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(72) Inventors:
• **Wu, Wei Cheng**
Taichung City (TW)
• **Ke, Zhao Quan**
Taichung City (TW)

(74) Representative: **Michalski Hüttermann & Partner**
Patentanwälte mbB
Kaistraße 16A
40221 Düsseldorf (DE)

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(71) Applicant: **Pro-Iroda Industries, Inc.**
Taichung City (TW)

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(54) **COMBUSTION SYSTEM AND METHOD OF OPERATION THEREOF**

(57) A combustion system using at least 90 wt% propylene glycol based liquid fuel includes a first fuel tank (10), a wick (11) inserted in the first tank, a sensing unit (12) configured to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank and send a fuel replenishment signal accordingly, a second fuel tank (20), a conduit system (30) connected with the first and the second fuel tanks (10, 20), and a drive unit (40) connected with the conduit system (30) and configured to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank to replenish the first fuel tank through the conduit system as well as to cool the wick.

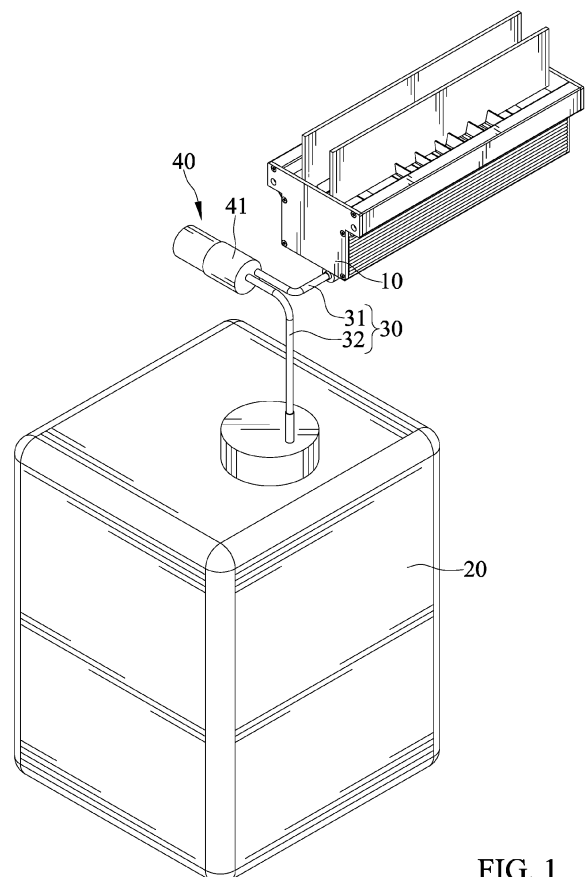


FIG. 1

Description

Background of the Invention

[0001] The present invention relates to a combustion system and method of operation thereof.

[0002] Current combustion systems, such as fireplaces, which can create warm and cozy atmosphere, mostly use an ethanol-based fuel, which is a highly flammable liquid, which may lead to an explosion risk or burn injuries during the procedure of filling fuel. The risk is especially high especially after the fireplace is completely extinguished or cooled sufficiently. Further, when a fireplace accidentally falls, ethanol-based fuels can cause the fire to spread rapidly. Likewise, isopropanol, which is also frequently used as a fuel, suffers similar disadvantages as ethanol-based fuels.

[0003] It has now been found that the above problems can be overcome by using propylene glycol based fuels. Propylene glycol based fuels contain at least 60 wt% propylene glycol and have a flash point of at least higher than 50°C, which can even be as high as 104°C depending on the compounding ratio. So propylene glycol based fuels are actually a non-inflammable flammable liquid fuel. "Non-inflammable" means that it won't catch fire when in contact with a flame (such as a match) at room temperature, and "flammable" means that it can burn under the right conditions. Further, burning propylene glycol based fuels will extinguish if poured onto a surface which is at a temperature the same as the ambient temperature, thereby preventing the fire from spreading.

[0004] Additionally, a wick is essential for supplying fuel to a flame and draws up the fuel by the capillary attraction. The wick may be made of, for example, glass fibers, ceramic fiber materials, silicate fiber materials or rock wool, or polymeric materials such as aramid fibers, cotton or porous materials such as pumice, or other wick materials known in the art. In contrast to wicks made of other materials, the metal wick does not produce carbonization and wear during combustion and so more suitable for burning propylene glycol based liquid fuels completely. However, metal wicks has a problem of getting overheated due to a good thermal conductivity of the metal, thereby affecting the flame size and transferring heat from the flame tip to the fuel.

[0005] Generally, when the flame is extinguished, the wick and the fuel are still hot, indicating that the fuel is evaporating to produce exhaust gas with toxic chemicals. While propylene glycol based fuel is a low smoke toxicity fuel, even the smallest amount of toxic chemicals can raise concerns regarding human health. Therefore, providing a combustion system that people can use without risk to their health and can be used in an environment with children and pregnant women is desirable.

[0006] The present invention is, therefore, intended to obviate or at least alleviate the problems encountered in the prior art.

Summary of the Invention

[0007] According to the present invention, a combustion system using at least 90 wt% propylene glycol based liquid fuel according to claim 1 includes a first fuel tank for containing the propylene glycol based liquid fuel, a wick for transmitting the propylene glycol based liquid fuel in the first tank, a sensing unit configured to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank and send a fuel replenishment signal accordingly, a second fuel tank for containing the propylene glycol based liquid fuel, a conduit system connecting the first fuel tank to the second fuel tank, and a drive unit connected with the conduit system and configured to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank to replenish the first fuel tank through the conduit system as well as to cool the wick.

[0008] Further, a method of operating the combustion system according to claim 9 includes preparing the combustion system; using the sensing unit to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank and send a fuel replenishment signal accordingly; and using the drive unit to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank to replenish the first fuel tank through the conduit system, and to cause the propylene glycol based liquid fuel from the second fuel tank to cool the wick.

Brief Description of the Drawings

[0009]

Fig. 1 is a perspective view of a combustion system in accordance with the present invention.

Fig. 2 is a partial, cross-sectional view of the combustion system of Fig. 1.

Fig. 3 is a flow chart illustrating the method of using the combustion system of the present invention.

Detailed Description of the Invention

[0010] FIG. 1 and FIG. 2 are perspective and partial, cross-sectional views of a combustion system in accordance with the present invention respectively. The combustion system of the present invention uses at least 90 wt% propylene glycol based liquid fuel. The combustion system includes a first fuel tank 10, a second fuel tank 20, and a drive unit 40.

[0011] The first fuel tank 10 is for containing the propylene glycol based liquid fuel and includes a wick 11 inserted therein for transmitting the propylene glycol based liquid fuel in the first tank 10. Preferably, the wick 11 is made of non wool material. Preferably, the wick 11 is made of metal. Preferably, the wick 11 is made of carbon fiber. The first fuel tank 10 also includes a sensing

unit 12 configured to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank 10 and send a fuel replenishment signal accordingly, i.e. when the liquid level is at a low predetermined level

[0012] The second fuel tank 20 is for containing the propylene glycol based liquid fuel. The second fuel tank 20 is connected to the first fuel tank 10 by a conduit system 30.

[0013] The drive unit 40 is connected with the conduit system 30 and configured to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank 20 to replenish the first fuel tank 10 through the conduit system 30 as well as to cool the wick 11.

[0014] Before the wick 11 is lit, the sensing unit 12 can sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank 10 in advance, and if the liquid level is low, it will send the fuel replenishment signal the driving unit 40. The signal causes the drive unit 40 to replenish the propylene glycol based liquid fuel in the second fuel tank 20 to flow into the first fuel tank 10 through the conduit system 30 until a high liquid level is achieved; on the contrary, a user can ignite the wick 11 if the liquid level is high. When the wick 11 is lit and starts to transmit the propylene glycol based liquid fuel in the first fuel tank 10 to a flame, once the sensing unit 12 senses that the propylene glycol based liquid fuel in the first fuel tank 10 is consumed to a low level, the fuel replenishing signal is sent to the drive unit 40, so that the drive unit 40 causes the propylene glycol based liquid fuel in the second fuel tank 20 to replenish the first fuel tank 10 through the conduit system 30, and the propylene glycol based liquid fuel from the second fuel tank 20 can not only supply fuel to and maintain the flame, but also cool the wick 11 heated by the flame so as to prevent the wick 11 from being overheated to affect the size and shape of the flame.

[0015] The above efficacy is based in particular on the high flash point characteristics of propylene glycol based fuels, utilizing the propylene glycol based liquid fuel from the second fuel tank 20 to cool the wick 11 that has been heated by the flame and stabilize the flame size and shape, generally Ethanol or isopropanol based fuels cannot be used in this way, because their flash point is extremely low, and they are ignited upon contact with the wick 11 heated by the flame, and cannot be used to cool the wick 11 at all.

[0016] In addition, the driving unit 40 is configured to receive a shutdown signal so as to pump the propylene glycol based liquid fuel in the first fuel tank 10 to the second fuel tank 20 by the conduit system 30. When the wick 11 is in the ignited state, once the driving unit 40 receives the shutdown signal, it starts to pump the propylene glycol based liquid fuel in the first fuel tank 10 to the second fuel tank 20 until the propylene glycol based liquid fuel is at a low level such that the wick 11 cannot generate a flame, or the propylene glycol based liquid fuel in the first

fuel tank 10 is completely pumped to the second fuel tank 20 to extinguish the flame of the wick 11. Further, when the wick 11 is in the ignited state, it will conduct the heat of the flame to the propylene glycol based liquid fuel in the first fuel tank 10. Thus, when the propylene glycol based liquid fuel is pumped to the second fuel tank 20 the wick 11 is also cooled, thereby better cooling the environment temperature. This is the characteristic of the high flash point of propylene glycol based fuel, and the propylene glycol based liquid fuel in the first fuel tank 10 is cooled by the propylene glycol based liquid fuel from the second fuel tank 20.

[0017] Further, when the driving unit 40 receives the shutdown signal and pumps the level of the propylene glycol based liquid fuel in the first fuel tank 10 to a height that cannot be transmitted by the wick 11 to generate a flame, or after the propylene glycol based liquid fuel in the first fuel tank 10 is completely pumped to the second fuel tank 20 (sensed by the sensing unit 12), it continues operating for a predetermined period of time so as to extract exhaust gas produced after the flame goes out through the conduit system 30.

[0018] In order to improve the cooling efficiency of the fuel, the volume of the first fuel tank 10 in this embodiment is smaller than the volume of the second fuel tank 20, and more preferably, the volume of the second fuel tank 20 is at least ten times larger than a volume of the first fuel tank 10.

[0019] Further, at least 90 wt% propylene glycol based liquid fuel used by the combustion system of the present invention can preferably contain 95 wt% propylene glycol.

[0020] Further, the conduit system 30 of the present invention can include a first conduit connecting the first fuel tank 10 to the drive unit 40 and a second conduit 32 connecting the second fuel tank 20 to the drive unit 40.

[0021] Further, the drive unit 40 includes a motor 41 which is adapted to transmit the propylene glycol based liquid fuel in the second fuel tank 20 to the first fuel tank 10 through the conduit system 30, or to transmit the propylene glycol based liquid fuel in the first fuel tank 10 to the second fuel tank 20 through the conduit system 30.

[0022] Fig. 3 shows a method flowchart of operating the combustion system using at least 90wt% propylene glycol based liquid fuel. The method includes preparing the combustion system, which has been described in detail above, and will not be repeated here for brevity; using the sensing unit 12 to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank 10 and send a fuel replenishment signal accordingly i.e. if the liquid level is not high enough for igniting wick 11; using the drive unit 40 to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank 20 to replenish the first fuel tank 10 through the conduit system 30, and to cause the propylene glycol based liquid fuel from the second fuel tank 20 to cool the wick 11, i.e. the propylene glycol based liquid fuel in the first fuel tank 10

reaches a height for igniting the wick 11 or maintaining the flame generated by the wick 11 in the ignited state, and it is worth noting that the wick 11 will heat up due to heat conduction in the ignited state, and the wick 11 can be cooled by supplementing the normal temperature propylene glycol-based liquid fuel from the second fuel tank 20 to achieve the cooling effect; and using the drive unit 40 to receive a shutdown signal and pump the propylene glycol based liquid fuel in the first fuel tank 10 to the second fuel tank 20 through the conduit system 30, and wherein the drive unit 40 continues operating for a predetermined period of time after receiving the shutdown signal and pumping the propylene glycol based liquid fuel in the first fuel tank 10 to the second fuel tank 20 so as to extract exhaust gas produced after the flame goes out.

[0023] The operating method of the combustion system further includes the steps that the driving unit 40 receives the shutdown signal, and accordingly, the propylene glycol based liquid fuel in the first fuel tank 10 is pumped to the second fuel tank 20 through the conduit system 30 until the propylene glycol based liquid fuel in the first fuel tank 10 is low and the wick 11 cannot generate a flame, or the propylene glycol based liquid fuel in the first fuel tank 10 is completely pumped to the second fuel tank 20, so that the flame of the wick 11 goes out.

[0024] After the driving unit 40 receives the shutdown signal and pumps the liquid level of the propylene glycol based liquid fuel in the first fuel tank 10 to a low level, or completely pumps the propylene glycol based liquid fuel in the first fuel tank 10 to the second fuel tank 20 (sensed by the sensing unit 12), it continues operating for a predetermined period of time to extract the exhaust gas generated by the extinguishment of the flame of the wick 11 through the conduit system 30.

Claims

1. A combustion system using at least 90 wt% propylene glycol based liquid fuel, the combustion system comprising:
a first fuel tank (10) for containing the propylene glycol based liquid fuel, a wick (11) for transmitting the propylene glycol based liquid fuel in the first tank, a sensing unit (12) configured to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank (10) and send a fuel replenishment signal accordingly, a second fuel tank (20) for containing the propylene glycol based liquid fuel, a conduit system (30) connecting the first fuel tank (10) to the second fuel tank (20), and a drive unit (40) connected with the conduit system (30) and configured to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank (20) to replenish the first fuel tank (10) through the conduit system (30) as well as to cool the wick (11).

2. The combustion system as claimed in claim 1, wherein the drive unit (40) is also configured to receive a shutdown signal so as to pump the propylene glycol based liquid fuel in the first fuel tank (10) into the second fuel tank (20).
3. The combustion system as claimed in claim 2, wherein the drive unit (40) is configured to continue pumping the propylene glycol based liquid fuel in the first fuel tank (10) into the second fuel tank (20) for a predetermined time after receiving the shutdown signal.
4. The combustion system of claim 1, wherein the volume of the first fuel tank (10) is smaller than the volume of the second fuel tank (20).
5. The combustion system as claimed in claim 4, wherein the volume of the second fuel tank (20) is at least ten times larger than a volume of the first fuel tank (10).
6. The combustion system as claimed in claim 1, wherein the propylene glycol based liquid fuel contains 95wt % of propylene glycol.
7. The combustion system as claimed in claim 1, wherein the conduit system (30) includes a first conduit (31) connecting the first fuel tank (10) to the drive unit (40) and a second conduit (32) connecting the second fuel tank (20) to the drive unit (40).
8. The combustion system of claim 1, wherein the drive unit (40) includes a motor (41).
9. The combustion system as claimed in claim 1, wherein the wick (11) is made of non wool material.
10. The combustion system as claimed in claim 1, wherein the wick (11) is made of metal.
11. The combustion system as claimed in claim 1, wherein the wick (11) is made of carbon fiber.
12. A method of operating a combustion system using at least 90wt% propylene glycol based liquid fuel, comprising:

preparing a combustion system which includes:

a first fuel tank (10) for containing the propylene glycol based liquid fuel with a wick (11) inserted therein for transmitting the propylene glycol based liquid fuel in the first fuel tank (10), and a sensing unit (12) disposed therein;
a second fuel tank (20) for containing the propylene glycol based liquid fuel;

a conduit system (30) connecting the first fuel tank (10) to the second fuel tank (20); and
a drive unit (40) connected with the conduit system (30)

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using the sensing unit (12) to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank (10) and send a fuel replenishment signal accordingly; and

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using the drive unit (40) to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank (20) to replenish the first fuel tank (10) through the conduit system (30), and to cause the propylene glycol based liquid fuel from the second fuel tank (20) to cool the wick (11).

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13. The method of operating the combustion system as claimed in claim 12 further comprising following steps: using the drive unit (40) to receive a shutdown signal and pump the propylene glycol based liquid fuel in the first fuel tank (10) to the second fuel tank (20) through the conduit system (30), and wherein the drive unit (40) continues operating for a predetermined period of time after receiving the shutdown signal and pumping the propylene glycol based liquid fuel in the first fuel tank (10) to the second fuel tank (20) so as to extract exhaust gas produced after the flame goes out.

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14. The combustion system as claimed in claim 9, wherein the wick (11) is made of metal.

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15. The combustion system as claimed in claim 9, wherein the wick (11) is made of carbon fiber.

Amended claims in accordance with Rule 137(2) EPC.

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1. A combustion system using at least 90 wt% propylene glycol based liquid fuel, the combustion system comprising:

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a first fuel tank (10) for containing the propylene glycol based liquid fuel, a wick (11) for transmitting the propylene glycol based liquid fuel in the first tank, a sensing unit (12) configured to receive an activating signal and sense the liquid level of the propylene glycol based liquid fuel in the first fuel tank (10) and send a fuel replenishment signal accordingly, a second fuel tank (20) for containing the propylene glycol based liquid fuel, a conduit system (30) connecting the first fuel tank (10) to the second fuel tank (20), and a drive unit (40) connected with the conduit sys-

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tem (30) and configured to receive the fuel replenishment signal so as to cause the propylene glycol based liquid fuel in the second fuel tank (20) to replenish the first fuel tank (10) through the conduit system (30) as well as to cool the wick (11), wherein

the drive unit (40) is also configured to receive a shutdown signal so as to pump the propylene glycol based liquid fuel in the first fuel tank (10) into the second fuel tank (20).

2. The combustion system as claimed in the previous claim 1, wherein the drive unit (40) is configured to continue pumping the propylene glycol based liquid fuel in the first fuel tank (10) into the second fuel tank (20) for a predetermined time after receiving the shutdown signal.

3. The combustion system of claim 1, wherein the volume of the first fuel tank (10) is smaller than the volume of the second fuel tank (20).

4. The combustion system as claimed in the previous claim 4, wherein the volume of the second fuel tank (20) is at least ten times larger than a volume of the first fuel tank (10).

5. The combustion system as claimed in claim 1, wherein the conduit system (30) includes a first conduit (31) connecting the first fuel tank (10) to the drive unit (40) and a second conduit (32) connecting the second fuel tank (20) to the drive unit (40).

6. The combustion system of claim 1, wherein the drive unit (40) includes a motor (41).

7. The combustion system as claimed in claim 1, wherein the wick (11) is made of non wool material.

8. The combustion system as claimed in claim 1, wherein the wick (11) is made of metal.

9. The combustion system as claimed in claim 1, wherein the wick (11) is made of carbon fiber.

10. A method of operating a combustion system using at least 90wt% propylene glycol based liquid fuel, comprising:

preparing a combustion system which includes:

a first fuel tank (10) for containing the propylene glycol based liquid fuel with a wick (11) inserted therein for transmitting the propylene glycol based liquid fuel in the first fuel tank (10), and a sensing unit (12) disposed therein;
a second fuel tank (20) for containing the

propylene glycol based liquid fuel;
a conduit system (30) connecting the first
fuel tank (10) to the second fuel tank (20);
and
a drive unit (40) connected with the conduit
system (30) 5
using the sensing unit (12) to receive an ac-
tivating signal and sense the liquid level of
the propylene glycol based liquid fuel in the
first fuel tank (10) and send a fuel replen- 10
ishment signal accordingly;

using the drive unit (40) to receive the fuel re-
plenishment signal so as to cause the propylene
glycol based liquid fuel in the second fuel tank 15
(20) to replenish the first fuel tank (10) through
the conduit system (30), and to cause the pro-
pylene glycol based liquid fuel from the second
fuel tank (20) to cool the wick (11); and
using the drive unit (40) to receive a shutdown 20
signal and pump the propylene glycol based liq-
uid fuel in the first fuel tank (10) to the second
fuel tank (20) through the conduit system (30),
and wherein the drive unit (40) continues oper- 25
ating for a predetermined period of time after
receiving the shutdown signal and pumping the
propylene glycol based liquid fuel in the first fuel
tank (10) to the second fuel tank (20) so as to
extract exhaust gas produced after the flame 30
goes out.

11. The combustion system as claimed in claim 7,
wherein the wick (11) is made of metal.

12. The combustion system as claimed in claim 7, 35
wherein the wick (11) is made of carbon fiber.

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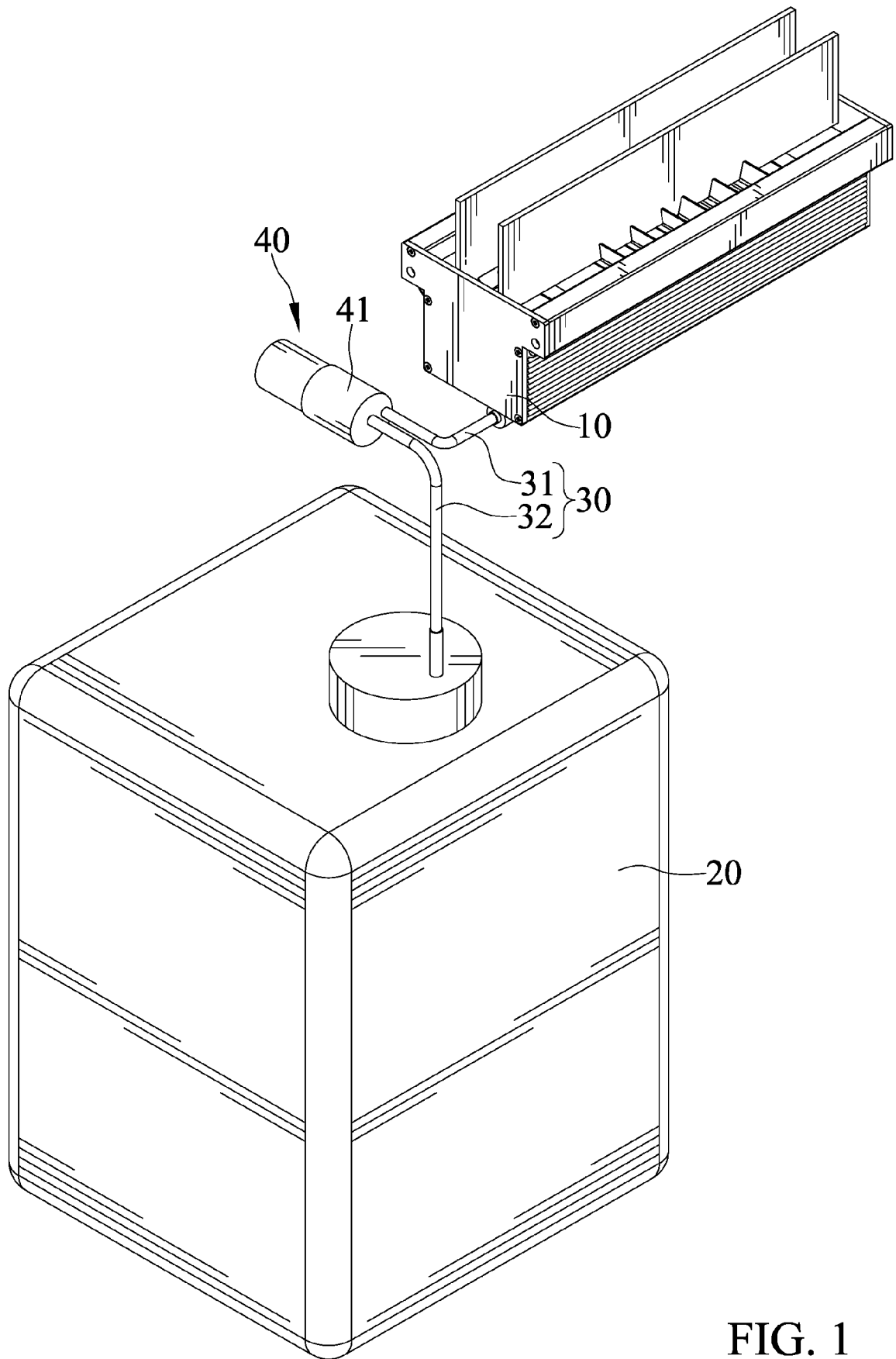


FIG. 1

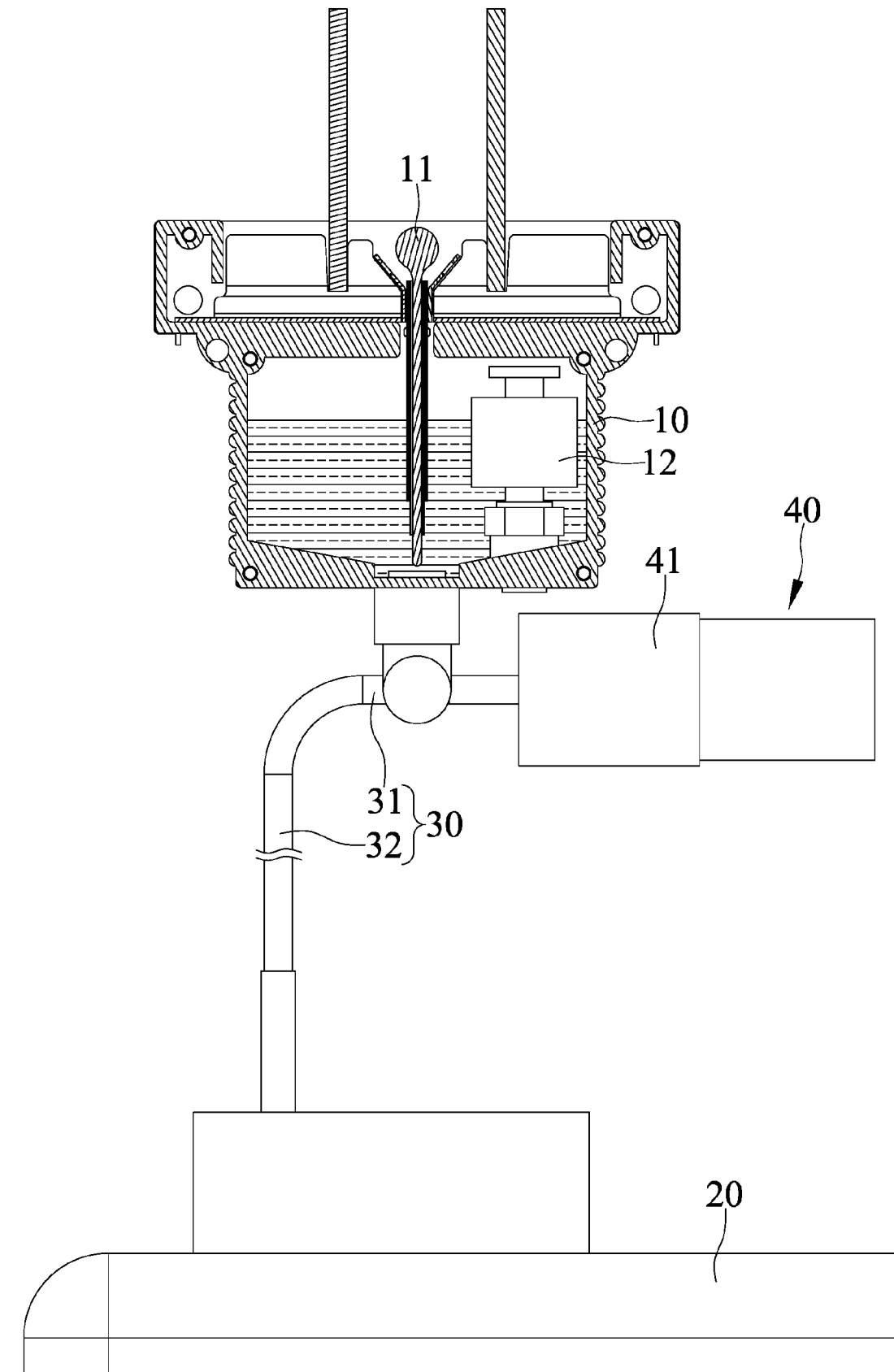


FIG. 2

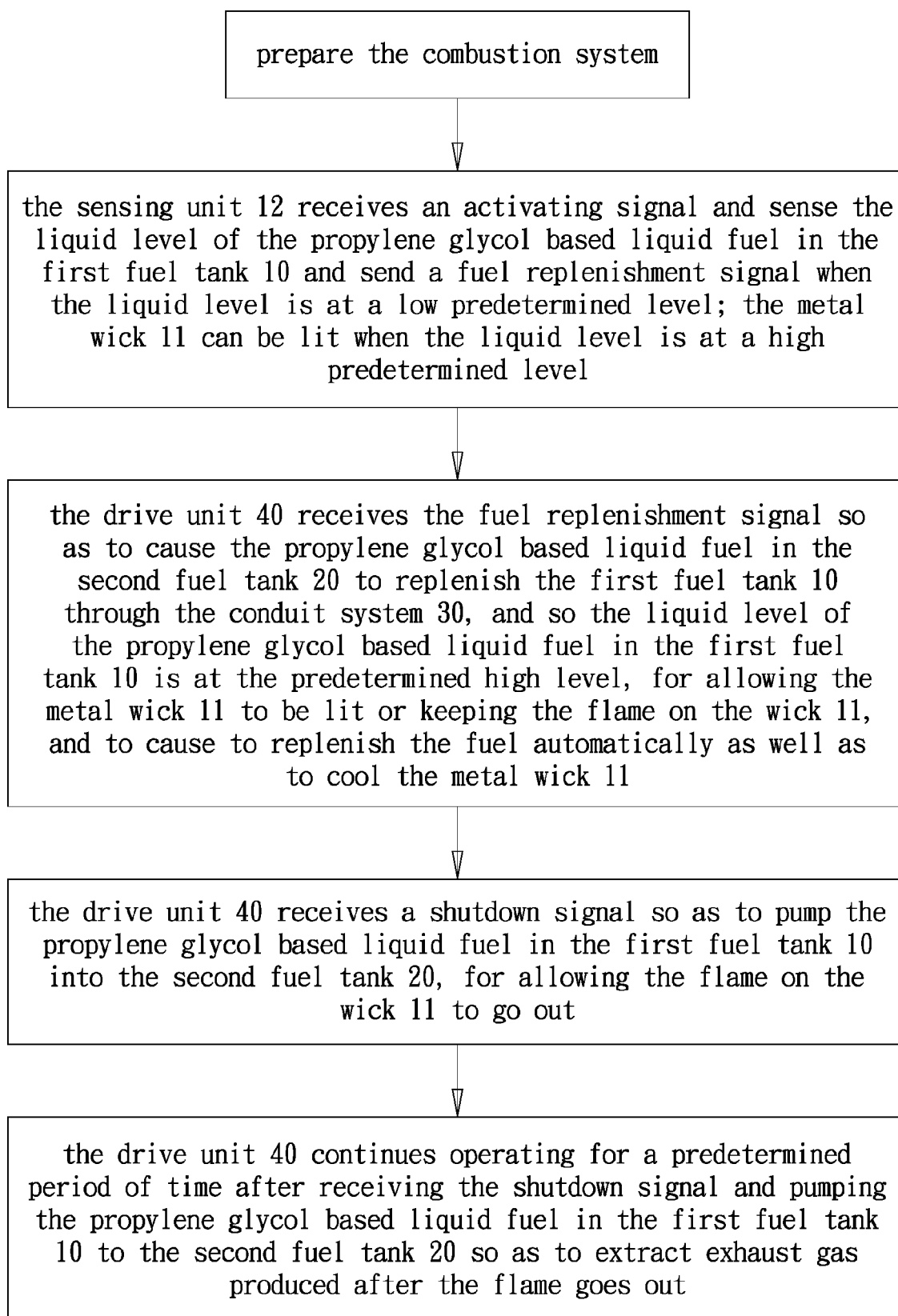


FIG. 3



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Application Number

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 November 2022	Examiner Rudolf, Andreas
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82