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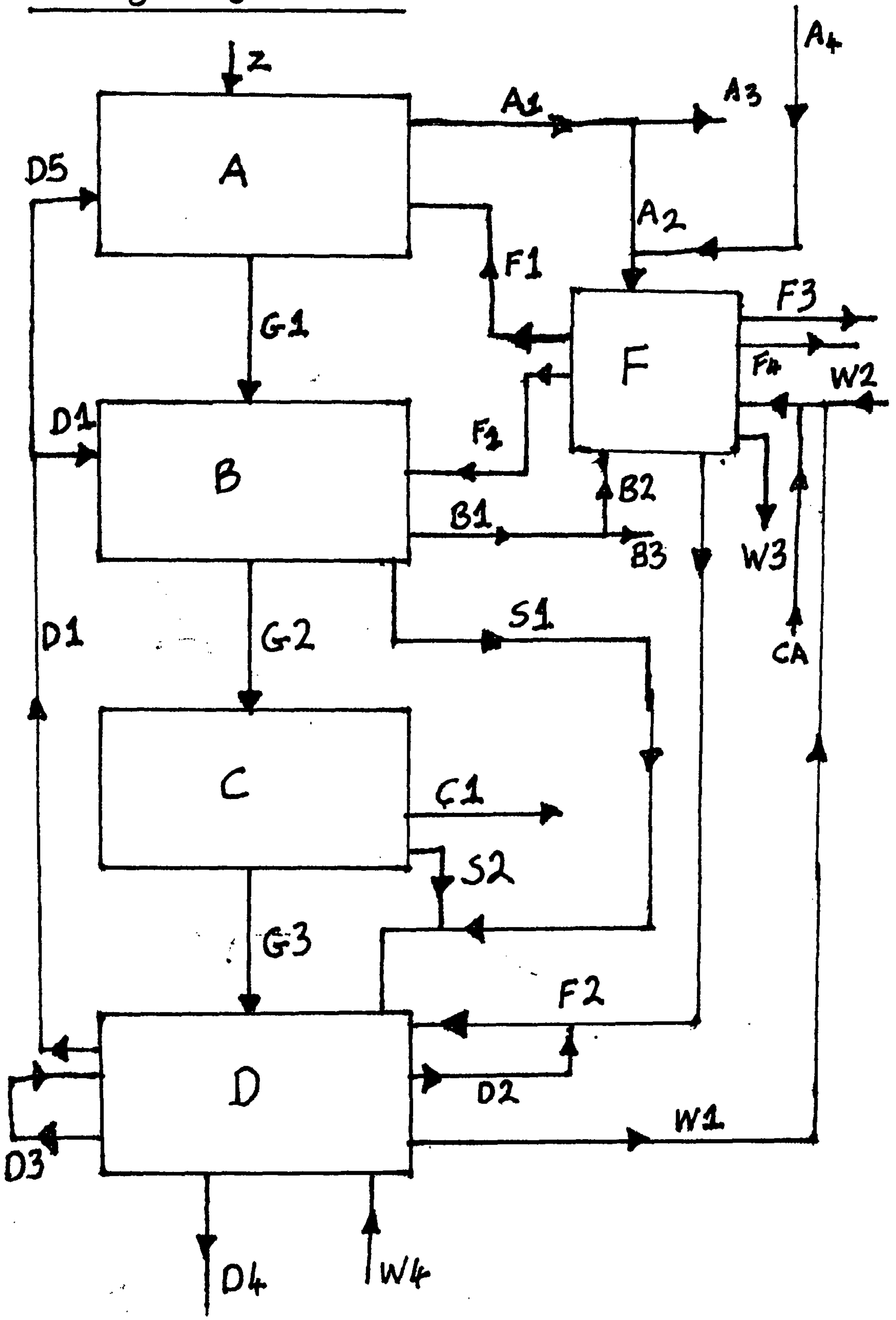
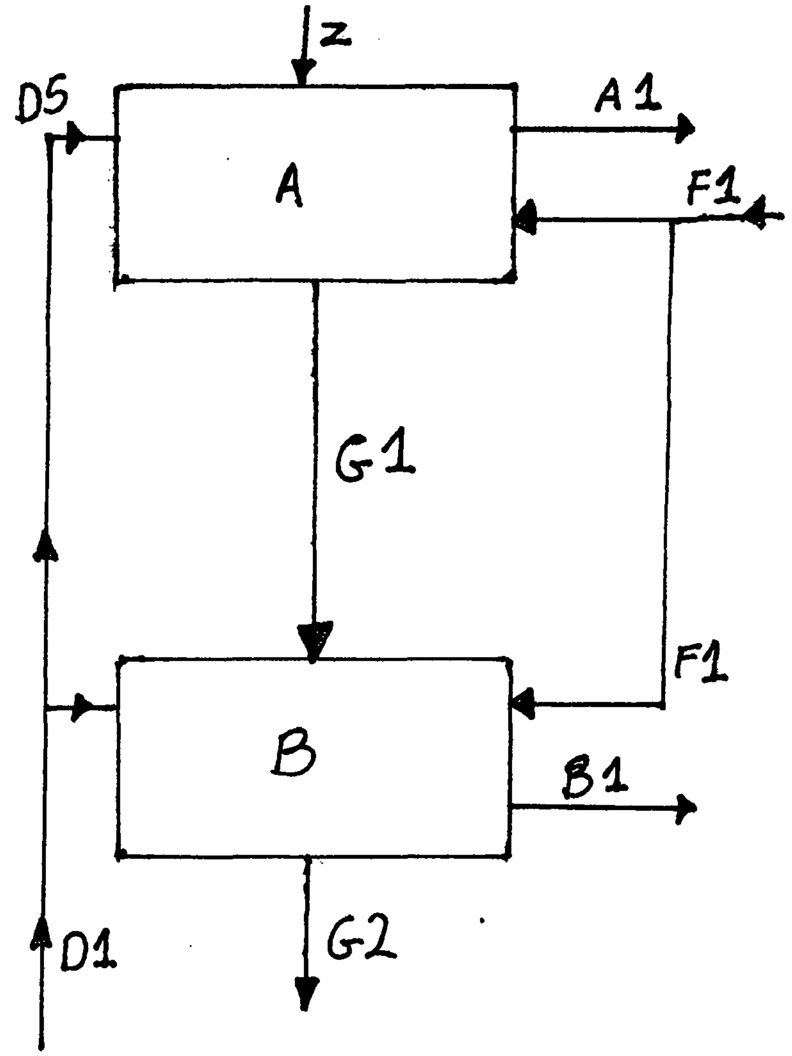
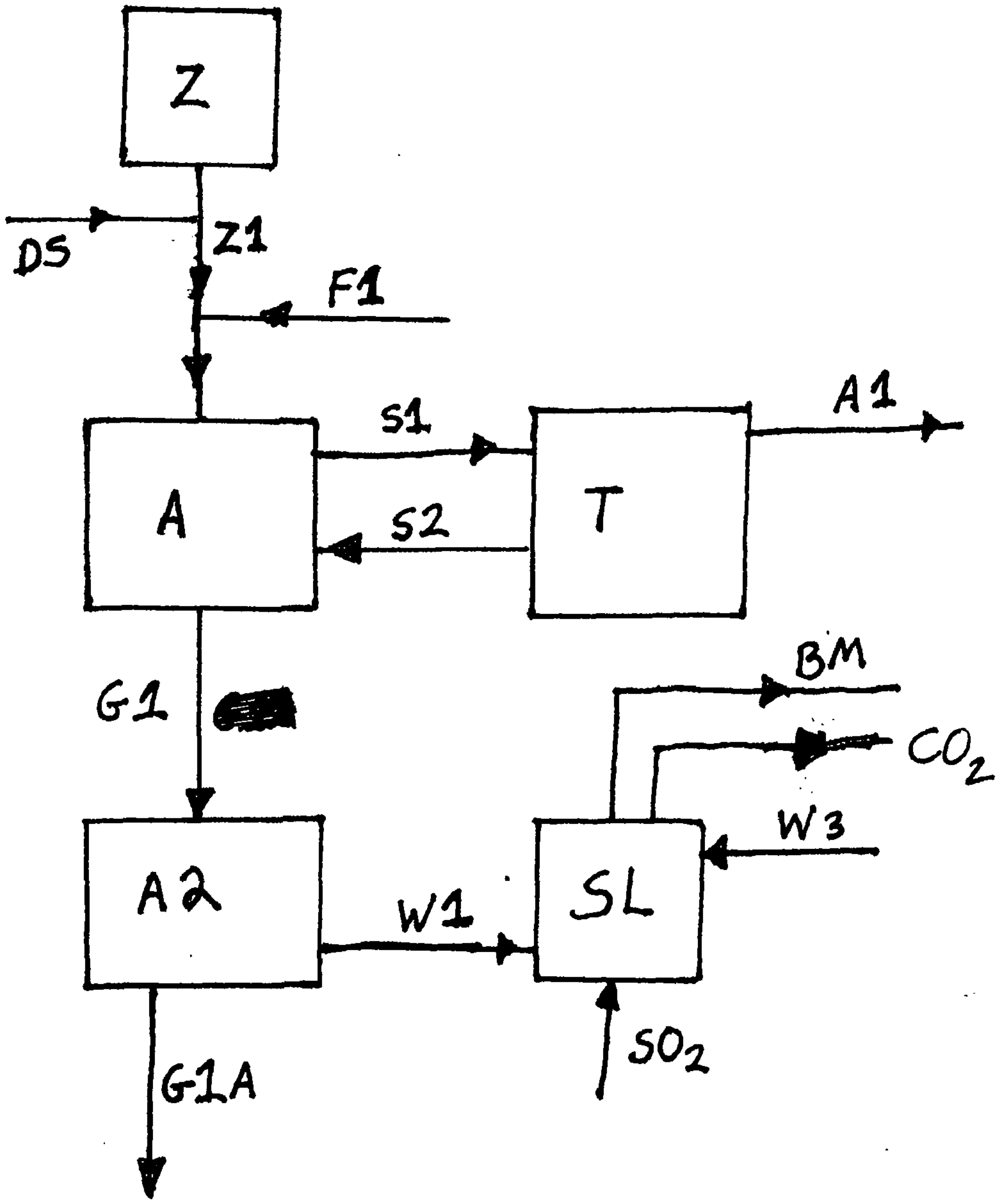
Drawings Figure 1



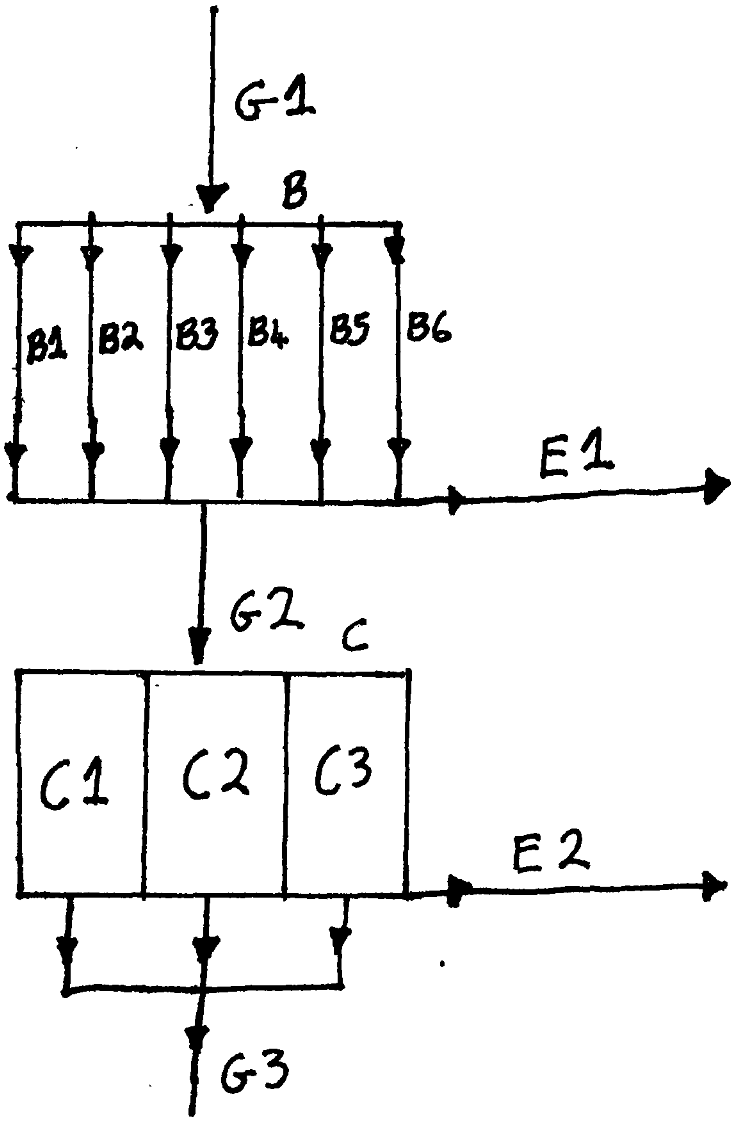
Drawings Figure 2



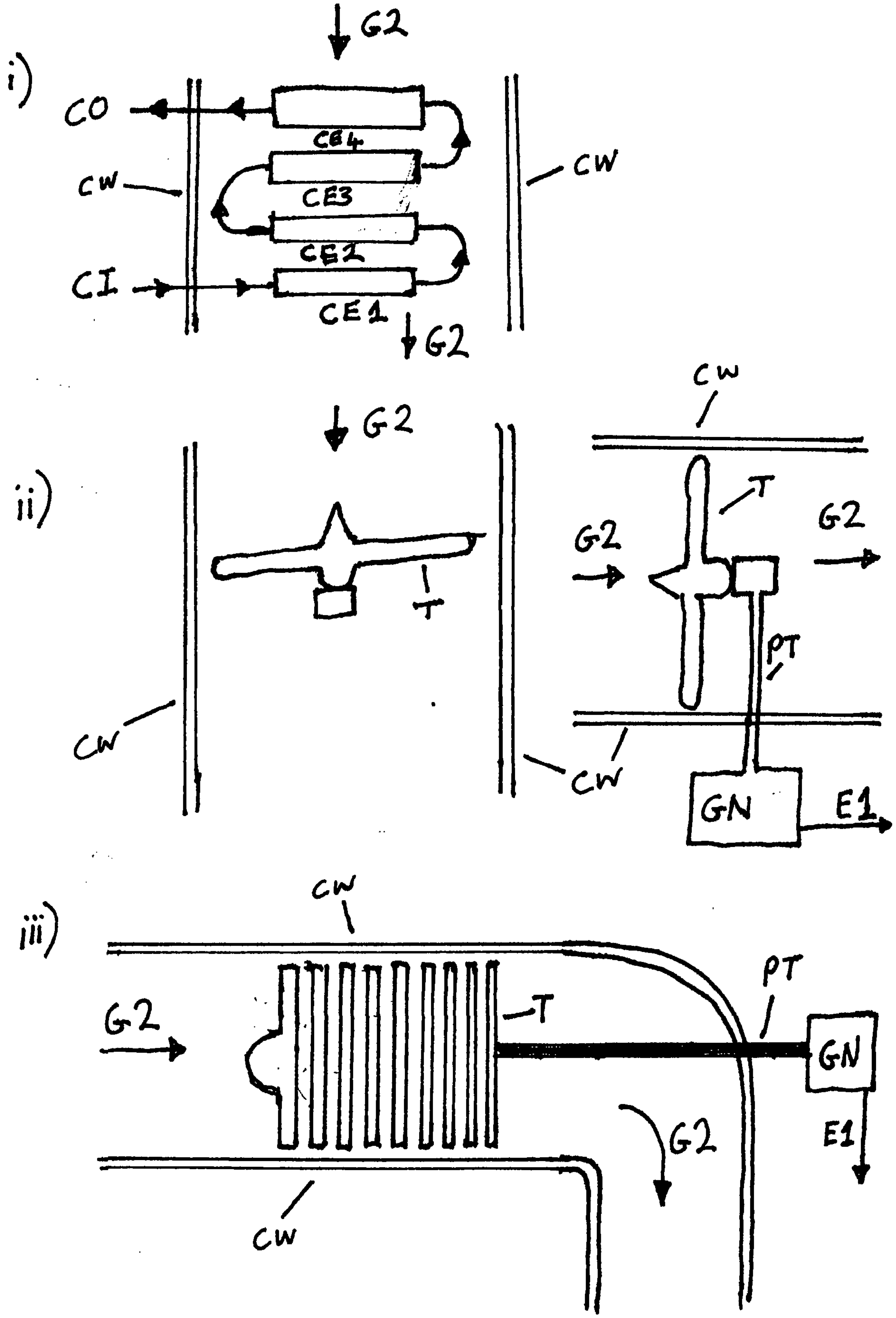
Drawings Figure 3



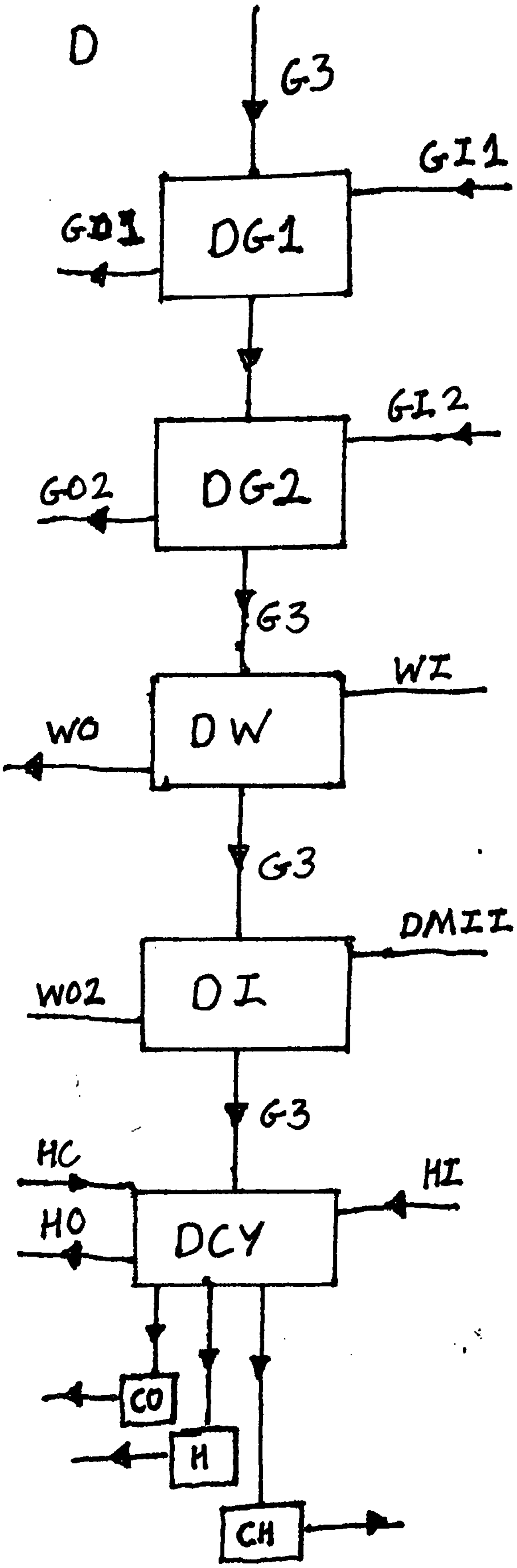
Drawings Figure 4



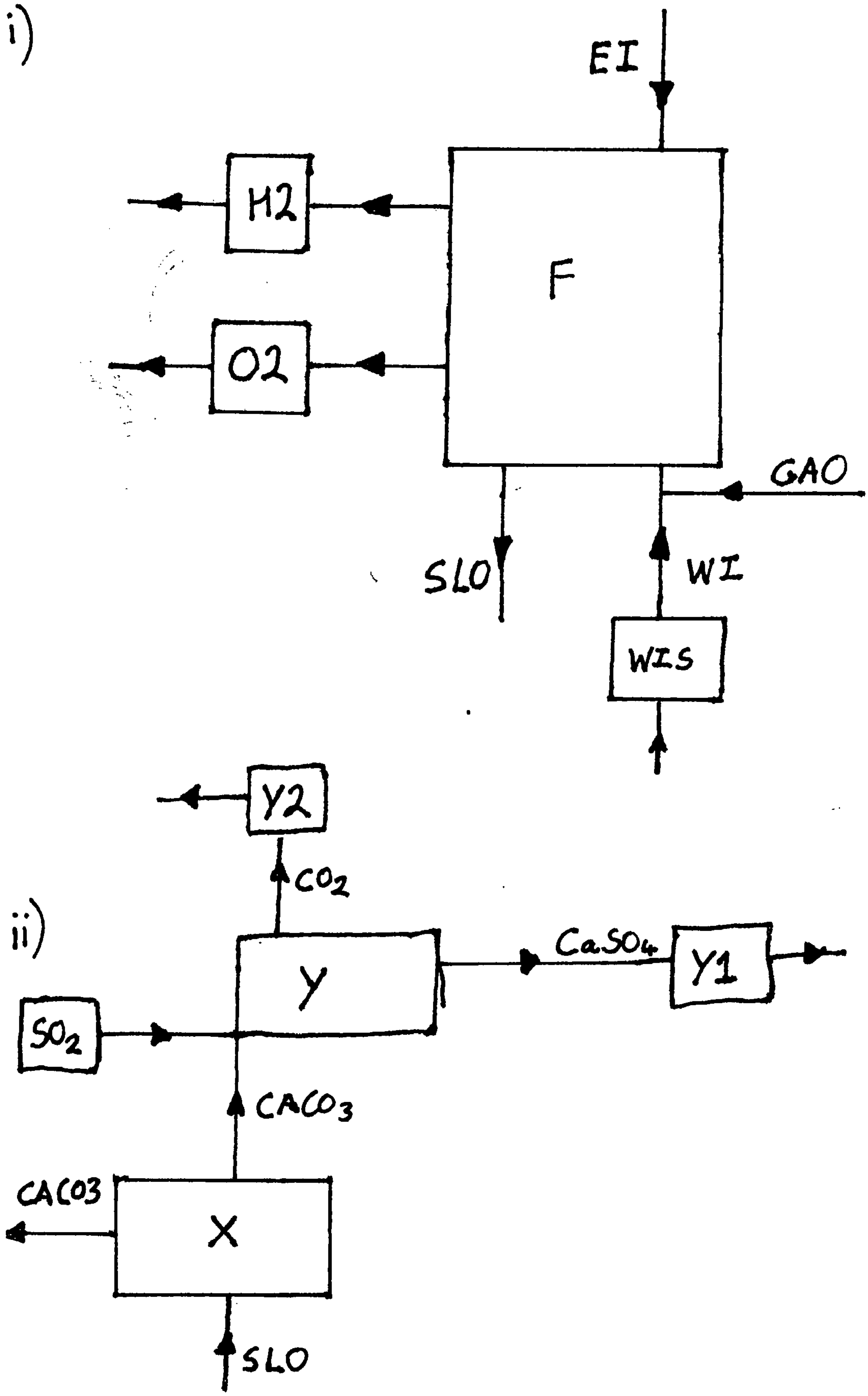
Drawings Figure 5



Drawings. Figure 6



Drawings Figure 7



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, CO_2 from the combustion was converted into CH_4 (Methane) in a Sabatier process .The Hydrogen and Oxygen required was generated from electrolysis of H_2O (water) ,using either renewable power source or power from the power station or piped in from remote water electrolysis facilities. Some CO_2 would be dissolved into H_2O in the cooling process, facilitating a process of making $CaCO_3$ (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 CO_2 emission power generation plant, primarily for the burning/combustion of Bio mass /Bio fuels, but fossil fuels could be used also. It can produced CH_4 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 $CaCo_3$ could be further converted into a form of cement $CaSO_4$, 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 CO_2 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 CO_2 and H_20 , 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 CO_2 separated out and processed through a Sabatier reaction , to give a post Sabatier stream of CH_4 ,H_20 and some CO_2 and H_2 unreacted which would be separated out and processed, the CH_4 being used as fuel for a concurrent power generation station ,or for use in the initial fuel burning plant (as a co fuel) ,the H_2 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 CH_4 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 CO2 and H2O ,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 CO2 and H2O , 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 CO2 and H20.

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 H2O 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 $CaCO_3$ 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 02 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 02 , (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 CH_4,O_2,H_2 or CO_2) 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 CH_4 gas ,H_2O vapour and some unreacted CO_2 gas and H_2 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 CO_2 as possible absorbed into the water.CH_4 and H_2 gases are not absorbed by water , so exit the ice cooling, as gases with most of the water and CO_2 removed in exit flow WO2.

This flow of post DI cooling may contain small amounts of water vapour and CO_2, 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 CH_4 (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 CH_4 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 CO_2 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 CO_2 will need removing at some early point in the cryogenic system or prior to it, if CO_2 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 $CaCO3$ removed from the electrolysis cells created by CAO Calcium Oxide reacting with CO2 dissolved in water if required, flow F4 is Calcium Sulphate CaS04 (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 CaCO3, 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 CO2 gas from making the Calcium Sulphate CaS04 which can be cooled and used for cooling and/or sent to component D for use in the Sabatier process for conversion into CH4 (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 /CH4) 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.

O2= 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 for GB1714707.5 version 7 30/06/2021 by John Jackson

1) A fuel combustion apparatus , comprising of at least one unit (A,B) (A where B is not present) or multiples thereof ;each said unit being operable to receive a fuel , combust said fuel with oxygen and produce combustion products , the said combustion products being able to be transferred to a further oxygen/fuel combustion unit , and that mechanical power so derived from the combustion method/apparatus ,using either gas turbine/s or boilers to raise steam to drive steam turbines , be used to generate electrical power which may be used by the apparatus and/or exported to an electrical grid ; and that post the single/final stage of combustion unit/s ,that the post combustion products be transferred to at least one heat recovery unit (C), being operable to receive , said combustion products and firstly that the post combustion products flow be used to transfer heat/recover heat from the said combustion products , wherein the said recovered heat be used for pre heating fuel/s and/or pre heating Oxygen feeds, and or extract heat to enable the further generation of electrical power via apparatus not shown in application , and or pre heat steam circuits/boiler feeds , and that secondly within the unit (C)that is able to generate electrical power by integral turbine/s ,powered by the flow of post combustion products through the unit (C) and generating electrical power, from the turbine/s: and the apparatus further having at least one cooling unit (D) being operable to receive the output products from at least one heat recovery stage (C): characterised by comprising of gas ,water and direct ice contact cooling stages/heat exchangers that are capable of exchanging heat to pre heat fuel/s/oxygen, and condense out vapours, and that the said post first cooling stage of unit (D) be followed by a Sabatier reactor/reaction being operable to react a supply of Hydrogen with the CO2 so found in any first cooling stage of unit (D) to produce a post Sabatier reaction products mostly containing CH4 and water vapour , with some unreacted products ,and that this post Sabatier reaction flow then passing through a further series of gas, water and direct ice contact cooling stages/heat exchangers , that are capable of condensing out vapours , but leave any uncondensed out gases to flow to a

cryogenic process ,from which heat may be recovered to pre heat fuel/s and or oxygen, and that the said cryogenic process is capable to remove any un reacted Sabatier reaction products and that it is able to produce liquid CH_4 and other cold/super cool CO_2 and H_2 products, so present to be separated , enabling process heat produced to be continuously recovered and where used to pre heat fuel/s and or oxygen feeds and convey recovered heat directly into combustion units so used by the apparatus , to the combustion units to enable a greater thermal efficiency/heat recovery, as well as greater electrical output per unit of fuel combusted, than systems not using this apparatus /method.

2) That further to claims 1, that the fuel combustion apparatus, where the post combustion products from a preceding combustion stage are combusted in a second unit of combustion, that this can be said to convey/contribute heat directly as a method to be utilised by the second/further stage of combustion in fuel use/power output, when compared to a system of combustion that does not utilise prior combustion products that are directly conveyed heat into a subsequent combustion stage ,as a source of heat/improved thermal efficiency.

3) That further to the preceding claims , that the apparatus consists of at least one water electrolysis unit (F) , wherein water is electrolysed ,in an electrolysis cell , to produce elemental component gases of the said water ,these being Hydrogen (H_2) and Oxygen (O_2) and that the said gases so produced are used in the method of the apparatus, and that said electricity to energise the electrolysis unit may come from electricity generated by the apparatus and/or from a renewable source of electricity.

4) That further to claims 1 ,that the fuel/fuels so used in at least one combustion unit (A,B) (or A if B is absent) may be from a subset of solid fuels ,Biomass , Bio solids, tyre crumb , waste derived fuels , liquid fuels, e.g. an alcohol, and gaseous fuels e.g. Methane and that said fuels may consist of a mixture of fuels and/or be co fuelled with Methane , and

that said Methane may come from a method of the apparatus , where it is produced from synthesising carbon dioxide produced ,as combustion products , in one or more ,combustion units (A,B) (or A if B is absent) ,with hydrogen ,in a Sabatier reactor/reaction unit/s to produce methane , the said methane then being cryogenically cooled to a liquid.

5) That the apparatus of preceding claims contain at least one combustion unit (A,B) (or A where B is absent) and at least one unit (C) unit and at least one (D) unit, and that they may be arranged/connected in multiplicities of said units in parallel or series configurations and/or as required by design.

6) That the apparatus of the preceding claims defined as at least one heat recovery unit (C) capable of receiving the combustion products of at least one combustion unit (A,B) (or A where B is absent) being located within the apparatus after any final combustion stage , having a heat exchanger , that may contain a coolant , that may power separate sub turbines for generating ,electrical power , and/or the heating of steam/boiler feeds to boilers , and/or the heating/pre heating of fuel/fuels prior to combustion, and/or the pre heating of Oxygen feeds prior to combustion, and that also the heat recovery unit (C) may contain a turbine/turbines ,so configured as to be powered by the combustion products , so flowing in a heat recovery unit (C),from the combustion units (A,B) (or A where B is absent), the said turbine/s capable of rotating an electrical generator ,to generate electrical power, to power parts of the apparatus , and enable a further electrical output from the same unit of fuel than can be gained by apparatus that is state of the art in energy systems ,that are unable to make energy from post combustion exhaust gases/flows .

7) That the apparatus of the preceding claims defined as at least one cooling unit (D) , be able to recover heat , and that said heat so recovered may be used to pre heat fuels and/or pre heat oxygen .prior to combustion , and that the cooling unit (D) may also be able

heat/warm. cooled/liquid methane ,synthesised by the apparatus ,to use either as co-fuel/fuel in at least one combustion unit (A,B) (or A where B is absent), and/ or to enable synthesised methane to be made into a gas suitable as standards for gas grid distribution.

8) That the apparatus of the preceding claims defined as at least one cooling unit (D) capable of receiving the combustion products from the unit (C), and that it consists of sequence of cooling stages, that are also able to condense and separate out water (and possibly other products that may use water as a solute, including CO2, and or any uncombusted solid particles) so contained in the combustion products , followed by a Sabatier reaction able to convert CO2 mixed with Hydrogen ,into CH4/Methane, followed by a further set/sequence of cooling stages, that are also able to condense and separate out water (and possibly other products that may use water as a solute) and then a cryogenic section , where the products from the said Sabatier reaction and cooling stages, is cooled to liquefy the synthesised CH4/Methane, with any Hydrogen gas remaining as a gas, the said Hydrogen gas being able to be reused in the Sabatier reaction, or used for cooling or as a fuel for combustion in at least one combustion unit (A, B) (or A where B is absent).

9) That the apparatus of preceding claims as at least one cooling unit D , having a sequence of cooling sections ,able to receive the combustion products from at least one heat recovery unit (C) ,in so cooling by the gas, water and direct ice contact heat exchanger effects of reducing the volume of gases/vapours as they cool, will create a temperature/pressure gradient between the entrance of post combustion products into unit (C)and the first series of cooling of unit (D)which may enhance the velocity of flow/pressure of flow of post combustion products within unit (C),upon the turbine/s ,creating an efficiency/increase electrical output, of the turbine/turbines so used to generate electricity , using the understood science of gases/vapours at temperatures/pressures/velocities/volumes being physically altered in

state and effects upon turbine power/efficiency/power output in that a greater pressure is upon the entry to a turbine/s, and that a cooled flow has a lower pressure than were any post turbine flow does not have a cooling section, acting to reduce the volume of the flow due to removing heat in gradient from high heat prior to turbine entry to low heat as the post unit (C) product flow is cooled and enabling a greater flow/pressure upon the turbine blades, than can be attained ,by apparatus that does not have post combustion flow cooling after the unit (C) turbine.

10) That the apparatus so defined in the preceding claims as at least one cooling unit (D) ,that the combustion products from the at least one heat exchange unit (C) ,be cooled by gas heat exchanger ,or multiples thereof , and then by a water cooled heat exchanger or multiples thereof , and then by direct contact with water ice ,or multiples thereof ,to condense out any water vapour (and possibly other products that may use water as a solute and or any uncombusted solid particles), and that CO2 may/can be absorbed by the water/ice as required , to create a separated water that has absorbed the CO2 to form a carbonated water, and that the said CO2 left as free gas , may then proceed from the direct water ice contact section to at least one Sabatier reaction unit/chamber where it is mixed with Hydrogen gas (both gases may be heated prior mixing) and then heated to at least 300oC and a pressure of 50psi/345Kpa (other temperatures and pressures for the reaction may be used) ,wherein any heat required for the reaction may be provided by a source of electricity/heated steam or other source , and that post Sabatier reaction the said products be kept at pressure until a temperature is reached of 200oC or below , where any reformation of products (as CH4/methane) into prior constituents (of CO2 and Hydrogen) may be halted, the apparatus post the Sabatier reaction containing at least one gas heat exchanger followed by at least one water cooling section , followed by at least one direct water ice contact section to condense out any water vapour (and possibly other products that may use water as a solute and or any solid particles), and that CO2 may/can be absorbed by the water/ice as required ,to form a separated

carbonated water, it is known by the current science that the Sabatier reaction is not a 100% reaction , and that in so mixing Hydrogen and CO_2 gases in a Sabatier reaction ,products from the reaction may contain unreacted Hydrogen and CO_2 gases , as well as the reacted products of CH_4/Methane and water vapour , and that said post Sabatier products once past the direct water ice contact section , should mostly consist of CH_4/Methane , with little/none water vapour and also some unreacted Hydrogen gas and possibly small amounts of CO_2 gas, this then flowing into the Cryogenic section of the cooling unit (D) , where CO_2 may be further removed , the Cryogenic sections main function being to liquefy the said CH_4/methane gas ,which being above that for the liquefication of Hydrogen gas , will leave the Hydrogen as a super cooled gas which can be separated from the liquid CH_4/Methane, heat so created/expressed by the method/apparatus of cooling unit D being recovered to pre heat fuels and/or oxygen prior to combustion in the combustion units (A,B) (or A where B is absent).

11) That further to claims 3 a method of improving the efficiency of at least one electrolysis unit (F) , where a source of water so used as electrolyte contains dissolved substances (and such water may come from the direct water ice cooling section of unit D) and in particular dissolved CO_2 and is said to be carbonated , that by adding a salt such as Calcium Oxide (CaO) ,that this improves ion transport within the electrolysis cell , whilst at the same time enabling a preciptible solid of Calcium Carbonate ($CaCO_3$) to form, (or other precipitate substance can be created dependent upon which salt is used), which can be removed from the electrolysis cell and used as a material , and or combined with sulphur dioxide to create a further material of $CaSO_4$ as a form of cement ,using the term adding a salt inferring other salts so added to the electrolyte may offer different products/cell efficiencies.

12) That further to claims 1 wherein at least one combustion unit (A,B) exists as concurrent combustion units , wherein said combustion products of a first combustion unit (A), are combusted again in a combustion unit (B) that the method in transferring the said combustion products enables , heat to be transferred to the subsequent combustion stage (and to any further B units in series) enabling a much more efficient use of heat by heat transfer in the post combustion product flow, and also enabling further and greater combustion of uncombusted products from a previous stage of combustion of the apparatus ,than would be seen by units that use air drafting (as the nitrogen component of atmospheric air is not being heated) and that any subsequent exhaust by combustion of the products of a prior combustion (where the prior combustion may be using a fuel/co fuel that creates uncombusted particulates/complex molecules of combustion) may therefor contain less uncombusted products such as smoke ,ash , soot's and char, as well as more simple molecules (mainly oxides) of any substances that do not produce CO2 when oxidised.

13) That further to claims 1 wherein at least one combustion unit (A,B) (or A where B is absent) exists ,that a method of firing/co firing by pre heating fuel/fuels and/or pre heating Oxygen using recovered heat from the apparatus , will enable an thermal efficiency of using flows of fuel/fuels/Oxygen to physically convey heat into the combustion process and give an improved thermal efficiency compared to combustion units that do not pre heat fuel/fuels and /or oxygen feeds with recovered heat.

14) That further to claims 1 , that a method of firing fuel/fuels/co firing at least one combustion unit (A,B) (or A where B is absent) with pre heated oxygen rather than atmospheric air , enables higher combustion temperatures to be reached , as combustion may be more complete , and will so cause thermal decomposition of complex molecules into simpler molecules and also the thermal decomposition of what may be termed difficult/complex fuels that require the higher

thermal combustion temperatures ,of complete combustion using Oxygen ,it being claimed that Oxygen combusted with CH4/methane fuel will enable temperatures of 2000oC or greater to be attained and more thermal decomposition that systems that do not use the high temperatures of Oxygen/fuel/fuels (if co firing) , and will also enable a greater thermal efficiency compared to combustion units, that have to heat the nitrogen component of atmospheric air, rather than just the oxygen component so required for combustion, and that further by using Oxygen (as an elemental gas) rather than atmospheric air containing Nitrogen gas (and other gases in small amounts) , the formation of Nitrogen Oxides from the atmospheric air if were to be so used , is reduced/eliminated.

15) That further to claims 1 that where a fuel such as Biomass/Bio solids/waste products that can be combusted / renewable/synthesised CH4/methane/Biogas is used in at least one combustion unit (A,B) (or A where B is absent) and that the fuel is from Bio derived substrate , that the emissions produced by the fuels combustion (and CH4 produced/synthesised), can be said to be from source that does not increase emissions ,in the way that the combustion of fossil fuel derived fuel sources are explained contribute to climate changes/global heating theory, and that this is an environmental benefit not previously utilised to the fullest extent in other combustion systems currently considered state of the art as they are unable to attain the thermal efficiencies of the method/apparatus illustrated in the application , and can be considered in its specific design/apparatus and method ,to be novel and attain thermal efficiencies , from heat recovery to a greater /fuller extent not seen in the prior art.