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(54) **COMBUSTION DEVICE WITH A SYSTEM OF PULSE HOT CYCLONES OF VACUUM TYPE WITH CONTROLLED ACCESS OF OXYGEN AND FUNCTION OF HEAT GENERATION**

(57) The claimed invention relates to devices for fuel combustion and/or disposal of waste, mainly of household type, constructed according to the principle of gas-producing combustion, in which fuel is supplied to or through the combustion zone by gravity, for example from a fuel container located above the combustion zone.

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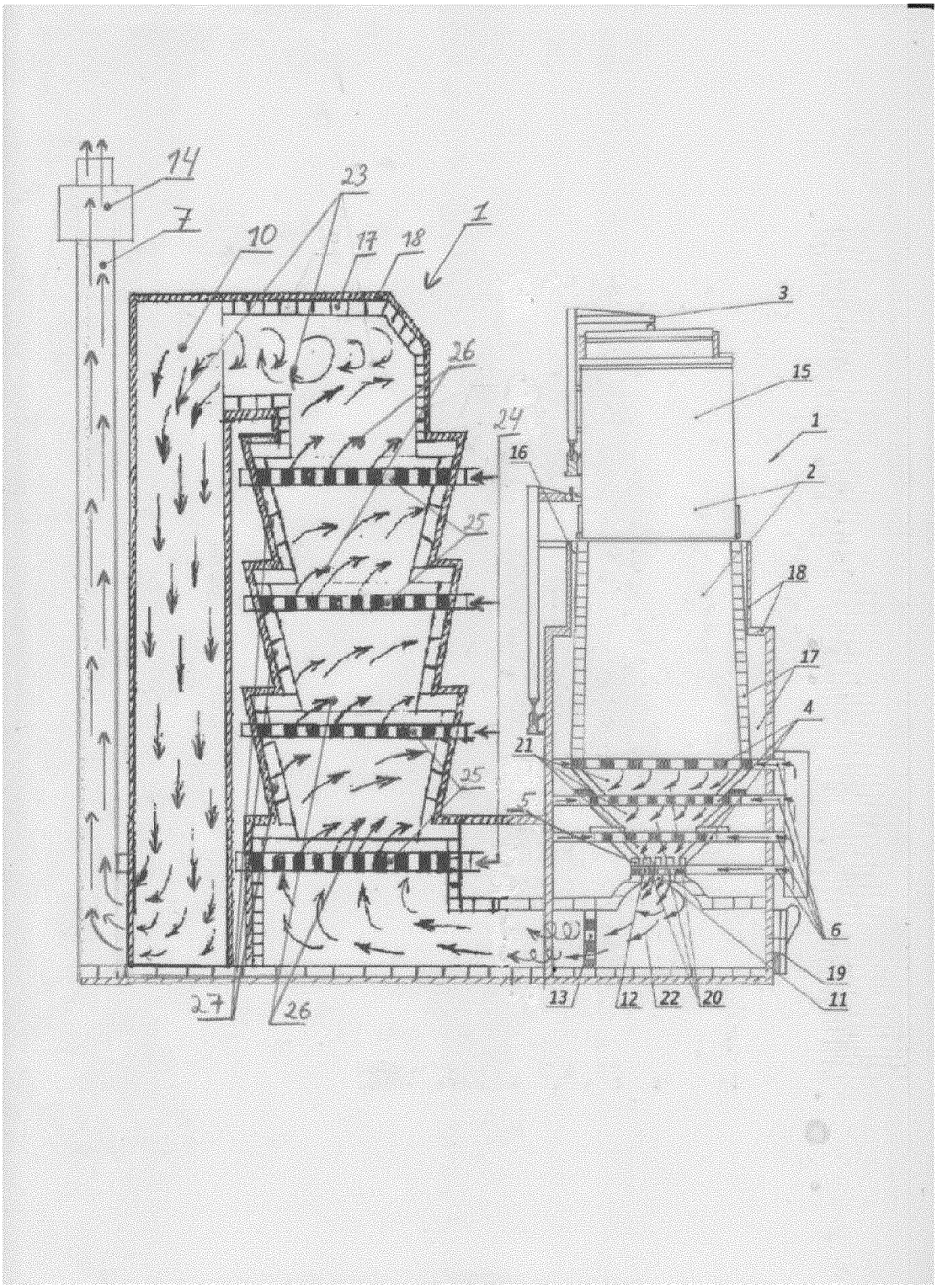
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Fig. 1

Description

Field of the Invention

[0001] The present invention relates to devices for fuel combustion and/or disposal of waste, mainly of household type (hereinafter referred to as the device), constructed according to the principle of gas-producing combustion, in which fuel is supplied to or through the combustion zone due to gravity, for example from a fuel container, which is located above the combustion zone (lower combustion process).

[0002] More specifically, the invention provides "a combustion device with a system of pulse hot cyclones of vacuum type with controlled access of oxygen and function of heat generation".

Background and Summary of the Invention

[0003] The combustion device with an additional system of pulse hot cyclones of vacuum type with controlled access of oxygen and function of heat generation comprises at least a partially thermally insulated housing, a fuel container with an upper means of supplying fuel, located in the housing below the fuel container, a combustion chamber, a grate, at least one means of supplying air to the interior space of the combustion chamber and at least one means for removing gaseous combustion products. The combustion chamber is made multi-staged and located above the grate, and is also equipped with a swirler of gas flows.

[0004] The device is additionally equipped with a system of pulse hot cyclones of vacuum type, which constantly change the pulses of vacuum force of cyclone-vortex flows, providing successive additional grinding and controlled postoxidation of any carbon and other residues. The successive repetition of the pulses of hot cyclones of vacuum type provides multiple additional afterburning, which significantly improves the quality of gases outgoing into the atmosphere and greatly improves the environment during disposal and processing. The process is carried out at a temperature of 1000-1700°C. The required stable temperature and purity of the gases supplied to a heat exchanger are provided by the pulse hot cyclones of vacuum type.

[0005] The device is equipped with the heat exchanger and at least one chamber of afterburning and postoxidation, located below the grate in front of the heat exchanger. The combustion chamber and the chamber of afterburning and postoxidation are vacuum-type, with an additional system of pulse hot cyclones of vacuum type with additional grinding and controlled postoxidation.

[0006] Waste from the woodworking industry, municipal enterprises, agricultural enterprises, etc. can be used as fuel.

[0007] As used herein, by fuel is meant the fuel specially intended for combustion, for example, wood pellets, sawdust, coal, etc., as well as waste of various types: of agricultural industry (corn, wood chips, seed husks, etc.), of animal industry (offals, animal parts, etc.), of chemical industry (rubber, plastic, etc.), rags, other solid household waste, in particular, such as refuse-derived fuel known as RDF (Refuse Derived Fuel), etc.

[0008] As used herein, by heat generation is meant obtaining heat from other types of energy, in particular in the process of combusting various types of fuel.

[0009] The inventors provided their own invention, ***patent of*** Ukraine UA118238C2, published on December 10, 2018, with an additional device equipped with a system of pulse hot cyclones of vacuum type.

[0010] A basic object of the invention is to provide, due to the structural features, vacuum-type cyclone-vortex flows to ensure uniform high-quality afterburning, breaking compacted fuel clusters and coal of different density and chemical composition, the absence of air pockets in the fuel, the avoidance of cooling the device part and partial removal of the latter from the required power and required temperature regime. The invention provides the construction comprising the set of truncated cones, with smaller bases directed downward, multi-stage nozzles located at an acute angle relative to the center of the cone being built in between the cones, which ensures the formation of continuous vacuum-type multi-stage cyclone-vortex flows that cannot be stopped. These flows create the effect of a vacuum-type turbine. When dense, wet and heavy fuel is loaded into the combustion device, the weight is distributed evenly on each of the cones, due to the large number of cones, which prevents the formation of compacted clusters and the burning of hollow pockets. This ensures uniform combustion and stable maintenance of the required power of the device and full control over the temperature. There is no grate in the form of a truncated cone with a smaller base directed upwards, instead of which a straight grate made of refractory material is installed, which is located under the set of truncated cones, with smaller bases directed downwards, which forms vacuum-type multi-stage cyclone-vortex flows due to the set of nozzles. It also ensures unhindered ash spillage and makes it impossible for the device to be melted and removed from the required power, and many times extends the time of uninterrupted operation of the device. Also, the device can be cleaned and maintained without stopping it.

[0011] An additional system of pulse hot cyclones of vacuum type was also developed. The additional device prevents carbon particles from entering the heat exchanger. It provides the successive pulsed additional grinding of carbon residues, controlled postoxidation and afterburning at a temperature of 1000-1700°C. This additional device significantly improves the quality of combustion and the environment.

[0012] A further object of the present invention is to provide the construction of universal combustion device which allows to burn fuel (solid fuel, household waste, and the like) without the need to reconfigurate the device for a specific type of fuel or for fuel with different para-

meters of humidity or particle size, and at the same time to generate heat due to the combustion of the obtained synthetic gas directly in the combustion chamber of the device. A further object is to avoid harmful emissions at the device exit without the need for additional filtration of combustion products by way of burning carbon monoxide and other harmful substances in the space of the combustion chamber and the chamber of afterburning and postoxidation.

[0013] A further object of the present invention is to increase the energy efficiency of using the device by ensuring the combustion process without involving additional energy sources. A further object is to increase the thermal power of heat generation to expand the field of application of the device. A further object of the invention is to expand the range of the heat generation power of the device with simultaneous stabilization of the required temperature of heat generation depending on the needs of the user of the device (with an error of no more than a few degrees). And a further object of the invention is to increase the convenience of using the device and its maintenance.

[0014] The above objects are attained in a combustion device with the function of heat generation, which comprises at least a partially thermally insulated housing, a fuel container with an upper means of fuel supply, a combustion chamber located in the housing below the fuel container, a grate, at least one means of supplying air to the interior space of the combustion chamber, and an additional device of pulse hot cyclones of vacuum type with controlled access of oxygen, which comprises at least a thermally insulated housing made of refractory material and one means for removing gaseous combustion products, According to the invention, the combustion chamber is multi-stage and located above the grate, and is also equipped with a vacuum-type swirler of gas flows. At the same time, the device is additionally equipped with a heat exchanger and at least one chamber of afterburning and postoxidation, located below the grate in front of the heat exchanger, wherein the combustion chamber and the chamber of afterburning and postoxidation are made according to the principle of creating vacuum-type cyclone-vortex flows.

[0015] According to a preferred embodiment of the device, the chamber of afterburning and postoxidation may comprise at least one swirler of gas flows.

[0016] According to a further preferred embodiment of the device, the chamber of afterburning and postoxidation may comprise at least one horizontal swirler of gas flows and at least one vertical swirler of gas flows arranged in series, and an additional device with a system of pulse hot cyclones of vacuum type.

[0017] According to a further preferred embodiment of the device, it can additionally comprise a smoke extractor connected to the means for removing gaseous combustion products.

[0018] According to a further preferred embodiment of the device, as a means of supplying air to the interior space of the combustion chamber, a set of nozzles connected into a single system can be used, the inlet holes of which are located on the surface of the housing along its height, and the outlet holes are connected at an acute angle to the side surface of each stage of the combustion chamber.

[0019] According to a further preferred embodiment of the device, each swirler of gas flows can have a circular cross-section, along the perimeter of which there are air supply channels made at an acute angle to the radial direction of the circular cross-section. Also, the device is additionally equipped with a system of pulse hot cyclones of vacuum type with controlled access of oxygen. The hot cyclones are also equipped with a set of nozzles.

[0020] According to a further preferred embodiment of the device, a chimney located after the heat exchanger can be used as the means for removing gaseous combustion products.

[0021] According to a further preferred embodiment of the device, the fuel container may comprise an upper part and a lower part, with the upper part being separable and equipped with a fuel loading door.

[0022] According to a further preferred embodiment of the device, the fuel container may comprise a lower part with at least partially lined surface located in the housing.

[0023] According to a further preferred embodiment of the device, the walls of the combustion chamber may comprise at least partially lined surface.

[0024] According to a further preferred embodiment of the device, the combustion chamber is made in the form of a set of truncated cones, with smaller bases directed downwards, between which multi-stage nozzles are embedded, located at an acute angle relative to the center of the cone.

[0025] There is the following cause and effect relationship between the set of essential features of the invention and the claimed technical result.

[0026] Equipping the device with a combustion chamber in the form of a set of truncated cones with smaller bases directed downwards, between which multi-stage nozzles are embedded, located at an acute angle relative to the center of the cone, ensures the formation of continuous multi-stage vacuum-type cyclone-vortex flows that work permanently and stably. These flows create a vacuum-type turbine effect. When dense, wet and heavy fuel is loaded into the combustion device, due to the presence of the set of cones, the weight of the fuel is distributed evenly to each of the cones, which prevents the formation of compacted clusters and burning-out of hollow pockets. This ensures uniform combustion and stable maintenance of the required power of the device and full control over the temperature regime of its operation.

[0027] Compared to the prior art, the use of a grate with a flat surface made of refractory material, which is located below a set of truncated cones, with smaller bases directed downwards, instead of the grate in the form of a truncated cone, with a smaller base directed upwards

(as in the prior art), forms, together with a set of nozzles, the multi-stage vacuum-type cyclone-vortex flows, ensures unhindered ash spillage and prevents the combustion chamber from being melted and the device removal from the required power, and extends the time of continuous operation of the device several times. The use of such construction of the grate allows the device to be maintained and cleaned without the need to stop it.

[0028] By way of creating light vacuum inside the multi-stage combustion chamber and due to the swirlers of gas flows, which are provided in each stage of the combustion chamber, cyclone-vortex gas flows are obtained in the interior space of the combustion chamber. The flows formed in this way make it possible to achieve the transformation of pyrolysis gases obtained during fuel combustion, first into synthesis gas, and then its combustion directly in the device. At the same time, the device is additionally equipped with at least one chamber of afterburning and postoxidation, inside of which the cyclone-vortex flows of gases are generated, and an additional system of pulse hot cyclones of vacuum type with controlled access of oxygen, which allows to increase the efficiency of the combustion process and additionally reduce the number of harmful substances, in particular CO, at the device exit.

[0029] The principle of cyclone-vortex combustion was developed as a result of studying the aerodynamics of tornadoes and atmospheric cyclones. Exactly the vacuum-type cyclone-vortex flows ensure entering the combustion products into the heat exchanger, mixing fuel with air into highly swirling flows in the combustion chamber. At the same time, the formation of cyclone-vortex flows precisely due to vacuum (the combustion chamber and the vacuum-type chamber of afterburning and postoxidation) ensures preliminary combustion of fuel instead of direct contact of flame with the heat exchanger, contributing to complete combustion of fuel.

[0030] By way of studying it was determined that vacuum generation is a necessary condition for increasing the efficiency of fuel combustion in cyclone-vortex flows. At the same time, the studies have shown that even the generation of vacuum using the natural draft of a heated means for removing gaseous combustion products (for example, a chimney) is sufficient to increase efficiency, which significantly increases the energy efficiency of the combustion process and allows the process to be carried out without the use of additional energy sources, for example, to create flows by means of electric fans and forced creation of pressure.

[0031] The combustion of synthesis gas directly inside the device for obtaining heat generation avoids the need to cool or filter the synthesis gas before its utilization, which ensures a reduction in energy losses, higher-quality high-calorific combustion, and makes the heat generation process more efficient and environmentally friendly due to an additional system of pulse hot cyclones of vacuum type with controlled access of oxygen, also allows for clear regulation and setting of accurate temperature indicators, depending on the device purpose. That allows to reduce the emissions of CO and other harmful substances several times, compared to the combustion of natural gas.

[0032] Also, testing of the proposed construction of the device showed that the use of multi-stage cyclone-vortex combustion chambers of vacuum type and an additional system of pulse hot cyclones of vacuum type with controlled access of oxygen allows for the gasification of materials of various types with high humidity (up to 75%) and different chemical composition, in particular, such as corn husks, wood chips, seed husks and other similar agricultural waste, plastic, household waste, rags, offals and other animal waste, solid household waste, etc., without the need to adjust the device for a certain type of fuel or fuel with different humidity parameters or different fractions. Moreover, the combustion of mixed fuel, for example, fuel of different types mixed together or loading of fuel in layers of different humidity, was tested. Thus, the device of the invention allows to achieve fuel combustion without its preliminary preparation, sorting or calibration.

[0033] At the same time, when using the claimed device, the heat output ranging from 20 kW to 20,000 kW was achieved depending on the purpose of heat generation with a stable heat generation temperature for each power. The said power range is achieved by reaching the temperature of the heated gases, as they enter the heat exchanger, in the range from 700°C to 2,700°C. Adjusting the thermal power of the device within the said range without changing its design is achieved by adjusting the supply of air flows that enter the combustion chamber for generating vacuum-type cyclone-vortex flows, additionally equipped with the system of pulse hot cyclones of vacuum type with controlled access of oxygen and regulation of draft generated due to the means for removing of combustion products (the chimney). Such adjusting can be carried out in any known way, in particular, with the help of adjustable nozzles, and is not the object of the present invention.

[0034] Also, equipping the chamber of afterburning and postoxidation with vacuum-type swirlers of gas flows, located sequentially in different areas (vertically and horizontally), allows to continue the processes of transformation of pyrolysis gases into synthesis gas and its combustion started in the combustion chamber, which additionally increases the efficiency of the heat generation process and allows to achieve thermal power within the range indicated above.

[0035] Equipping the device with the smoke extractor communicated with the means for removing gaseous combustion products, allows to increase the efficiency of creating a draft to obtain vacuum inside the device, as well as to increase the convenience of adjusting the cyclone-vortex flows with an additional system of pulse hot cyclones of vacuum type with controlled access of oxygen to change the power of heat generation.

[0036] The use of the set of nozzles, in particular,

adjustable ones, as a means of supplying air to the interior space of the combustion chamber, the inlet holes of which are located on the surface of the housing along its height, and the outlet holes communicate with the side surface of each stage of the combustion chamber, is one of the optimal ways for supplying air to the combustion chamber to obtain vacuum-type cyclone-vortex flows also in the additional system of pulse hot cyclones of vacuum type with controlled access of oxygen, which also ensures air supply adjustment.

[0037] The use of swirlers of gas flows with a circular cross-section, along the perimeter of which air supply channels are located, made at an acute angle to the radial direction of the circular cross-section, allows to obtain cyclone-vortex flows even at a relatively small draft in the combustion chamber.

[0038] The use of the system of pulse hot cyclones of vacuum type, which constantly change the pulses of the vacuum force of cyclone-vortex flows, ensures successive additional grinding and controlled postoxidation of any carbon and other residues. The successive repetition of the pulses of hot cyclones of vacuum type provides multiple additional afterburning, which significantly improves the quality of gases outgoing into the atmosphere and greatly improves the environment during disposal and processing. The process is carried out at a temperature of 1000-1700°C. The necessary stable temperature and purity of the gases supplied to the heat exchanger are provided by pulse hot cyclones of vacuum type.

[0039] The use of the chimney located after the heat exchanger as a means for removing gaseous combustion products also allows for the heat generation process by the device itself.

[0040] The embodiment of the fuel container with an upper part and a lower part, with the upper part being made separable and equipped with the fuel loading door, allows to increase the convenience of access to the interior space of the fuel container and the combustion chamber.

[0041] At the same time, the embodiment of the lower part of the fuel container with at least partially lined surface, located in the housing, and the walls of the combustion chamber with at least partially lined surface allows to increase the efficiency of fuel gasification regardless of its type, as well as to increase the resistance of the device elements to acidic and alkaline environments and any temperature regimes.

Brief description of the drawings

[0042] The following is an embodiment of the combustion device with function of heat generation and a method of fuel combustion and heat generation using such device. The embodiment is illustrated by the following drawings:

Fig. 1 is a general cross-sectional view of the device.
Fig. 2 is a cross-section taken along line A-A in Fig. 1.

[0043] The given embodiment of the device and the method of its use do not limit other embodiments of the device to the stated limits, but only explains the possibility of carrying out the invention and individual moments of its implementation.

In Figs. 1-2 the following designations are used:

[0044] The combustion device with function of heat generation comprises at least partially thermally insulated housing 1, the fuel container 2 with the upper fuel supply means 3, the cyclone-vortex combustion chamber 4 of vacuum type (hereinafter referred to as the combustion chamber 4) located in the housing 1 below the fuel container 2, the grate 5, the set of nozzles 6 as a means of supplying air to the interior space of the combustion chamber and the chimney 7 as a means for removing gaseous combustion products.

[0045] The inlet holes of the jets 6 are located on the surface of the housing 1 along its height, and the outlet holes are connected to the side surface of each stage of the combustion chamber 4. The jets 6 are adjustable.

[0046] The combustion chamber 4 is multi-staged, located above the grate 5, and is also equipped with the vacuum-type swirler 8 of cyclone-vortex gas flows.

[0047] The swirler 8 of gas flows of each stage of the combustion chamber 4 has a circular cross-section (Fig. 2) and along the perimeter thereof there are air supply channels 9, made at an acute angle to the radial direction of the circular cross-section.

The device is additionally equipped with the heat exchanger 10 located in front of the chimney 7 in the direction of moving the combustion products from the combustion chamber to the device exit.

[0048] The device also comprises the chamber 11 of afterburning and postoxidation, located below the grate 5 in front of the heat exchanger 10. This chamber is also equipped with a vacuum-type cyclone-vortex swirler of gases, like the chamber 4.

[0049] The chamber 11 of afterburning and postoxidation may comprise the swirlers of gas flows similar to the swirler 8 located in the combustion chamber 4, in particular, at least one horizontal swirler 12 of gas flows and at least one vertical swirler 13 of gas flows, arranged in series.

[0050] The device is additionally equipped with the system of pulse hot cyclones of vacuum type with controlled access of oxygen. This additional system comprises a thermally insulated housing 18 made of refractory material, comprising a set of hot cyclones 27, which ensures constant changes in vacuum force. Each hot cyclone is equipped with a nozzle 24 which provides controlled access of oxygen. Turbines 25 provide cyclone-vortex flows 26 for additional grinding, postoxidation and afterburning of carbon residues and other harmful gases, and also provide stabilization of the required temperature and additional cleaning of hot gases 23 before being fed into the heat exchanger 10. The use

of the new system of pulse hot cyclones of vacuum type with controlled access of oxygen provides multiple additional afterburning that improves the quality of gases outgoing into the atmosphere and significantly improves the ecology during disposal and processing. It does not leave carbon residues in the ash, and the carbon dioxide content is reduced almost to zero.

[0051] The device can additionally comprise the smoke extractor 14 in the chimney 7.

[0052] The fuel container 2 comprises an upper part 15 and a lower part 16. The upper part 15 is made separable and equipped with the fuel loading door with the upper fuel supply means 3. The lower part 16 is located in the housing 1 and is made with at least partially lined surface 17 of refractory materials.

[0053] The walls of the combustion chamber 4 are also made with an at least partially lined surface 17 of refractory materials.

[0054] Refractory materials for lined surfaces 17 can be selected, for example, from such materials as chamotte, mullite corundum, Bacor, zirconium and other similar materials known from the prior art. The choice of refractory materials depends on the type of fuel, in particular, such as RDF, which need to be disposed or combusted in the device. Depending on the required power of the device, the total weight of refractory materials can range from 200 kg to 20,000 kg. Due to the proper selection of refractory materials the efficiency of gasification of any fuel is additionally achieved, as well as the resistance to acidic or alkaline environments and significant temperature regimes.

[0055] The housing 1 can have a hermetically sealed metal casing 18 to improve the quality of control over the combustion process and prevent environmental influences on the processes taking place in the device.

[0056] The chamber 11 of afterburning and postoxidation additionally comprises the door 19 for removing ash.

The principle of use of the invention

[0057] Fuel of any type and parameters, in particular, mixed type (for example, maize tops and cobs, wood chips, seed husks and other agricultural waste, rubber, plastic, oil refinery waste, peat, coal, household waste, rags, offals, bones, feathers and other animal waste, solid household waste) is loaded into the container 2 through the fuel loading door 3 equipped with a jack. Loading can be done manually or automatically depending on the furnace power. Additional loading of fuel, for example, from storage, can be carried out at any time after loading the first portion of fuel during operation of the device without stopping it. Additional loading of fuel can be carried out through the upper means 3 of fuel supply manually or with the help of automatic loading systems of the known type: revolver, conveyor, screw, elevator and other similar systems. The volume of the container 2 can range from 0.11 m^3 to 6.5 m^3 depending on the required thermal power. The fuel by gravity enters the cyclone-vortex combustion chamber 4 of vacuum type. The fuel located in the combustion chamber 4 is ignited through the door on the side surface of the housing 1.

[0058] Air is supplied to the combustion chamber 4 through the set of nozzles 6 using the natural draft created by vacuum of the chimney 7. At the same time, even the natural draft of the chimney 7 heated by the combustion products, is sufficient to create vacuum in the combustion chamber 4. Due to the created vacuum, when air is supplied through the nozzles in the multi-stage combustion chamber 4, due to the swirlers 8 of the gas flows powerful cyclone-vortex flows 20 of vacuum type are formed. Vacuum can also be created with the help of the smoke extractor 14.

[0059] The combustion process takes place only directly in each stage of the combustion chamber 4. At the same time, any solid fuel is converted into pyrolysis gas 21 in the vacuum-type cyclone-vortex flows 20.

[0060] Combustion of fuel and its transformation into synthesis gas 22 is carried out in the combustion chamber 4 gradually due to its subsidence in the direction of the grate 5 under its own weight.

[0061] During the device operation the lined surface 17 of refractory material allows to heat the inner surface of the walls of the container 2 and the combustion chamber 4 to the required temperature, and is a powerful heat accumulator. When fuel of any humidity, any fraction and any chemical composition comes into contact with the walls of the container 2 and the combustion chamber 4, the fuel is instantly gasified into pyrolysis gas 21.

[0062] Due to the powerful vacuum-type cyclone-vortex flows 20, high temperature and controlled air flow through the nozzles 6 directly in the combustion chamber 4 the obtained pyrolysis gas 21 is transformed into high-calorific synthesis gas 22.

[0063] The entire mass of fuel loaded into the device is held by the grate 5. In addition to holding the fuel the grate 5 ensures the passage of the obtained synthesis gas 22 into the vacuum-type chamber 11 of afterburning and postoxidation which also comprises the means for creating cyclone-vortex flows (swirlers 12 and 13).

[0064] In the chamber 11 of afterburning and postoxidation, for synthesis gas 22 and residual pyrolysis gases 21, by means of the swirlers 12 and 13, powerful cyclone-vortex flows are created, mixing them with oxygen of the air that enters this chamber from nozzles 6. Thus, powerful heating and complete combustion of all gases entering the chamber, even inflame-resistant gases, are achieved.

[0065] A small percentage of unburned fuel can also enter the chamber 11 through the grate 5, which ensures the gasification of all gases that have entered the chamber 11. The use of two swirlers, 12 and 13, of gas flows, located in different planes, and the additional use of the new system of hot cyclones of vacuum type with controlled access of oxygen allows to further increase the efficiency of gasification and production of synthesis gas, and the repetition of the processes of additional grinding,

postoxidation and afterburning of carbon residues and other harmful substances, i.e. to ensure more complete combustion of any type of fuel with any moisture content and any chemical composition, which allows to significantly reduce the emissions of CO and other harmful substances, compared to the combustion of natural gas, thereby increasing the safety of the environment and the high thermal power of the device, which does not decrease over time.

[0066] After the high-quality combustion of synthesis gas 22, the flow of gases 23 heated to the required temperature in the range from 700°C to 2700°C, is obtained, which enters the heat exchanger 10. The temperature of the heated gases within the said range can be adjusted depending on the requirements for the required thermal power of air flows for gasification and calorific parameters of the fuel. As such a heat exchanger, a water-heating heat exchanger or one with air heat exchange, a steam boiler, a heat exchanger for fusing or melting glass, porcelain, ceramics, sponge glass, heating and melting metals and the like, an auxiliary device to boilers of an existing boiler house, etc., can be used.

[0067] Unburned fuel particles (ash) are removed from the chamber 11 through the door 19 using mechanical or automatic means, depending on the model of the device, even during its operation.

[0068] Thus, the use of the present invention makes it possible to burn fuel (solid fuel, household waste, and the like) without the need to reconfigurate the device for a specific type of fuel or for fuel with different parameters of humidity or particle size, precisely due to the formation of vacuum-type cyclone-vortex flows in the combustion chamber and the chamber of postoxidation and afterburning, and at the same time to generate heat due to combustion of the obtained synthetic gas to significantly reduce harmful emissions at the device exit, increase the energy efficiency of the device and the thermal power of heat generation, expand the adjustment interval of the heat generation power of the device and achieve stabilization of the required temperature of heat generation depending on the needs of the device user, as well as to increase the convenience of using the device and its maintenance compared to the prior art and other installations of a similar purpose.

Claims

1. A combustion device with the function of heat generation, comprising: at least partially thermally insulated housing, a container with an upper means of supplying fuel, located in the housing below the container, a combustion chamber, a grate, at least one means of supplying air to the interior space of the combustion chamber, and at least one means for removing gaseous combustion products, **characterized in that** the combustion chamber is made multistaged and located above the grate, and is also equipped with a swirler of gas flows, wherein the device is additionally equipped with a new system of pulse hot cyclones of vacuum type with controlled access of oxygen, which provides periodic repetition of the processes of changing the vacuum force for additional grinding of carbon residues and other harmful gases, their postoxidation and final afterburning, as well as stabilizes the required temperatures for various types of heat exchangers, according to the technical problem to be solved.

2. The combustion device according to claim 1, **characterized in that** the chamber of afterburning and postoxidation comprises at least one swirler of gas flows.

3. The combustion device according to claim 2, **characterized in that** the chamber of afterburning and postoxidation comprises at least one horizontal swirler of gas flows and at least one vertical swirler of gas flows, located in series, and is additionally equipped with the system of pulse hot cyclones of vacuum type with controlled access of oxygen.

4. The combustion device according to claim 1, **characterized in that** it additionally comprises a smoke extractor connected to the means for removing gaseous combustion products.

5. The combustion device according to claim 1, **characterized in that** as the means of supplying air to the interior space of the combustion chamber, a set of nozzles connected into a single system is used, with the inlet holes being located on the surface of the housing along its height, and the outlet holes being connected to the side surface of each stage of the combustion chamber.

6. The combustion device according to claim 1, **characterized in that** the swirler of gas flows has a circular cross-section, along the perimeter of which there are air supply channels made at an acute angle to the radial direction of the circular cross-section, wherein the device is additionally improved due to the new system of pulse hot cyclones of vacuum type with controlled access of oxygen, which is equipped with a multi-stage pulse system of nozzles, which consistently provide postoxidation and afterburning of the carbon residues and other harmful gases.

7. The combustion device according to claim 1, **characterized in that** a chimney located after the heat exchanger is used as the means of removing gaseous combustion products.

8. The combustion device according to claim 1, **characterized in that** the container comprises an upper part and a lower part, wherein the upper part is made

separable and equipped with a fuel loading door.

9. The combustion device according to claim 1, **characterized in that** the container comprises a lower part with at least partially lined surface located in the housing.

10. The combustion device according to claim 1, **characterized in that** the walls of the combustion chamber comprise at least partially lined surface.

11. The combustion device according to claim 1, **characterized in that** the grate is made with a flat surface of refractory material.

12. The combustion device according to any claims of 1, 5 and 6, **characterized in that** the combustion chamber is made in the form of a set of truncated cones, with smaller bases directed downwards, between which the multi-stage nozzles located at an acute angle to the center of the cone are embedded, wherein the device is additionally equipped and improved with the system of multi-stage pulse hot cyclones of vacuum type with controlled access of oxygen, which provides periodic repetition of the processes of changing the vacuum force for additional grinding of carbon residues and other harmful gases, their postoxidation and final afterburning, as well as stabilizes the required temperatures for various types of heat exchangers, according to the technical problem to be solved.

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

1. A combustion device with the function of heat generation, comprising: a thermally insulated housing (1), a container (2) with an upper fuel supply means (3), located in the housing (1) below the container (2), a combustion chamber (4), a grate (5), at least one means of supplying air to the interior space of the combustion chamber, and at least one means for removing gaseous combustion products, wherein the combustion chamber (4) is made multi-staged and located above the grate (5), and is also equipped with a swirler (8) of gas flows, and **characterized in that** the device comprises a system of pulse hot cyclones (27) of vacuum type with a means to control access of oxygen, adapted to provide periodic repetition of the processes of changing the vacuum force for additional grinding of carbon residues and other harmful gases, their postoxidation and final afterburning, and residual purification and a means for stabilizing the required temperatures for various types of heat exchangers (10).

2. The combustion device according to claim 1, **characterized in that** the device comprises a chamber (11) of afterburning and postoxidation comprising at least one swirler (8) of gas flows.

3. The combustion device according to claim 2, **characterized in that** the chamber (11) of afterburning and postoxidation comprises at least one horizontal swirler (12) of gas flows and at least one vertical swirler (13) of gas flows, located in series and is additionally equipped with the system of pulse hot cyclones (27) of vacuum type with controlled access of oxygen.

4. The combustion device according to claim 1, **characterized in that** the device additionally comprises a smoke extractor (14) connected to the means for removing gaseous combustion products.

5. The combustion device according to claim 1, **characterized in that** as the means of supplying air to the interior space of the combustion chamber (4), a set of nozzles (6) connected into a single system is used, with the inlet holes being located on the surface of the housing along its height, and the outlet holes being connected to the side surface of each stage of the combustion chamber (4).

6. The combustion device according to claim 1, **characterized in that** the swirler (8) of gas flows has a circular cross-section, along the perimeter of which there are air supply channels made at an acute angle to the radial direction of the circular cross-section, wherein the device is additionally equipped with the system of pulse hot cyclones (27) of vacuum type with controlled access of oxygen, which is equipped with a multi-stage pulse system of nozzles, which consistently provide postoxidation and afterburning of the carbon residues and other harmful gases.

7. The combustion device according to claim 1, **characterized in that** a chimney (7) located after the heat exchanger (10) is used as the means of removing gaseous combustion products.

8. The combustion device according to claim 1, **characterized in that** the container (2) comprises an upper part and a lower part, wherein the upper part is made separable and equipped with a fuel loading door (3).

9. The combustion device according to claim 1, **characterized in that** the container (2) comprises a lower part with at least partially lined surface located in the housing (1).

10. The combustion device according to claim 1, **characterized in that** the walls of the combustion chamber (4) comprise at least partially lined surface.

11. The combustion device according to claim 1, **characterized in that** the grate (5) is made with a flat surface of refractory material.

12. The combustion device according to any claims of 1, 5 and 6, **characterized in that** the combustion chamber (4) is made in the form of a set of truncated cones, with smaller bases directed downwards, between which the multi-stage nozzles located at an acute angle to the center of the cone are embedded, wherein the device comprises a system of pulse hot cyclones (27) of vacuum type with a means to control access of oxygen, adapted to provide periodic repetition of the processes of changing the vacuum force for additional grinding of carbon residues and other harmful gases, their postoxidation, final afterburning and residual purification, and a means for stabilizing the required temperatures for various types of heat exchangers (10).

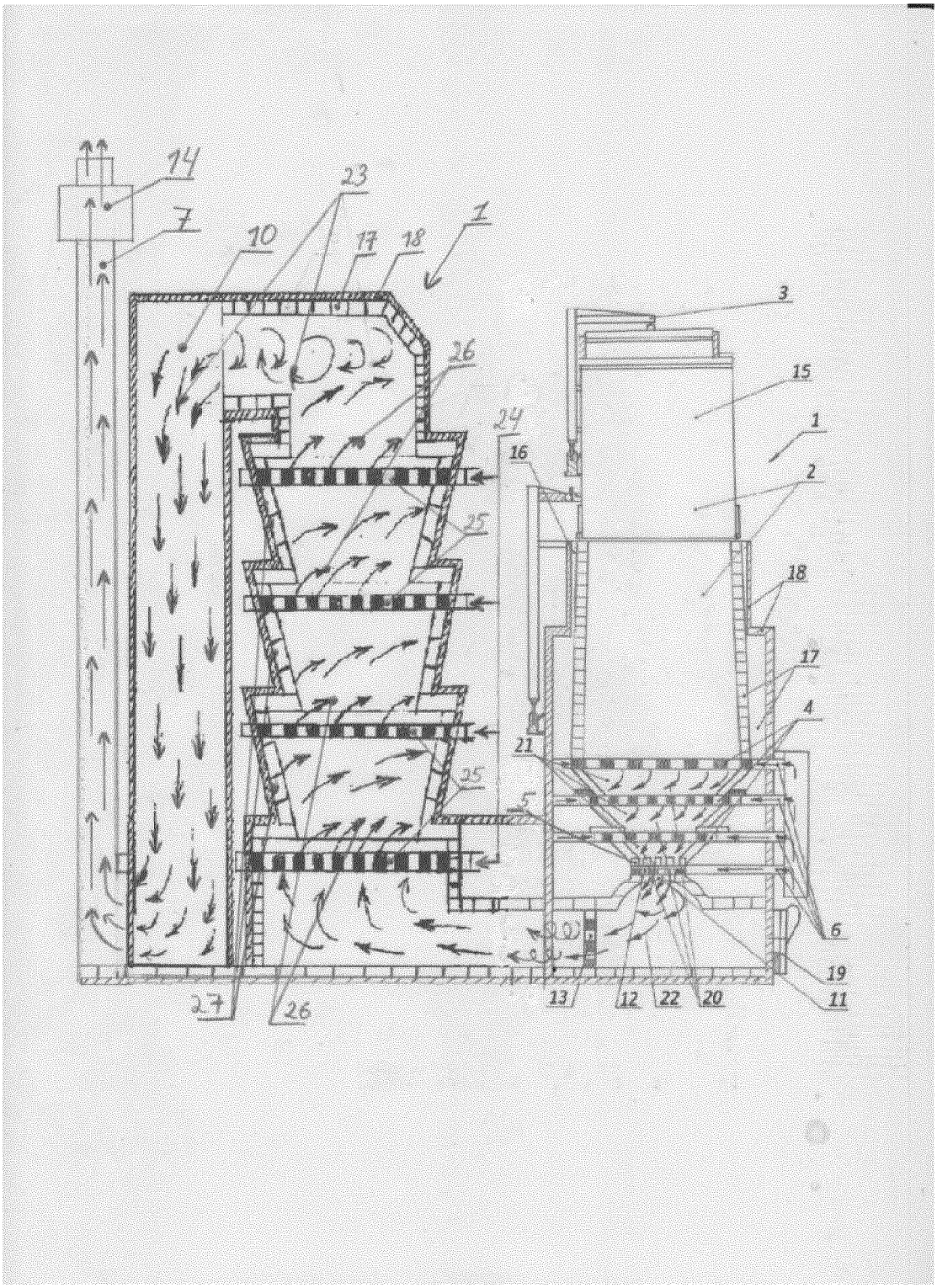
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Fig. 1

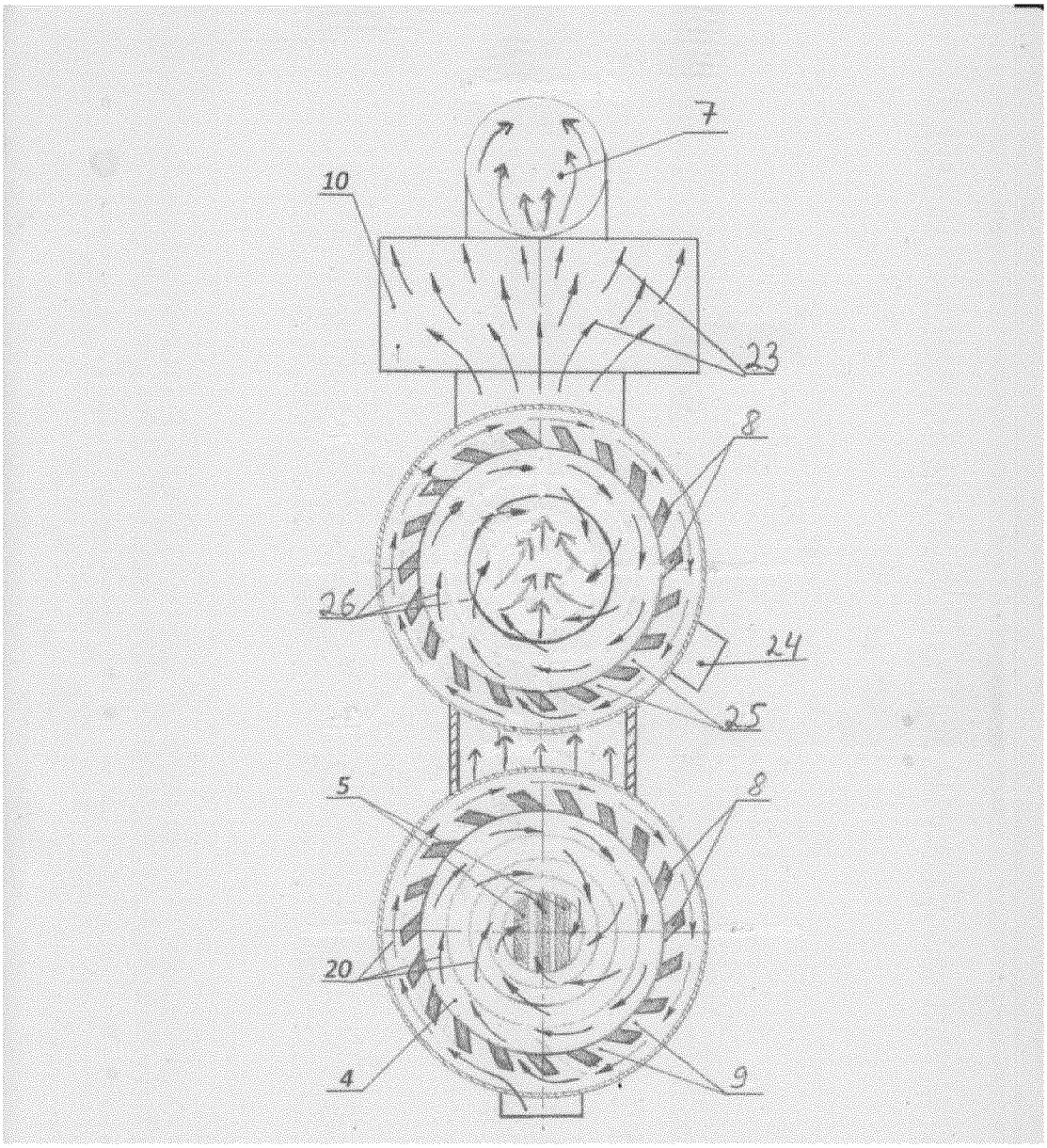

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 23 02 0265

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	UA 118 238 C2 ([UA]) 10 December 2018 (2018-12-10) * the whole document *	1-12	INV. F23B30/00 F23B10/02 F23B50/06
Y	US 5 046 435 A (KUGLER KURT [DE]) 10 September 1991 (1991-09-10) * column 7, line 17 - line 39 * * figure 1 *	1-12	F23G5/16 F23G5/24 F23G5/32 F23L17/00
Y	DE 10 2020 113657 A1 (DUERR SYSTEMS AG [DE]) 25 November 2021 (2021-11-25) * page 6, paragraph 35 - page 8, paragraph 44 * * figure 1 *	1-12	
A	US 4 529 377 A (ZINN BEN T [US] ET AL) 16 July 1985 (1985-07-16) * column 4, line 15 - column 6, line 50 * * figures 1,2 *	1-12	
A	FR 2 769 078 A1 (ASS DE SAUVEGARDE DE L ENFANCE [FR]) 2 April 1999 (1999-04-02) * page 5, line 12 - page 6, line 6 * * figure 1 *	1-12	TECHNICAL FIELDS SEARCHED (IPC) F23B F23G F23L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	17 October 2023	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

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17-10-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
UA 118238 C2	10-12-2018	NONE	
US 5046435 A	10-09-1991	AT E93602 T1	15-09-1993
		CA 2023955 A1	06-07-1990
		DE 4000265 A1	12-07-1990
		EP 0408702 A1	23-01-1991
		JP H02503712 A	01-11-1990
		US 5046435 A	10-09-1991
		WO 9007681 A1	12-07-1990
DE 102020113657 A1	25-11-2021	CN 115769025 A	07-03-2023
		DE 102020113657 A1	25-11-2021
		DE 112021002859 A5	02-03-2023
		EP 4153912 A1	29-03-2023
		WO 2021233500 A1	25-11-2021
US 4529377 A	16-07-1985	NONE	
FR 2769078 A1	02-04-1999	NONE	

EPO FORM P0459

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

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Patent documents cited in the description

- UA 118238 C2 **[0009]**