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(71) Demandeur/Applicant:
KING, FORREST A., US

(72) Inventeur/Inventor:
KING, FORREST A., US

(74) Agent: NEXUS LAW GROUP LLP

(54) Titre : REACTEURS A GAZ NATUREL ET PROCEDES
(54) Title: NATURAL GAS REACTORS AND METHODS

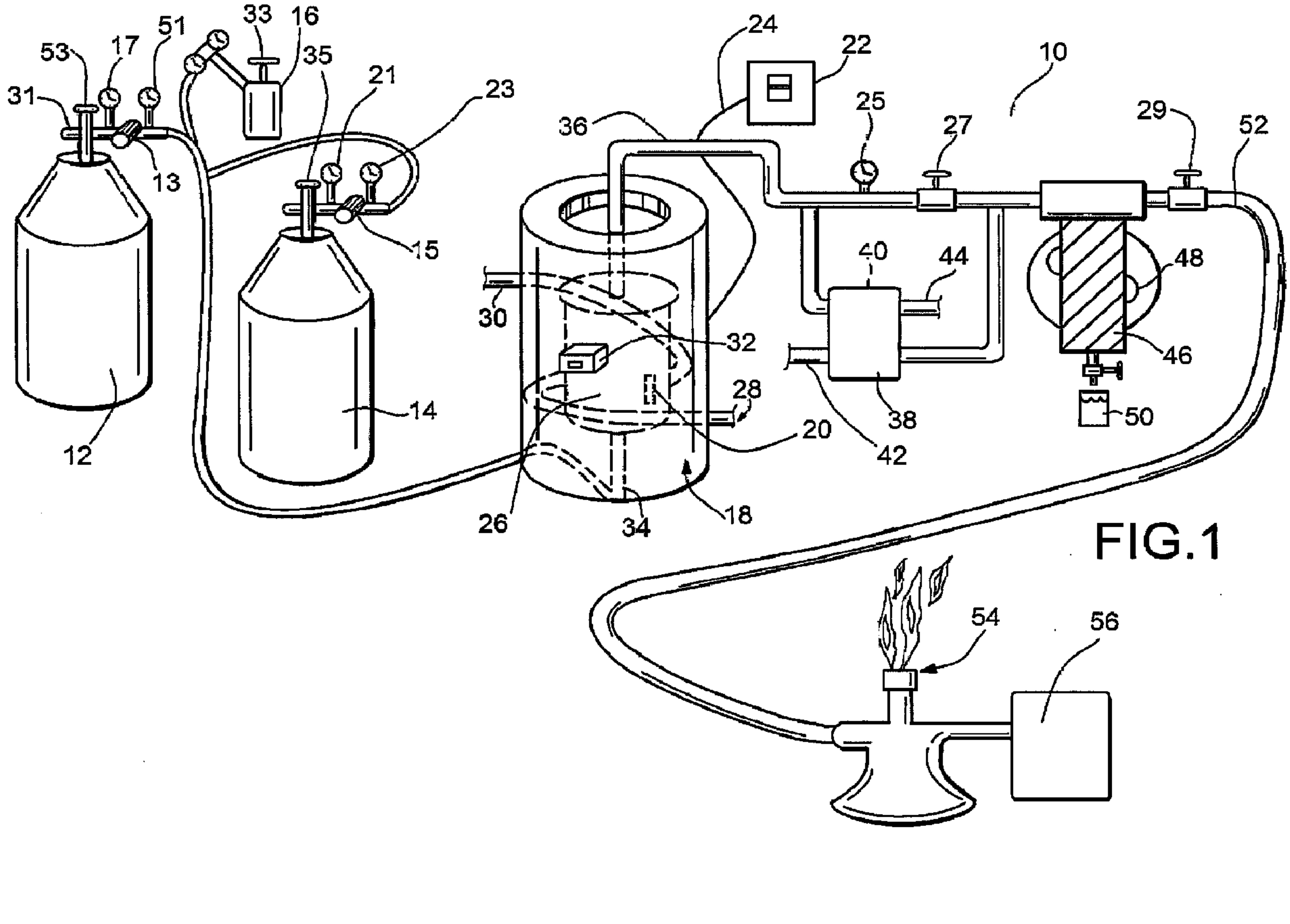

FIG.1

(57) Abrégé/Abstract:
A method of producing heat for industrial purposes such as power generation can use at least one, if not two exothermic reactions. First, methane may be produced from carbon dioxide and hydrogen in a reactor. This reaction produces heat. The methane may

(57) Abrégé(suite)/Abstract(continued):
be burned, or oxidized (which is also an exothermic reaction) to produce carbon dioxide and hydrogen. Oxygen and/or hydrogen may supplement the process as could be produced from the electrolysis of water. Carbon dioxide may be obtained from a variety of sources.

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(72) Inventor; and
(71) Applicant : **KING, Forrest, A** [US/US]; 8011 Turtle Lane, Ooltewah, TN 37363 (US).

(74) Agent: **STARK, Stephen, J.**; Miller & Martin PLLC, Suite 1200 Volunteer Building, 832 Georgia Avenue, Chattanooga, TN 37402-2289 (US).

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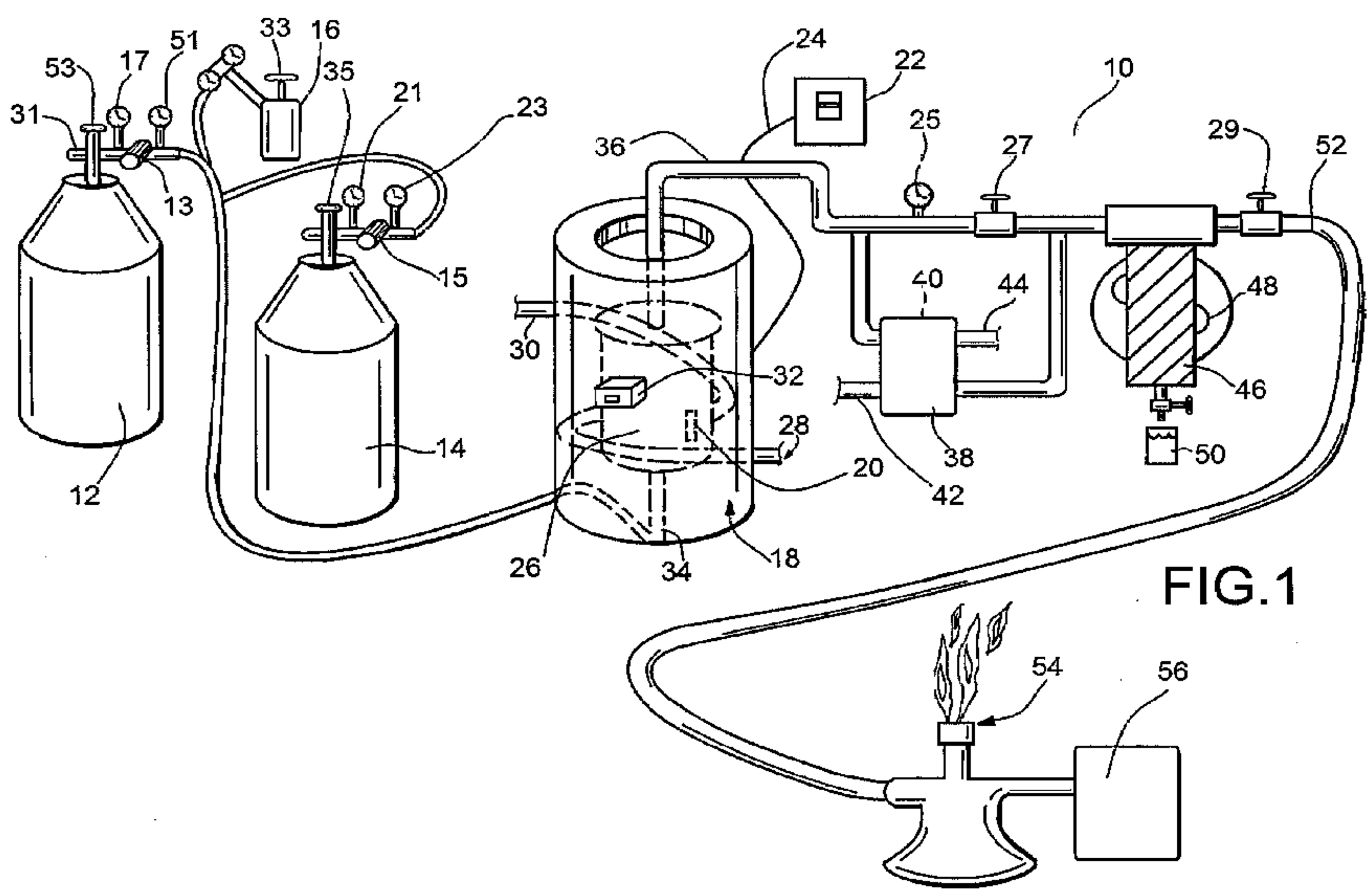

FIG.1

(57) Abstract: A method of producing heat for industrial purposes such as power generation can use at least one, if not two exothermic reactions. First, methane may be produced from carbon dioxide and hydrogen in a reactor. This reaction produces heat. The methane may be burned, or oxidized (which is also an exothermic reaction) to produce carbon dioxide and hydrogen. Oxygen and/or hydrogen may supplement the process as could be produced from the electrolysis of water. Carbon dioxide may be obtained from a variety of sources.

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NATURAL GAS REACTORS AND METHODS

Claim of Priority

[0001] This application claims the benefit of U.S. Provisional Application No. 62/108,220 filed January 27, 2015, which is included herein by reference, in its entirety.

Field of the Invention

[0002] The present invention relates to a natural gas reactor and method of use whereby at least one, if not two reactors are utilized to generate heat and/or possibly produce component gasses for various uses.

Background of the Invention

[0003] Until recently, natural gas used to be relatively expensive. Accordingly, a need exists to produce relatively inexpensive natural gas under at least some conditions.

[0004] Furthermore, many industrial requirements require heat for various processes. Various food companies and other industries consume enormous amounts of natural gas which is used as a source of heat to manufacture potato chips and other snacks. What if this heat could be produced in a much more cost effective manner? The present method employed by some snack manufacturing plants is to burn natural gas. Accordingly, a need exists to produce heat for use in industrial or other environments while also possibly producing at least one of methane (CH_4), carbon dioxide and/or carbon monoxide and/or hydrogen.

Summary of the Invention

[0005] It is an object of many embodiments of the present invention to provide an improved heat producing and heating systems for industrial environments.

[0006] It is another object of many embodiments of the present invention to provide an improved method of producing methane from hydrogen and carbon dioxide.

[0007] It is another object of the present invention to provide an improved method of cyclically performing exothermic reactions in an effort to greatly enhance the heating capability from methane in environments, particularly when oxygen and/or hydrogen can be relatively inexpensively obtained.

[0008] Accordingly, the present invention relates to a first reactor which receives the inputs of carbon dioxide and hydrogen and then through a fusion reaction at temperatures such as about 500° Celsius in the presence of a catalyst, an exothermic reaction is conducted to produce methane gas CH_4 (i.e., natural gas) and water. In the testing conducted by the applicant, roughly 98% conversion was achieved.

[0009] Although a heater is required initially to heat the reactor to 500° Celsius, the reaction of the fusion of carbon dioxide with hydrogen is a self-sustaining exothermic reaction which was found to produce more than enough heat to maintain the temperature as well as provide an additional heat source that could be utilized for industrial environments. For instance, a food industry would require a temperature of roughly 350° Fahrenheit to fry potato chips. Accordingly, using the applicant's process there is a sufficient heat from this first process that could be utilized to provide at least some of the heat.

[00010] The carbon dioxide and hydrogen may come from various sources and they may either be waste products themselves or be provided relatively cost efficiently. For instance, the hydrogen may be produced through other technology of the applicant such as from electrolysis of water utilizing solar energy or other energy sources that could be extremely cost effective. One may also be able to find an inexpensive source of carbon dioxide such as from waste products of fermentation, oxidation of methane, products of combustion, or even being emitted from volcanos, hot springs or geysers or from the dissolution of water and various acids.

[00011] In fact, the applicant is working on methods to separate carbon dioxide from air which would provide an extremely inexpensive source of carbon dioxide.

[00012] Once the first process of producing methane gas and water is performed to produce methane, the methane could be burned for additional heat and/or alternatively, utilizing a partial oxidation reaction, effectively the process could be reversed so that the CH_4 and possibly steam and/or oxygen could be directed into the same or another reactor with a catalyst to provide an exothermic catalytic partial oxidation reaction and a water gas shift reaction so that the methane together with water and/or oxygen can shift to at least one portion of carbon monoxide and water and/or carbon dioxide and hydrogen and more heat. If the hydrogen and the carbon dioxide are not necessary for further industrial processes, the hydrogen and carbon dioxide can be run back through the first reactor to produce methane and water again thereby producing the first process i.e. the first exothermic reaction and more heat.

[00013] Assuming another 98% efficient conversion, the consumption of methane is roughly about 4%, through the cycle. In industrial or other environments, this could reduce the current usage of methane to produce heat by a factor of about 25 which could significantly lower the heating bills for a company to roughly 4% of their current expenses. After the capital costs of the reactor systems and heat exchangers are in place, roughly 4% of the current costs are expected for the same amount of heat. This would appear to be particularly attractive for many applications. Furthermore, in countries such as Japan, particularly if there is an excess supply of hydrogen and carbon dioxide in the marketplace, clean natural gas (i.e. methane) can be produced for power generation, heating and/or other purposes. Furthermore, the two cyclical reaction processes can be employed for various heating sources such as to generate power or other purposes.

Brief Description of the Drawings

[00014] The particular features and advantages of the invention as well as other objects will become apparent from the following description taken in connection with the accompanying drawings in which:

Figure 1 is a schematic representation of the presently preferred embodiment of the present invention of a first portion of the invention, namely, the conversion of carbon dioxide and hydrogen to methane and water;

Figure 2 is a schematic representation of the conversion of methane and oxygen and/or water to at least one of CO_2 and hydrogen if not carbon monoxide and/or water through the catalytic partial oxidation process;

Figure 3 is a chemical representation of oxidation path of methane CH_4 to CO_2 and hydrogen;

Figure 4 is a chemical representation of the fusion of carbon dioxide and hydrogen into methane and water; and

Figure 5 is a schematic representation of an industrial system using the reactors for heat.

Detailed Description of the Drawings

[00015] Figure 1 shows a presently preferred embodiment of the present invention addressing in a first direction where carbon dioxide and hydrogen represented by $CO_2 + H_2$ as shown in first and second canisters **12,14** are combined to form methane CH_4 and water and energy (as an exothermic reaction). The carbon dioxide and hydrogen may come from different sources or be premixed such as provided in first canister **12** and/or second canister **14.** For ease of use the applicant has a premixed carbon dioxide and hydrogen in the first canister **12** and provides nitrogen purge with second canister **14.** Other embodiments may have yet another canister, separate such as canister **16** which could be similar or dissimilar to first canister **12** to provide a supply of hydrogen and/or carbon dioxide (opposite of first canister **12**) to reactor **18** for the fusion reaction to occur.

[00016] The process of forming methane from CO_2 and hydrogen is often referred to as the Sabatier reaction or Sabatier process. When combined with the catalytic partial oxidation reaction shown in Figure 4, two exothermic reactions can cyclically be provided.

[00017] The initial heat for the first process is optimally in a range of at least about 300° - 400° Celsius and preferably occurs in the presence of a nickel catalyst **20**. Once the desired starting temperature is achieved in the reactor **18** such as with a power supply illustrated as being provided switch **22** (such as providing electricity through power line **24** to heater **26**), the reaction can begin. Once the reaction starts, the reactor **18** may continue to be brought up to temperature or temperature maintained, with the power secured from switch **22.** The temperature of the reactor **18** can be maintained, and in fact give off extra heat such through heat exchanger represented by inlet **28** and outlet **30** which could direct the fluid through reactor **18** and take off extra heat to maintain the optimal temperature. The optimal pressure of the reactor **18** may also be maintained during this process.

[00018] While a nickel catalyst can be used, ruthenium on alumina may also be utilized as well as other catalysts which would be known to those of ordinary skill in the art. Hydrogen can be readily obtained from the electrolysis of water as one of ordinary skill in the art would understand. Carbon dioxide might be obtained from combustion processes, oxidation of methane from naturally occurring sources such as volcanic eruptions, geysers, etc., or it may also be extracted from air or fossil fuel waste such as by the amine process which is a scrubbing process normally used to remove hydrogen sulfide H_2S and carbon dioxide from gasses. CO_2 scrubbers are utilized in various applications.

[00019] Meter **32** can report the temperature inside the reactor **18** so that the operator will know when to begin the reaction once the desired temperature has been achieved and the flow of gasses can commence. The exothermic reaction in the reactor **18** can then begin to generate heat. The carbon dioxide and hydrogen are preferably directed through at least one inlet **34** or possibly through separate inlets into the reactor **18** to where the exothermic reaction in the present catalyst **20** occurs. Hot gasses are directed out outlet **36** where they can then proceed through a heat exchanger **38** which may have a meter **40** to advise of the temperature. Heat exchanger **38** may have inlet **42**. Outlet **44** may provide a source of heat which may also be utilized for various purposes such as for power and/or heat purposes. Fluid may pass through a heat exchanger in the reactor **28** as represented by inlet **28** and outlet **30** as would be understood by those of ordinary skill in the art. Water can be turned into steam in one or both of these heat exchangers for use with other heating operations. Other fluids could be utilized with other embodiments. The exhaust gas from the reactor **18** can then proceed to a knock-out drum **46** or other heat exchanger so that water can be separated from methane. Cooling can be provided such as by fan **48** and/or a similar structure like a heat exchanger **38** or otherwise so that water for the reactor **18** can then be ejected such as from outlet **50** which has been found to be a particularly purified form of water. Methane can exit from outlet **52** and can either be burned such as with one or more burners **54** and/or stored in storage **56** as would be understood by those of ordinary skill in the art. This is reaction is exothermic in nature.

[00020] With the methane being stored, it can then be utilized in a separate process in a cyclical manner as shown by Figure 2 to continue to generate even more heat. The second reaction can be provided by system **60** showing a methane supply **62** with pressure gauges **64,66** and regulator **68** and can direct a flow of methane into reactor **70** possibly along with a supply of oxygen **72** and/or steam or water **74** which may be obtained from the system **10** or otherwise. Oxygen may be obtained from a possible electrolysis reaction which the hydrogen was obtained for the first process or system **10** shown in Figure 7. The oxygen **72** and/or hydrogen and/or methane can react with the catalyst **76** in the reactor **70** to ultimately form carbon dioxide **78** and hydrogen **80** is shown in Figure 2 and/or alternatively form carbon monoxide **82** and/or water **81** and/or hydrogen **89**.

[00021] It is preferred to continue the process to form the catalytic partial methane oxidation process from methane supply **52** all the way to carbon dioxide and hydrogen which is an exothermic reaction giving off heat such as to heat exchanger **86** represented by inlet **88** and outlet **90** for which such heat can be utilized to produce steam and/or heat for use in turbines for power generation and/or for heat in other heat exchangers. For instance, Figure 5 shows a heater **100** comprised of reactors **18** and **70** as well as heat exchanger **38** and/or possibly others in an industrial setting such as a heater **100** receiving product or supply being provided on belt **102** as input and then being removed from belt **104** as output such as could occur in the cooking of potato chips and/or other processes. Of course, other industrial processes may use any one of the various heat exchangers **18** and/or reactors **18,38**,**70** and/or others as would be understood by those of ordinary skill in the art.

[00022] Referring back to Figure 1, in the process the system **10** may employ a way to regulate pressure of the various gasses such as through the use of one or more regulators **13,15** and use of pressure gauges such as **17,51,21,23,25** and others. Various cutoff valves **27,29,53,33,35** and others may be useful for various embodiments for safety or other purposes.

[00023] Similarly, in Figure 2 cutoff valves **101,103,105** and/or others may be utilized Regulator **68** and **107** may be utilized as well as pressure gauges **64,66,109,111** and/or others. Various temperatures can be monitored such as with meter **113**. Water may be extracted in valve **115** or otherwise if at all, and of course, the knock-out drum **117** can have a heat exchanger with inlet **120** and outlet **119** as would be understood by those of ordinary skill in the art or could take other forms of heat exchangers.

[00024] By running the two exothermic reactions simultaneously within a heater **100**, a large amount of heat can be produced. This heat can be provided for various processes. If the heat were utilized to heat in place of only the burning of natural gas, the applicant believes that with the efficiencies of being roughly 98% conversion in both directions, the total loss in completing the cycle would be roughly 4%. The amount of heat generated could be roughly about 25 times that of the amount if methane alone were simply burned. With the amount of methane roughly consumed by the process due to inefficiencies, this is 25 times less for the same amount of heat and is believed to be a huge improvement and cost savings over prior art. Other embodiments may not be this efficient but the applicant believes that the generation of at least about ten times as much heat as a traditional natural gas burner in terms of efficiency is relatively easily achieved. Some embodiments of this technology may achieve efficiencies closer to 25 times.

[00025] Certainly either of the two processes shown in Figures 1 and/or 2 can be run in a single direction for various embodiments, for instance, if there is an abundance of carbon dioxide and hydrogen on location, then the heat reaction could possibly be utilized for various purposes while the methane could be used for traditional natural gas applications. Similarly, if there is an abundance of methane, an ability to manufacture CO_2 and hydrogen gas for various purposes could be used, possibly while enjoying the heat for certain applications. At least one or both of these processes may be employed in a cyclical manner for use in generating steam or other heating applications such as heating buildings, heating water such as to steam for power generators, and/or providing other mechanical and/or chemical processes including the generation of various gasses.

[00026] Numerous alterations of the structure herein disclosed will suggest themselves to those skilled in the art. However, it is to be understood that the present disclosure relates to the preferred embodiment of the invention which is for purposes of illustration only and not to be construed as a limitation of the invention. All such modifications which do not depart from the spirit of the invention are intended to be included within the scope of the appended claims.

[00027] Having thus set forth the nature of the invention, what is claimed herein is:

1. A method of heat generation and producing methane comprising the steps of:

(a) providing hydrogen and carbon dioxide to a reactor;

(b) exothermically reacting the hydrogen and carbon dioxide in the reactor to form methane, water and heat;

(c) separating the methane from the water; and

(d) at least one of the following steps:

(i) using the heat from the reactor for an industrial process selected from the group of generating power in a turbine and heating;

(ii) burning the methane for an industrial process selected from the group of generating power in a turbine and heating; and

(iii) oxidizing the methane of step (b) in an exothermic reaction to produce at least carbon dioxide and hydrogen, at least one of which is used to repeat step (a) above, and heat, said heat used for an industrial process selected from the group of generating power in a turbine and heating.

2. The method of claim 1 wherein step (d)(iii) is performed and the oxidation step further produces carbon monoxide and water, with at least one of the carbon dioxide and hydrogen separated from the carbon monoxide.

3. The method of claim 2 wherein step (d)(iii) is performed and both the carbon dioxide and hydrogen are used to repeat step (a).

4. The method of claim 1 wherein step (d)(iii) is performed and both the carbon dioxide and hydrogen are used to repeat step (a).

5. The method of claim 1 further comprising a heat exchanger receiving output of the reactor, said heat exchanger used for an industrial process selected from the group of generating electricity and heating.

6. The method of claim 1 wherein the carbon dioxide provided for step (a) is:

(a) a waste product from one of

(i) combustion, and

(ii) fermentation;

(b) generated from dissolution of water and an acid;

(c) generated form an amine process from fossil fuels; and

(d) obtained from a natural emission from one of:

(i) geysers,

(ii) hot springs; and

(iii) volcanoes.

7. The method of claim 1 wherein the hydrogen provided for step (a) is generated from the step of electrolysis of water.

8. The method of claim 7 wherein the step of electrolysis performed generates oxygen, and the oxygen is used in step (d)(iii).

9. The method of claim 1 wherein the reactor has a heat exchanger for use with step (d)(i).

10. The method of claim 1 further comprising the step of providing a heater, said heater initially heating the reactor to ab least 300 C to begin the exothermic reaction step, and then securing the heater while continuing the exothermic reaction step.

11. The method of claim 1 wherein the reactor has a catalyst selected from the group of nickel, ruthenium and alumina, and the exothermic reaction step utilizes the catlalyst to assist in performing the reaction.

12. A method of heat generation and producing methane comprising the steps of:

(a) oxidizing methane in an exothermic reaction to produce heat and at least carbon dioxide and hydrogen, said heat used for an industrial process selected from the group of generating power in a turbine and heating;

(b) providing hydrogen and carbon dioxide (having the at least one from step (a)) to a reactor;

(c) exothermically reacting the hydrogen and carbon dioxide in the reactor to form methane, water and heat;

(d) separating the methane from the water; and

(e) at least one of the following steps:

(i) using the heat from the reactor for an industrial process selected from the group of generating electricity and heating; and

(ii) burning the methane for an industrial process selected from the group of generating electricity and heating.

13. The method of claim 12 wherein both the hydrogen and the carbon dioxide are provided to the reactor from the oxidizing step.

14. The method of claim 12 wherein when step (a) is performed and the oxidation step further produces carbon monoxide and water, with at least one of the carbon dioxide and hydrogen separated from the carbon monoxide.

15. The method of claim 12 wherein steps (a) – (e) are performed repeatedly in a cycle.

16. The method of claim 12 further comprising a heat exchanger receiving output of the reactor, said heat exchanger used for an industrial process selected from the group of generating electricity and heating.

17. The method of claim 12 wherein the carbon dioxide provided for step (a) is:

(a) a waste product from one of

(i) combustion, and

(ii) fermentation;

(b) generated from dissolution of water and an acid;

(c) generated form an amine process from fossil fuels; and

(d) obtained from a natural emission from one of:

(i) geysers,

(ii) hot springs; and

(iii) volcanoes.

18. The method of claim 12 wherein the reactor has a heat exchanger for use with step (d)(i).

19. The method of claim 12 further comprising the step of providing a heater, said heater initially heating the reactor to ab least 300 C to begin the exothermic reaction step, and then securing the heater while continuing the exothermic reaction step.

20. The method of claim 12 wherein the reactor has a catalyst selected from the group of nickel, ruthenium and alumina, and the exothermic reaction step utilizes the catlalyst to assist in performing the reaction.

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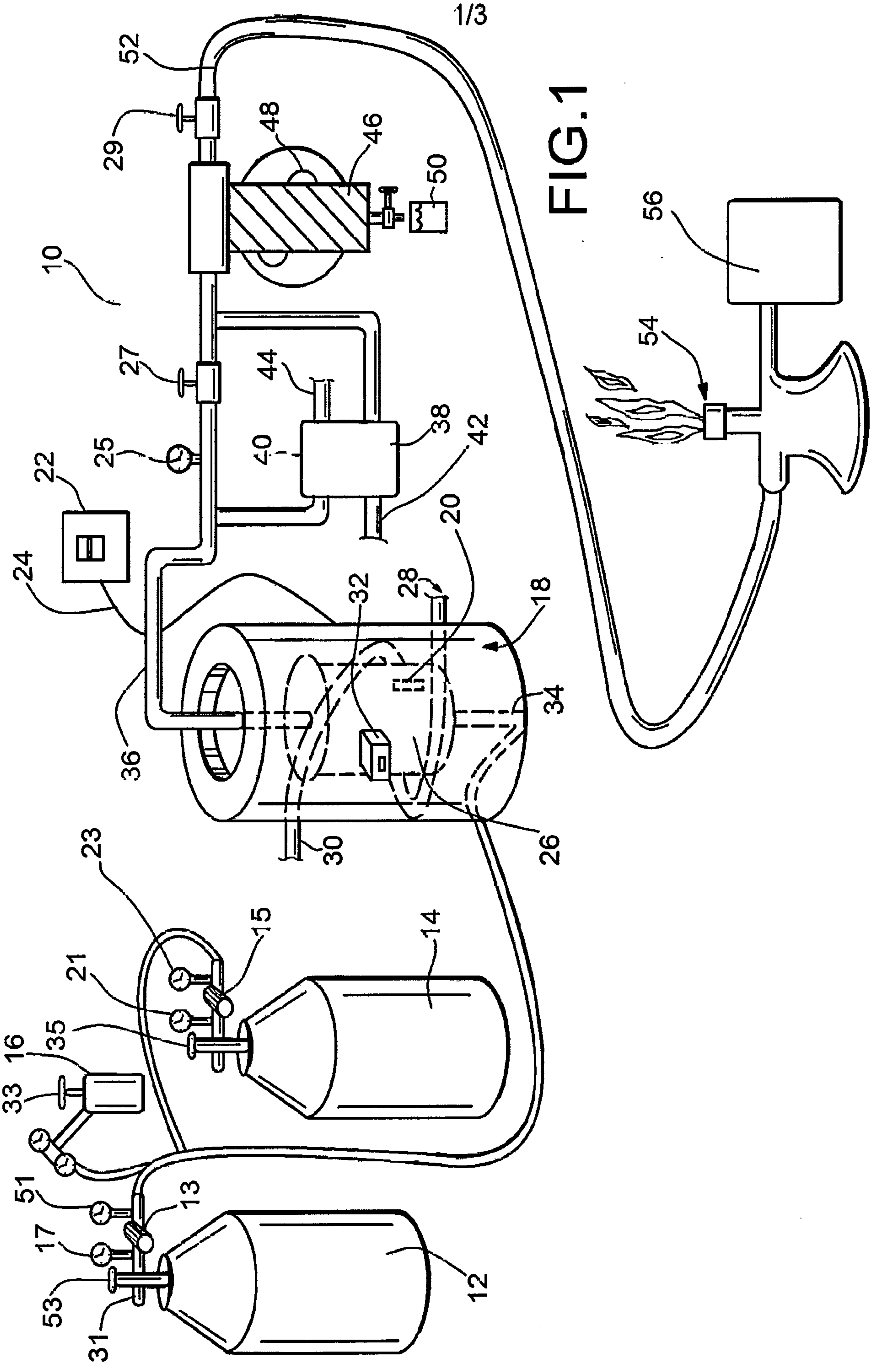
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FIG.1

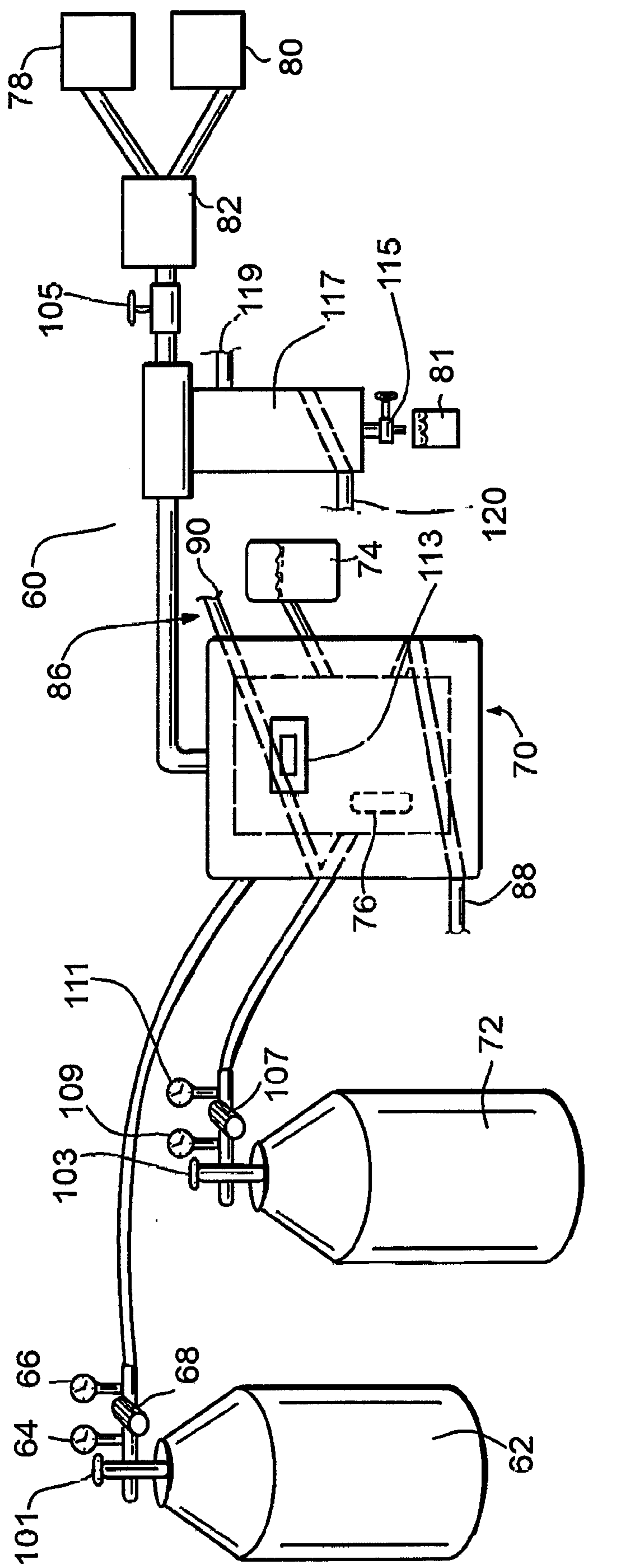
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FIG.2

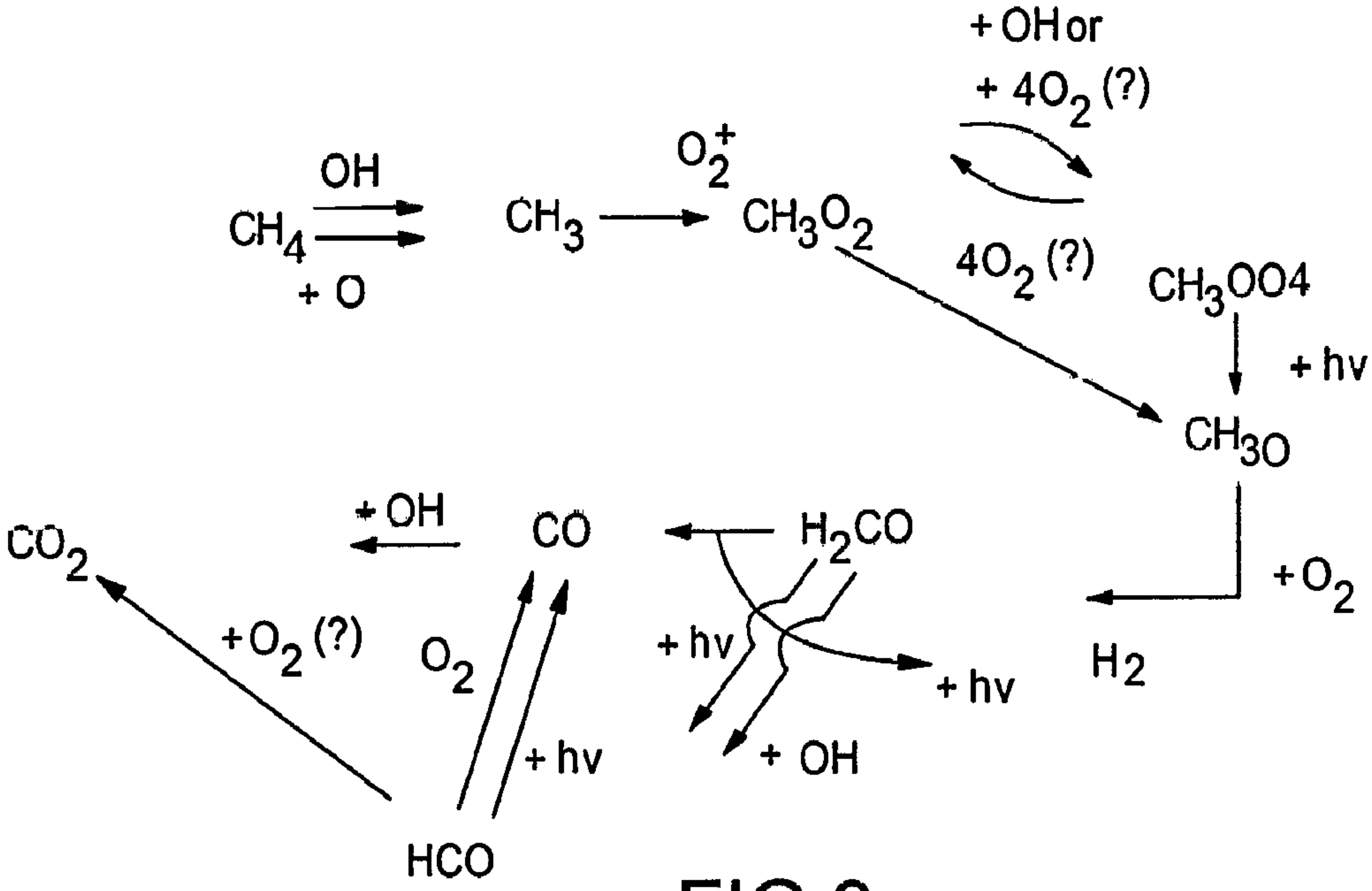

FIG.3

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_20 + \text{energy}$$

FIG.4

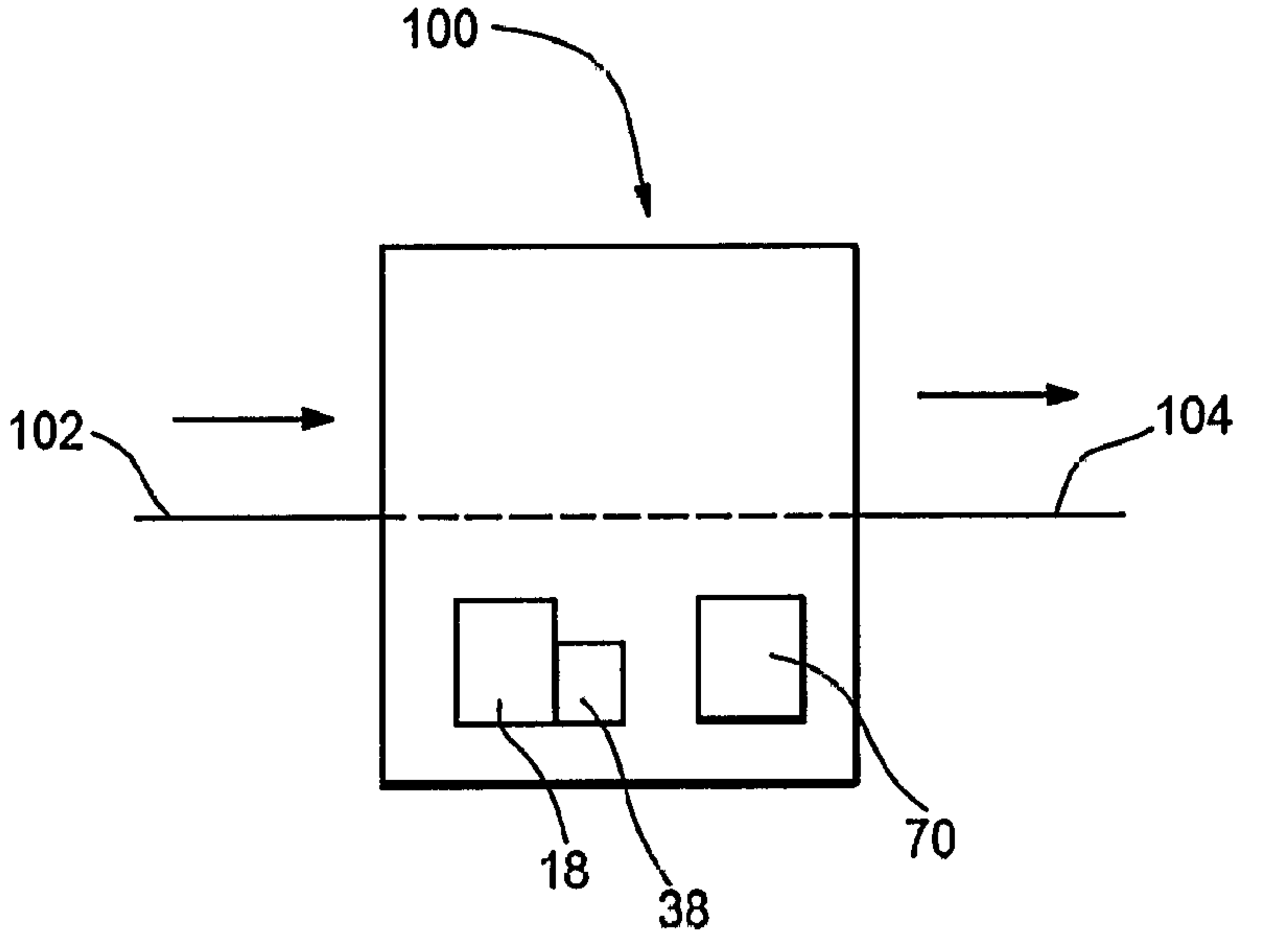

FIG.5

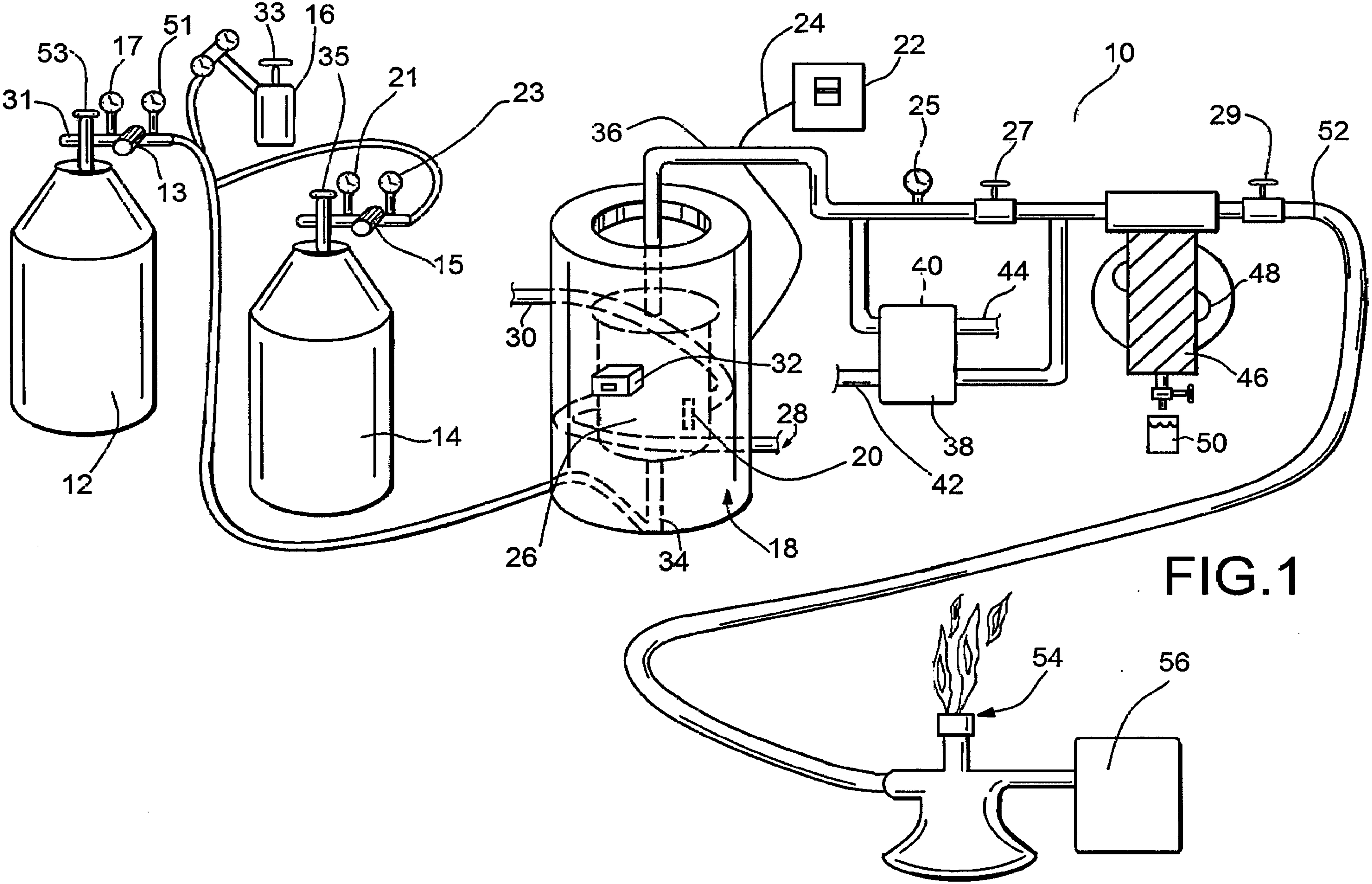

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FIG.1