



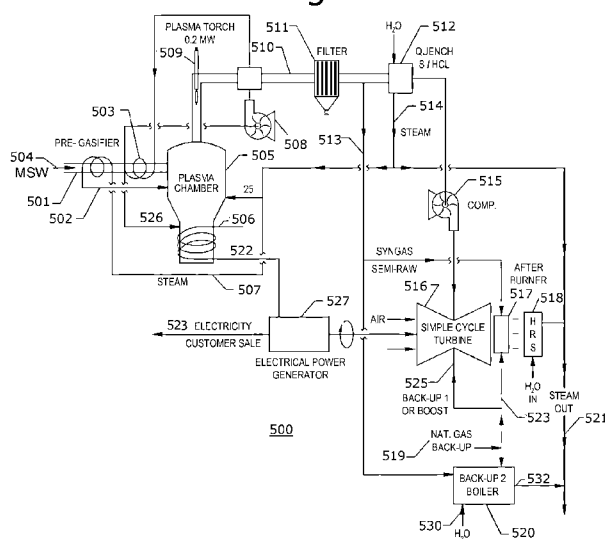
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(54) Title: COST EFFECTIVE PLASMA COMBINED HEAT AND POWER SYSTEM**Fig. 5**

(57) Abstract: A method of generating syngas as a primary product from renewable feedstock, fossil fuels, or hazardous waste with the use of a cupola. The cupola operates on inductive heat alone, chemically assisted heat, or plasma assisted heat. Cupola operation is augmented by employing carbon or graphite rods to carry electrical current into the metal bath that is influenced by the inductive element. The method includes the steps of providing a cupola for containing a metal bath; and operating an inductive element to react with the metal bath. A combination of fossil fuel, a hazardous waste, and a hazardous material is supplied to the cupola. A plasma torch operates on the metal bath directly, indirectly, or in a downdraft arrangement. Steam, air, oxygen enriched air, or oxygen are supplied to the metal bath. A pre-gasifier increases efficiency and an afterburner is added to a simple cycle turbine with fossil fuel augmentation.

Cost Effective Plasma Combined Heat and Power System

Background of the Invention

FIELD OF THE INVENTION

5 This invention relates generally to systems for generating heat and power, and more particularly, to an inductive and plasma based system that generates Combined Heat and Power (hereinafter, "CHP") using multiple back up modes of operation.

DESCRIPTION OF THE RELATED ART

10 CHP systems, as well as plasma based systems, are known. Although these two types of known systems have been combined in simple arrangements, such as internal combustion based systems, there is a need for a system that achieves the benefits and advantages of both such technologies.

It is, therefore, an object of this invention to provide a system the achieves the benefits of Combined Heat and Power systems, and plasma based systems.

15 It is another object of this invention to provide a cost-effective, commercially viable, renewable CHP system.

Summary of the Invention

The foregoing and other objects are achieved by this invention which provides, a method of producing CHP, the method including the steps of:

20 providing a cupola for containing a plasma source.; and
delivering a feedstock to the cupola.

In accordance with a specific illustrative embodiment of the invention, the feedstock is a fossil fuel. In other embodiments, the feedstock is a hazardous waste, and in still further embodiments, the feedstock is a combination of any
25 organic compound, fossil fuel, or hazardous material.

In one embodiment, there is further provided the step of providing a metal bath within the cupola. Advantageously, there is further provided the step of operating an inductive element to react with the metal bath to generate syngas. Additionally, there is provided the step of supplementing the step of operating an
30 inductive element by the further step of operating a plasma torch. A plasma torch is operated on the metal bath, in one embodiment, selectably directly and indirectly. In some embodiments, the step of operating a plasma torch is

performed in a downdraft arrangement, and in yet further embodiments, the step of operating a plasma torch is performed at an angle other than vertical.

There is provided the further step of supplementing the step of operating an inductive element by performing the further step of injecting steam to enhance the production of syngas. The step of operating an inductive element is supplemented by performing the further step of injecting a selectable one of air, oxygen enriched air, and oxygen. In a further embodiment, there is provided the further step of supplementing the step of operating an inductive element by performing the further step of conducting electrical energy via a conductive rod formed of a selectable one of graphite and carbon into the metal bath.

In accordance with a further method aspect of the invention, there is provided a method of producing CHP, the method including the steps of:

providing a cupola for containing a metal bath; and
operating an inductive element to react with the metal bath to generate syngas.

In a still further method aspect of the invention, there is provided a method of producing CHP, the method including the steps of:

providing a cupola for containing a metal bath;
operating an inductive element to react with the metal bath; and
supplementing the step of operating an inductive element by the further step of operating a plasma torch and a pregassifier.

In yet another aspect of the invention, there is provided a method of producing CHP, the method including the steps of:

providing a cupola for containing a metal bath;
operating an inductive element to react with the metal bath; and
supplementing the step of operating an inductive element by the further step of propagating a selectable one of plasma and electricity into the metal bath to supplement heating of the cupola by the step of operating an inductive element with a pregassifier and a turbine generator and a heat recovery system (hereinafter, "HRS").

In a still further method aspect of the invention, there is provided a method of producing CHP, the method including the steps of:

providing a cupola for containing a metal bath;
operating an inductive element to react with the metal bath; and

supplementing the step of operating an inductive element by the further step of propagating a selectable one of plasma and electricity into the metal bath to supplement heating of the cupola by the step of operating an inductive element with a pregassifier and a turbine generator which is augmented with an afterburner
5 before the HRS.

In one embodiment, there is provided the further step of supplementing the step of operating an inductive element by performing the further step of conducting electrical energy via a conductive rod formed of a selectable one of graphite and carbon into the metal bath.

10 In a further embodiment, the pregassifier is multiple stages. The first stage of the gassifier is heated by steam and the second stage is heated by higher temperature steam, air, molten salt, or any other high temperature heat transfer medium.

In accordance with a method aspect of the invention, there is provided a
15 method of producing combined heat and power with the use of inductive furnace technology, and optionally with plasma assisted heat with direct, or indirect applications of energy. Additionally, the method of the present invention optionally employs downdraft assisted plasma energy. In accordance with a specific illustrative embodiment, the method of the present invention produces heat via an
20 inductive heating element by exciting and heating a metal bath in a cupola. The metal bath is used, in some embodiments, to produce syngas alone as a heat source or it is supplemented by a plasma torch system. In some embodiments, the cupola is used to process renewable feedstocks, fossil fuels, or hazardous materials. The heat required to produce syngas is, in some embodiments, supplemented by
25 injection of air, oxygen enriched air, or oxygen into the cupola. The syngas process is also supplemented, in some embodiments, by the injection of steam to the cupola.

The system is configured in a novel way to yield extremely high overall efficiency. A combination of common production components and a high efficiency
30 system design are incorporated in a novel way to achieve the goal of a low cost CHP system. The feedstock to run the operation in some embodiments, is a renewable fuel such as Municipal Solid Waste (hereinafter, "MSW"), biomass, algae, or fossil fuels.

The invention utilizes the high temperature syngas produced by the
35 inductive plasma process with a simple cycle turbine operating at its maximum fuel

inlet temperature. An afterburner located at the outlet of the turbine and before a HRS. The fuel for the afterburner is delivered to the system at the maximum allowable temperature. The high velocities, elevated temperatures, available oxygen, and mixing characteristics at the turbine outlet before the afterburner promote high efficiency in the afterburner and exceptionally high efficiency in the HRS for steam production. The overall system efficiency in some embodiments of the invention is over twice that of conventional coal steam generators in use today. The novel addition of natural gas in the system also allows for redundancy and scalability in the system. The steam output is be tripled in many cases by the additional injection of natural gas to the afterburner. In some embodiments of the invention the turbine has its syngas-derived fuel sweetened with the natural gas, if necessary. Finally an advantageous use of pregassifiers is utilized in the system to boost the overall plant efficiency and attain the goal of a cost effective production facility.

The inventive system also takes incorporates the use of inductive baths with direct acting, indirect acting, and down draft, plasma assist. Additionally, the system of the present invention incorporates an afterburner application on the outlet of the simple cycle turbine to improve system efficiency.

Brief Description of the Drawing

Comprehension of the invention is facilitated by reading the following detailed description, in conjunction with the annexed drawing, in which Fig. 1 is a simplified schematic representation of a specific illustrative embodiment of a system configured in accordance with the principles of the invention.

Detailed Description

Fig. 1 is a simplified schematic representation of a cupola arrangement constructed in accordance with the invention;

Fig. 2 is a simplified schematic representation showing in greater detail a lower portion of the cupola of Fig. 1;

Fig. 3 is a simplified schematic representation showing an indirect application of a plasma torch on an inductive metal bath and the cupola;

Fig. 4 is a simplified schematic representation showing a second indirect application of a plasma torch disposed at an angle relative to the cupola; and

Fig. 5 is a simplified schematic representation of a specific illustrative embodiment of a system configured in accordance with the principles of the invention for producing combined heat and power.

Detailed Description

5 Fig. 1 is a simplified schematic representation of a cupola arrangement 100 constructed in accordance with the invention. As shown in this figure, a cupola shell 101 is provided with an inlet 104 for introducing a feedstock (not shown) that in some embodiments of the invention is a renewable feedstock, a fossil fuel, or a hazardous waste (not shown). Any combination of the three forms of feedstock can
10 be used in the practice of the invention. There is additionally provided in an outlet port 106 for enabling removal of the generated syngas (not shown). In contrast to conventional inductive furnaces that facilitate a large outlet for metal or alloy production, there is no other outlet for such product. There is but an additional small drain 110 for eliminating inorganic slag.

15 It is a feature of the present invention that primarily organic compounds are processed to produce syngas. The specific illustrative embodiment of the invention described herein is essentially a bucket arrangement wherein an indirect electrical arc services a non-transfer inductive furnace. This is distinguishable from the conventional use of an inductive furnace, which is to make metals and alloys.

20 Fig. 1 further shows cupola arrangement 100 to have a direct acting plasma torch 115, which in some embodiments of the invention, as will be described below in relation to Figs. 3, and 4, is an indirect acting plasma torch, to assist in the cupola heating process. In other embodiments, plasma torch 115 is a carbon or graphite rod that is used to conduct AC or DC electrical energy into a metal bath
25 120. The return path for the electrical energy has been omitted from this figure for sake of clarity.

 There is provided in this specific illustrative embodiment of the invention a cathode 122 that is coupled electrically to an inductive element 125. Additionally, inductive element 125 has associated therewith an anode 127.

30 Air, oxygen enriched air, or oxygen are injected into cupola arrangement 100 via an inlet 130 to assist in the generation of heat using chemical energy and steam that is delivered via an inlet 132. The chemical energy and steam are injected for the further purpose of assisting in the generation of syngas. The

process of the present invention can, in some embodiments, be performed in a pyrolysis, or air starved, mode of operation.

Fig. 2 is a simplified schematic representation showing in greater detail a lower portion of cupola arrangement 100 of Fig. 1. Elements of structure that have previously been discussed are similarly designated. Inductive element 125 reacts on metal bath 120. Metal bath 120 can consist of any metal or alloy such as aluminum for low temperature work or titanium for high temperature work. Metal bath 120 is kept at a constant fill level 134 by operation of slag drain 110 through which a slag product 135 is drained.

Fig 3 is a simplified schematic representation showing a cupola arrangement 200, wherein there is illustrated an indirect application of a plasma torch 115 on an inductive metal bath and the cupola for enhancing the heating process. In this specific illustrative embodiment of the invention, plasma torch 115 has a power capacity of 0.2 MW. Elements of structure that have previously been discussed are similarly designated. As shown in this figure, syngas outlet 106 is lengthened in this specific illustrative embodiment of the invention, and is shown to have vertical and horizontal portions, 106a and 106b, respectively. Indirectly acting plasma torch 115 is, in this embodiment, inserted in the end of vertical section 106a. In this specific illustrative embodiment of the invention, syngas outlet 106 is refractory-lined and insulated (not shown).

In the embodiment of Fig. 3, there is shown an inlet 107 via which is provided municipal solid waste (MSW) (not specifically designated) as a feedstock. Of course, other types of feedstock, as hereinabove noted, can be used in the practice of the invention.

The product syngas in this embodiment is forced to exit into vertical section 106a where it communicates with the high temperature plume (not specifically designated) and the radiant heat that is issued by plasma torch 115. The syngas and syngas outlet 106 both are heated by operation of plasma torch 115. In this specific illustrative embodiment of the invention, the heated horizontal portion 106b of syngas outlet 106 is subjected to a heat extraction arrangement that delivers the heat to inlet 107 for the purpose of pre-gasifying the MSW feedstock. The heat extraction arrangement is formed by an impeller 210 that urges a fluid (not shown) along a fluid loop that includes a region 212 where the fluid is heated by communication with heated horizontal portion 106b of syngas outlet 106. The heated fluid then is propagated to a heat exchanger 215 where a portion of the

heat therein is transferred to the incoming MSW feedstock that is being delivered at inlet 107.

There is additionally shown in this figure a steam inlet 132, as hereinabove described. However, the steam is shown in this figure to be supplied by a steam supply 220, and the steam then is conducted to a further heat exchanger 225 where a portion of the heat in the steam is transferred to the incoming MSW feedstock that is being delivered at inlet 107. Heat exchangers 215 and 225 thereby constitute a pre-gassifier for the MSW feedstock, whereby the production of syngas is enhanced.

Fig 4 is a simplified schematic representation of a cupola arrangement 250 showing a second indirect application of a plasma torch that is disposed at an angle relative to the cupola. Elements of structure that have previously been discussed are similarly designated. As shown in this figure, the outlet port 106 is fabricated in part at an angle that in some embodiments is greater than 90° to induce tumbling and mixing in the product syngas (not shown). Thus, in addition to vertical and horizontal portions, 106a and 106b, respectively, there is shown in this specific illustrative embodiment of the invention an angular portion 106c. Plasma torch 115 is shown to be inserted in angular portion 106c.

Fig. 5 is a simplified schematic representation of a specific illustrative embodiment of a system 500 configured in accordance with the principles of the invention for producing combined heat and power. As shown in this figure, a main feed tube 501 serves as an input for feedstock, in the form of Municipal Solid Waste 504 ("MSW") for fueling the system. Feed tube 501 is preheated in a novel way to increase efficiency with a heat transfer system 502 that is, in the embodiment, operating on waste low pressure steam heat generated from sensible heat that is recovered from the inductive/plasma process taking place in a plasma/inductive chamber 505.

In this embodiment, sensible heat is recovered using a syngas quench system 512 that serves to generate waste heat steam 514. This steam, which is delivered to the pregassifier along steam conduit 507, is typically below 400° F. A second stage of pregassifier energy is provided to the feedstock to improve system efficiency, at a higher temperature at pregassifier loop 503. Pregassifier loop 503 extracts heat from syngas 510 by operation of an impeller, such as compressor 508, which urges a flow of heated fluid (not specifically designated) through the loop. At least a portion of the heated fluid, in this specific illustrative

embodiment of the invention, is delivered to plasma/inductive chamber 505 at an input 526. Plasma/inductive chamber 505 incorporates, in some embodiments, a cupola arrangement (not specifically designated in this figure), as described above.

5 This added energy serves to improve overall performance by the use of waste heat recovered from sensible energy on the outlet of the plasma/inductive chamber 505. In this case the transfer media is typically air or extreme high temperature steam. More exotic heat transfer media like molten salt are used in some embodiments. It is to be understood that the system of the present invention is not limited to two stages of pregasification heat process and transfer,
10 as multiple such gassifier systems are used in the practice of some embodiments, of the invention.

As noted, MSW 504 is used as a feedstock in this process example. Inductive coil 506 and plasma torch 509 are the primary energy sources or inputs that react with MSW 504 to produce Syngas 510. Inductive coil 506 reacts against
15 a molten metal bath (not shown) in plasma/inductive chamber 505.

A filter 511 and quench system 512 are portions of the emission reduction system. Sorbents (not shown) are injected and used in some embodiments, but have been omitted in this figure for sake of clarity of the drawing. The semi-processed syngas 510 is split out through conduit 513 and fed directly into an
20 afterburner 517 at the highest temperature available. The balance of the syngas is fed into a compressor 515 and boosted in pressure to be fed into turbine 516. Air (not specifically designated) enters turbine 516, and the high temperature, high velocity, and turbulent air at the outlet (not specifically designated) of turbine 516 is boosted to a higher energy state through the added energy of afterburner 517.
25 A heat recovery system ("HRS") 518 is shown to be in direct communication with the energy-rich outlet gas from the turbine produces steam 521, which is sold to customers.

Electrical power 523 is generated at electrical generator 527, which as shown, receives rotatory mechanical power in this embodiment from turbine 516.
30 Electrical output power 522 from the electrical generator is used to run the process in plasma chamber 505. Also, electrical output power 523 is available for sale to a third party. Natural gas or other fossil fuel gas is boosted into turbine 516 at input 522 to enhance performance and reliability. Natural gas or other fossil fuel energy is boosted into input 523 of afterburner 517. This too enhances overall
35 system performance and reliability.

This process of the present invention also serves as a system backup if the production of syngas 510 is for any reason stopped or reduced. A second back up boiler 520 functions as a redundant steam generator to expand the production range of the facility and to add another level of redundancy to the steam production. As shown, back-up boiler 520 receives water in this embodiment at an input 530 and issues steam at an output 532. Back-up boiler 520 is, in some embodiments, operated on syngas, fossil fuel, or a combination of both. In addition, a natural gas source 519 is shown to supply back-up boiler 520 and also serves as a boost to turbine 516 at an input 525.

Although the invention has been described in terms of specific embodiments and applications, persons skilled in the art may, in light of this teaching, generate additional embodiments without exceeding the scope or departing from the spirit of the invention described and claimed herein. Accordingly, it is to be understood that the drawing and description in this disclosure are proffered to facilitate comprehension of the invention, and should not be construed to limit the scope thereof.

What is claimed is:

1. A method of producing combined heat and power, the method comprising the steps of:
 - providing a cupola for containing a plasma source.; and
 - 5 delivering a feedstock to the cupola.
2. The method of claim 1, wherein the feedstock is a fossil fuel.
3. The method of claim 1, wherein the feedstock is a hazardous waste.
4. The method of claim 1, wherein the feedstock is a combination of any organic compound, fossil fuel, or hazardous material.
- 10 5. The method of claim 1, wherein there is further provided the step of providing a metal bath within the cupola.
6. The method of claim 5, wherein there is further provided the step of operating an inductive element to react with the metal bath to generate syngas.
7. The method of claim 6, wherein there is further provided the step of
- 15 supplementing said step of operating an inductive element by the further step of operating a plasma torch.
8. The method of claim 7, wherein said step of operating a plasma torch is performed to operate on the metal bath selectably directly and indirectly.
9. The method of claim 8, wherein said step of operating a plasma torch
- 20 is performed in a downdraft arrangement.
10. The method of claim 8, wherein said step of operating a plasma torch is performed at an angle other than vertical.
11. The method of claim 6, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the
- 25 further step of injecting steam to enhance the production of syngas.
12. The method of claim 6, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of injecting a selectable one of air, oxygen enriched air, and oxygen.
13. The method of claim 6, wherein there is provided the further step of
- 30 supplementing said step of operating an inductive element by performing the further step of conducting electrical energy via a conductive rod formed of a selectable one of graphite and carbon into the metal bath.

14. A method of producing combined heat and power, the method comprising the steps of:

providing a cupola for containing a metal bath; and

operating an inductive element to react with the metal bath to generate
5 syngas.

15. The method of claim 14, wherein there is provided the further step of delivering a feedstock to the cupola.

16. The method of claim 15, wherein the feedstock is a fossil fuel.

17. The method of claim 15, wherein the feedstock is a hazardous waste.

10 18. The method of claim 15, wherein the feedstock is a combination of any organic compound, fossil fuel, or hazardous material.

19. The method of claim 14, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of operating a plasma torch.

15 20. The method of claim 19, wherein said step of operating a plasma torch is performed to operate on the metal bath selectably directly and indirectly.

21. The method of claim 19, where a plasma torch is arranged in a downdraft arrangement to work in series with the inductive furnace

20 22. The method of claim 21, where the plasma torch in a downdraft arrangement is placed at an angle other than vertical.

23. The method of claim 14, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of injecting steam to enhance the production of syngas.

25 24. The method of claim 14, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of injecting a selectable one of air, oxygen enriched air, and oxygen.

25. A method of producing combined heat and power, the method comprising the steps of:

providing a cupola for containing a metal bath;

30 operating an inductive element to react with the metal bath; and

supplementing said step of operating an inductive element by the further step of operating a plasma torch and a pregassifier.

26. The method of claim 25, wherein said step of operating a plasma torch is performed to operate on the metal bath selectably directly and indirectly.

27. The method of claim 25, wherein there is further provided the step of supplementing said step of operating an inductive element by performing the further step of adding chemical heat.

5 28. The method of claim 25, wherein there is further provided the step of supplementing said step of operating an inductive element by performing the further step of injecting steam to enhance the production of syngas.

29. The method of claim 25, wherein there is further provided the step of supplementing said step of operating an inductive element by performing the further step of injecting a selectable one of air, oxygen enriched air, and oxygen.

10 **30.** A method of producing combined heat and power, the method comprising the steps of:

providing a cupola for containing a metal bath;

operating an inductive element to react with the metal bath; and

15 supplementing said step of operating an inductive element by the further step of propagating a selectable one of plasma and electricity into the metal bath to supplement heating of the cupola by said step of operating an inductive element with a pregassifier and a turbine generator and a heat recovery system.

20 31. The method of claim 30, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of operating a plasma torch.

32. The method of claim 31, wherein said step of operating a plasma torch is performed to operate on the metal bath selectably directly and indirectly.

25 33. The method of claim 30, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of injecting steam to enhance the production of syngas.

34. The method of claim 30, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of injecting a selectable one of air, oxygen enriched air, and oxygen.

30 35. The method of claim 30, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of conducting electrical energy via a conductive rod formed of a selectable one of graphite and carbon into the metal bath.

36. A method of producing combined heat and power, the method comprising the steps of:

providing a cupola for containing a metal bath;

operating an inductive element to react with the metal bath; and

5 supplementing said step of operating an inductive element by the further step of propagating a selectable one of plasma and electricity into the metal bath to supplement heating of the cupola by said step of operating an inductive element with a pregassifier and a turbine generator which is augmented with an afterburner before the heat recovery system.

10 **37.** The method of claim 36, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of operating a plasma torch.

38. The method of claim 37, wherein said step of operating a plasma torch is performed to operate on the metal bath selectably directly and indirectly.

15 **39.** The method of claim 36, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of injecting steam to enhance the production of syngas.

40. The method of claim 36, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the
20 further step of injecting a selectable one of air, oxygen enriched air, and oxygen.

41. The method of claim 36, wherein there is provided the further step of supplementing said step of operating an inductive element by performing the further step of conducting electrical energy via a conductive rod formed of a selectable one of graphite and carbon into the metal bath.

25 **42.** The method of claim 36 where the pregassifier includes multiple stages.

43. The method of claim 42 where the first stage of the gassifier is heated by steam and the second stage is heated by higher temperature steam, air, molten salt, or any other high temperature heat transfer medium.

30 **44.** A method of producing combined heat and power, the method comprising the steps of:

providing a cupola for containing a metal bath;

operating an inductive element to react with the metal bath to generate syngas; and

35 providing the syngas to an afterburner to produce steam.

45 The method of claim 44, wherein said step of providing the syngas to an afterburner to produce steam includes the further step of providing natural gas to the afterburner.

Fig. 1

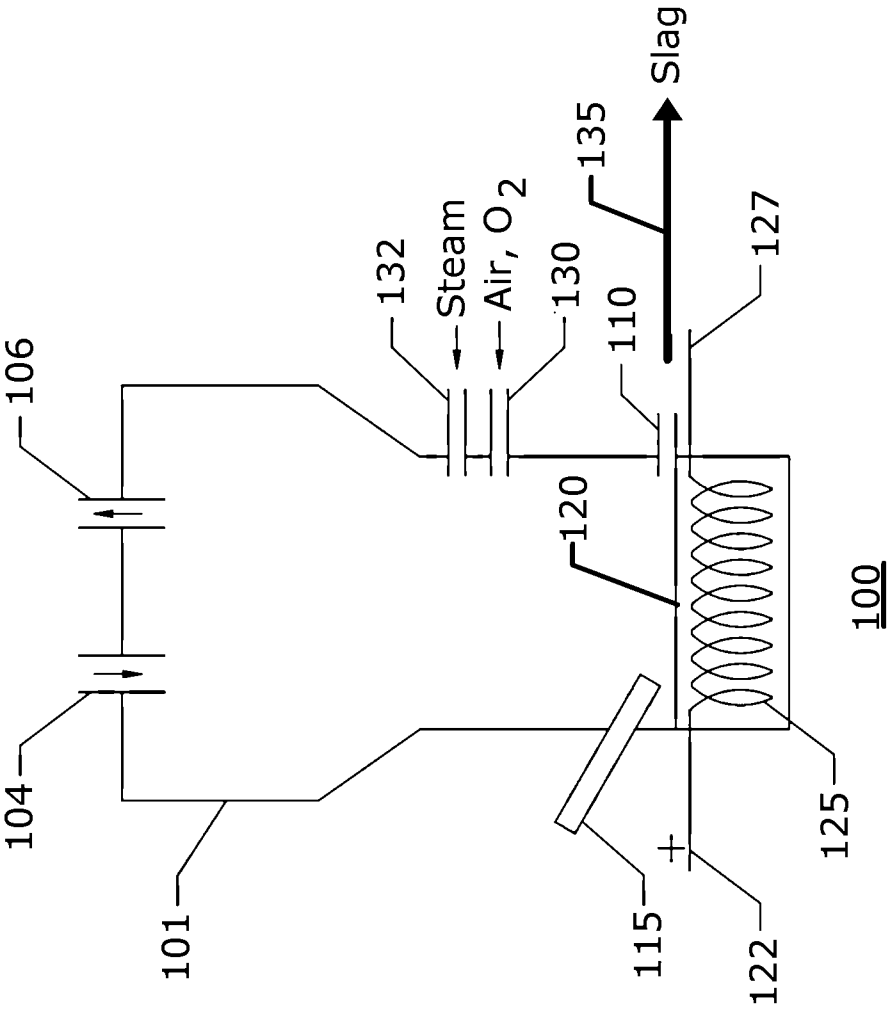


Fig. 2

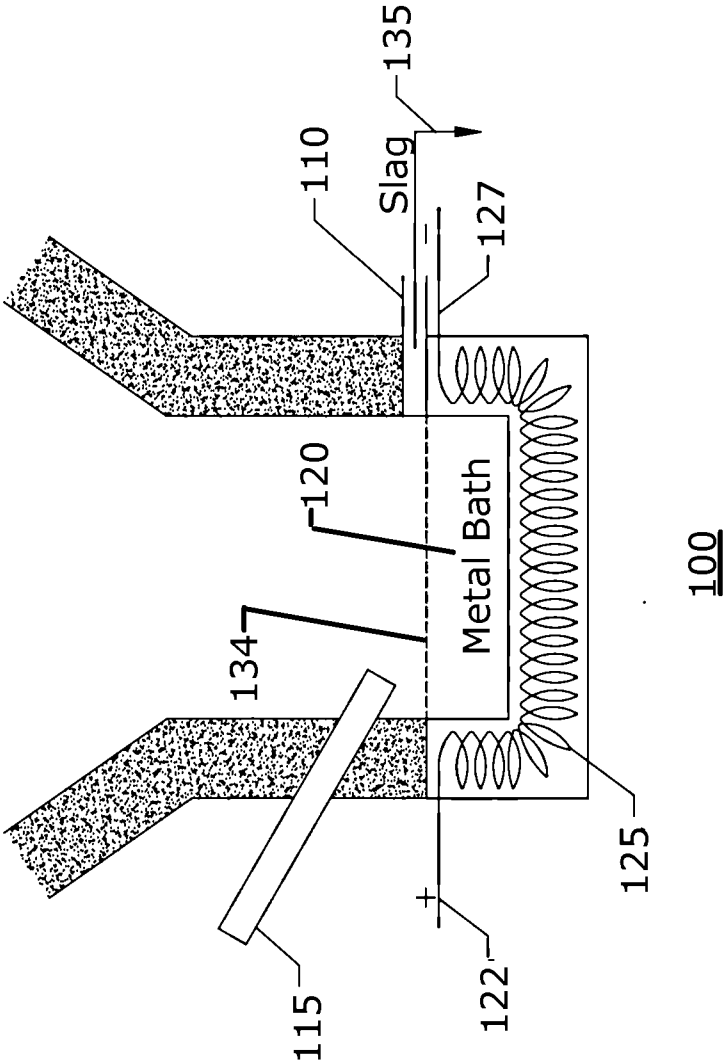


Fig. 3

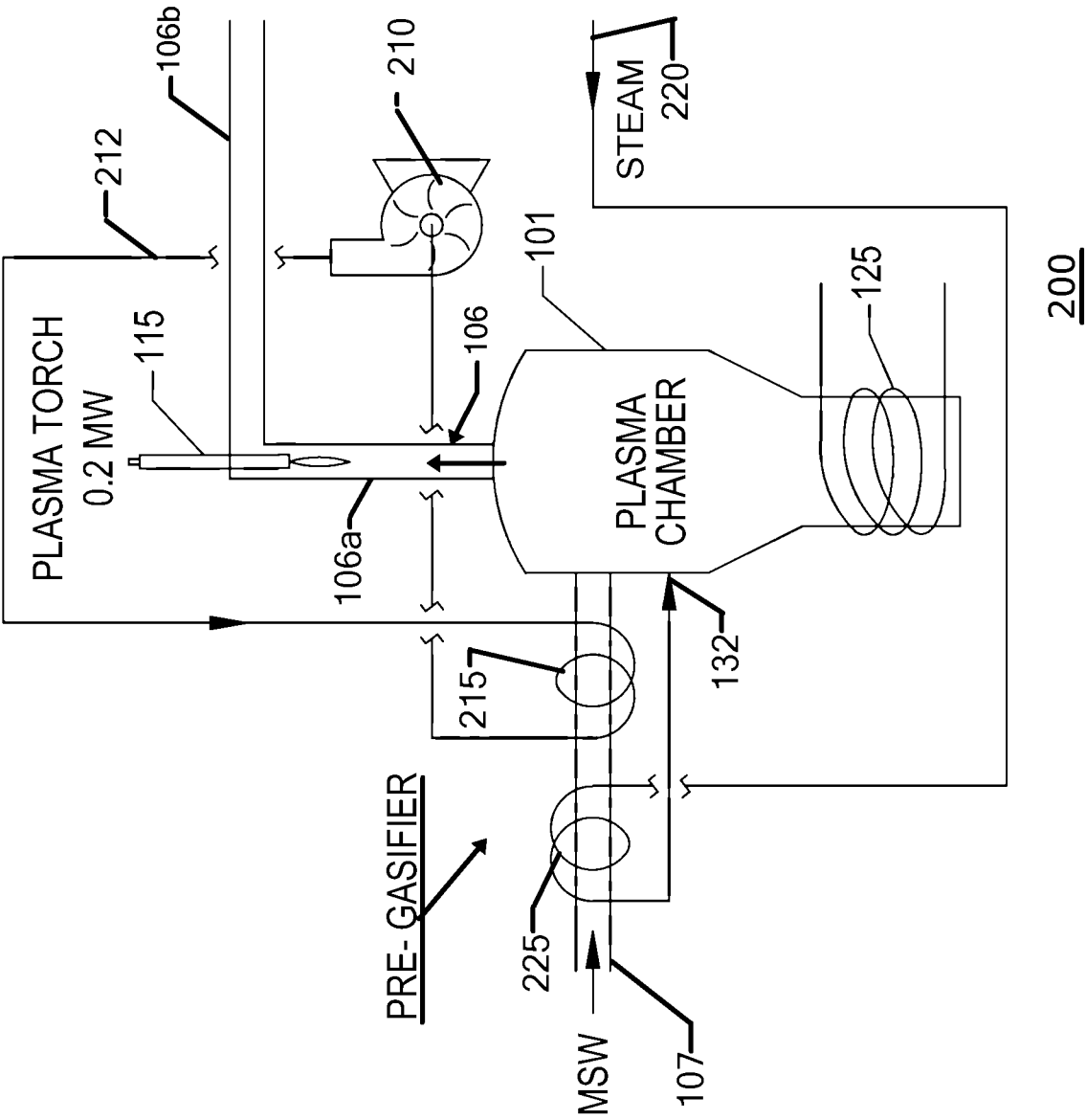


Fig. 4

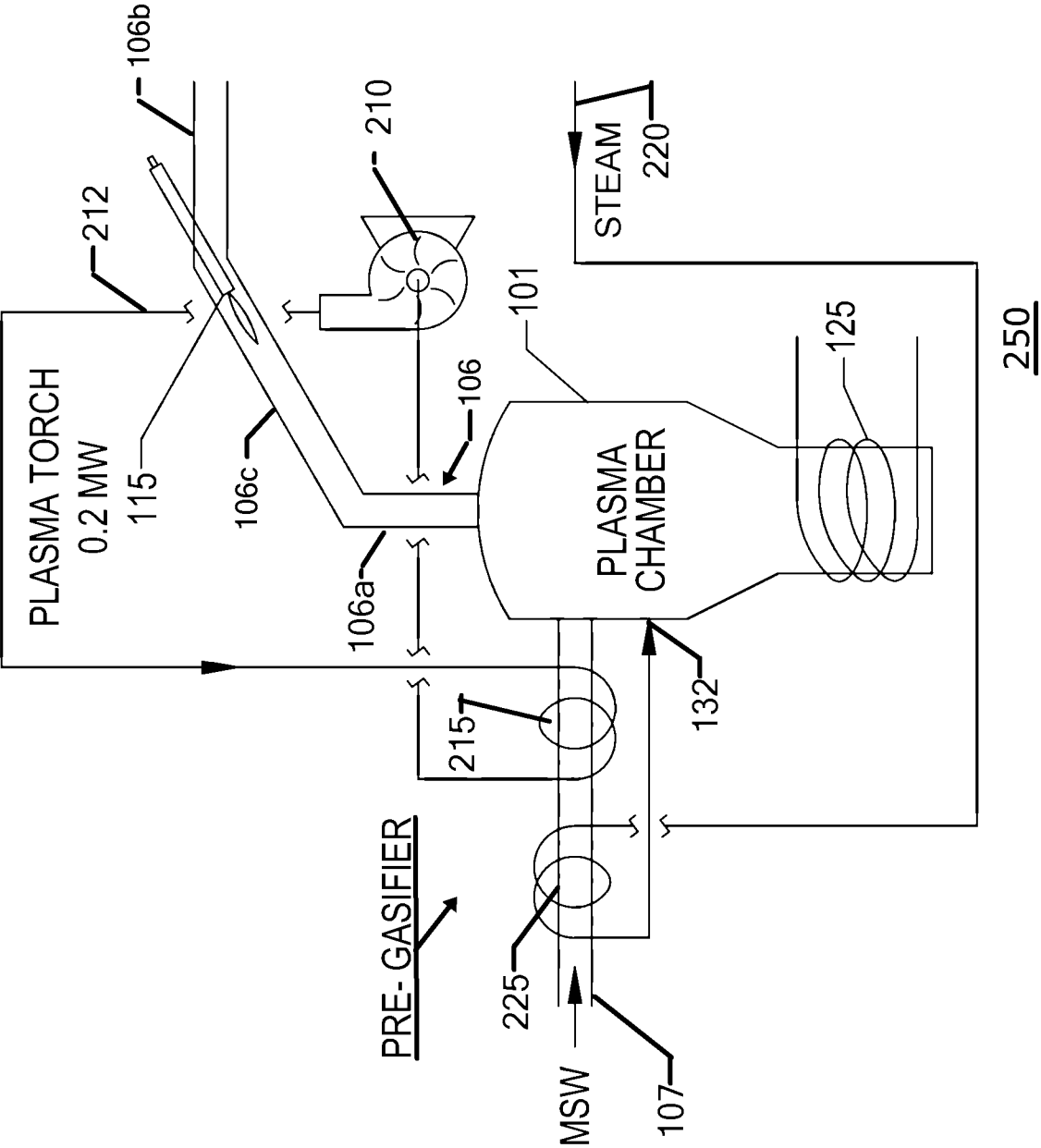
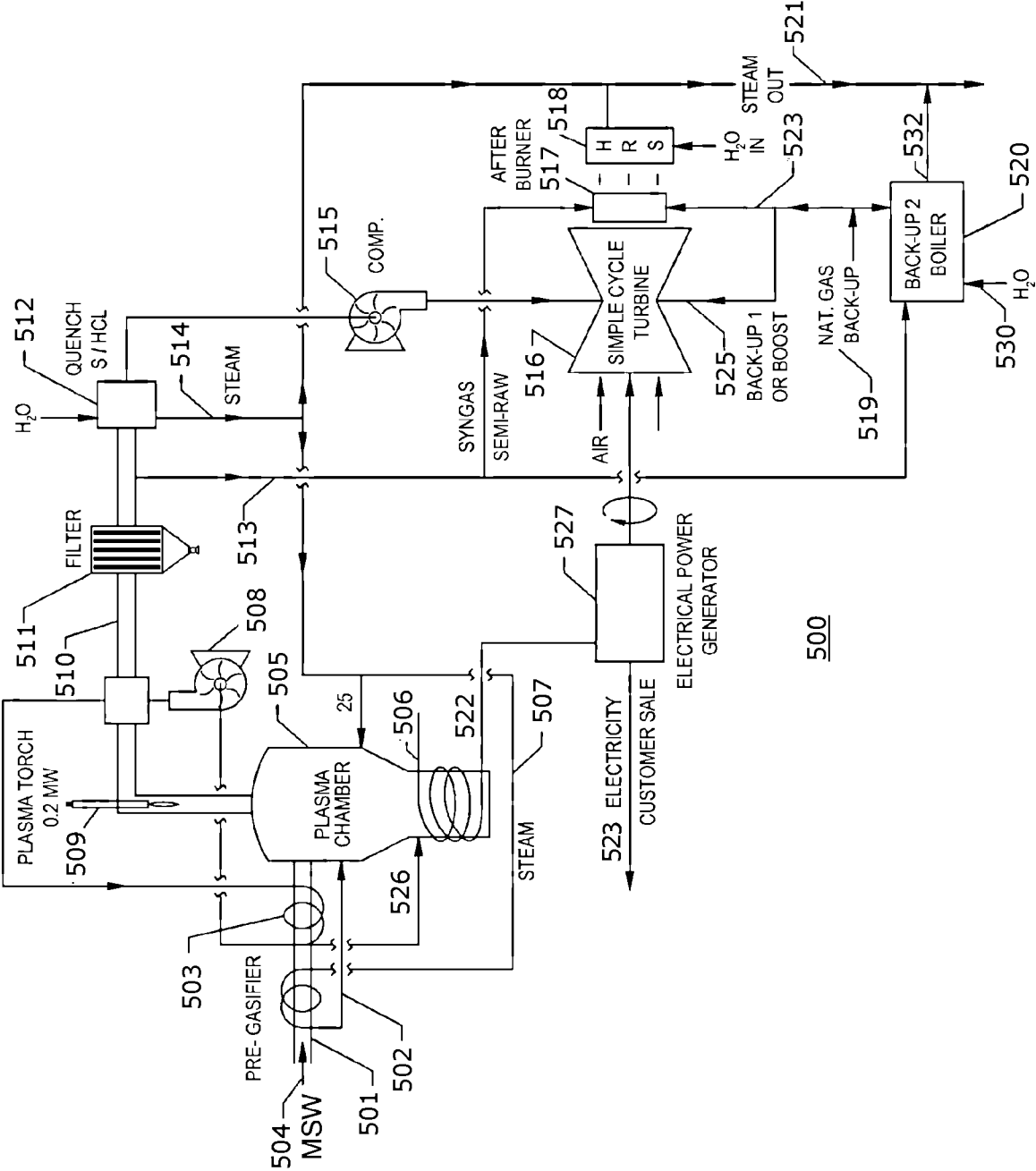


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 12/24726

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - C06B 43/00, C06D 5/00 (2012.01)

USPC - 60/215

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC: 60/215Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 60/200.1, 205, 205, 215, 722, 734 (keyword limited--see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST(PGPB, USPT, EPAB, JPAB); Google Scholar

Search Terms Used: Syngas synthetic gas plasma torch induction hazardous gas fuel injection metal bath feedstock feed stock power heat cupola turbine

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 2009/0133407 A1 (SAWYER) 28 May 2009 (28.05.2009), Abstract, para [0003], [0012]-[0013], [0028]-[0029], [0032], [0036], [0038], [0041]	1-4 ----- 5-41
Y	US 4,514,219 A (DE SAINT MARTIN) 30 April 1985 (30.04.1985), col 3, ln 66- col 4, l n 8, Fig. 1	5-45
Y	US 6,372,156 B1 (KONG et al.) 16 April 2002 (16.04.2002), col 2, ln 66- col 3, ln 8, col 4, ln 1-19, col 5, ln 11-33	6-45
Y	US 6,175,183 B1 (LIEHR) 16 January 2001 (16.01.2001), col 2, ln 55- col 3, ln 14	13, 35, 41

☐ Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search

03 June 2012 (03.06.2012)

Date of mailing of the international search report

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