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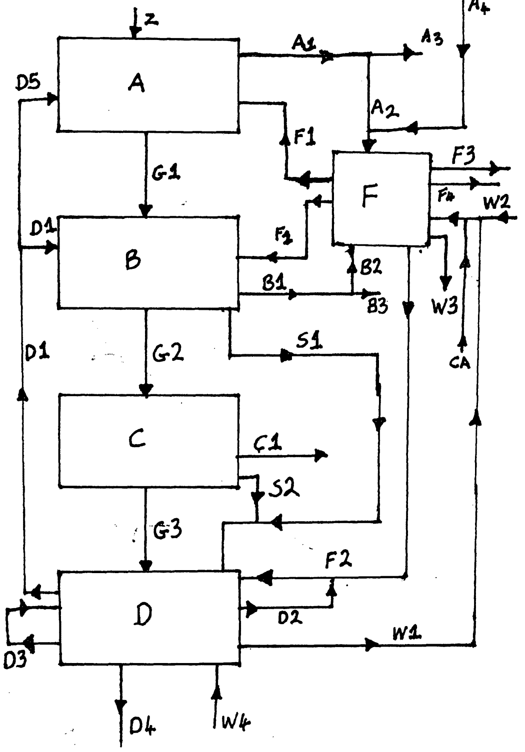
(58) Field of Search:
Other: **WPI, EPODOC, TXTA**

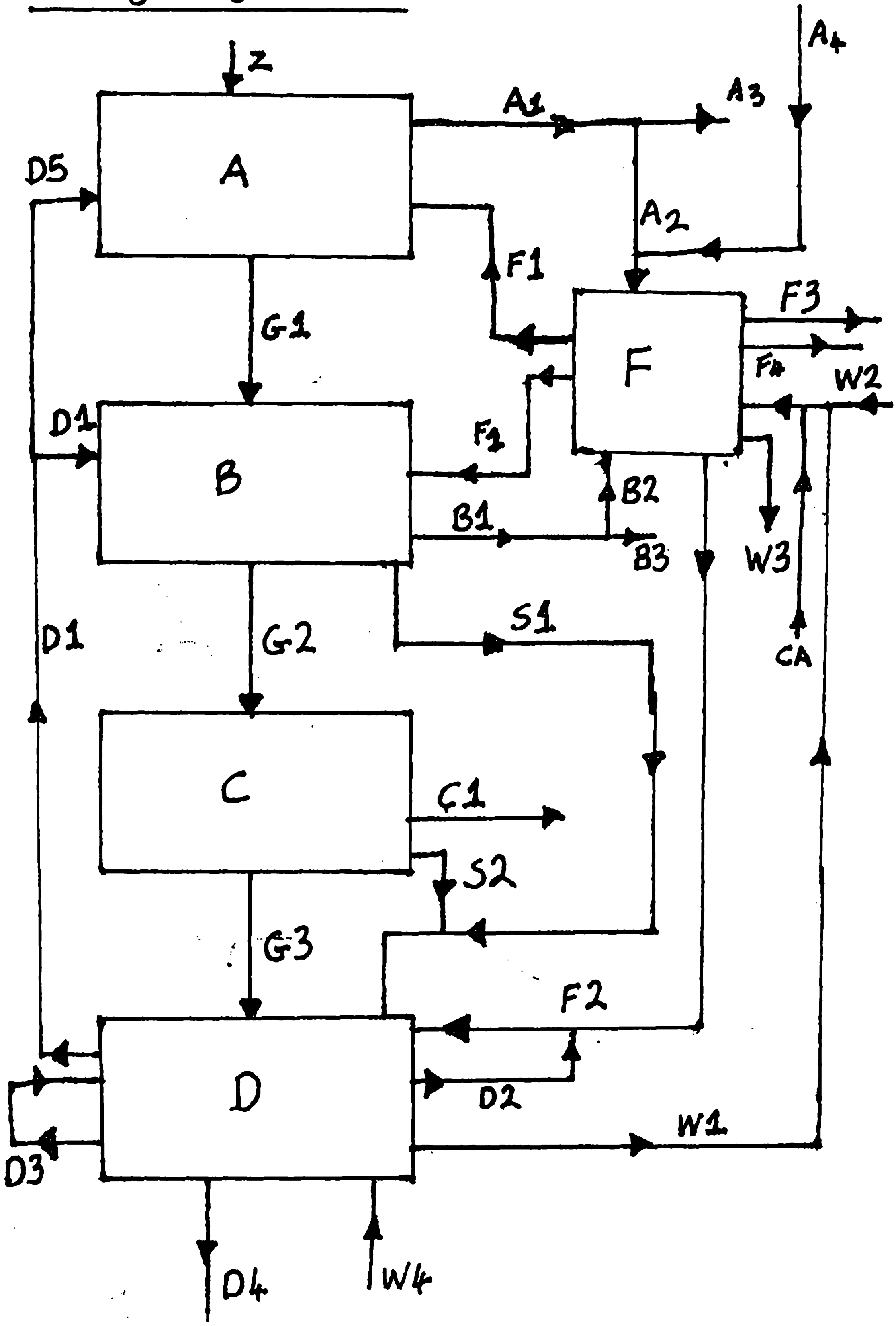
(54) Title of the Invention: **A design for an efficient symbiotic energy plant**
Abstract Title: **An efficient power plant which recycles the by-products of production**

(57) A power station is fueled by fossil fuels or biomass increases efficiency and reduces harmful emissions. Electrolysis may separate water into hydrogen and oxygen, with a calcium carbonate ($CaCO_3$) slurry remaining. Renewable energy, such as solar energy, may power the electrolysis. The oxygen may be used to increase combustion efficiency in the power station's main furnace. The hydrogen may react with the carbon dioxide (CO_2) produced by the main furnace, in a Sabatier reaction, to make methane (CH_4), to provide further fuel for burning. The calcium carbonate may be reacted with sulfur dioxide (SO_2) to form calcium sulfate ($CaSO_4$), which may be used for cement.

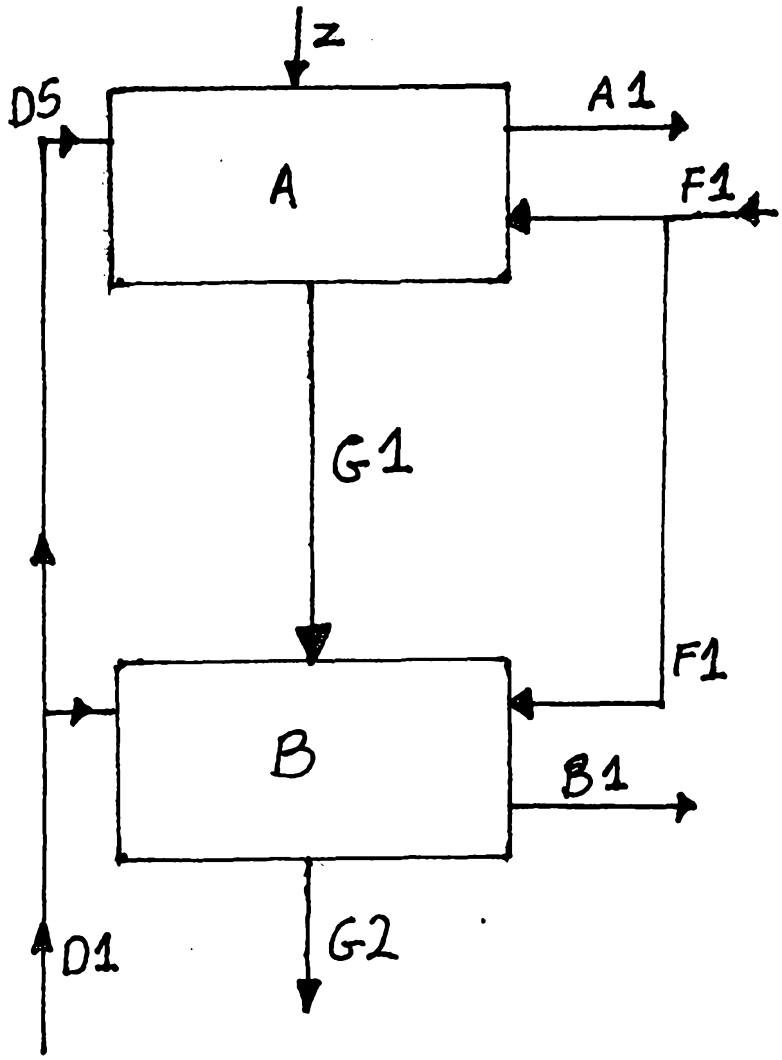
Figure 1



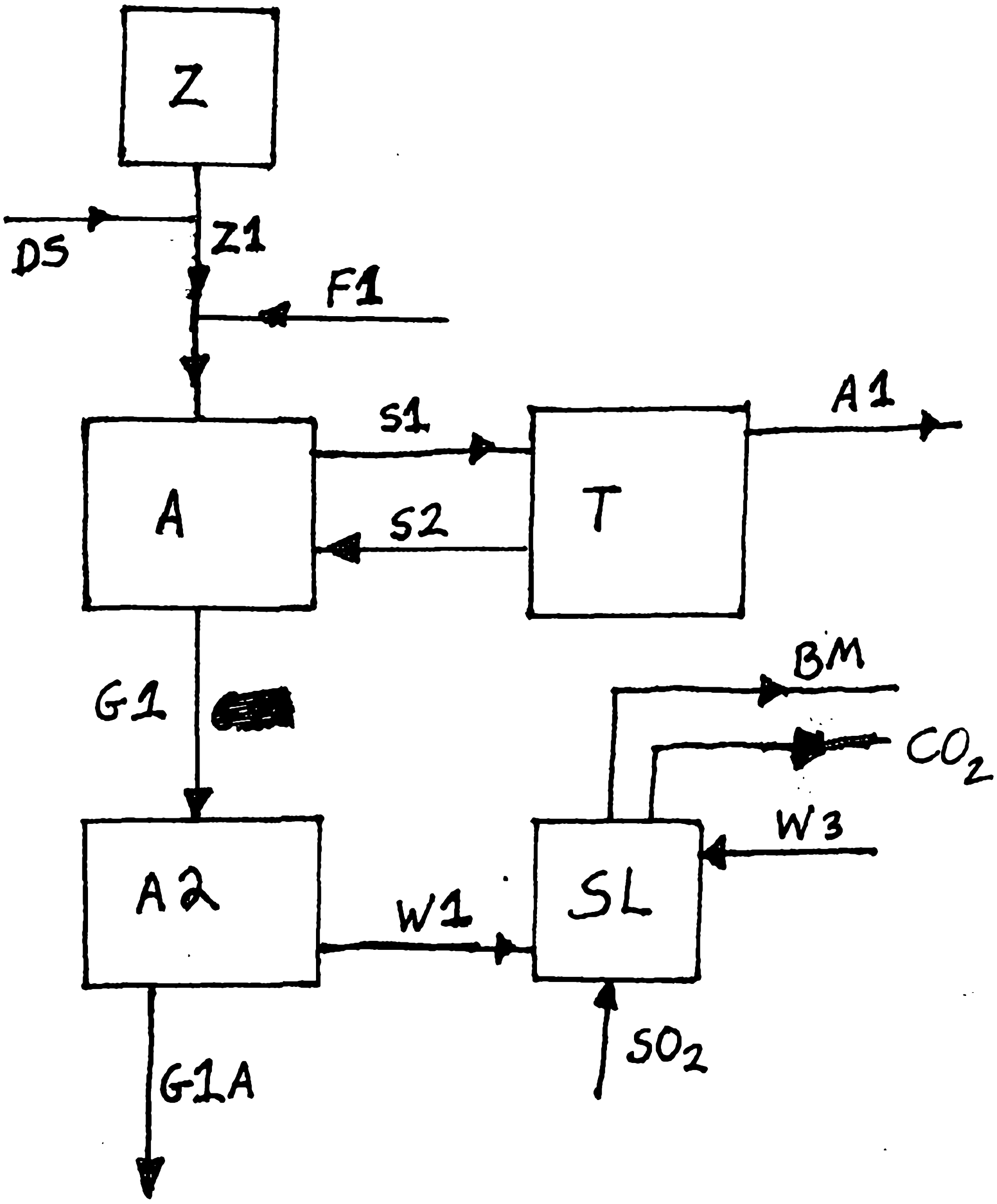
Drawings Figure 1



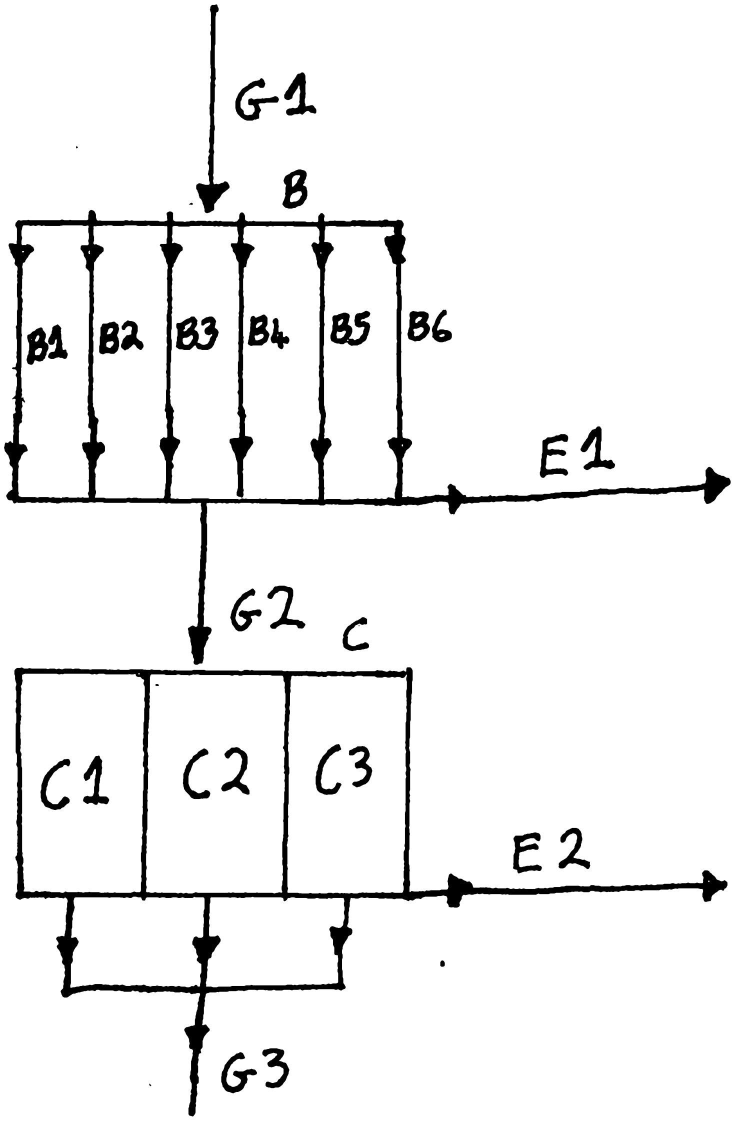
Drawings Figure 2



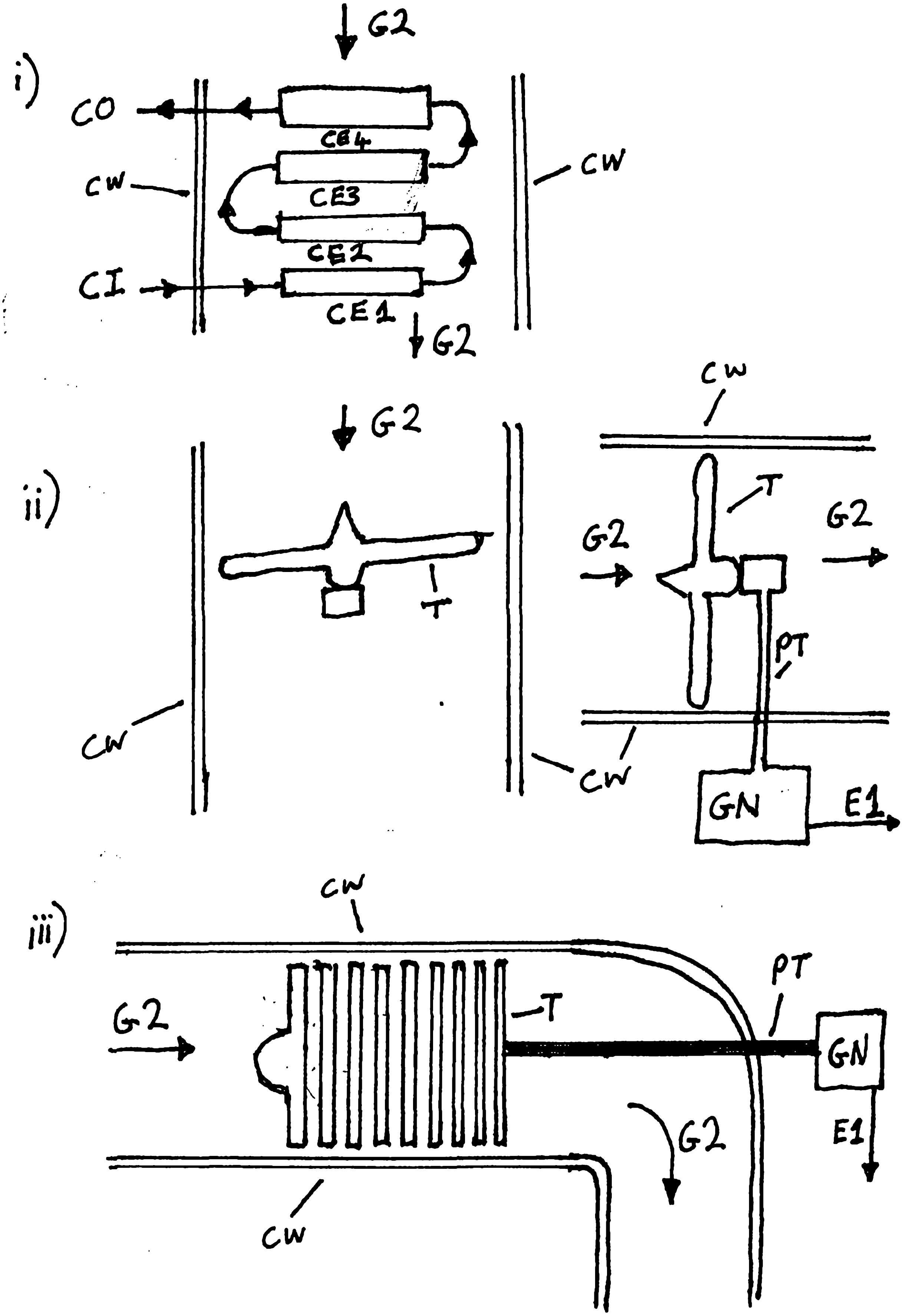
Drawings Figure 3



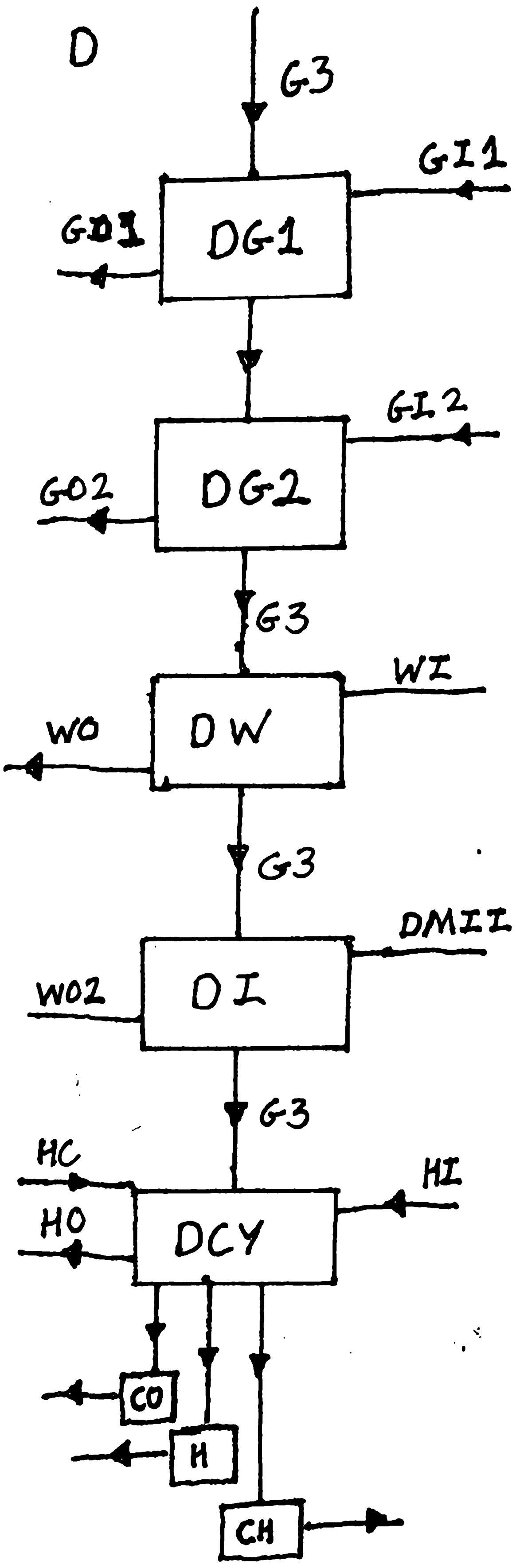
Drawings Figure 4



Drawings Figure 5

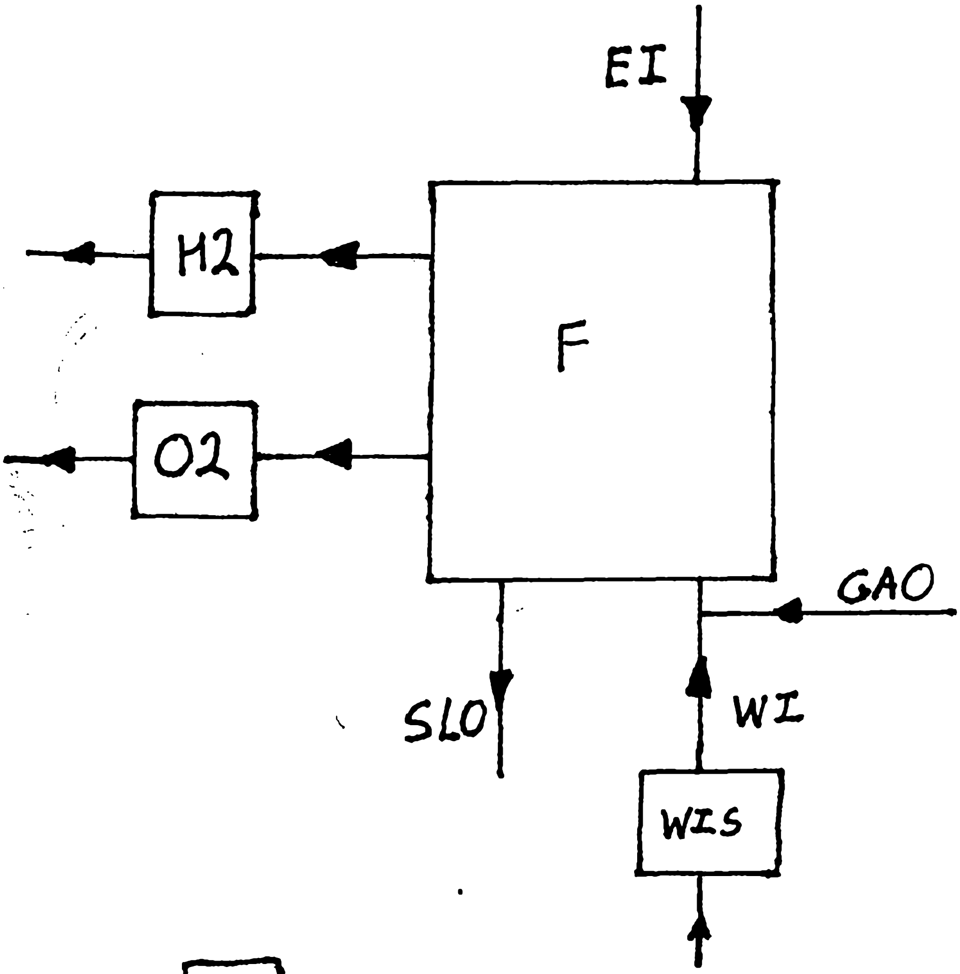


Drawings Figure 6

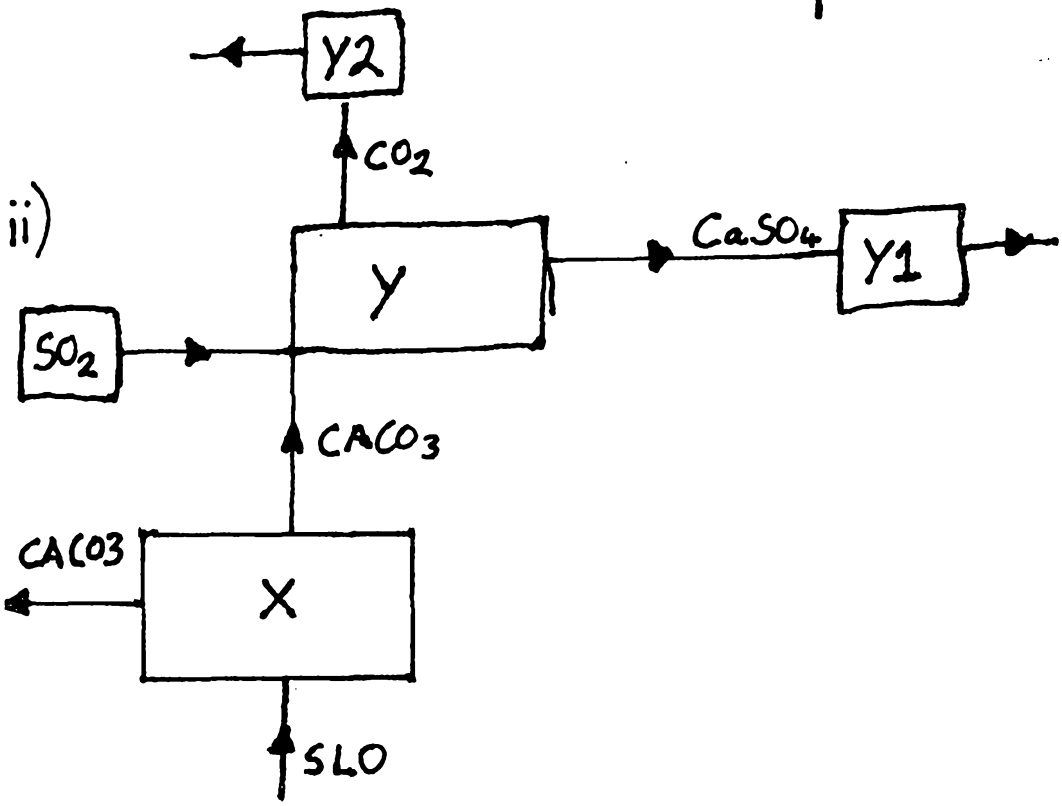


Drawings Figure 7

i)



ii)



Title : A design for an efficient symbiotic electricity power generation plant

By John Jackson Sept 09 2017

Background: A design for a electricity power generation plant was filed in June 2016, this utilised oxygen combustion of a fuel to produce steam to power turbines, to generate electricity, $CO2$ from the combustion was converted into $CH4$ (Methane) in a Sabatier process .The Hydrogen and Oxygen required was generated from electrolysis of $H2O$ (water) ,using either renewable power source or power from the power station or piped in from remote water electrolysis facilities. Some $CO2$ would be dissolved into $H20$ in the cooling process, facilitating a process of making $CaC03$ (Calcium Carbonate) when CaO (Calcium Oxide) was added to the water before/during use in the electrolysis process. This was designed to be low or even zero $CO2$ emission power generation plant, primarily for the burning/combustion of Bio mass /Bio fuels, but fossil fuels could be used also. It can produced $CH4$ via the Sabatier process for further use in combustion or for distribution to the Gas grid as well as electricity to the electrical grid by electricity generation from boilers steam turbines and generators or gas turbines and generators, the $CaCo3$ could be further converted into a form of cement $CaS04$, reducing emissions from cement production and giving a further economic ability. This design became patent application GB1613728.3 and has gone through the search process .The design noted that these power stations could be arranged in a symbiotic way to gain further efficiencies .The design does give some useful efficiencies both thermally and in power outputs however there is a further improvement on the symbiotic design, which this patent application would like to apply for ,using the same basis as GB1613728.3,but more refined in description and with an explanation of the efficiency possible if arranged in a symbiotic arrangement ,placing the components to improve methane production and to explain the modality better that was envisaged when filing the initial design (unpublished) that led to the patent application GB1613728.3.Since filing GB1613728.3 I have filed a patent for an electrolysis device which I hope will improve Hydrogen and Oxygen production from the splitting of the water molecule , as in application GB1613728.3 I was conscious that water electrolysis has a number of competing of designs ,so referring to it as an electrolysis bank ,was a less complicated way of trying to describe the various competing water electrolysis systems , and in this application as in GB1613728.3 reference is “electrolysis bank” meaning a device that can split and separate the water molecule, into its component elements of Oxygen and Hydrogen gases by passing an electrical current through the electrolyte (water).The best electrolysis cell for water electrolysis has so far achieved a 60% efficiency of electrical input into creating elemental Hydrogen and Oxygen gases ,small gains are important and adding a salt can improve efficiency ,in this example Calcium Oxide can be used ,which also removes and CO2 in the electrolyte (water) that may be present , in so doing creating Calcium Carbonate ,which will need removing for the cell .They system could be run without the Calcium Oxide , salt being added as in GB1613728.3 , noting another way of removing any dissolved CO2 in the water , would not occur which may create electrode build up or erosion. In GB1613728.3 it was envisaged that renewable electricity would be mostly used to power the electrolysis bank, allowing for electricity from the energy plant to be used when renewables are not available, since then it may be possible for the electricity generated by the power plant (combustion) could supply enough electricity, however leaving the option may allow these power plants to choose, where a plentiful renewable energy supply is available. The energy used to make the Calcium Oxide should ideally be a renewable, however Calcium Carbonate is the basic material to make Calcium Oxide, so it could be used as a recyclable product, rather than conversion into Calcium Sulphate CaSO4 as a useful building material.

Introduction and brief description: The combustion of Biomass or other fuels in Oxygen , rather than traditional air feed , offers an immediate thermal efficiency improvement ,in that energy is not wasted in heating the 78% of the Nitrogen (and other none oxygen gases) present in air , energy that is wasted in the flue products ,post combustion. Oxygen combustion also gives elevated combustion temperatures and higher velocity post combustion gaseous flue speeds, which poses a problem when higher electrical output power stations 500MW and over are required, higher velocities or higher internal flue pressures are possible and can have additional turbine placements (thought about in the first design), to generate electricity, however these velocities in more pure combustion streams which require little $CO2$ separation (where the combustion is controlled and clean as is possible in oxygen combustion) ,the majority of the post combustion flue products stream would be $CO2$ and $H20$, which in a traditional power station would be cooled and released to atmosphere , which is in effect an energy loss and such excess heat is rarely utilised except in urban heating systems , which are suitable for places where long cold weather periods are found. In the design application GB1613728.3 these same flue products are cooled and the $CO2$ separated out and processed through a Sabatier reaction , to give a post Sabatier stream of $CH4$,$H20$ and some $CO2$ and $H2$ unreacted which would be separated out and processed, the $CH4$ being used as fuel for a concurrent power generation station ,or for use in the initial fuel burning plant (as a co fuel) ,the $H2$ being fed back to the Sabatier reaction , or used for cooling , or as a combustion fuel source . So an initial power generation plant would make fuel for subsequent and concurrent power plants in arrangements to give grouping higher power outputs and energy and thermal efficiencies.

However whilst energy recovery is possible by having concurrent power stations of design GB1613728.3 and gives a Sabatier process for producing $CH4$ and other products, heating up of pre Sabatier reactants and cooling of post Sabatier reaction products, uses energy (which can be recovered) and it is felt that, if the secondary power generation plant could run in certain way at possible high internal pressures, that a further improvement may be possible.

A brief outline is if we take our initial biomass fuel /oxygen burning plant (other combustable fuels may be used) , we take our high velocity flue gas/products (with some filtering out of ash/char) , carry them in an insulated pipe feed , which then splits into multiple flows (as required but 2, 4 ,6 etc. are natural thoughts, although it could be one or many flows as required to the situation) , each individual flow then feeds a combustion chamber which is fuelled by methane and Oxygen (which can be pre heated utilising recovered heat for efficiency) which heats water to make steam to power turbines , to generate electricity Further turbines to generate electricity ,internal to the flue and post combustion products stream are also possible.

Given the post combustion products stream from the initial power station could be at high temperatures , when fed to these secondary electrical power generation plants , they would be more thermally efficient and use less fuel/oxygen .The CO2 ,hot water or steam vapour in the flue gas products , should not affect combustion , in the secondary CH4/oxygen fuelled power stations .Complete combustion of CH4 with Oxygen, gives CO2 and H2O , which would then go onto Sabatier process , with the CO2 and H2O from the initial power station or can be fed to yet another (as hot post combustion flue products with no intermediate Sabatier process) power generation station and CH4/oxygen combustion further .Whilst this process is repeatable , there is obviously a point where the accumulated H2O and CO2 needs processing , to give CH4 and recover the H20 and other products. However such a design does allow for large electrical power output ,power stations in a symbiotic , co relational design pattern , giving a useful base load electrical power generation system and a modality ability , not currently seen in current power stations, where some sections could be reduced or increased , to give larger or smaller electrical power outputs.

Description:

To try and describe every detail of complex energy generation system is difficult, this systems has options and modalities of operation which greatly help to give overall improved efficiencies of any combustion energy generation plant in use at the time of writing.

In a basic manner as in patent application GB1613728.3 this plant combusts a fuel, with Oxygen to generate electricity via Boilers and steam turbines and electricity generators and/or gas turbines, electricity generators .In patent application GB1613728.3 I realised that a symbiotic relationship of two or more power in a series arrangement plants would allow for greater outputs of electrical power and or CH4 production. This patent application whilst using the same innovative steps as in GB1613728.3 enhances and explains the symbiotic efficiency possible from the original design.

Fuels for the primary combustion component A ideally is biomass , however any combustable fuel can be used , and is combusted stoic metrically (with the required amount of oxygen gas and not air), this is an immediate efficiency gain as the large volumes of air to supply the oxygen component for the combustion are not required to be heated, so more of the heat produced can be converted into powering the boilers to raise steam to power steam turbines and electricity generators .Gas turbines work on gas expansion and heat is often although not always recovered ,gas turbines have advantages in speed of bringing into operation and closing down and a less complex and less costly and combust gases. Simple turbines that work by the pressure and velocity of a liquid or gas, passing over there blade arrangement to create a turning force to power generators are an old invention, such as windmills, wind turbines , water wheels and water turbines.

When combusting with oxygen, the fuels Joule energy value is optimised better , however this can also cause much higher temperatures in the combustion chamber or area of combustion , which in a conventional non-nuclear mass electricity generation plant would create more need for cooling .The temperatures and internal pressures ,post combustion flue products velocities ,possible with fuel/oxygen combustion require careful thought to boiler and gas turbine design, however this design attempts to show how these may be done ,and is more refined than patent application GB1613728.3.

A fuel ideally Biomass, but could be synthesised Methane, Alcohol, tyre crumb or a fossil fuel, is burnt/combusted with Oxygen , giving heat energy and post combustion flue gas products .The post combustion flue products flow could be of a high velocity/pressure and temperature , and it is possible that the primary stage of combustion in component A could be done at high pressure, if required .Combustion of fuels creates CO2 (carbon dioxide) and water (H2O) mostly , but other components in the fuel can create ,other molecules such as nitrogen oxides which may not be required. There may also be solid particulates of ash/char or unburnt products in the post combustion flue products stream. The Sabatier process requires CO2 and Hydrogen to make CH4 and water. If this primary combustion stage can produce a flue products flow composed of just CO2 and water ,this helps with processing further along , drawings figure 3 anticipates that where some separation of CO2 is required it can be incorporated .

The alcohol and methane burning/combustion with oxygen does not in general create ,post combustion flue gas products other than CO2 and H2O ,so these are ideal fuels to be combusted pre to Sabatier reaction processing , however the water produced (in combustion of any fuel) in current understanding , should be removed prior to the Sabatier process. If an efficient Sabatier process were possible, that could operate with water and CO2, then the whole energy system could be simplified, however once the CH4 and water are created by the Sabatier process, it must be reduced in temperature whilst maintaining a pressure as it can revert back to CO2 and Hydrogen, hence most systems end up with a controlled Sabatier process, requiring the CO2 to be separated out from the water in post combustion product streams. The Sabatier process is not 100% efficient as it is a gas mixing process, this means that unreacted CO2 and H2 can be in the post Sabatier product flow as well as the H2O and CH4.

So in drawings Figure 1 the description of the combustion flow is important, from component A in post combustion products flow G1 , we would have (with efficient combustion) a flow composed mainly of hot /high pressure high velocity CO_2 and H_2O ,which may be considered as heat source ,it is gaseous/vapour so if it is divided into individual balanced flows in component B into either gas turbines or individual furnaces to power boilers, we can have a secondary combustion ,using oxygen combustion but using methane as a fuel (other fuels may be used) , gaining not only the heat input from the primary post combustion flue products flow , but using the increased fuel energy conversion gained by oxygen combustion , creating a highly efficient second stage combustion system that creates a post combustion flue product flow consisting mostly of CO_2 and H_2O , again this could be a high pressure combustion system to help with velocities of the internal flue products and increase boiler heat transfer. The high temperatures possible make the component C, a way of recovering this heat and/or making further electrical power using turbines powering generators, these turbines being powered by post combustion flue gas pressure/velocities rather than combustion.

Flow G3 is the cooled post combustion products flow (from component B or component A if B is absent) and should be composed of CO_2 and H_20.

The purpose of component D is to not only cool the post combustion flue products flow but to heat gases used as coolants, it is both a cooling system and heat recovery system and has two cycles both similar only in the second cycle it would be processing the products from the Sabatier process flow to cool and remove the H_2O and then to go onto a cryogenic process to make liquid Methane and gaseous Hydrogen, Methane becoming a liquid before Hydrogen.

In component D the combustion flow products from component B having passed through the heat exchanger/electricity generation in component C ,will be warm to hot ,it is not possible to specify a precise temperature but 100-180oC or less would be useful. This flow G3 then enters (see drawings figure 6) DG1 which is cooled by a gas cooled heat exchanger, cool or cold gas is fed via GI1 and flows out as GO1, the flow G3 then continues to a second heat exchanger DG2 also gas using a gas coolant fed via GI2 and flows out as GO2.After this stage the flow G3 then goes to a water cooled heat exchanger section, to bring the flow G3 down to 5-10oC, so that water vapour may be condensed out.

The absorption of CO2 increases with lower temperatures being about 4g per litre at 10oC, so in this water cooled stage, water vapour condensing out will absorb some of the CO2 making a carbonated water condensate.

The now liquid water and gaseous CO2 can be passed through a crushed, flaked, cubed ice column, it is envisaged this to be a vertical column ,will be fed by ice at the top ,in system that allows for ice filling ,but sealed to the outside and perhaps to above atmospheric pressures, should the internal flow G3 be pressurised. In this first pass the duration may be short and most of the post combustion product flow water , water vapour should be removed leaving cooled CO2 gas .The ice may be demineralised to increase CO2 absorption .The ice is fed as flow DMII and exits the column as flow WO which will be cool, but not frozen water. This exit flow WO can go straight to the electrolysis as carbonated water, or can become the cooling water flow input for the previous DW stage, the WO outflow becoming the WI input flow (not shown in drawings figure 6).

The now cooled CO2 gas with the water removed of G3 at 0-10oC is suitable for using in the Sabatier process, which is in the DCY section, the temperatures and pressures required to gain the Sabatier reaction are quite high, however an efficient heat exchanger would allow the Sabatier process post reaction outflow to heat the incoming pre reaction CO2 and H2 gases. Sabatier reaction temperatures and pressures are around 300-400oC and 50psi (other temperatures and pressures may be used),so additional heating will be required , which can be done using electricity generated or a renewable source , or using steam or recovered heat from other sections of the system , the high temperatures suggest steam .The cool CO2 is heated along with the H2 separately taken up to 300oC and then fed and mixed to gain the 50psi pressure and suitable reaction duration time .The CO2and H2 is converted into CH4 and H20 , however it is not a completely efficient reaction , so in the post Sabatier process outflow stream as well as products CH4 and H2O we should also find some unreacted CO2 and H2.It is felt that the temperature of the post Sabatier outflow must be below 200oC before the pressure of 50psi (or other pressure used) can be reduced .

This post Sabatier process ,product stream then goes through a further cooling process similar to the one used earlier (not shown in drawings) i.e. a second DG1 ,DG2 ,DW and DI section as shown in figure 6 , to bring the post Sabatier products stream down to 0-10oC , condensing out the water vapour and absorbing some or all of any residual CO2.Any residual Hydrogen and the bulk CH4 gases are not or poorly absorbed by water, so pass through the ice column , any CO2 left would best be removed prior to the final cryogenic separation stage ,the flow of now CH4 and H2 gases , with water and CO2 removed can be taken down to very low temperatures to make Liquid Methane CH4 , the hydrogen at the temperature of CH4 liquefication remains a gas , so can be separated.

The separated out methane, can be stored as liquid, but as the energy system combusts CH4, this very cold liquid CH4 can be used as coolant either in DG1 and DG2 sections of component D, once gaseous it may be dried if required and processed to grid standards and fed to the gas grid.CH4 used in the onsite energy system can be dried and used to recover heat, Methane having a very useful property of having a very high auto ignition temperature, enabling it recover heat. This hot Methane can then fed into any co firing system used in the primary combustion component A, to increase boiler efficiency, or fed into the combustion section of the boilers of component B to increase boiler efficiency.

The use of hot Methane significantly increases the Boiler efficiency and may also improve gas turbine efficiency .Oxygen from the water electrolysis bank can also be used to recover heat and fed into the boilers of gas turbines adding a further efficiency.

So with oxygen combustion and hot methane and oxygen feeds boiler and gas turbine power and efficiency can be increased, which translates to less fuel being required.

It is assumed that components A and B will combust fuel, in a boiler, where heat from combustion is transferred, to heat water to steam and high pressure steam to turn steam turbines which in turn power electrical generators , and as stated earlier oxygen combustion may allow for high pressure combustion to occur. Gas turbines may be used most likely in component B and the heat recovery will need to increased in section C ,gas turbines powering an electrical generator .In either component A or B boilers or multiplicity of boilers ,steam turbines and generators is implied as is any multiplicity of gas turbines.

If high pressure combustion systems can be used further opportunities for post combustion flue product flow , where pressures and velocities can be suitably high , turbines can be used to generate electrical power directly as shown in figure 5 ii) and iii) .

The overall output of the energy system is affected by the power inputs of electricity to electrolyse water into H2 and O2 gases, which are high ,one value recently quoted was 1 megawatt to make 5000m3 of H2 per hour, the efficiency of the water electrolysis bank F in terms of electrical input is at the time of writing unknown , and in large power plants the electrical power requirements could be quite high in the order of 100s of MW, however the components A and B of primary and secondary combustion work in way to give greatly increased energy efficiency per Kg of fuel burnt compared to current technology , as well the opportunities for turbines to generate electricity ,that can use the post combustion flue gas products flow ,pressures and velocities. The efficiency of component B if burning Methane means that less methane would be required compared a current technology energy plant, inferring that greater amounts of CH4 can be fed into gas grids. It is hoped that these symbiotic plants will give greater combustion thermal energy efficiency to enable them to generate sufficient electrical power to supply the water electrolysis bank F and need little or none renewable energy supplies.

Where water supplies may be a problem fuels such as alcohol offer a great production of water from combustion, and oxygen combustion does offer the opportunity to use higher free water content fuels. The high temperatures of oxygen combustion and co firing of fuels stiochmetrically (with Oxygen) bring previous difficult fuels that gave emission problems due to low temperature combustion, into range , and may offer a route for number of previously more difficult fuels to combust.

The water electrolysis bank F, splits the water molecule into its component elemental gases of Hydrogen and Oxygen, electrolysis cell efficiency can be improved by adding a salt to the electrolyte, as water can absorb CO2, this can be used, by adding to this CO2 saturated water, Calcium oxide which in the electrolysis cell creates Calcium Carbonate as a solid deposited on one the electrodes , which can be removed from the electrolysis cell ,and further processed as slurry through which SO2 (and/or other products/substances) can be bubbled through to create CaSO4 or Calcium Sulphate which is form of cement and used in the building industry and by product of CO2, which can be processed in the Sabatier process. The outputs of this material may not be high, but may well offer a small economic benefit in making a by-product that can be used. If the water electrolysis bank F does not want to use a salt in electrolysis, it can still operate, so the use of CaO is a choice to make use of the CO2 saturated water and a small improvement in water electrolysis cell efficiency.

Modality : A further benefit is modality, this energy system is thought to be a base load system running for long periods day and night as ,they do not suite on off cycles .However where electricity demand patterns are more seasonal , by division/multiplicity of boilers/ gas turbines in components A and B , and in C sections can be closed down to run at lower outputs .

It is also possible to repeat component B combustion , rather than post combustion flue products going to a heat recovery section C , enabling a highly efficient methane (or other fuel) system to be used and the possibility to build very high MW power generation plants 2000MW and higher, but not as much Methane to store.

This modality offers further energy efficiency over seasonal variations which in the UK are quite marked, mid-winter using double the amount of electricity than in mid-summer , so in a UK summer a system of these energy plants can be run to lower electrical outputs and burning of fuel or some shut down completely, in a UK winter the plants can be run to full electrical output and fuel use , so unlike nuclear and current combustion technology energy production plants ,power production to the electricity grid can be varied from the power plants .

Other modalities may be not having a component B section, or design for specialist fuels such as tyre crumb or oil sludge or bio solids. Excess Oxygen produced can be used to oxygenate bodies of water, rivers or oceans.

Possible modifications and variations:

1) Additional component B secondary combustion sections can be added in series to increase electrical outputs and optimise the efficiency of secondary combustion and hot oxygen and Methane feeds to the combustion, creating a high efficiency high electrical output system.
2) The making of CaCO3 in the water electrolysis cells/bank is an option and need not be done, removing the energy requirement of making the CaO.
3) Turbines utilising the pressure and velocity of post combustion product flows can be utilised to power electricity generators to give additional electrical power outputs.
4) Gas turbines powering electricity generators can be used in place of boilers powering steam turbines that power electrical generators in components A or B, however it is felt that boilers, raising steam to power steam turbines will offer greater efficiencies.
5) Alcohol can be used in the secondary combustion component B; however it is felt that Methane will offer a better efficiency.
6) Secondary component B can be removed to have a simplified system, primary combustion component A, to cooling and the Sabatier process and cryogenic separation.
7) By using multiple boilers/steam turbines or gas turbines (which generate electricity from electrical generators)in components A and B can have sections that can be shut down to provide electrical outputs during periods of lower electrical demand, and increased for when higher electrical outs are required, offering a wider efficiency in fuel use.
8) By having sections for post combustion product flows in section C , heat recovery sections/turbine electricity generators can be closed or opened to match ,post combustion product flows.
9) The use of gas cooling, to cool post combustion product flows, not only heats the gases, but expands the gases, the pressure can be used to power smaller turbines that may generate electricity or have another use.

10) Hot Methane and Oxygen feeds to combustion centres can increase thermal efficiency and reduce fuel use compared to systems that do not pre heat fuel or oxygen.

Advantages of the invention:

1) High amounts of electrical energy production are possible.
2) Carbon dioxide from combustion can be converted into Methane via the Sabatier process, creating a low or zero CO2 emission electrical energy generation system.
3) Current thermal and energy efficiency of current technology combustion electricity production power plants and nuclear electricity production plants can be greatly improved.
4) Biomass fuels can be combusted in these plants as well as fuels previous unused that only combust cleanly in high combustion temperatures.
5) The higher energy efficiency means less fuel needs to be combusted enabling Biomass fuels and recycled fuels to be more widely used.
6) By using the post combustion products flow from the primary combustion component A to heat a secondary combustion component B, large amounts of heat energy can be used to reduce the fuel consumption of the secondary combustion component.
7) By recovering heat from the system and putting it into Methane and Oxygen combustion feeds, recovered heat can be re used to increase the thermal efficiency of components A and B.
8) Dissolved CO2 in water from the process used by the water electrolysis bank can be made into CaCO3, by adding CaO to make a salt electrolyte that can improve electrolysis cell efficiency. Further processing of the CaCO3 by bubbling sulphur dioxide through a CaCO3 slurry can produce a building material CaSO4.
9) Methane gas can be synthesised from CO2 making electricity power generation low or zero CO2, and providing methane source not from fossil fuel production systems.
10) Using biomass fuels can help to reduce the atmospheric CO2 by utilising plant photosynthesis to use CO2 and store Carbon and release O2.
11) Oxygen combustion offers more efficiency than using air to supply the oxygen for combustion as the other components of air do not have to be heated, and reduce Nitrogen oxide emissions.

12) Oxygen combustion means higher combustion temperatures can be attained , bringing previously difficult fuels into use such as low grade biomass of paper and cardboard, tyre crumb and can use higher moisture fuels .The higher temperatures also help with emissions of oils and fats and complex combustion substances/molecules.

13) Hot Methane and Oxygen feeds to combustion centres can increase thermal efficiency and reduce fuel use compared to systems that do not pre heat fuel or oxygen.

14) Early calculations suggest that the high efficiency will give an excess of Oxygen gas compared to the hydrogen required for the Sabatier reaction, this excess of Oxygen gas can be used to oxygenate rivers or oceans and Increase River and marine life, or the excess oxygen could be used to power more efficient internal combustion engines or some other use.

Introduction to drawings:

Drawings and keys are referred to components as they can best be described without confusion and complexity, beginning as basic framework of the whole system or in sections which will be further described in the description.

Drawings Figure 1: A schematic view of flows of materials and energy in the power/energy generation system.

There are 5 main sections key as A,B,C,D and F .A is the initial combustion power plant generating electricity is the secondary combustion plant generating electricity ,C is heat exchange plant that may also generate electricity, removing heat from the flue gas from plant B (or plant A if Plant B is not present),plant D is the Sabatier process, heat exchanger and consequential cooling section and cryogenic section to cool the flue gas products of D and separate out the gaseous and other components(or B or A if section C is absent) and section F is the "electrolysis bank" where water is split and separated into its elemental gases Hydrogen and Oxygen , using electricity either from a renewable source or from the power generation plants A,B or C. The flow of combustion products within the furnaces/boiler of A and B is shown as G1 and G2 , flow G3 is from the heat recovery/heat exchanger to the section D the cooling section to remove the water , then the CO2 and Hydrogen are mixed and processed in the Sabatier reaction , and then secondary cooling to remove the water and final cryogenic cooling section to separate post Sabatier products to make liquid CH4, gaseous H2.

To take each main component in turn

Component A key is the primary combustion plant , it is fed with fuel Z , this fuel is primarily envisaged as Biomass or recycled wood/paper/cardboard, however fuels such as Ethanol , plant and animal oils/fats , shredded or powdered tyres , waste mineral oil, or fossil fuels, or synthesised methane. The products are combusted to heat a boiler to provide steam for turbines or multiplicity of turbines to generate electricity, or for gas turbines or multiplicity of gas turbines should steam turbines not be used, however it is envisaged that boiler and steam turbines will be a preferable energy conversion of heat to electrical energy. From component F (The water electrolysis bank) we have flow F1 which is the O2 (elemental oxygen) flow to the burners /furnace/grate.

Flow F1 can be used to assist fuel supply Z to the point of combustion e.g blowing biomass into the combustion zone, it can also be heated from recovered heat (not shown in drawings) to improve thermal efficiency, noting also that such O2 may have to be dried (water removed)prior to use (drying not shown in drawings).Input D5 is synthesised Methane (CH4) from the Sabatier reaction component D ,again this can be heated using recovered heat to improve thermal efficiency (not shown in drawings) and may need to be dried (water removed) prior to use (not shown in drawings).Flow A1 is electrical flow , from electricity generated via gas or steam turbines or multiplicity of gas or steam turbines as part of component A . Flow G1 may contain internal pipe turbines that use the pressure and velocity of the G1 flow to generate electricity (see Drawings figure 5 ii and iii).

Pipe or flue gas transfer system G1 should contain a hot stream of high velocity post combustion products mostly of CO2 (Carbon Dioxide) and H2O (as water vapour), some ash char and unburnt products may also be present as well as some other oxides or gases. This pipe or flue post combustion transfer should be designed to cope with high temperatures and pressures , as should the construction of the furnace chamber and boilers and designed for long running time periods , it may be above ground or underground and should be well insulated to keep heat loss down.

Component B (see drawings figure 2) receives the post combustion flue gas products of component A via pipe ,post combustion transfer system G1 where it is distributed to the combustion chambers/furnaces/gas turbines of component B , as it is hot this aids thermal efficiency .Oxygen is supplied via flow F1 (this may be pre dried and pre heated using recovered heat not shown in drawings).Flow D1 is synthesised Methane from the Sabatier process of component D (this may be pre dried and pre heated using recovered heat not shown in drawings) to improve overall thermal efficiency. The synthesised Methane CH4 is combusted with Oxygen O2 , (and the flue products of component A) ,as either in gas turbine or multiplicity of gas turbines system to make electricity or a boiler or multiplicity of boilers to make steam, to power steam turbines or multiplicity of steam turbines to make electricity(not shown in drawings).

The post combustion products from either gas turbine or furnace flue products are symbolised as flow G2 which is pipe containing post combustion flue products and a transfer system consisting mainly of CO2 (Carbon dioxide) and H2O (water vapour) and some ash/ char and unburnt products may be present as well as other gases or products. Flow G2 may contain internal pipe turbines that use the pressure/ velocity of the G2 flow to generate electricity (see Drawings figure 5 ii and iii). Pipe or flue gas transfer system G1 should contain a hot stream of high velocity post combustion products mostly of CO2 (Carbon Dioxide) and H2O (as water vapour), some ash/ char and unburnt products may also be present as well as some other oxides or gases. This pipe or flue post combustion transfer should be designed to cope with high temperatures and pressures , as should the construction of the furnace chamber and boilers and designed for long running time periods , it may be above ground or underground and should be well insulated to keep heat loss down.

Flow B1 represents the flow of electricity from either gas turbine or multiplicity of gas turbines or boiler steam powered turbines or multiplicity of steam powered turbines, to power generators to make electricity. Flow A1 represents the flow of electricity from either gas turbine or multiplicity of gas turbines or boiler steam powered turbines or multiplicity of steam powered turbines, to power generators to make electricity.

Flow Z is the fuel supply to component A primary combustion section.

Component C and Drawings Figure 5

Section i) shows a schematic flow of flow G2 (post combustion flue products stream from component B or component A if B is absent) into component C which is a heat exchanger, to remove heat from the flow G2 and/or an internal turbine or multiplicity of turbines to use the pressure velocity/velocity of the post combustion products of flows G2 from component B and/or flow G1 from component A if component B is absent .The heat extracted/recovered being used to either power a further gas turbine or heat water in boiler to power a further steam turbine (not shown in drawings) or to be used as recovered heat elsewhere in the full system e.g. heating Oxygen or Synthesised Methane prior to combustion in components A or B. Key CW is the pipe wall containing the post combustion flue products G2 (or G1 if component B is absent), a counter current internal heat exchanger in series as key CE1,CE2,CE3 and CE4 (more or less heat exchangers may be used) , flow G2 (or G1 if component B is absent) passing through or around, heating the external surface of the heat exchanger, transferring heat to a flowing material internal, in a counter current manner, and separate from and perhaps pressurised , the post combustion flue products flow G2 (or G1 if component B is absent).using a counter current heat exchanger should enable higher heating of the coolant material shown exiting the combustion flow products pipe wall as key CO , flow CO then going on to power either a gas turbine or multiplicity of gas turbines to power generators to make electricity (not shown in drawings)or heat a boiler/s to make steam to power a steam turbine or multiplicity of steam turbines to make electricity (not shown in drawings).Flow CO once its heat is transferred returning to the heat exchanger system as key CI flow.

Figure 5 ii) shows a single turbine key as T (overhead and side view) within the post combustion flow G2 (the G1 is also a placement for these) very similar to wind turbine key CW is the pipe wall containing the post combustion products , the gases and vapours strike the turbine blade surface , so designed to rotate in one direction, to drive a belt/rope/chain or hydraulic pump key PT , to transfer the rotational power through the combustion flue products wall (but keeping internal pressures/products within the post combustion flue gas pipe/transfer system) , to drive a generator key GN to make electricity flow E1.

Drawings Figure 5 iii) Shows a more complex multiple section turbine, key T, which would look like a gas turbine, which may make better use of the pressure , this taking the rotational power of the turbine T , through a shaft, key PT, to power a generator key GN to make electricity shown as flow E1.

Component D receives the post combustion flue gas products flow from component C (see drawings figure 1) as flow G3, which having some heat removed in component C ,should be ready for cooling to remove the water vapour .Drawings figure 6 show stages within component D, starting with post combustion flow G3 , entering heat exchanger DG1 , which is cooled by gas (either CH4,O2,H2 or CO2) the coolant entering into the heat exchanger DG1 as flow GI1 and exiting the heat exchanger as GO1.

Flow G3 then exits DG1 and passes through heat exchanger DG2 which is cooled by gas (CH_4, O_2, H_2 or CO_2), the coolant entering into the heat exchanger as flow GI2 and exiting the heat exchanger as flow GO2.

Flow G3 then exits DG2 and enters heat exchanger DW, which is water cooled heat exchanger which should cool flow G3 to around 10oC .The coolant water (or chilled water not shown in drawings) enters into the heat exchanger as flow WI and exiting the heat exchanger as flow WO which may then flow to the water electrolysis bank component F (not shown in drawings figure 6).

Flow G3 then exits DW and enters a further cooling stage DI where Ice (formed from demineralised water if required) is introduced as cube or flake or crushed physical form in the top of vessel , flow G3 coming into direct contact with the ice allowing for the water vapour to condense out and absorb some of the CO_2in flow G3 , to create carbonated water which then may be used either as a direct feed to the water electrolysis bank component F (not shown in drawings figure 6) , or used as cooling water for the DW heat exchanger as flow WI , the water may contain some combustion products e.g. flecks of char/ash or molecules of other substances which may require removal (not shown in drawings figure 6).The mostly CO_2 vapour that now composes flow G3 (as the water has been removed) exiting section DI is cool at around 0-10oC .

The flow G3 now mostly composed of CO_2 gas and some water vapour and other combustion flue products is cool at 0-10oC and can be stored (not shown in drawings figure 6) , then moves into a Sabatier process (not shown in drawings) where it is mixed with hydrogen fed by flow HI at a ratio 1volume of CO_2 gas to 4 volumes of Hydrogen/H_2 gas (mixing at same temperature and pressure), pressurised and heated (to 50psi and 300-400oC or other pressure temperature combination as required) to facilitate the Sabatier reaction, where CO_2+H_2 is converted into CH_4 gas and H_2O water vapour and some unreacted Hydrogen gas and CO_2 gas. The heat from the Sabatier reaction can be recovered in a heat exchanger process (not shown in drawings figure 6), but may also require additional heat inputs, which may come by electrical heating from on site or renewable electricity supplies to site, or from steam or heat recovered in components A,B,C or D (not shown in drawings figure 6) or other source of heating .The post Sabatier reaction products should be cooled to less than 200oC whilst at pressure and it is hoped the process will have a heat exchanger process to get below 100oC ,key HC is for coolant input and key HO is for coolant exit ,HO supplying a source of recoverable heat for e.g. heating or drying in heat exchanger not shown in drawings.

The post Sabatier reaction flow consisting of CH4 gas ,H2O vapour and some unreacted CO2 gas and H2 gas , must now go through another cooling stage similar to that as described above with DG1 ,DG2 ,DW stages and DI stages (this similar stage not shown in drawings figure 6 and some components may be changed dependent upon what is required except for the DI stage) at the DI stage the post Sabatier product flow should be less than 10oC but above 0oC again coming into direct contact with ice as described in previous DI system, to remove the water vapour and as much CO2 as possible absorbed into the water.CH4 and H2 gases are not absorbed by water , so exit the ice cooling, as gases with most of the water and CO2 removed in exit flow WO2.

This flow of post DI cooling may contain small amounts of water vapour and CO2, which may need to be removed before the cryogenic cooling. The flow then moves to a very low temperature cryogenic system taking the temperature down to the liquid point of CH4 (methane) , the heat produced can be recovered and used elsewhere, the Hydrogen has a lower liquefication point than Methane so should remain a gas , the gaseous Hydrogen and liquid methane then need to be separated, the liquid CH4 then being dried if required and going to store key CH , to be used as required e.g. a gas coolant prior to going to processing for supply to the gas grid standard or to store as Liquid Methane. The hydrogen gas, would be energy expensive to liquefy and store and would need drying prior to going to store key H, as a super cooled gas it could be used for cooling electrical generators used in the components A,B,C and/or reused in the Sabatier process to reduce water electrolysis requirements, or used as a fuel in combustion components A and B.

The absorption of CO2 into water to produce a carbonated water that can be used in the electrolysis bank, is temperature dependent and it may well be that some CO2 will need removing at some early point in the cryogenic system or prior to it, if CO2 can be removed in the cryogenic process and separated out then it can go to store CO to be used either for cooling, or to be re used in the Sabatier reaction, or other use or release to atmosphere.

Component D sequence is based the first sequence of cooling is to separate out the water and some CO2 and other post combustion products, components of stream G3 , which is shown in drawings figure 6 , however the stage DCY contains both a Sabatier process and further cooling process similar to the drawings in figure 6 and the Sabatier process and second cooling stage are not shown in the drawings figure 6 .The post Sabatier reaction products only (and not the post combustion flue products G3) proceed to the cryogenic process stage , to make gaseous Hydrogen and Liquid Methane.

Section D as whole may be changed to improve efficiency, should process evidence allow for the Sabatier reaction to take place in high amounts of water vapour and is designed, as current information suggests water should be removed prior to the Sabatier reaction, and the variant will be shown in modifications and variations section.

This concludes the drawings to show the main process flow and I will now show the introduction to drawings as figures 1 to 7

Drawings figure 1 schematic diagram of whole system

Key

A=primary combustion section fed by fuel Z and Dried Methane fuel supply D5, oxygen supply F1 possibly at High internal pressures, and post combustion flue product flow G1

B=secondary combustion section fed by fuel D1 (dried methane/CH4 gas), oxygen supply F1 and post combustion stream from primary combustion G1 possibly at high internal pressures. Secondary post combustion stream from B is G2.

C=Heat exchanger or multiplicity of heat exchangers to recover heat and/or turbine or multiplicity of turbines powered by the velocity/pressure of the direct flow of G2 becoming outflow G3.

D=Cooling of post combustion product flow G3 to remove water , then to process in a Sabatier reaction , fed by Hydrogen supply F2, and heat recovered or steam from B or C shown as flows S1 and S2 respectively to supply any heat required to sustain the Sabatier reaction. Flow D2 is hydrogen recovered from the final cryogenic process, if re used back into the Sabatier process (other routes for recovered Hydrogen gas are not shown Drawings figure 1) .Flow W4 is water in feed of filtered, demineralised water for ice making and cooling, Flow W1 is carbonated water to flow to the electrolysis bank. Flow D4 is the CH4 gas/liquid from the Cryogenic separation process for use as fuel or to store or any other use e. g. cooling. Flow D1 is the direct flow of dried Methane/CH4 for use in component B secondary combustion as flow D1 and/or component A primary combustion as flow D5. Flow D3is any CO2 as gas that can be separated and re used in Sabatier process or other use.

A1=flow of electricity from component A (produced by combustion of fuel Z with Oxygen flow F1, by either gas turbine or multiplicity of gas turbines to power electricity generators or boilers, to make steam to power steam turbines or multiplicity of boilers and steam turbines to power electricity generators not shown in drawings).To flow A2 to supply electricity to the water electrolysis bank, or to flow A3 to the electricity distribution grid system. Flow A4 is electricity from a renewable source such as solar energy, wind energy or hydro energy if required.

B1=flow of electricity from component B (produced by combustion of fuel D1 with Oxygen flow F1, by either gas turbine or multiplicity of gas turbines to power electricity generators or boilers, to make steam to power steam turbines or multiplicity of boilers and steam turbines to power electricity generators not shown in drawings).Flow B2 to supply electricity to the water electrolysis bank F, or flow B3 to the electricity distribution grid system.

C1=flow of electricity from turbine or multiplicity of turbines powered by post combustion stream G2, flow S2 is heat recovered from heat exchangers either in steam or other substance, and/or additional boiler/s creating a further possible steam turbine/s, using just the recovered heat to power a electricity generator to give additional electrical power to flow C1 (boilers and turbines and electricity generators not shown in drawings).

Component F= the electrolysis bank , powered by electricity sources flows,A2,A4 and B2.electricty flow C1 could also be used to power the water electrolysis bank (not shown in drawings) .Flow F1 is the oxygen produced from the splitting electrolysis of water into its component elemental gases (Hydrogen and oxygen which may also be dried if required).Flow F3 is Calcium Carbonate $CaCO_3$ removed from the electrolysis cells created by CAO Calcium Oxide reacting with CO_2 dissolved in water if required, flow F4 is Calcium Sulphate $CaSO_4$ (the Calcium Carbonate treated with Sulphur dioxide gas) if required. Flow CA is Calcium Oxide added to water to be used in the water electrolysis bank, prior to electrolysis to improve the electrical efficiency of the electrolysis cell and make $CaCO_3$, which will build up on an electrode in the electrolysis cell/bank requiring removal from the electrode and from the electrolysis cell to become product flow F3. Flow W3 is CO_2 gas from making the Calcium Sulphate $CaSO_4$ which can be cooled and used for cooling and/or sent to component D for use in the Sabatier process for conversion into CH_4 (not shown in drawings).

Flows G1,G2 and G3 will be in contained pipes or transfer system capable of withstanding high pressures and temperatures and be insulated.

Drawings Figure 2 simplified Schematic flow showing

Key (see also above Drawings figure 1 for detailed explanation of key labels)

Component A fed by fuel Z and Methane fuel flow D5 (if required), oxygen supply F1, electricity output A1 .Post combustion flue products flow G1 to secondary combustion component B where fuel D1 (Methane /CH_4) is combusted with oxygen from flow F1.post combustion flue products from B forming flow G2.Electricty produced as described in previously in drawings Figure 1 as flows A1 and B1.

Drawings Figure 3 showing a schematic flow of a variation of component A discussed further in modifications and variations section.

Key

Z= fuel source
D5= Methane supply, possibly dried and heated using recovered heat.
Z1= fuel source mixed with Methane
F1=oxygen supply (from water electrolysis bank component F not shown)

A=combustion chamber to provide heat energy for boilers or multiplicity of boilers to raise steam.
S1= steam from boiler to power steam turbines section T or multiplicity of steam turbines.
S2= steam return from steam turbine or multiplicity of steam turbines section T back to boiler to be re heated.
T=Steam turbine and electricity generator or multiplicity of turbines and electricity generators.
A1=electricity flow from generators to further use or to electricity grid.
G1=post combustion flue gas flow to section A2.
A2=Separation system to remove, ash/char or other particulates.
W1=Flow of ash/char other particulates to slurry tank SL.
G1A=outflow of post combustion stream from combustion section A, with ash/char other particulates.
SL=Is slurry tank containing particulates from combustion and CaCo3 from electrolysis bank as flow W3,flow SO2 adding sulphur dioxide gas , to create CaSO4 exiting the slurry tank as flow BM.CO2 produced in the process exiting the slurry tank via flow CO2.
SO2= Sulphur dioxide gas supply to be bubbled through the CaCO3/ash/char/particulates slurry.
BM=CaSO4 outflow from slurry tank
CO2=CO2 outflow from reaction of SO2 with CaCO3 in the slurry tank.
W3= CaCO3 slurry input to the slurry reaction tank from the water electrolysis bank.

Drawings Figure 4 showing schematic division of flows to provide even flows and facilitate plant modality, to secondary combustion component B, bank of electricity generators and heat recovery section C.

Key
G1=combustion products flow from primary combustion component A
B= component B
B1=1st boiler, steam turbine and electricity generator or gas turbine and electricity generator feed and combustion unit.
B2=2nd boiler, steam turbine and electricity generator or gas turbine and electricity generator feed and combustion unit.

B3=3rd boiler, steam turbine and electricity generator or gas turbine and electricity generator feed and combustion unit.

B4=4th boiler, steam turbine and electricity generator or gas turbine and electricity generator feed and combustion unit.

B5=5th boiler, steam turbine and electricity generator or gas turbine and electricity generator feed and combustion unit.

B6=6th boiler, steam turbine and electricity generator or gas turbine and electricity generator feed and combustion unit.

G2=collected post combustion flue gas flows from B1, B2, B3, B4, B5 and B6.

E1 =Electricity flow from component B.

C=component C

C1=section of heat exchanger and /or additional turbine/s powered by the pressure/velocity of post combustion flow, receiving part of the divided post combustion flow from G2.

C2=section of heat exchanger and /or additional turbine/s powered by the pressure/velocity of post combustion flow, receiving part of the divided post combustion flow from G2.

C3=section of heat exchanger and /or additional turbine/s powered by the pressure/velocity of post combustion flow, receiving part of the divided post combustion flow from G2.

E2=electricity generation from turbines powering and electricity generator.

G3=post component C1, C2 and C3 sections manifold, to collect the post combustion flue gas flow exiting from C1, C2 and C3.

Drawings Figure 5 Cross section through sections of C showing simple heat exchanger and turbine powered by the flow /velocity of the post combustion flue gas products from component B.

Key (see description component C and drawings figure 5 as above)

Drawings Figure 6 showing product flows ,of post combustion flue products in a cooling stage prior to the Sabatier process to remove water and repeated after the Sabatier process to remove water and CO2 (as required) to the final cryogenic stage to separate out the Hydrogen and Methane .

Key see component D section above in introduction to drawings.

Drawings Figure 7

i) Schematic view of electrolysis bank F showing

Key

F=component F ,the electrolysis bank , where water is split into its component elements of Hydrogen and Oxygen gases , by passing an electric current between electrodes suspended in an electrolyte (water or water and a salt).Or other water electrolysis process.

H2=Hydrogen gas separated from electrolysis cell reaction.

02= Oxygen gas separated from electrolysis cell reaction.

SLO=CaCo3 (calcium carbonate solids) removed from the electrolysis cells as part of reaction in energised electrolysis process, will be a slurry containing CaCO3 and water.

WIS=Store of water (from component D with CO2 absorbed to create a carbonated water) or water from external supply (not necessarily carbonated and if the making of CaCO3 in the electrolysis cells is not required, could be plain de mineralised, de carbonated water).

CAO=The flow of CaO (calcium oxide) added to the carbonated water flow feed into the electrolysis cells, to react during the energised electrolysis process , with the CO2 absorbed in the water feed ,to produce CaCO3 and improve the efficiency of the electrolysis cell , by creating an enhanced ionic creation. If CaCo3 is not to be made, then CaO need not be added and the electrolysis cell can be run on plain water.

EI=Electrical inputs to energise the electrolysis bank/cells/electrodes.

Claims:

1) That this energy system offers greater thermal and electrical power generation efficiency than current combustion electricity production technology.
2) That water can be electrolysed to produce Hydrogen and Oxygen gases by passing an electric current through water from electrodes suspended or held within the water/electrolyte.
3) That using a primary combustion component A to feed its post combustion flue products to a secondary combustion component B residual heat can be used to enhance the thermal efficiency of component B , combustion and reduce the fuel used.
4) That using methane and Oxygen gases to recover heat and create hot Methane and Oxygen feeds ,and then be fed to use in combustion either as mono fuel fired or co firing can increase thermal efficiency of either primary or secondary combustion components
5) That CH_4 methane can be synthesised from CO_2 of post combustion products using the Sabatier process.
6) By repeating the secondary combustion component B in series, preferably using CH_4 as fuel high electrical outputs can be achieved.
7) That this energy system can be reduced or increased to match electrical energy or CH_4 production requirements ,giving much greater energy control in larger demand patters or seasonal demand patterns.
8) That this system may produce an excess of Oxygen from water electrolysis which may be used to oxygenate bodies of water , rivers and oceans , helping to provide greater marine biology productivity and sequester more CO_2 in such bodies of water.
9) That this energy system can produce high electrical outputs which can be put to electrical distribution grids and also produce synthesised methane which can be put to gas grid distribution systems.
10) That this system offers low or zero CO_2 emissions in operation.

Amendments to the claims have been filed as follows

Revised claims v3 for GB1714707.5

1. That this device/system of this patent application ,is a fuel combustion system and that it consists primarily of , unit/units so arranged to make a continuous high electrical energy outputs to a distributed electrical and/or high power mechanical outputs, continuously and related in arrangement to bring about efficiencies of heat, fuel and reduced direct emissions of combustion products to atmosphere, not seen in technology currently in use and that the arrangements of units contained in this patent application is considered state of the art. The unit/units mentioned above are comprised of singly/or are multiples/multiplicities thereof, the following combustion units and /or water electrolysis units, and /or remote water electrolysis units , and/or heat recovery units , and/or cooling units , and/or Sabatier reaction chamber/process units and /or remote satellite Sabatier reaction chamber/process units ,and/or gas separation units ,and/or water removal units and/or electricity generators ,which either combined or in part ,can exhibit new and novel advantages over current technology of power stations that combust fuels to supply an electrical distribution grid and/or combustion systems that provide mechanical outputs or/ and in certain variants ,provide an excess of synthesised methane in a continuous output where a Sabatier reaction is used ,to gas distribution and grid systems as shown by schematic drawing figure 1 and other drawings of the patent application.

2. It is further claimed to claims 1 that the unit/units of combustion will use the convention that a fuel when combusted releases energy ,mostly in the form of heat that is converted to either a mechanical output shafts/drives such as found in gas turbine ,or by the heat raising steam in a boiler and the said steam being used to drive steam turbines which in turn have mechanical shafts /drives outputs, and that said mechanical shafts/drives can be tasked with generating electricity , as the convention of rotary electrical generator and/or tasked with providing mechanical power.

3. It is further claimed to claims 1 and 2 that the system has variants of engineering that are specifics of invention and the patent application ,that offer an advantage over current technology where a fuel is combusted and exhaust/emissions are released to atmosphere directly ,in that substantial

emissions to atmosphere consist of the gas Carbon dioxide and it is known that a chemical conversion of Carbon dioxide to Methane ,is possible, using what is known as a Sabatier reaction/Sabatier reaction chamber , where Hydrogen gas is mixed with Carbon dioxide gas and subjected to controlled and specified temperature and pressure ,to make Methane and water. It is further claimed that being able to synthesise a fuel from post combustion emissions is a more efficient system for combustion, and reduces emissions to atmosphere directly from such combustion systems in use that can only emit exhausts to atmosphere.

4. That further to claims 2 and 3, the term combustion, is conventionally defined as oxidation of a substance/fuel that takes place at a rapid rate of reaction, releasing energy mostly as heat/ pressure changes due to the heat energy, where said pressure changes are so confined/managed as to produce mechanical movement/force. It is convention that in combustion the main source of oxygen is as free elemental gas and that in most combustion reactions, the Oxygen reacts to form molecular oxides and/or other substances, which can be said to be the post combustion products, which in single stage combustion event/process are routed as exhaust. It is further known that said exhausts of combustion carry with them some of the heat energy that was produced by the combustion reaction, and that in most combustion systems currently in use ,this heat is waste heat as heat is not usually considered a fuel ,as it is a product of combustion. In most single stage combustion systems in use this heat loss/waste as energy is considerable. It is claimed that if waste heat from combustion can be recovered and reused then the efficiency of fuel used increases, and that the re use/or optimised use of heat energy is conventionally termed, in combustion systems as thermal efficiency.

5. Further to claims 4 and conventions it is known , that in power stations that generate electrical power to electrical distribution grids using a single stage combustion process (of boilers to raise steam to power steam turbines to drive electrical generators) that only around 35% of the fuel energy combusted is converted into electrical energy ,in some more modern designs this has been increased to 45% and in power stations that use waste heat to power district heating systems (sometimes termed as

combined heat and power plants or CHP) this efficiency can increase to 60% of overall fuel conversion . It is further claimed that heat lost as exhaust in single stage combustion power stations, without a heat re use system of a CHP design will be losing 16-20% of heat energy of the fuel in the exhaust.

6. Further to claims 4 it is convention that where a combustion system uses a single stage process of combustion as gas turbine that fuel efficiency to electrical power or mechanical power is around 50% of fuel conversion.

7. It is further claimed as convention that most combustion systems obtain the oxygen for combustion from air, by what is termed air drafting, air being composed of different gases, free elemental Oxygen gas comprises around 21% of airs substance, Nitrogen as free elemental gas comprises around 78% of airs substance. In internal combustion engines and gas turbines ,the presence of Nitrogen is mechanically useful in that it enables gaseous expansion/and pressure and a piston engine or gas turbine running with air with the nitrogen removed ,would run much hotter and may offer material destruction as the Nitrogen also acts to remove heat build-up. It is also convention that most gas turbine or reciprocating engines try and cool fuel/air/oxygen mixtures prior to combustion to enable more fuel/air/oxygen to be introduced into any combustion stage or process, to give a greater expansion effect of products formed and greater power output. It is convention further that the Oxygen required for complete combustion , can be determined as an oxygen to fuel ratio ,but that air drafting systems would use more oxygen , as in combustion the free Nitrogen gas forms Nitrogen oxides , effectively removing Oxygen from the complete oxidation of the fuel/fuels so being combusted .It is further claimed that the oxygen fuel ratio is greater for an air drafted combustion system attempting to attain complete combustion ,than for a combustion system using air with the Nitrogen component removed.

8. That further to claims 4 and 7 that it is convention that complete combustion is attained if sufficient free Oxygen is present to oxidise all of the fuel, and would release more energy/heat energy. It is also claimed as convention, that complete combustion would create post

Revised claims v3 for GB1714707.5 continued

combustion products of gases or vapours of much simpler chemical composition than the initial fuel. It can also be said in convention that incomplete combustion can leave particles of uncombusted or partially combusted fuel as fine particles/deposits and or more chemically complex gases or vapours, which can be harmful/toxic pollutants. It is claimed as convention that attaining more complete combustion is a fuel use efficiency and with some fuels a lowering of pollutants in emissions post combustion. It is convention also that high temperature combustion, if also complete combustion, would create post combustion products of more simple molecules as gases or vapours.

9. It is further convention that an alternative to conventional air drafting for combustion, is to use oxygen or as near to pure oxygen gas as can be obtained and no air be allowed into combustion , and that when so ignited as fuel and oxygen, and or give sustained combustion post ignition of oxygen and fuel, that with sufficient control of fuel and oxygen that complete combustion can be obtained, releasing more energy/heat energy. Further that where a gas as fuel is combusted with Oxygen that the combustion is rapid and can produce very high temperatures and/or high flame temperatures e.g. Methane with oxygen as flame produces flame temperatures with parts of the flame at over 2000oC.

10. It is convention that any fuel with a carbon element component, when combusted completely with oxygen releases energy and produces an oxide of carbon called carbon dioxide. Many fuels are rated using there carbon content ,in physical chemistry and it is convention that fuels with greater carbon to carbon or C-C linkages are considered to have a higher energy output when combusted , as the fuel has a greater density of carbon ,per unit of mass or volume .It is also convention that most fuels in common use in combustion , are termed hydro-carbons and it is convention that this term relates to molecules containing Hydrogen, Oxygen and Carbon elements in differing ratios on the molecular structure of the fuel, which also determines many physical and chemical properties of hydro-carbon molecules. Fuels that can be combusted may also have other organic and inorganic chemistry molecules, which when combusted/oxygen combusted and/or are subject to high flame temperatures can form other chemical molecules, post combustion. The conventions of combustion/oxygen combustion chemistry of hydro-carbons is that the molecules form oxides ,releasing heat ,these oxides in oxygen combustion are conventionally Carbon dioxide and water , as the fuel (as pure hydro-carbon fuel) was solely composed of hydrogen ,oxygen and carbon. Very few fuels are pure hydrocarbons. It also convention that many hydro-carbon fuels and organic/inorganic chemistry fuels when combusted and/or subjected to very high temperatures form into simple substances either as elements or molecules, and it is further convention that higher combustion temperatures give more molecular breakdown to elements or simple molecules ,than lower combustion temperatures such as those temperatures found in traditional air drafting or combustion as compressed fuel or burning/combustion in a single mass or mass of uneven/irregular sizes. It is convention that more complete combustion can be achieved in fuels of small physical particle size or freely available as a simple molecule, as the conversion to oxides, that release energy is so much faster if sufficient oxygen is present for complete combustion, such a rapid rate of combustion also giving elevated temperatures per unit of fuel combusted. It is convention that incomplete combustion will not release as much energy, as heat ,and may also not generate as many oxide molecules as well as residues of complex molecules that have not been broken down into simpler molecules or elements. It is further convention that such incomplete combustion products in low temperature or single stage combustion process/units, of usually solid fuels and/or so called fossil fuels e.g. Coal , that when combusted produce residues of ash/char mainly due to the conventions above ,which are a by-product of combustion and/or are stored or converted into materials. It is further convention that complete combustion is generally desired to give efficiency of heat output per unit of fuel used, and that incomplete combustion is considered thermally inefficient.

11. That further to claims 1 it is claimed ,an efficient arrangement particular to this patent application is of putting combustion units in sequence ,in way termed sequential combustion , whereby a fuel is combusted and that the products of what may be termed a primary combustion unit/component are contained within containment ,which may be termed

Revised claims v3 for GB1714707.5 continued
as a flue and so sealed to prevent escape/leak of the post combustion products and also that the containment offer thermally efficient carriage of the said post combustion products ,over a short distance and into the combustion area of a further or secondary combustion unit/section , whereby a fuel is combusted again and that this may be termed 2 stage sequential combustion .The post combustion products from the secondary stage then proceeding in containment to either further combustion units ,heat recovery sections, cooling sections and Sabatier reaction as required ,or if required released to atmosphere. It is further claimed that where additional units of combustion are required that they can be arranged in parallel or series units, such additional units being used to either have greater power outputs and/or to enable difficult fuels to combust to go through the required amount of combustion stages so that complete combustion of the fuel/fuels can be attained. It is claimed that a 2 stage sequential combustion arrangement may be suitable for most applications see drawings figure 1 ,key component A being the primary combustion unit and component B being the secondary combustion unit.

12.It is also claimed further to claims 11 and being an efficient arrangement that the patent application can combust a variety of fuels in its combustion units ,however it is preferred and advantageous that the fuel used in secondary combustion (or further units of combustion) be a gas preferably natural gas and or Methane. Also drawings figure 1 shows a supply to the combustion units A and B of a flow D1 which is Methane synthesised and separated from a Sabatier reaction chamber/Sabatier reaction process. It is claimed that the synthesised Methane of flow D1 can be used to co fire/co fuel with other fuels in varying amounts as required, to either component A or component B of drawings figure 1, it is however preferred that the flow D1/or natural gas be used solely, or as mixture to fuel secondary or further units of combustion, as this gives higher flame temperatures particularly as oxygen/methane flame from a burner. It is claimed that products of incomplete combustion such as ash ,char, soot's and smoke be further combusted in a secondary stage of combustion (or further combustion stages) to gain the complete combustion of claims 8,9 and 10, whereby the post combustion products

Revised claims v3 for GB1714707.5 continued

of a prior combustion stage are so mixed/introduced into a subsequent combustion stage so that said prior combustion products are subjected as fully as possible to the high flame temperatures/high heat environment of the secondary combustion unit and if required further controlled to gain complete combustion by additional oxygen. It is further claimed that in using sequential combustion as oxygen combustion and also a secondary combustion unit using Methane and/or natural gas as fuel would be a an efficient system for dealing with fuels that are chemically or physically difficult to combust, and are used in a primary combustion unit and that sequential combustion as an oxygen fuel system would produce little or none physical post combustion products such as ash, char,soots and smoke particles if complete combustion is achieved.

13. Further to claims8,9,10 and 12 it is claimed that the variety of fuels capable of being combusted in an sequential combustion ,oxygen/fuel combustion system , as fuel sources either in mixture/co fuel/co firing or used as sole fuel, in a primary combustion unit are but not exclusively ,biomass, bio solids ,heavy oil, bio oils ,bunker fuel, coal , powdered tyre waste streams with metals removed/ tyre derived fuel oil, alcohols ,oils fats and waxes, wood waste. That this variety of fuels, able to be used gives greater fuel selection and use and enables fuels previously difficult to burn to meet pollution and environment concerns and that this invention enables wastes to be used as fuels that single combustion stage technology does not as it does not completely or creates pollutants that cannot/should not be released to atmosphere and or toxic residues as in claims 8.That also high moisture fuels (above 10% moisture e.g. bio solids at 30% moisture) can be combusted in sequential combustion oxygen/fuel system.

14. It is further to claims 1and 5 claimed that by using sequential combustion, heat contained/carried by post combustion flows/exhaust can be said to add to the heating requirement of any subsequent combustion stage and that this may reduce the fuel requirement of said subsequent next combustion stage. Further to claims 10,11 and 12 it is claimed that by using sequential combustion as an oxygen fuel combustion system that as Oxygen is normally a gas that heat can be transferred, by heat exchanger

Revised claims v3 for GB1714707.5 continued
to pre heat the oxygen prior to combustion and also that a fuel can be pre heated (as required/permitted by its chemical and physical properties and or design of system requirements) using a heat exchanger. It is also claimed that elemental gases can be taken to quite high pre heating temperatures and that this is useful whereby the system can recover and induce such high temperatures in gaseous feeds of oxygen or fuel, particularly where a combustion stage is fired by gaseous oxygen and a gaseous fuel from separate feeds prior to mixing and ignition and dependent upon volumes use could introduce heat into the combustion unit or than heat produced directly from combustion , and lower the fuel requirement of such a combustion stage.

15.That further to claims 1 and drawings figure 1 key component F it is claimed that the device/system in using combustion will require a supply of oxygen for combustion/oxygen combustion/sequential combustion oxygen system and that this is preferred to come from the electrolysis of water, electrolysis so defined as passing an electrical voltage/current ,between an anode electrode and cathode electrode suspended/within an electrolyte (and or other definition of electrolysis), which being composed of Oxygen and Hydrogen atoms as H2O that said H20 when electrolysed will produce Hydrogen and Oxygen gases as products.

16.That further to claims 1 and drawings figure 1 key component F it is claimed that the device/system in using a Sabatier reaction chamber/Sabatier reaction process will require a supply of Hydrogen and that this is preferred to come from the electrolysis of water, which being composed of Oxygen and Hydrogen atoms as H2O that said H2O when electrolysed will produce Hydrogen and Oxygen gases as products. That the Hydrogen produced can also be used for coolant purposes and/or a fuel.

17.That further to claims 1 it is claimed that where the said method of electrical power generation is from combustion in boilers to raise steam to power steam turbines and where fuels/co firing fuel can be pre heated and further where oxygen of an oxygen fuel combustion system can be pre heated prior to a combustion stage that this can reduce the fuel requirement of any combustion stage so used.

18. It is claimed further to claims 17 that any pre heating of either fuel, oxygen ,air if from waste or exhaust heat , so collected from a heat recovery section such as in drawings figure 1 key as component C and drawings figure 5i), and/or waste heat/heat produced from a cooling/cryogenic process as in drawings figure 1 component D and in drawings figure 6 that this would enable an improved thermal efficiency and fuel use efficiency compared to systems that do not recover heat and induce the heat to pre heat fuel/fuels and/or Oxygen.

19. Further to claims 18 that post any final combustion stage, particularly where a high moisture fuel is used and or high amounts of water vapour present in the post combustion products flow, that the said post final stage combustion products flow will be carrying considerable heat energy, as it is convention that water has high specific heat capacity value, and that in a sequential combustion system water/water vapour could be present in high volumes, amounts. In drawings figure 1 component C is a heat recovery section and component D (in part, a cooling component that can produce heat, to be recovered), where high water vapour post combustion flows are made .e.g. by a high moisture fuel being combusted, the component C could recover a lot of /most of heat to any coolant/ heat exchange coolant e.g. oxygen or a fuel to high temperature, the said oxygen or fuel as a coolant then carrying this heat back into one or more combustion sections. It can be claimed that high moisture fuels when combusted in a sequential combustion system ,enables high amounts of water vapour to be produced , which will enable (with suitable heat exchangers) a greater amount of heat to be recovered and returned to (as pre heated fuel and/or pre heated oxygen) to any/all combustion/sequential combustion sections. It can said therefore that high moisture fuels when combusted can enable greater heat to be recovered and reintroduced into combustion sections/units.

20. That further to claims 18 and claims 19 , in removing heat(in drawings figure 1 key component C /heat recovery section) from any final post

Revised claims v3 for GB1714707.5 continued

combustion product flow will reduce the volume of the said post final stage combustion products flow, and that if the component C is connected to a cooling section key component D/cooling section ,that a continuous flow of decreasing volume is attained ,which will have pressure/pressure gradient and that in drawings figure 5 ii) iii) shows turbines powered directly by the pressure of the cooling and/or post combustion products flow ,either as similar to a wind turbine/single propeller and/or as a turbine of multiple blade sections ,similar to a gas turbine that can drive additional electrical generators or power output shafts (or multiples thereof) and the patent application claims that additional power outputs can be engineered compared to a combustion system that does not cool the post combustion product flow, creating additional electrical/mechanical power outputs than seen on combustion systems that do not use heat recover and cooling sections, and can be said/claimed to give such systems a greater electrical/mechanical power output per unit of fuel used.

21. It is claimed that the component D shown in drawings figure 1 is a cooling section using gas and water heat exchangers (or combination thereof) to get the post combustion products flow in a first stage to a temperature of 0-5oC (drawings figure 6 key DG1,DG2,DW ,DI and DCY) and remove any water vapour .This cool/cold water can be used as coolant and then transported and or treated to remove any physical or chemical contaminants as required , and if required transported to the electrolysis unit/units of claim 15 and 16, to be electrolysed to produce hydrogen and Oxygen gases and/or used in ice making , and it is further claimed that from claims 13and 19 that in being able to combust a high moisture content fuel that the said water vapour that can be removed ,and will be greater than any combustion system that cannot combust high moisture fuels, and this recovery of water from combustion will reduce the water requirement for water electrolysis if required, of the system, enabling sequential combustion systems to be located in places where less water is available and allow water to be recovered from the combustion process ,as a by-product which could be used for agriculture or other use.

Revised claims v3 for GB1714707.5 continued

22. That further to claims1, 2,15 and 16 that the electrical supply for the electrolysis of water may come from a renewable source and or source external to the plant, but it is preferred that the design/system uses a continuous sequential combustion system and oxygen fuel combustion method ,of primary and secondary combustion (or additional connected unit/units of combustion that are connected in either series or parallel arrangements) ,whereby the steam/or mechanical power turn electrical generators to produce electricity for the use by the electrolysis unit/units to electrolyse water H2O to its products of Hydrogen and Oxygen gases.

23. It is convention that electrolysis systems use the DC wave form of electrical power/supply and that most supplies to and from grid networks are AC wave form ,that these waveforms are convertible using understood electrical technology control means in use, and that the patent application as a result of this convention refers to electrical supply/flow in general terms without naming the waveform directly, and it possible that in actual engineering that electrical waveform conversion uses could not be used and that certain units could be tasked with generators specific to the specific electrical waveform/quality required. That the drawings Figure 1key A2,A4 ,B2 , drawings figure 4 key E1 and E2 ,drawings figure 5 ii) and iii) key E1, Drawings figure 7 key EI, are given as electrical flow/supplies without specific referral to waveform type or placing of waveform converters/or specific waveform type electrical generators for ease of description.

24. That further to claims 1,2 ,20and 21 that a controlled fuel or oxygen input so used to a combustion unit, can be pre heated ,dependent upon its behaviour chemically and physically ,when so heated to elevated temperatures, so as to either aide combustion and/or be a supply of heat energy. The heat for pre heating using recovered heat from the processes, from either drawings figure 1 key component C and/or component D , drawings figure 6 key DCY sections or any other suitable heat source to transfer heat ,by routing the supply of fuel in containment through suitable heat exchangers, either singularly or in a concurrent/sequence to amplify the heat being carried by the pipe/supply of said fuel to supply one or multiplicity of combustion units with a controlled flow of pre heated fuel and/or oxygen. The heat energy ,so introduced being claimed to help reduce the fuel requirement, required by the design specification ,compared to a system of fuel combustion that does not pre heat the fuel to elevated temperatures and/or recovers waste/surplus heat from combustion or heat recovery or cooling sections of the process/system or part thereof. It is claimed further that , what may be termed conventionally as solid fuels/or fuels containing physical solids are thought to be able to pre heated even if having a high water content in the method of combustion termed as Oxygen combustion . It is further claimed that gaseous fuels/fuels that can be transported with high levels of pre heating and/or transported in the absence of an oxygen/oxidative e.g. methane which has high temperature of spontaneous combustion that such physical properties further enhance the amounts of heat that can be recovered and re introduced into a combustion unit or multiples thereof.

25. That further to claims 1 ,3and 21 the cooling component key D as in drawings figure 1 and drawings figure 6 key DCY contains a Sabatier reaction chamber capable of receiving a continuous flow of cooled post final combustion stage products flow drawings figure 6 as flow key G3,that is preferred to be a flow of mostly CO2 as gas with most/all water vapour removed and also all/most non CO2 physical and chemical impurities removed and that the said Sabatier reaction chamber is able to mix hydrogen gas (from claims 4) with CO2 in a controlled and correct ratio (convention ratio as 4 volumes of hydrogen to one volume of CO2 at standard temperature and pressure) , and that this be taken to a temperature and pressure as well mixed gases (convention of the Sabatier reaction varies but is given as 300-400oC and 50psi/345 kilopascals, other temperatures and pressures may be used),to cause CO2 to react with Hydrogen to make CH4 methane and water H20 ,which should exit the Sabatier reaction chamber in a continuous manner and proceed as drawings figure 6 DCY to be cooled ,but that the flow be kept at pressure (convention of 50psi/345 kilopascals other pressures may be used) until the flow can be cooled to below 200oC and or what temperature the chemical re combination (sometimes called steam reformation) of CH4 into CO2 is stopped , and the flow is composed of chemically stable molecules and or any atomic gases remaining in the post Sabatier flow,

Revised claims v3 for GB1714707.5 continued
which may be some CO2 and hydrogen gases unreacted in addition to CH4 and H2O.That the said post Sabatier flow be cooled to around 0-5oC in a final section DCY which being that the flow that again passes through direct ice contact , can remove any water vapour and can remove some/all CO2 , by the said CO2 being absorbed by the water ,this making use of the convention that hydrogen and Methane are not absorbed by water and that these may pass through the DCY section as gases, and also that CO2 is heavier than Hydrogen and Methane and so any Carbon dioxide Hydrogen and Methane in a vertical column, will allow CO2 to be separated out leaving a flow consisting of mainly CH4 and any residual/unreacted Hydrogen to flow to a Cryogenic cooling freezing section ,drawings figure 6 key DCY, where the said flow of CH4 and residual H2 gases can be taken to very low freezing temperatures to liquefy the CH4 component and if required the hydrogen component , but be able to draw them as separated substances if required .The convention being that CH4 liquefies at around -160oC and Hydrogen at around -180oC (at pressure to be specified/determined) . It is claimed that the heat from cooling post final combustion stage and post Sabatier reaction stage and from the freezing/liquefication and/or any ice making for DI and DCY stages will be considerable and that the cooling system is designed to process.

26.the large volumes expected in large combustion system , efficiently in stages that can be of differing size/throughput as required, and or re arranged as required ,it being difficult to be precise on final engineering of this component D .It is claimed that component D can produce as end product liquefied CH4 in a continuous manner (bar any intermediate storage/balance sections) , and it is further claimed that such a system will produce heat for recovery to pre heat Oxygen or fuel and that the heat from the freezing/cryogenic/gas liquefying section ,acts an additional heat source ,than the fuels so combusted in the system and enables heat (that may otherwise be wasted) be used to reduce fuel used ,giving a fuel combusted efficiency/thermal efficiency that other systems not having a continuous production of liquefied CH4 from a Sabatier reaction ,are unable to attain , as heat can be used as recovered introduced

Revised claims v3 for GB1714707.5 continued

back into combustion sections with fuel and/or Oxygen so supplied to said combustion units.

27. It is convention/understood that steam that is normally lost in boiler/steam circuits to steam turbines , sometimes referred to as "blow down" and released to atmosphere , can be used in an oxy fuel sequential combustion system ,by injecting it/releasing it into pre (preferred) or post combustion flows , and it is further claimed that this would aid water recovery and thermal/fuel used efficiency.it is convention that such steam "blow downs" can be some 10% or more of a boilers consumption /making of steam and is known as an important loss of fuel energy in boiler steam/steam turbine energy systems.

28. It is further claimed that where an electrolysis system is of classic description/convention/understanding ,of electrodes suspended in an electrolyte to enable a voltage/current to be passed through the electrolyte and create ions/ion transport flow/mechanism, so shown in drawings figure 1 and description of drawings as key component F ,that where water from the ice cooling sections of component D see drawings figure 6 key DI and DCY and that the said water be containing dissolved/absorbed CO2 , be used as part/all of the water supply for water electrolysis in component F , that by adding a salt named as Calcium Oxide ,that this increases the number of ions and increases the efficiency of the electrolysis cell/units ,reducing the electrical requirement of the cell , and that when electrolysis is occurring that this will cause the CO2 dissolved in the water to form into CaCO3 as precipitating solid on one the electrodes and that this may be used as building material or other use if removed from the electrolysis cell, and it can be claimed that some of the CO2 produced from combustion can be made into CaCO3 a building material, and offers a way of sequestering CO2 from combustion into a useful by product, which other combustion systems that do not have an electrolysis cell/units, are unable to do.

29. It is further claimed that a conventional single unit combustion system such as a power station making electricity to an electricity distribution grid releases post combustion products/flows to atmosphere (in some examples doing some scrubbing or emissions cleaning) and that this

Revised claims v3 for GB1714707.5 continued

system as in claims 1 and 2 and as a continuous contained flow of post combustion products ,to heat recovery ,cooling and conversion to CH4/liquefied CH4 ,that combustion sections may be pressurised , by a mechanical annular /constriction or by design of the boiler combustion pathways , to enable, where possible/required an increased residual time in a combustion section and enable more complete combustion ,improved thermal eficiency,before exhaust to a concurrent stage of combustion or heat recovery.

30. It is further claimed that a combined effect in fuel used/thermal efficiency is in certain specifications of engineering further to claims 1,2,3,4,7,8,10,11,12,14,16,17,18,19,20,21,22,23,24,25,26,27and 28 that in 2 stage sequential combustion system as shown in drawings figure 1 , that where a design is chosen that would combust solely natural gas as a fuel and or co fired with synthesised methane from a Sabatier reaction ,whereby fuel and oxygen is pre heated using recovered heat ,to the fullest extent and utilising claims 11,13,14 and 28,that where a second stage combustion unit/units are figuratively tasked with generating electricity for the/a electrolysis bank/electrolysis units (although first stage and second stage ,or further stages of combusted could be tasked cooperatively or differently in supplying electricity for electrolysis of to supply the electrical distribution grid/and or mechanical drives as in claims 1) ,that the said fuel use of the secondary combustion stage could be very low compared to the fuel requirement of a single combustion unit , and that because of this low fuel use , that the said production of hydrogen and Oxygen from water electrolysis of claims 15,16 and/or, utilising the power/electrical power so made and or electricity from a renewable source ,that this enables a combustion system that can make mechanical/electrical power and make in a figurative second stage combustion ,the power/electrical power for the electrolysis of water ,to also produce hydrogen that can be reacted via a Sabatier reaction , to convert CO2 from the said combustion of all/part of the combustion units post combustion ,by reacting the said CO2 with Hydrogen to make CH4 methane , and that because a significant improvement in heat/thermal efficiency ,compared to traditional combustion systems that are non-sequential combustion systems, that the energy so used as fuel ,to make

Revised claims v3 for GB1714707.5 continued
the said hydrogen is greatly reduced compared to traditional combustion systems and that because of this ,it is possible that methane/CH4 can be so made in an excess by the system of claims 1 ,3, 26, and enable the conversion of part/all of the total CO2 emission output of the system to be made into CH4/liquefied CH4 (other than the portion used as fuel by the system) , enabling this energy system to make a fuel in general use as CH4/liquefied CH4 for transport or for introduction to a gas/natural gas distribution grid. This implies that such a plant/energy system would emit little or no CO2 to atmosphere directly and that if burning/combusting waste materials would enable a replacement for electricity power generation and or other energy use that currently uses so called fossil fuels or nuclear power , as materials that were previously difficult to combust , can be combusted, and that the system can supply energy for water electrolysis unit/units to make CO2 emissions from not only combustion, but also from cement making into CH4 which is a fuel, and that further it is claimed that such a system will enable the reduction of global CO2 emissions to be greatly and significantly reduced , as well as using a wider variety fuels that were previously out of reach/difficult to combust . The patent application claims therefore to be a waste stream, high temperature disposal system, and or high output electrical generation system, and/or high thermal efficiency energy combustion system and/or continuous producer of a fuel as CH4/liquifiedCH4 from CO2 from said combustion. It is convention/knowledge that a traditional design single combustion unit, generating electricity and or mechanical power to output shafts in the function of power station , that only 35 to 45% of the energy of the fuel is converted into electrical energy to distribute to the electrical grid ,it is also convention/knowledge that where a more modern design of power station uses , waste heat as CHP unit (combined heat and power) that 60% of the energy of the fuel can be achieved .It is claimed that as heat is recovered to use in the combustion system that as an electrical power generation plant it will be possible to increase the conversion of fuel energy into electrical power ,to electrical distribution , taking the current best efficiency of around 45% of conversion of fuel to electricity ,to over 60%, and emit little or no emissions to atmosphere making the designs so outlined in this patent application the most fuel efficient ,high

Revised claims v3 for GB1714707.5 continued

output power stations/combustion systems currently in use in the world and also the lowest direct CO2 emissions to atmosphere and allows for CH4 to be liquefied to make a fuel which could also be used to replace fossil fuels and enable further CO2/pollution emission cuts from the use of fossil fuels in transport.

Application No:	GB1714707.5	**Examiner:**	Gareth Jones
Claims searched:	1 - 10	**Date of search:**	15 December 2017

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 -10	US2012/0193925 A1 (JURANITCH) See all figures and at least paragraphs [0053] to [0069]
X	1 - 10	US2015/0089919 A1 (HELMHOLTZ) See whole document.
X	1 - 10	DE102012214907 A1 (SIEMENS AG) See WPI abstract, accession number: 2013-S58382 and figure 1.
X	1 - 10	DE102011013922 A1 (VOITH) See abstracts and figures.
X	1 - 10	DE202010012734 U1 (CARBON CLEAN) See abstracts and figures.
X	1 - 10	DE202011005536 U1 (DAHL) See abstracts and figures.
X	1 - 10	CN105648466 A (JIA) See whole document (an electronic translation of the description is available on Espacenet).

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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, TXTA

International Classification:

Subclass	Subgroup	Valid From
F01K	0013/00	01/01/2006
C25B	0001/04	01/01/2006
F01K	0003/18	01/01/2006