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(71) Applicant: **Corten Art Doo Sabac**
15000 Sabac (RS)

(72) Inventor: **Loli , Bojan**
15000 abac (RS)

(74) Representative: **Brkic, Zeljka**
Plavsa & Plavsa
Patentna kancelarija
Strumicka 51
11050 Beograd (RS)

(54) **BIOFIREPLACE WITH AUTOMATIC COMBUSTION CONTROL**

(57) Biofireplace with automatic combustion control consists of assemblies: tank (1) with peristaltic pump (2), preheater (3), evaporator (4), burner (8) and electronic equipment that allows management and control of the combustion process of bioethanol. The operation of the device is enabled and controlled by a microprocessor (15) connected to a peristaltic pump (2), an ultrasonic sensor (16) of the fuel level, electric heaters (5, 6), a sensor (31) for the presence of ethanol vapor, a sensor (32) for control of the horizontality of the device and the sensor (33) for the control of mechanical shocks or impacts. The device has a preheater (3) positioned below the burner (8) so that the copper capillary tube (22) that supplies fuel to the evaporator (4) uses the heat of the burner (8) to preheat the liquid bioethanol so that the need to engage electric heaters (5, 6) is reduced, i.e., it enables the operation of biofireplaces at ambient temperature. A perforated aluminum tube (26) is derived in the burner (8), which enables even distribution of vapor into the combustion chamber, which then, during the combustion with oxygen, creates a laminar diffusion flame along its entire length.

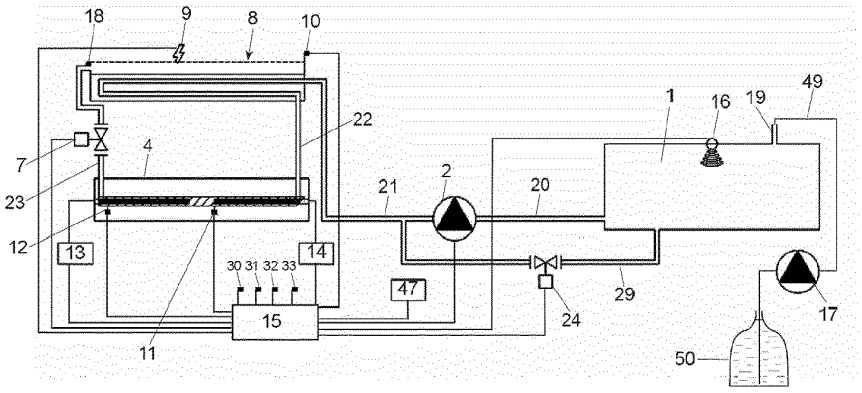

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The technical field to which the invention relates in general, belongs to the field of heating i.e., fireplaces, and specifically relates to a biofireplace which uses bioethanol as fuel.

[0002] According to the International Patent Classification (IPC, 2020.01) the subject of the invention is classified and marked with the basic classification symbol F24C 5/02 which defines ovens and stoves fired with liquid fuels with evaporating burners, as well as the secondary classification symbol F23D 5/04 relating to burners in which liquid fuel evaporates in a partially enclosed combustion chamber, with or without chemical transformation of the evaporated fuel, and F23N 5/00 defining combustion control systems.

TECHNICAL PROBLEM

[0003] The technical problem to be solved by the present invention consists in the following: how to solve design of a fireplace that uses 97-99 % bioethanol as fuel, in which a microprocessor with PWM width modulation is used for optimization to provide complete combustion of alcohol vapors, which enables preheating of vapor during operation before entering the burner with minimal engagement of electric heaters, which is safe in cases of impact or mechanical shocks, the presence of carbon monoxide and carbon dioxide, as well as in case of power failure of electronic components of the system, unforeseen absence of flame, and besides is distinguished with reduced flame temperature, and thus oxidation of atmospheric nitrogen (NO and NO2) and which is more economical in terms of saving electricity, and at the same time is easily adaptable in design to the forms and requirements for modern aesthetic interior design.

BACKGROUND OF THE INVENTION

[0004] Bioethanol fireplaces have much greater variability in shape and technical characteristics compared to other heating devices, because they are used for additional heating. The main purpose is decorative, so their design is often more important than its working properties. Some general characteristics are common to them, so we can classify them into several categories:

- Desktop "lamps", which are used as decorative accessories mainly in hotel rooms, restaurants, offices. They are usually used briefly, so people are only exposed to their emissions on certain occasions. The technology of the burner is extremely simple, and mainly consists of a simple metal vessel with one or more slots on the top, while the aesthetic characteristics of their design are adapted to the requirements of the users. The flame is mostly completely open or only partially protected by small glass walls. The reference power for this type of device is less than 2 kW, and their typical capacity is less than 1 liter.
- Fireplace-like appliances are similar in size, aspect and method of use to wood-burning fireplaces. Their appearance may resemble a classic fireplace or have a modern design, but they are always characterized by a kind of frame that surrounds the flame zone, with one or more burners. They often contain decorative elements to simulate wooden logs. The reference power for this type of device is about 4 kW, and their typical capacity is between 2 and 5 liters.
- Furnace-like appliances, usually sold and used as auxiliary heating devices, are often similar to pellet stoves and may have electronic controls for automatic on and off, power regulation or thermostats, and forced convection for more efficient hot air diffusion. The reference power for this type of device is about 5 kW, and their typical capacity is more than 3 liters with the possible presence of an auxiliary fuel tank.

[0005] Bioethanol used as a fuel is a chemical compound with well-known chemical and physical properties; whose names: ethanol, bioethanol or simply alcohol, refer to ethanol products. Most alcohol fireplaces are designed to burn liquid ethanol. The ethanol combustion process is a chemical reaction expressed as follows:

$$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_{2O}$$

[0006] This stoichiometric equation gives the theoretical amount of oxygen required for the complete oxidation of ethanol, which is three molecules of oxygen, with two molecules of carbon dioxide and three molecules of water. This is a theoretical relationship, while in practice, in order to achieve a good and complete combustion process, the device must be adapted to the specific environment or location. In addition, it is also important to keep in mind that the oxidizer most commonly used is not pure oxygen, but air composed of 21 % oxygen and about 79 % nitrogen. Nitrogen "dilutes" combustion products and reduces the combustion temperature, and in addition is responsible for the formation of nitrogen oxides, which are formed at high flame temperatures, even if the fuel does not contain nitrogen. In principle, manufacturers

expect complete combustion of fuels, that should "only" produce combustion products carbon dioxide and water. In fact, given the poor design of the burners, the typical absence of fans that promote forced ventilation or the imperfection of the device for checking the degree of mixing of air and fuel vapor in the core of the device, due to conditions of incomplete combustion, various pollutants can appear.

[0007] A review of the available patent documentation and other professional literature, as well as available technical and advertising literature of a large number of companies specializing in the production of biofireplaces, found the following:

The American application US 8622053 published on January 7, 2014, entitled "Burner and the way it works", shows a device that uses alcohol vapor as fuel, the volume flow of which is constant, so the flame height is constant depending on the previously set value. With this device, the amount of liquid phase in the evaporator directly depends on the amount of liquid phase in the tank, because they are connected by the principle of connected vessels. Therefore, the amount of vapor changes with the emptying of the tank, which affects the height of the flame (the flow of generated alcohol vapor is not constant). With this device, the amount of vapor generated depends exclusively on the volumetric flow through the pump, because all the supplied liquid phase to the evaporator is generated as vapor, where the volumetric flow is defined by the user and regulates the flame height.

[0008] In contrast to the previously described technical solution, the present invention contains a much more efficient technical solution for obtaining vapor from bioethanol, which means that the conversion from liquid bioethanol to the gaseous phase is performed under controlled conditions. In addition, in order to increase the degree of efficiency within the device, the preheater is designed so that in addition to increasing the temperature of bioethanol, it also has the function of cooling the burner itself, which ensures a lower temperature of the device itself.

[0009] The European patent application EP 2549182 published on 13 November 2013 under the title "Liquid fuel fireplace" shows a burner with two tanks which has a heater positioned outside the evaporator and heats the preheater vessel in which there is a larger amount of liquid phase. According to this solution, the connection of an additional external fuel tank during the operation of the device is envisaged, without affecting the functionality and height of the flame. The assembly of this device includes cooling fans located inside the thermal protectors. This solution is complex and requires a complicated construction of fireplace protection in case of unforeseen problems. By connecting an additional external tank, there is a problem with the functionality or flame height of the device. In addition to being much simpler and much smaller in size, the present invention also enables the connection of an external tank, provided that this does not affect the functionality and height of the flame, i.e., the laminarity of the vapor combustion.

[0010] In the European patent application EP 2028420 published on 25.01.2012 under the title "Automatic system of fuel supply of the furnace", a device is presented with a system of automatic filling of the furnace with liquid fuel used in household heating furnaces, especially fireplaces, which has a control unit with fuel quality sensors and sensors housed in the power supply system providing additional system security. The device is fed by an air pump, the efficient operation of which requires absolute tightness in the tank itself, which is a short-term and unsafe solution. In addition, the liquid phase of the fuel is brought to the burner itself where the transition from the liquid phase of the fuel to the alcohol vapor takes place. In that case, there is direct contact between the liquid phase and the flame, which is an unsafe solution. Extinguishing the flame is performed with a movable cover which is a physical obstacle to the supply of oxygen. After stopping the combustion process, alcohol vapor is retained in the device, which is also problematic from the aspect of safety.

[0011] According to the present solution, there is no safety breach of this type, since there is no direct contact between the liquid fuel and the flame, i.e., only alcohol vapor is brought into the burner.

[0012] In the useful model CN 211502903 U published on September 15, 2020. under the title "Module for the supply of fuel to the stove fired on alcohol and the device for its combustion", a device intended for use as a furnace in households is shown, where this solution structurally contains three pumps that ensure the delivery of liquid to the burner. The fact that the transition from the liquid phase to the alcohol vapor takes place in the burner itself represents the essential difference between this and the present invention. Namely, the fuel mixture is obtained by spraying the liquid phase inside the burner, which is a great disadvantage of this stove from the aspect of safety, and which has been overcome by the present invention.

[0013] In the Polish patent application PL 222427 V1 published on July 29, 2016 under the title "Liquid fuel biofireplace burner and its control system" shows a device having the shape of a profiled pipe and in the upper part contains a chamber open at the top, with only one closed chamber under the profiled pipe representing space for steam distribution and fuel evaporation. Like the present invention this furnace contains a fuel dosing pump, and in the upper part it has connectors for draining excess fuel in case of emergency. Under the burner in a closed chamber is located the control system connected to the information manipulator via Wi-Fi. This solution is unsafe because in case of power failure or problems in the system of the device, in the evaporation chamber for liquid and in the burner itself, the process of transition of liquid fuel into alcohol vapor continues until the moment of cooling the heater. This means that the alcohol vapor is retained in the device itself and is a flammable mixture which is problematic from a safety aspect. In addition, according to the present invention, in the case of an increase in the flow of the dosing pump, the heated fuel can be

returned to the storage tank, as a result of which thermal energy is dissipated and the fuel temperature in the tank itself increases. The design of the present biofireplace avoids such mistake, because in the event of a power failure, the system automatically closes with a solenoid valve, so the amount of alcohol vapor generated in the evaporator does not increase, and at the same time opens a valve that returns liquid and gaseous fuel to the tank.

[0014] The difference between these inventions is that according to the technical solution of the patent PL 222427 V1, the heater is located below the burner itself, whereby during the combustion of vapor, its temperature is constantly increasing and thus increased propagated to the device. The present invention provides that the heating of liquid fuel is performed in a capillary tube in a preheater which takes over the heat of the burner during operation, the temperature of which decreases as a result. This results in a reduction in the use of electricity necessary for the complete conversion of liquid bioethanol to the gaseous state in the evaporator.

[0015] The published patent application EP 3211304 A1 dated August 30, 2017 entitled "Bioethanol furnace" shows a simple solution of a furnace that uses bioethanol as fuel, which is fed directly into the burner in a liquid state. The mixture obtained in this way cannot have diffusion, laminar combustion, but the flame will be swirling with a tendency to turn into turbulent depending on the amount of oxygen supplied. In addition to this, the disadvantage of this furnace is the operation of the device at lower ambient temperatures, because the carburetor at low temperatures cannot provide the mixture for complete combustion. The problem occurs because the flame comes into contact with the liquid phase of the fuel, which endangers the safety of the user. In addition, the return pump returns the heated fuel to the tank, which increases the temperature of the device itself. With the design solution of the present device, all the mentioned shortcomings have been avoided.

[0016] Patent application WO 2013107455 A2 published on July 25, 2013 entitled "Electronically controlled burner" shows a device consisting of at least one fuel tank connected to an evaporation accelerator whose heating is achieved by a heater, a flame carrier and an ignition element. The device contains an electronically controlled burner. In the central part of the burner, a sprayer is placed providing bioethanol vapor delivery to the burner, on the upper plate of which there are openings for combustion. The disadvantage of this solution is that due to the use of a ball that regulates the operation of the sprayer, there are frequent delays. This is avoided by a simple evaporator solution with a perforated tube through the openings of which bioethanol vapor comes out evenly distributed in the burner.

BRIEF SUMMARY OF THE INVENTION

[0017] The present invention completely solves previously defined technical problem. The essence of the invention is reflected in the fact that in accordance with the invention the biofireplace is constructed consisting of assemblies: tank with peristaltic pump, preheater, evaporator, burner and electronic equipment that allows management and control of bioethanol combustion process, which uses a microprocessor to optimize alcohol combustion with PWM width modulation, which enables economical preheating of vapor leaving to the burner, and is safe in cases of mechanical shocks, the presence of carbon monoxide and carbon dioxide, as well as in case of power failure of electronic system components, unforeseen absence of flame, and in addition, it is characterized by reduced flame temperature and oxidation of atmospheric nitrogen (NO and NO_2), higher efficiency, i.e. saving of electricity, and at the same time it is easily adaptable to the forms and requirements for modern aesthetic interior design.

[0018] The essence of the invention is the construction of a preheater which raises the temperature of liquid bioethanol before entering the evaporator, as a result of which the use of electric heaters is reduced to a minimum, because the heat generated as a byproduct of bioethanol vapor combustion in the burner is used to heat bioethanol. This is achieved by positioning the preheater immediately below the burner, where a copper capillary tube is inserted into the groove in the preheater housing, which extends axially along the entire lower surface of the burner, effectively absorbing the burner heat, resulting in a decrease of atmospheric nitrogen oxidation NO and NO_2.

[0019] The novelty of the invention is the construction of the burner which provides the optimal ratio of fuel and air and their mixing, whereby provide maximum combustion efficiency with minimal occurrence of by-products that otherwise occur as a result of incomplete combustion. The burner is designed in such a way that the flame that is created in it is uniform along the entire length, and the combustion is laminar and diffusion and does not have to be controlled manually.

[0020] The essence of the invention is the installation of a microprocessor whose primary role is flame height control achieved by digital speed control of the stepper motor of a peristaltic dosing pump, where the microprocessor allows defining limit values of CO_2 and CO concentrations, at which the device automatically shuts off.

[0021] The novelty of the invention is reflected in the optimization of the evaporator by automatic correction of the heater switching on, which thus maintains a constant temperature necessary for the complete conversion of liquid bioethanol into vapor.

The device according to the present invention has multiple advantages, of which several are the most important, namely:

- the use of PWM pulse width modulation drastically reduces electricity consumption;
- the device during operation largely enables the conversion of liquid bioethanol into vapor without the use of heaters;

- by using a digital signal, the noise effect is minimized, which is a great advantage compared to analog control;
- it is completely safe, and in addition it is easy to maintain without the use of special tools and does not require special training of operators.

DESCRIPTION OF THE DRAWINGS

[0022] In order to facilitate the understanding of the invention, the inventor, only for example, refers to the attached outlines of the application and where:

- Figure 1, shows a schematic representation of the connection of the assemblies that make up the present fireplace;
- Figure 2, shows the axonometric appearance of the preheater with the capillary tube protective plate open in a bottom view;
- Figure 3, shows axonometric appearance of the preheater bottom plate;
- Figure 4, shows the axonometric appearance of the evaporator without the lid with capillary tube in a side view;
- Figure 5, shows the axonometric appearance of the evaporator without the lid and without capillary tube in side view;
- Figure 6, shows the axonometric appearance of the evaporator lid in a side view;
- Figure 7, shows the assembly appearance of the evaporator in axonometry in a side view;
- Figure 8, shows an axonometric view of the burner from above;
- Figure 9, shows the appearance of the burner in side view;
- Figure 10, shows the appearance of the burner from above;
- Figure 11, shows the appearance of the burner in cross section A-A.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The present invention relates to a biofireplace with automatic combustion control and as can be seen from the figures of the attached drawing it consists of assemblies: tank 1 with peristaltic pump 2, preheater 3, evaporator 4, burner 8 and electronic equipment that allows management and control over bioethanol combustion process.

[0024] The tank 1 is of a hollow square shape, made of stainless steel - Inox, with an opening 19 on the upper side to which is connected the hose 49 for refueling from the bottle 50 by means of a peristaltic pump 17. The tank 1 is connected by means of a pipe 20 to the suction part of the peristaltic pump 2 whose delivery part is connected to the preheater 3 through the pipe 21. In the tank 1 there is an ultrasonic sensor 16 of the fuel level which at any time monitors the information on the amount of fuel and forwards it to the microprocessor 15. Bioethanol used for the present biofireplace is of the concentration 97-99 %.

[0025] The present invention envisages the use of a microprocessor 15 that works with digital signals, so that the control of the combustion process is fully automated and digitized. The basic function of the microprocessor 15 is to monitor changes in the control parameters of the combustion process in real time and control the actuating peripherals (such as a peristaltic pump and preheater), in order to maintain constant operation without changing the required flame height. In this way, a flame uniform over the entire length of the burner 8 was obtained, with complete, laminar and diffusion combustion. The microprocessor 15 also enables the definition of limit values for temperature, CO_2 or CO concentrations, at which the device switches off automatically. Today, there are a large number of different types of microprocessors on the market and they are constantly being improved. Since the operation of the microprocessor 15 is well known in the state of art, for the purpose of easier understanding of the invention and for better clarity, only a mode of its operation is given in the detailed description.

[0026] The preheater 3, as seen in Figures 2 and 3, which serves to raise the temperature of the liquid bioethanol before entering the evaporator 4 according to the invention, is positioned below the burner 8 and consists of a thermally insulated aluminum housing closed on the upper side by an aluminum plate 25 with a circular opening 46 and a groove 37 into which a copper capillary tube 22 is inserted. In order to prevent heat loss and unnecessary heating of the device itself, the preheater housing 3 is closed by an aluminum plate 34 on which an opening 45 is made in accordance with the opening 46. An inlet 48 is passed through these openings through which bioethanol vapor enters the burner 8. By this position of the preheater 3 the use of electricity required for the operation of the evaporator 4 is reduced, because in optimal conditions the thermal energy of the burner 8, located above the preheater 3, is sufficient to convert liquid bioethanol into vapor without the use of heaters 5, 6. After establishing the operating temperature burner 8, in the preheater 3, the heating of the copper capillary tube 22 is performed only by the heat generated by the operation of the burner 8.

[0027] It should be noted that in this way, the heat of the burner 8 is taken over while reducing the flame temperature, i.e., reducing the harmful by-products of combustion, which is proportional to the oxidation of atmospheric nitrogen NO and NO_2.

[0028] The power control of heaters 5, 6 is made by PWM (Pulse Width Modulation). Digital control of analog circuits

drastically reduces the cost of the control system and achieves significant energy savings. Today's microcontrollers generally have built-in PWM peripherals which further facilitates implementation. The main advantage of using PWM is that the signal remains digital all the way from the processor to the receiver, so DA conversion is not required. By using a purely digital signal, the noise effect is minimized, which is a great advantage over analog transmission and PWM control of the dosing pump motor. Microprocessors and PWM modulators are well known in the state of art and their operation has not been explained in particular detail.

[0029] The burner assembly 8, as seen in Figures 8, 9, 10 and 11, forms an aluminum housing 28 which is open on the upper side and via on the lower side via the upper plate 25 connected to the preheater 3 by rigid connection. In the housing 28, the perforated aluminum tube 26 is inserted of the square cross section. The perforation of the pipe 26 is made by circular openings 27, the diameter and arrangement of which are calculated in such a way as to allow even distribution of vapor and creation of a laminar diffusion flame along the entire length of the burner 8. The housing 28 is a chamber in which alcohol vapors are mixed with oxygen from the air, and complete combustion is achieved by dosing fuel with a peristaltic pump 2 in a value defined by the maximum allowed flow rate controlled by the microprocessor 15. In the center of the longer side of the housing 28 of the burner, an opening is made in which the ignitor 9 of the spark is inserted perpendicularly. A temperature sensor 18 is installed at the inlet of the aluminum tube 26 of the burner, which informs the microprocessor 15 that the appropriate temperature of the alcohol vapor has been reached, i.e., that the alcohol vapor has entered the burner 8 and that the initial ignition can be performed, thus starting the combustion process.

[0030] The fuel from the preheater 3 through the capillary tube 22 goes to the evaporator assembly 4 which is formed of a metal housing 35 in the form of a hollow square in the centers of the shorter sides of which, threaded flanges 44 are made in which are disassembly axially fixed mutually separated heaters 5, 6, whereby the heater 5 is located at the inlet of the evaporator 4, while the heater 6 is located at the outlet of the evaporator 4. Over the heater 5, 6 along the entire length spirally wound capillary tube 23 in which the liquid fuel is converted into vapor which through the solenoid valve 7 goes into a perforated aluminum tube 26 located in the combustion chamber of the burner 8. The solenoid valve 7 is normally open and its function is to immediately close the vapor supply to the burner 8 in case of irregularities in the operation of the system and to deliver information on incorrect and unsafe operation to the microprocessor 15. From Figure 4 and 5, it can be seen that there are temperature sensors 11, 12 in the evaporator housing 35, wherein the sensor 11 measures the fuel temperature in the part of the capillary tube 23 around the heater 5, while the sensor 12 measures the fuel temperature in the part of the capillary tube 23 around the heater 6 at the evaporator outlet 4. The optimal temperature for biofireplace operation is achieved by PID control whose function is to heat bioethanol near heaters 5, 6 near the point of transition to ethanol vapor, in cases when this is not achieved by preheater 3, which is the case when starting the device or during the first few minutes when the heat energy of the burner 8 was not transferred to the preheater 3. Temperature sensors 11, 12 after measuring the temperature of bioethanol, deliver the read data to the microprocessor 15 which by PWM control 14 controls the power of the heater 5, 6 to obtain a temperature of about 70 ° C at which the liquid bioethanol is completely converted to vapor. Thus, optimally preheated bioethanol vapor through the insulated capillary tube 23 reaches the inlet 48 passed through the openings 45, 46. In order to prevent heat loss and possible unnecessary heating of the entire device, the sides of the housing 35 are on both sides insulated with a layer 36 of mineral wool. The lid 38 of the evaporator, Figures 7 and 8, is made of the same material as the housing 35 has a "P" profile and dimensions equal to the upper open surface of the housing 35. At both ends of the housing 35 are vertical tubular outlets 39, 40 through which the ends of the pipes 22, 23 are passed. In order to prevent heat loss, the outlets 39, 40 are filled with stone wool 43, and the capillary tube 23 is insulated with liquid ceramics. On the upper edges of the longer sides of the housing 35, four washers 41 are positioned by means of which the lid 38 is fixed by screws through the openings 42.

[0031] The principle of operation of the present device, shown schematically in Figure 1, takes place as follows: when starting the device, the microprocessor 15 gives a command to the peristaltic pump 2 to fill the evaporator 4 with liquid bioethanol. At the same time, heaters 5, 6 convert liquid bioethanol into vapor. When the temperature sensors 11, 12 deliver information to the microprocessor 15 that the temperature at which the bioethanol vapor has been produced is reached, the high voltage spark of the igniter 9 perform initial ignition, thus starting the combustion process. A flame detection sensor 10 is installed in the burner 8, which controls the ignition success, i.e., whether it is necessary to restart the ignitor 9, which is defined by the microprocessor 15. The described process includes how to start the device. Once started, the combustion of bioethanol in the burner 8 continues with the operating mode which takes place by transporting fuel from the tank 1 by means of a peristaltic pump 2 attached on the pipe 20 to the preheater 3 which uses the thermal energy generated by burning bioethanol vapor in the burner 8 so that liquid fuel enters the evaporator 4 preheated. The thermal energy obtained by operation of the burner 8 spreads to the evaporator 4 and is sufficient to convert the liquid bioethanol into vapor without switching on the heaters 5, 6. At the beginning of operation of the device the fuel temperature is equal to ambient temperature, so at lower starting temperatures device requires operation of the heaters 5, 6. By switching to continuous operation mode of the device, heaters 5, 6 are switched off and preheating of fuel, i.e. transformation from liquid to gaseous state is done by using the heat generated by heating the space around the burner 8. The process of stabilizing the system is regulated by microprocessor 15 by the PID regulation (with minimum deviation from

the initial set temperature equilibrium parameters), whereby a smooth process of evaporation of liquid fuel is achieved. During the operation of the device, the temperature sensors 11, 12 deliver information to the microprocessor 15, which controls the operation of the heaters 5, 6 in order to achieve the optimal operating temperature of bioethanol vapor of about 70 ° C. The bioethanol vapor thus obtained from the evaporator 4, through the insulated capillary tube 23, reaches the inlet 48, passed through the openings 45, 46 and welded to the aluminum tube 26 of the burner, and then passes through the openings 27 and after ignition burns in the burner housing 8. Circular openings 27 are calculated to ensure even distribution of vapor along the entire burner 8, resulting in even flame along the complete length. The combustion chamber in the housing 28 allows optimal mixing of alcohol vapors with oxygen from the air resulting in laminar diffusion combustion. Regular shutdown of the system is performed by the microprocessor control 15 so that the normally open solenoid valve 7 loses voltage and closes the flow of fuel into the capillary tube 23, as a result of which combustion in the burner 8 stops almost instantly, burning all remaining vapor in the aluminum tube 26. Simultaneously, normally closed solenoid valve 24 installed on the pipe 29, loses voltage and opens the return line after which the remaining vapor in the system is returned to the tank 1, where it is cooled and converted into a liquid state. In this way, the retention of alcohol vapor in the system as well as the creation of overpressure are avoided.

[0032] Forced shutdown of a biofireplace due to a power outage is manifested by the loss of power to all electronic devices in the fireplace. Thus, the normally open solenoid valve 7 loses voltage, closes by interrupting the flow of alcohol vapor into the burner 8, and the combustion process is interrupted. The process of forced shutdown, in the physical sense, is almost the same process as with regular shutdown of the system.

[0033] The forced shutdown of the biofireplace due to malfunctions is controlled by a microprocessor 15, whose operation is based on monitoring parameters such as the presence of carbon monoxide using a sensor 30 that detects the presence of the same, then the presence of ethanol vapor inside the device using the sensor 31, horizontality of the device by means of sensors 32 and mechanical shocks or impacts by means of sensors 33 (tilt sensor). A problem in operation can occur for an unknown reason (the flame has been extinguished), which is registered by the flame presence sensor 10 which sends a signal via the microprocessor 15 to the ignitor 9 to restart the initial ignition process. The process of initial ignition is limited in time and after a certain time, if a continuous combustion process is not established, the microprocessor 15 performs forced shutdown of the system. Monitoring of the device operation is enabled by the display 47.

METHOD OF INDUSTRIAL OR OTHER APPLICATION OF THE INVENTION

[0034] Industrial production of the present invention is absolutely possible in factories for the production of stoves, ovens and fireplaces, and even in well-equipped mechanical workshops.

[0035] The invention is suitable for serial production and its application is especially recommended in cases when additional heating is required in the living, working and rest areas. The application of the invention is especially recommended in buildings and spaces that need to meet high aesthetic criteria.

[0036] Due to the ecological characteristics, the device can be used to equip a space where people of all ages live.

Claims

1. Biofireplace with automatic combustion control comprising a tank (1) with a peristaltic pump (2), an evaporator (4), a burner (8) and electronic control and operation equipment, **characterized in that** the tank (1) with an ultrasonic sensor (16) for the fuel level made of stainless steel - Inox with an opening (19) to which is connected a hose (49) for refueling from the cylinder (50) by means of a peristaltic pump (17), connected by a pipe (20) to the suction part of the peristaltic pump (2) whose delivery part is connected via a tube (21) to a preheater (3) whose outlet part is a tube (22) connected to a spiral copper capillary tube (23) of an evaporator (4) whose outlet is connected to a perforated tube (26) of the burner (8).

2. Biofireplace with automatic combustion control, according to claim 1, **characterized in that** the preheater (3) consists of a thermally insulated aluminum housing positioned below the burner (8), the upper side of which is closed by an aluminum plate (25) on which a circular opening is made. (46) and a groove (37) in which a copper capillary tube (22) is inserted on the underside protected by an aluminum plate (34) on which an opening (45) is made in accordance with the opening (46) through which the inlet (48) is passed.

3. Biofireplace with automatic combustion control, according to claim 1, **characterized in that** the evaporator (4) consisting of a metal housing (35) in the shape of a hollow square in which the threaded flanges (44) are made in the centers of the shorter sides disassemble fixed axially, oppositely placed rod heaters (5, 6), where the heater (5) is located at the inlet of the evaporator (4), while the heater (6) is located at the outlet of the evaporator (4), and by

the fact that around the heaters (5, 6) along the entire length the spiral capillary tube (23) is wound and by that in the housing (35) of the evaporator temperature sensors (11, 12) are derived, and **in that** all the lateral sides of the evaporator housing (35) of the evaporator, on the inside and outside, are insulated with a layer (36) of mineral wool, and **in that** the evaporator lid (38) is made of the same material as the housing (35) which in cross section has the appearance of a "P" profile and is equal in dimensions to the upper open surface of the evaporator housing (35), whereby on the top side of it vertical tubular outlets (39, 40) are derived filled with stone wool (43), through which the ends of the capillary tube (23) are passed insulated with liquid ceramic, and **in that** on the upper edges along the side walls of the housing (35), four washers (41) are positioned by means of which the lid (38) is fixed by screws through the openings (42).

4. Biofireplace with automatic combustion control, according to claim 1, **characterized in that** the burner (8) forms an aluminum housing (28), open with its entire lower surface and by means of an upper plate (25) firmly connected to the preheater (3), wherein in the housing (28) of the burner (8) is axially inserted aluminum tube (26), perforated by a circular openings (27), of square cross-section, on the lower side of which the inlet (48) is fixed by welding, and by that an opening is made in the center of the longer side (28) of the burner (8) into which an ignitor (9) is inserted laterally, while a temperature sensor (18) is installed at the entrance of the aluminum tube (26).

5. The mode of operation of the biofireplace with automatic combustion control, according to claim 1, **characterized in that** the operation and control of the biofireplace based on data from sensors (10, 16, 30, 31, 32, 33) is controlled by a microprocessor (15) connected to the peristaltic pump (2), solenoid valves (7, 24) and heaters (5, 6), where the control is performed by PWM (Pulse Width Modulation).

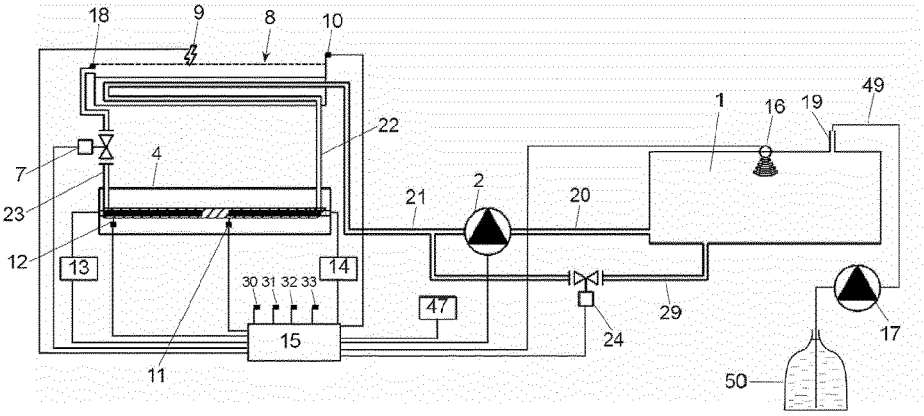

Fig. 1

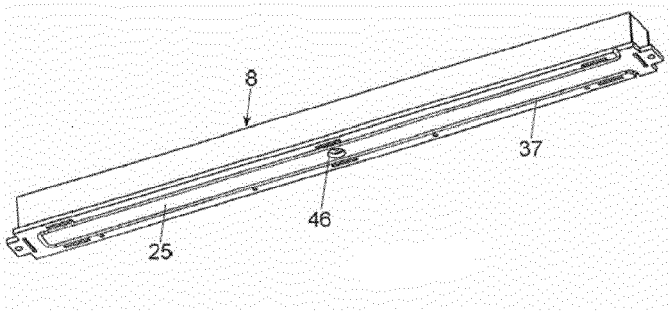

Fig. 2

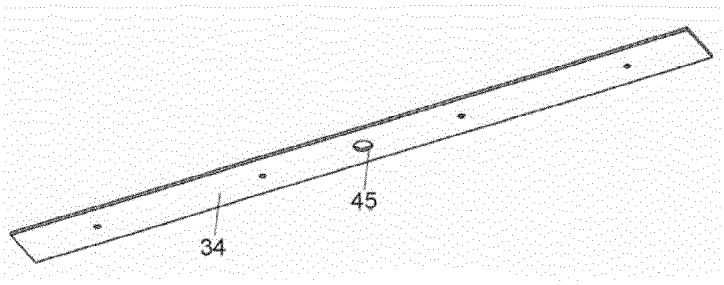

Fig. 3

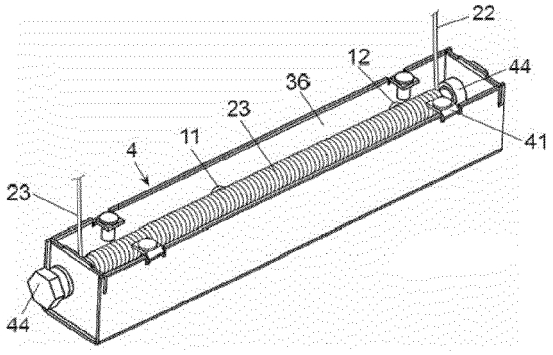

Fig. 4

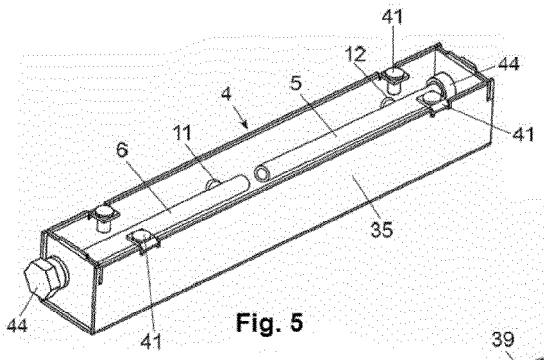

Fig. 5

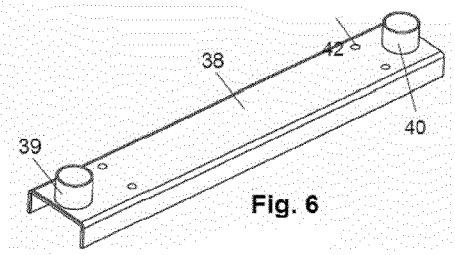

Fig. 6

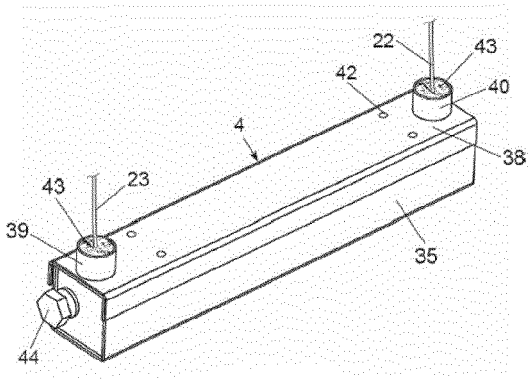

Fig. 7

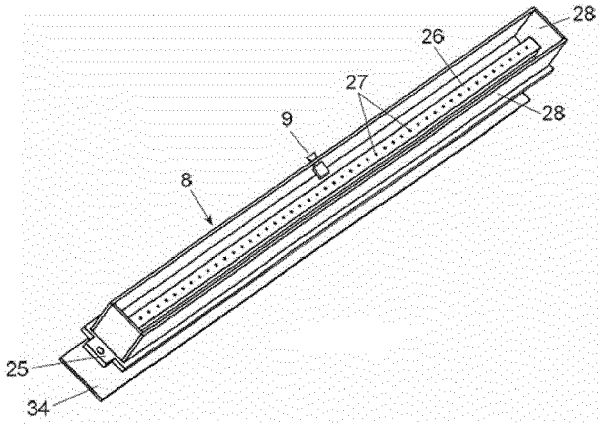

Fig. 8

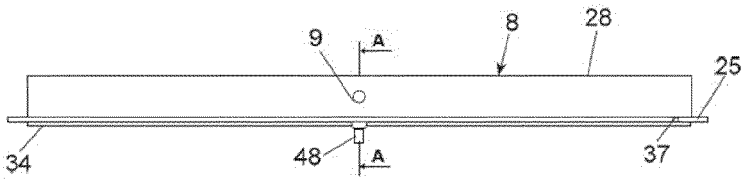

Fig. 9

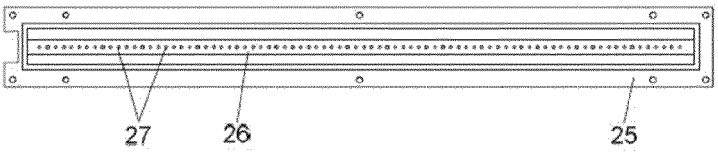

Fig. 10

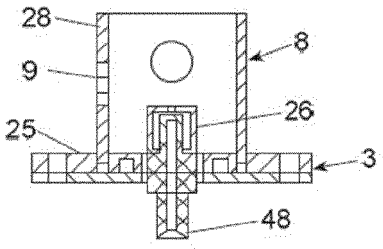

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 21 16 9576

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	WO 2013/107455 A2 (DECOFLAME APS [DK]) 25 July 2013 (2013-07-25) * page 15, line 15 - page 23, line 25 * * figures 1-3 *	1-5	INV. F23D5/18 F23K5/04 F23K5/22 F23N1/00
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A	WO 2009/098167 A1 (BRISACH [FR]; ROUSSEAU THIERRY [FR]) 13 August 2009 (2009-08-13) * page 6, line 1 - page 16, line 33 * * figures 1-7 *	1-5	
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F23D
F23C
F23K
F23N
F24C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 October 2021	Rudolf, Andreas

CATEGORY OF CITED DOCUMENTS

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

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