			Expansion			Output			
atm	moles	moles	atm	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W 0-->1	W 2-->3	net work	HP
					atm	K	kJ	K	K	atm	atm	K	I-atm	I-atm	kJ	
1	0.0420	0.00523	1.19	1.33	25.5	430	1.50	859	1289	72.5	2.9	513	-3.09	7.52	4.43	0.449
1	0.0420	0.00871	1.31	1.34	28.6	437	2.50	1332	1768	106.7	4.2	704	-3.42	11.08	7.66	0.776
1	0.0420	0.0122	1.44	1.34	31.7	442	3.50	1745	2187	141.1	5.6	871	-3.74	14.65	10.91	1.105
1	0.0420	0.0157	1.56	1.35	34.8	446	4.51	2110	2556	175.6	7.0	1018	-4.07	18.23	14.16	1.434
2	0.0840	0.00523	2.19	1.33	46.4	424	1.50	454	879	93.4	3.7	350	-5.70	9.69	3.99	0.404
2	0.0840	0.00871	2.31	1.33	49.5	428	2.50	728	1157	127.7	5.1	461	-6.03	13.25	7.23	0.732
2	0.0840	0.0122	2.44	1.33	52.6	432	3.50	983	1415	162.1	6.5	563	-6.35	16.83	10.47	1.061
2	0.0840	0.0157	2.56	1.34	55.7	435	4.51	1221	1656	196.5	7.8	659	-6.68	20.41	13.73	1.391
3	0.1261	0.00523	3.19	1.32	67.3	422	1.50	309	731	114.3	4.5	291	-8.31	11.86	3.55	0.360
3	0.1261	0.00871	3.31	1.33	70.4	425	2.50	501	926	148.6	5.9	369	-8.63	15.43	6.79	0.688
3	0.1261	0.0122	3.44	1.33	73.5	428	3.50	684	1112	183.0	7.3	443	-8.96	19.00	10.04	1.017
3	0.1261	0.0157	3.56	1.33	76.6	430	4.51	859	1289	217.5	8.7	513	-9.29	22.58	13.29	1.347

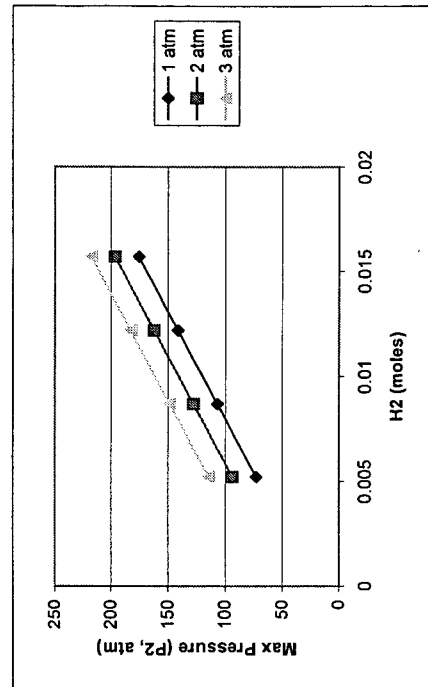
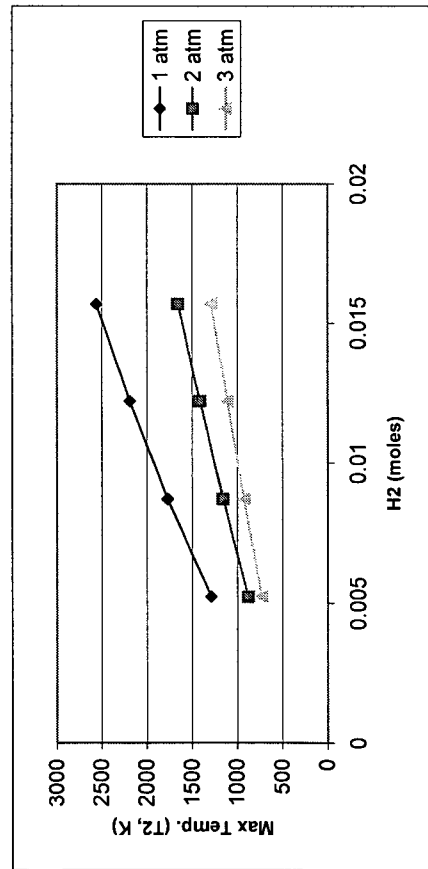


Figure 12

C.R. = 10				Compression				Combustion				Expansion				Output			
D.S. = 0.069 Liter		Vo = 0.69 Liter		To = 300 K		Po	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W0→1	W2→3	net work	HP
Ps	n (H2O)	n (H2)				atm		atm	K	kJ	K	K	atm	atm	K	l-atm	l-atm	kJ	
1	0.0280	0.00523	1.28	1.34	27.8	653	1.50	1220	1873	74.1	2.9	746	-3.34	7.69	4.35	0.441	89		
1	0.0280	0.00871	1.47	1.35	32.5	665	2.50	1840	2504	109.4	4.4	997	-3.82	11.36	7.54	0.764	154		
1	0.0280	0.0122	1.65	1.35	37.1	674	3.50	2353	3027	144.9	5.8	1205	-4.31	15.04	10.73	1.087	219		
1	0.0280	0.0157	1.84	1.36	41.8	682	4.51	2786	3468	180.4	7.2	1380	-4.80	18.73	13.93	1.411	284		
2	0.0560	0.00523	2.28	1.33	48.7	641	1.50	662	1303	95.0	3.8	519	-5.95	9.86	3.92	0.397	80		
2	0.0560	0.00871	2.47	1.34	53.4	649	2.50	1044	1693	130.4	5.2	674	-6.43	13.54	7.10	0.720	145		
2	0.0560	0.0122	2.65	1.34	58.0	656	3.50	1387	2043	165.8	6.6	813	-6.92	17.22	10.30	1.043	210		
2	0.0560	0.0157	2.84	1.34	62.7	662	4.51	1698	2360	201.4	8.0	939	-7.41	20.91	13.50	1.368	275		
3	0.0840	0.00523	3.28	1.33	69.6	637	1.50	454	1091	115.9	4.6	434	-8.55	12.03	3.48	0.352	71		
3	0.0840	0.00871	3.47	1.33	74.2	643	2.50	728	1371	151.3	6.0	546	-9.04	15.71	6.67	0.676	136		
3	0.0840	0.0122	3.65	1.33	78.9	648	3.50	983	1631	186.8	7.4	649	-9.53	19.39	9.87	0.999	201		
3	0.0840	0.0157	3.84	1.34	83.5	653	4.51	1221	1874	222.4	8.9	746	-10.02	23.09	13.07	1.324	266		

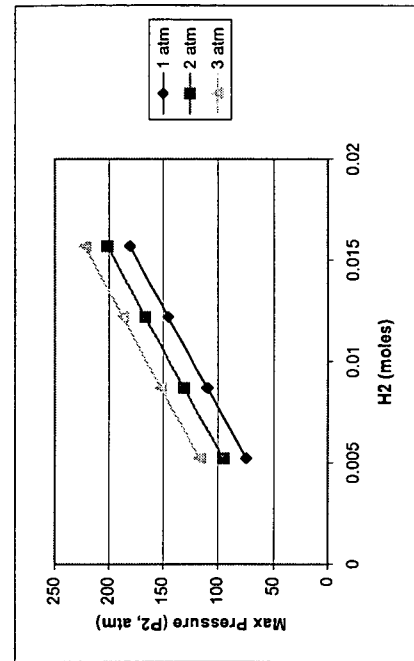
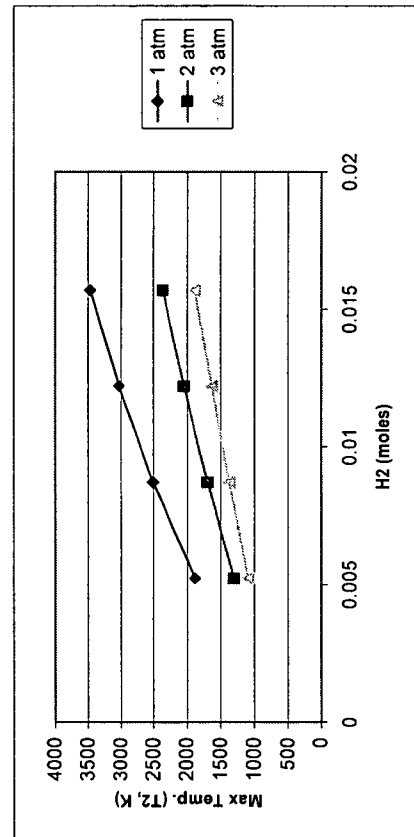


Figure 13

C.R. = 10																
D.S. = 0.069 Liter																
Vo = 0.69 Liter																
To = 400 K																
Compression				Combustion				Expansion				Output				
Ps	n (H2O)	n (H2)	Po	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W 0-->1	W 2-->3	net work	HP
atm	moles	moles	atm		atm	K	kJ	K	K	atm	atm	K	l-atm	l-atm	kJ	
1	0.0210	0.00523	1.37	1.34	30.2	879	1.50	1546	2425	75.7	3.0	965	-3.58	7.86	4.28	0.433
1	0.0210	0.00871	1.62	1.35	36.4	897	2.50	2273	3170	112.1	4.5	1262	-4.23	11.64	7.41	0.751
1	0.0210	0.0122	1.87	1.36	42.6	911	3.50	2849	3760	148.6	5.9	1497	-4.88	15.43	10.55	1.068
1	0.0210	0.0157	2.12	1.36	48.8	921	4.51	3317	4238	185.1	7.4	1687	-5.53	19.22	13.69	1.387
2	0.0420	0.00523	2.37	1.33	51.0	860	1.50	859	1719	96.6	3.8	684	-6.19	10.03	3.84	0.389
2	0.0420	0.00871	2.62	1.34	57.2	873	2.50	1332	2205	133.1	5.3	878	-6.84	13.82	6.98	0.707
2	0.0420	0.0122	2.87	1.34	63.4	884	3.50	1745	2629	169.6	6.8	1047	-7.49	17.61	10.12	1.025
2	0.0420	0.0157	3.12	1.35	69.7	893	4.51	2110	3003	206.2	8.2	1195	-8.14	21.41	13.27	1.345
3	0.0630	0.00523	3.37	1.33	71.9	853	1.50	594	1447	117.5	4.7	576	-8.80	12.20	3.41	0.345
3	0.0630	0.00871	3.62	1.33	78.1	863	2.50	942	1804	154.0	6.1	718	-9.45	15.99	6.55	0.663
3	0.0630	0.0122	3.87	1.34	84.3	871	3.50	1258	2129	190.6	7.6	848	-10.10	19.79	9.69	0.982
3	0.0630	0.0157	4.12	1.34	90.5	879	4.51	1547	2425	227.2	9.0	966	-10.75	23.59	12.84	1.301

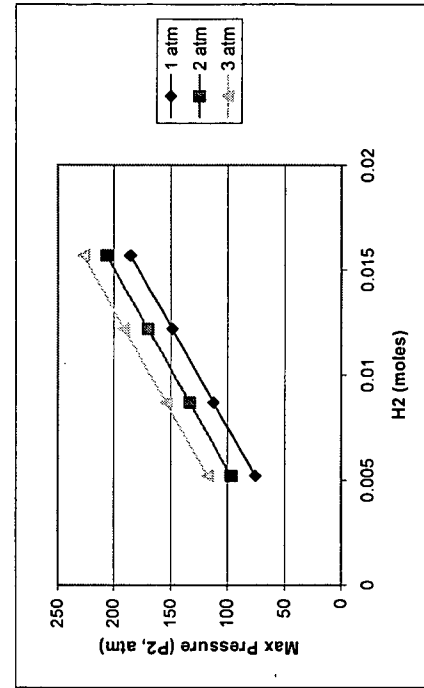
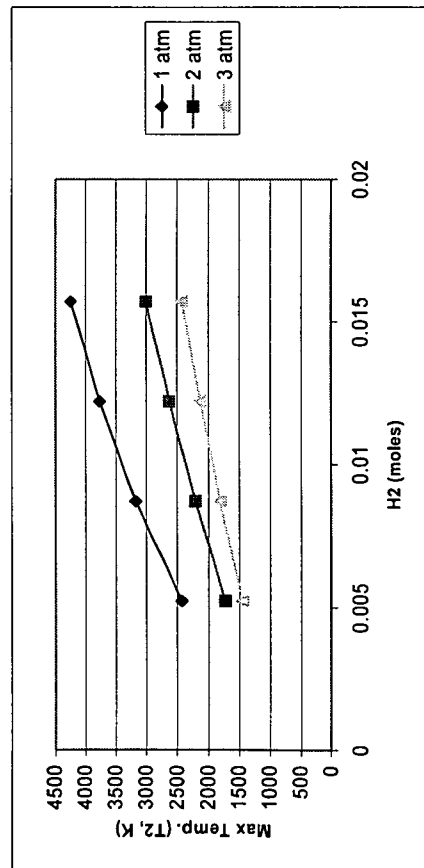


Figure 14

C.R. = 10				D.S. = 0.069 Liter				Vo = 0.69 Liter				To = 300 K																			
Ps		n (H2O)		n (H2)		Po		gamma		P1		T1		Q		delta T		T2		P2		T3		W 0->1		W 2->3		net work		HP	
atm	atm	moles	moles	atm	atm	atm	atm	atm	atm	atm	atm	K	K	KJ	K	K	K	K	atm	atm	K	K	l-atm	l-atm	l-atm	l-atm	kJ	kJ			
1	1	0.0280	0.01	1.54	1.35	34.2	668	2.87	2040	668	2.87	2040	668	2.87	2040	668	2.87	2040	668	2.87	2040	668	2.87	2040	668	2.87	2040	668	2.87	2040	
1	1	0.0280	0.02	2.07	1.36	47.6	689	5.74	3231	689	5.74	3231	689	5.74	3231	689	5.74	3231	689	5.74	3231	689	5.74	3231	689	5.74	3231	689	5.74	3231	
1	1	0.0280	0.03	2.61	1.37	61.0	702	8.61	4011	702	8.61	4011	702	8.61	4011	702	8.61	4011	702	8.61	4011	702	8.61	4011	702	8.61	4011	702	8.61	4011	
1	1	0.0280	0.05	3.68	1.38	87.9	717	14.35	4971	717	14.35	4971	717	14.35	4971	717	14.35	4971	717	14.35	4971	717	14.35	4971	717	14.35	4971	717	14.35	4971	
2	2	0.0560	0.01	2.54	1.34	55.1	652	2.87	1175	652	2.87	1175	652	2.87	1175	652	2.87	1175	652	2.87	1175	652	2.87	1175	652	2.87	1175	652	2.87	1175	
2	2	0.0560	0.02	3.07	1.35	68.4	668	5.74	2040	668	5.74	2040	668	5.74	2040	668	5.74	2040	668	5.74	2040	668	5.74	2040	668	5.74	2040	668	5.74	2040	
2	2	0.0560	0.03	3.61	1.36	81.8	680	8.61	2705	680	8.61	2705	680	8.61	2705	680	8.61	2705	680	8.61	2705	680	8.61	2705	680	8.61	2705	680	8.61	2705	
2	2	0.0560	0.05	4.68	1.37	108.6	696	14.35	3658	696	14.35	3658	696	14.35	3658	696	14.35	3658	696	14.35	3658	696	14.35	3658	696	14.35	3658	696	14.35	3658	
3	3	0.0840	0.01	3.54	1.33	76.0	645	2.87	825	645	2.87	825	645	2.87	825	645	2.87	825	645	2.87	825	645	2.87	825	645	2.87	825	645	2.87	825	
3	3	0.0840	0.02	4.07	1.34	89.3	658	5.74	1491	658	5.74	1491	658	5.74	1491	658	5.74	1491	658	5.74	1491	658	5.74	1491	658	5.74	1491	658	5.74	1491	
3	3	0.0840	0.03	4.61	1.35	102.6	668	8.61	2040	668	8.61	2040	668	8.61	2040	668	8.61	2040	668	8.61	2040	668	8.61	2040	668	8.61	2040	668	8.61	2040	
3	3	0.0840	0.05	5.68	1.36	129.4	684	14.35	2893	684	14.35	2893	684	14.35	2893	684	14.35	2893	684	14.35	2893	684	14.35	2893	684	14.35	2893	684	14.35	2893	

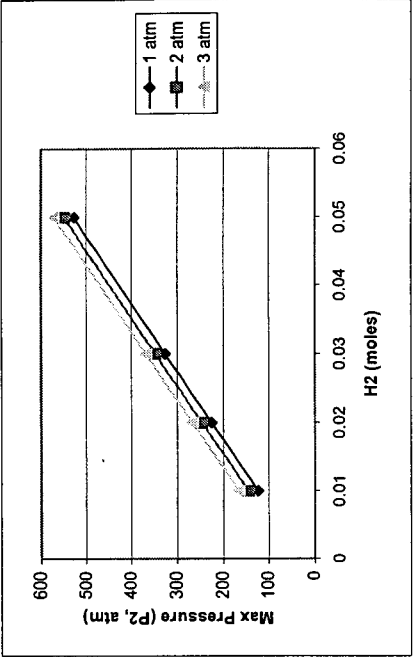
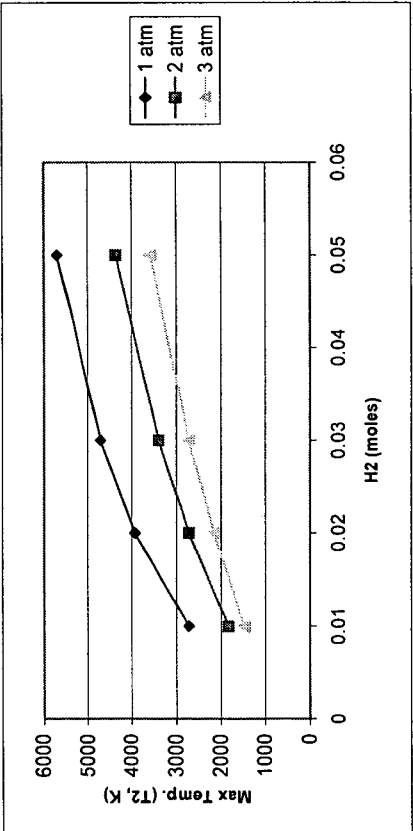


Figure 15

C.R. = 10				D.S. = 0.069 Liter				Vo = 0.69 Liter				To = 300 K			
Ps	n (H2O)	n (H2)	Po	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W0->1	W2->3	Output
atm	moles	moles	atm		atm	K	kJ	K	K	atm	atm	K	l-atm	l-atm	net work kJ
1	0.0280	0.06	4.21	1.38	101.3	721	17.22	5288	6009	629.3	25.1	2392	-10.99	65.34	54.35
1	0.0280	0.07	4.75	1.38	114.7	725	20.09	5540	6265	730.6	29.1	2494	-12.38	75.86	63.47
1	0.0280	0.08	5.28	1.38	128.2	728	22.96	5745	6473	831.9	33.1	2577	-13.78	86.37	72.59
1	0.0280	0.1	6.35	1.39	155.1	732	28.70	6059	6791	1034.4	41.2	2704	-16.57	107.40	90.83
2	0.0560	0.06	5.21	1.37	122.0	702	17.22	4011	4713	650.7	25.9	1876	-13.59	67.56	53.97
2	0.0560	0.07	5.75	1.37	135.4	707	20.09	4308	5015	752.0	29.9	1997	-14.99	78.08	63.09
2	0.0560	0.08	6.28	1.37	148.8	711	22.96	4562	5272	853.4	34.0	2099	-16.39	88.60	72.22
2	0.0560	0.1	7.35	1.38	175.7	717	28.70	4971	5688	1056.0	42.0	2264	-19.18	109.64	90.46
3	0.0840	0.06	6.21	1.36	142.8	689	17.22	3231	3920	671.9	26.7	1561	-16.20	69.76	53.56
3	0.0840	0.07	6.75	1.36	156.2	694	20.09	3525	4219	773.3	30.8	1680	-17.60	80.29	62.69
3	0.0840	0.08	7.28	1.37	169.6	699	22.96	3783	4481	874.7	34.8	1784	-19.00	90.82	71.82
3	0.0840	0.1	8.35	1.37	196.4	705	28.70	4215	4920	1077.4	42.9	1959	-21.79	111.86	90.07

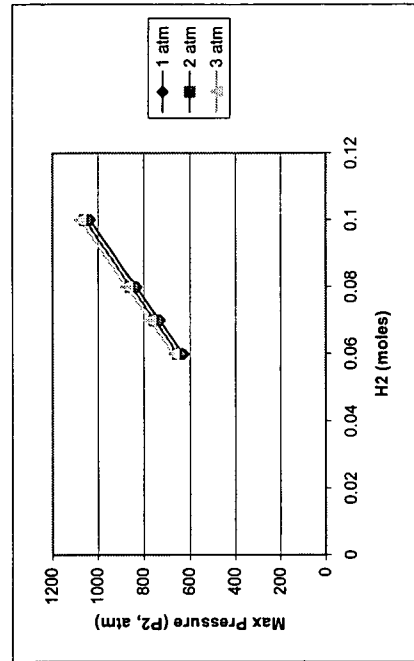
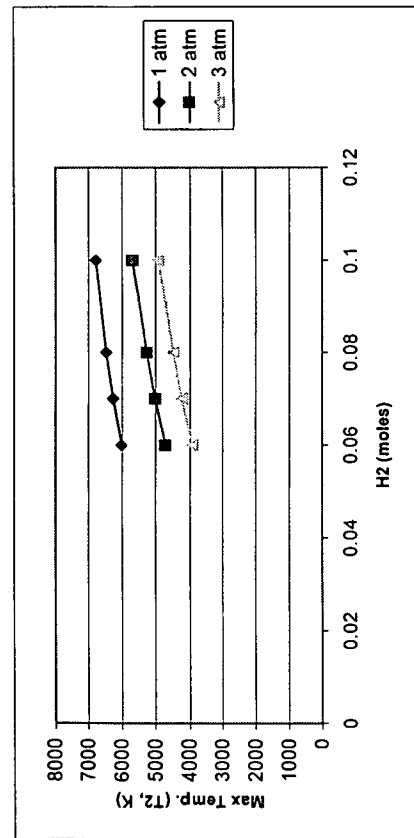


Figure 16

C.R. = 10				D.S. = 0.069 Liter				Vo = 0.69 Liter				To = 300 K				
Ps	n (H2O)	n (H2)	Po	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W 0->1	W 2->3	net work	HP
atm	moles	moles	atm		atm	K	kJ	K	K	atm	atm	K	I-atm	I-atm	kJ	
1	0.0000	0.06	3.21	1.40	80.7	754	17.22	7757	8510	607.6	24.2	3388	-8.38	63.08	54.70	1114
1	0.0000	0.07	3.75	1.40	94.1	754	20.09	7757	8510	708.8	28.2	3388	-9.77	73.59	63.82	1300
1	0.0000	0.08	4.28	1.40	107.6	754	22.96	7757	8510	810.1	32.3	3388	-11.17	84.11	72.94	1486
1	0.0000	0.1	5.35	1.40	134.5	754	28.70	7757	8510	1012.6	40.3	3388	-13.96	105.14	91.17	1857
2	0.0100	0.06	3.57	1.39	88.0	740	17.22	6649	7388	615.4	24.5	2941	-9.31	63.89	54.58	1112
2	0.0100	0.07	4.11	1.39	101.5	742	20.09	6787	7529	716.7	28.5	2997	-10.71	74.41	63.70	1298
2	0.0100	0.08	4.64	1.39	114.9	743	22.96	6895	7638	817.9	32.6	3041	-12.10	84.92	72.82	1483
2	0.0100	0.1	5.71	1.40	141.8	745	28.70	7052	7797	1020.4	40.6	3104	-14.90	105.95	91.05	1855
3	0.0200	0.06	3.93	1.39	95.4	729	17.22	5818	6546	623.1	24.8	2606	-10.24	64.70	54.46	1109
3	0.0200	0.07	4.46	1.39	108.8	732	20.09	6033	6765	724.4	28.8	2693	-11.64	75.21	63.58	1295
3	0.0200	0.08	5.00	1.39	122.3	734	22.96	6205	6939	825.7	32.9	2763	-13.03	85.73	72.70	1481
3	0.0200	0.1	6.07	1.39	149.2	737	28.70	6464	7201	1028.2	40.9	2867	-15.83	106.76	90.93	1852

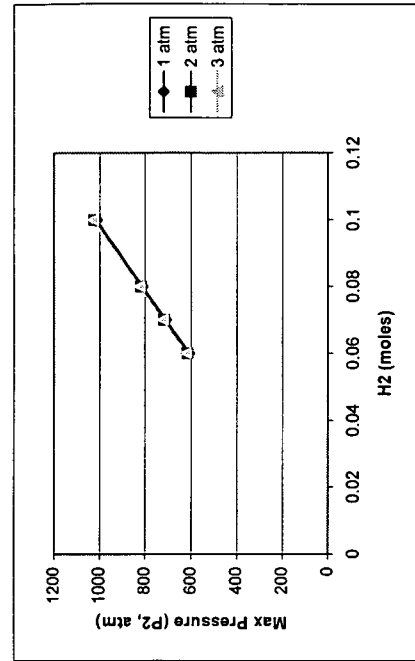
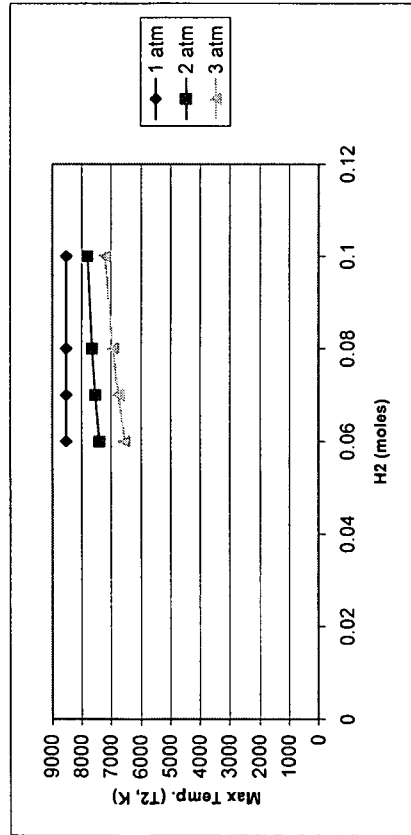


Figure 17

C.R. = 10				D.S. = 0.069 Liter				Vo = 0.69 Liter				To = 300 K				
Ps	n (H2O)	n (H2)	Po	Compression			Combustion			Expansion			Output			
atm	moles	moles	atm	gamma	P1	T1	Q	delta T	T2	P2	P3	T3	W 0→1	W 2→3	net work	HP
					atm	K	kJ	K	K	atm	atm	K	l-atm	l-atm	kJ	
1	0.1000	0.06	6.78	1.36	154.6	684	17.22	2909	3593	684.0	27.2	1430	-17.69	71.01	53.33	5.402
1	0.1000	0.07	7.32	1.36	168.0	689	20.09	3194	3883	785.4	31.3	1546	-19.08	81.54	62.46	6.327
1	0.1000	0.08	7.85	1.36	181.4	693	22.96	3447	4140	886.8	35.3	1648	-20.48	92.07	71.59	7.252
1	0.1000	0.1	8.92	1.37	208.2	700	28.70	3878	4578	1089.5	43.4	1823	-23.27	113.12	89.85	9.102
2	0.1500	0.06	8.57	1.35	191.8	672	17.22	2216	2888	721.6	28.7	1150	-22.34	74.92	52.58	5.326
2	0.1500	0.07	9.10	1.35	205.2	676	20.09	2468	3144	823.1	32.8	1252	-23.74	85.46	61.72	6.252
2	0.1500	0.08	9.64	1.36	218.5	680	22.96	2698	3378	924.5	36.8	1345	-25.14	95.99	70.85	7.178
2	0.1500	0.1	10.71	1.36	245.3	687	28.70	3103	3790	1127.4	44.9	1509	-27.93	117.05	89.12	9.028
3	0.2000	0.06	10.35	1.34	229.0	664	17.22	1790	2454	759.1	30.2	977	-27.00	78.81	51.82	5.249
3	0.2000	0.07	10.89	1.35	242.4	668	20.09	2011	2679	860.6	34.3	1066	-28.39	89.35	60.96	6.175
3	0.2000	0.08	11.42	1.35	255.7	672	22.96	2216	2888	962.1	38.3	1150	-29.79	99.89	70.10	7.101
3	0.2000	0.1	12.49	1.35	282.5	678	28.70	2586	3264	1165.1	46.4	1299	-32.58	120.96	88.38	8.953
																1800

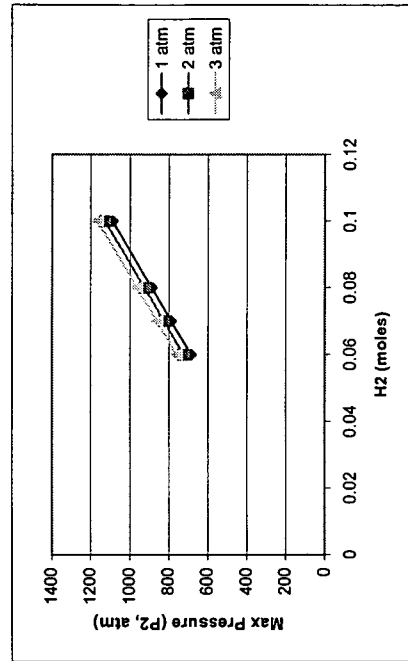
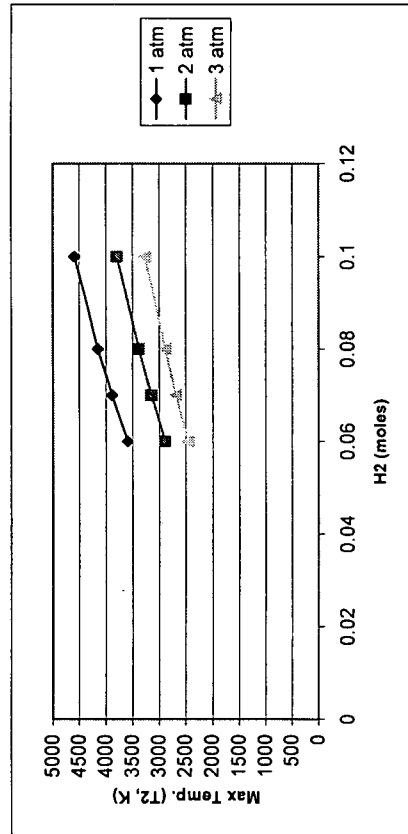


Figure 18

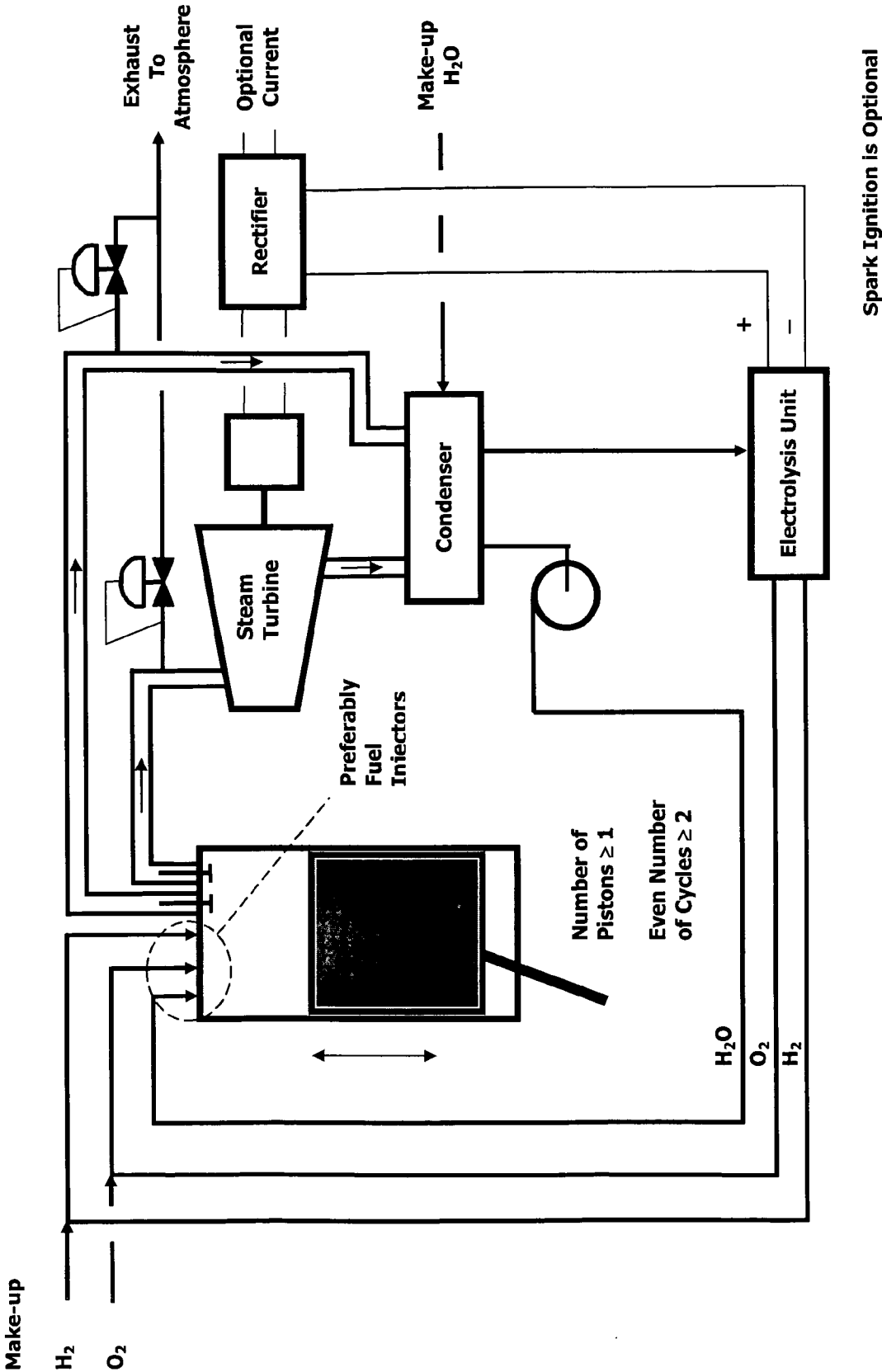
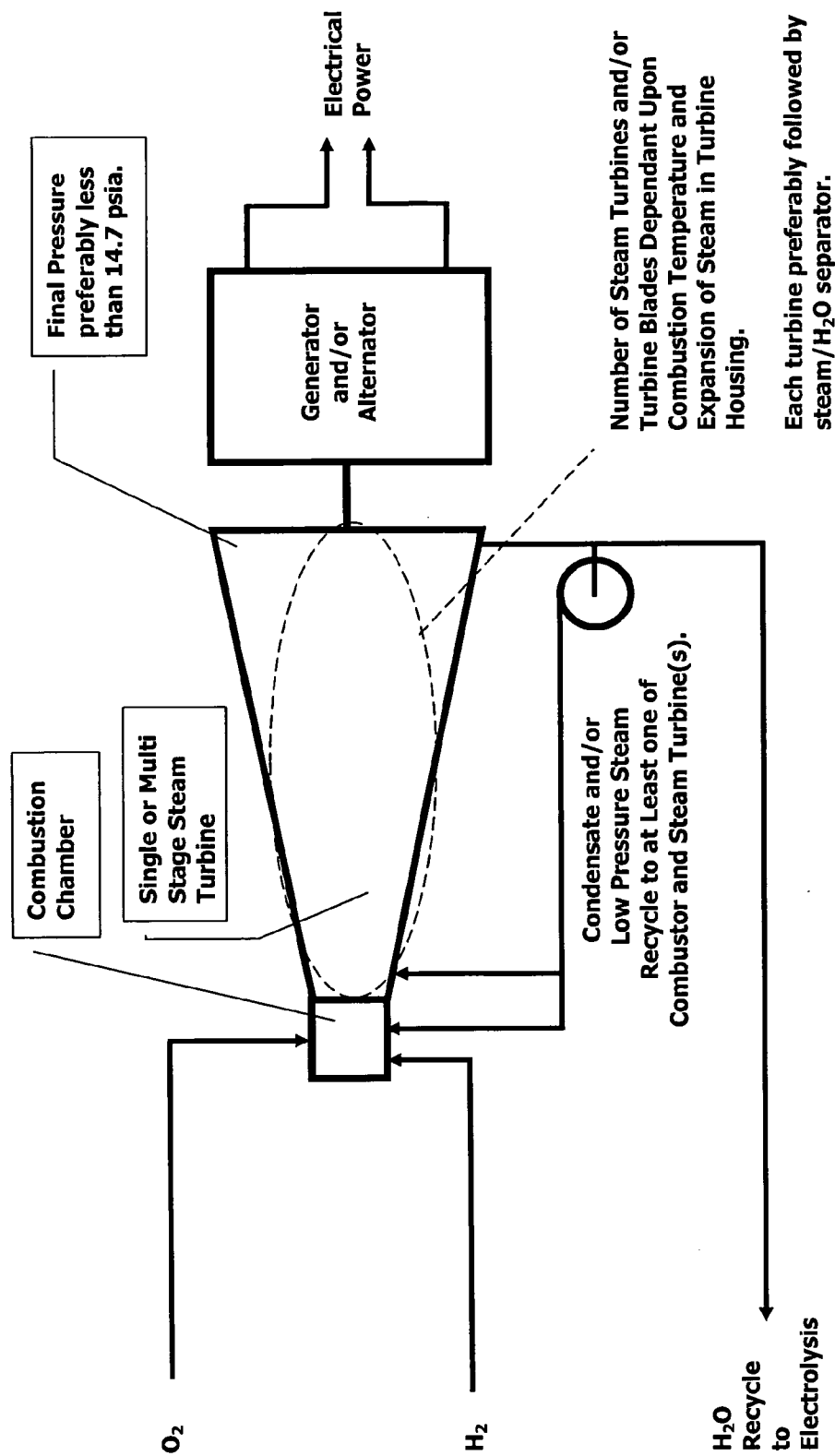


Figure 19



Space Engine Including The Haase Cycle with Energy Recovery Cooling

Figure 20

