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(54) **HEATING APPARATUS AND METHOD OF USING THE LATTER**

HEIZGERÄT UND VERFAHREN ZU DESSEN VERWENDUNG

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a low-emission heating apparatus that uses the well-known process of pyrolysis, also called cracking, or gasification, of a biomass, for example pellets or other materials derived from wood, to produce heat. The heating apparatus can be applied in the field of heating spaces, for example domestic or industrial, of public premises, or ones open to the public, but also in the field of boilers to produce domestic water and/or to be used in heating systems.

BACKGROUND OF THE INVENTION

[0002] Heating apparatuses are known, commonly called stoves, which use biomass in an inconsistent form for fuel, for example formed by chips, pellets or suchlike, in which combustion occurs thanks to the presence of a comburent, usually consisting of the oxygen contained in the ambient air, which is supplied as primary and secondary air. The primary air is made to enter a brazier to fuel the combustion of the biomass after the latter has first been ignited.

[0003] When operating at steady state, pyrolysis occurs during combustion, that is, the physical and chemical decomposition process of the combustible biomass, caused by it being heated to temperatures between about 300°C and about 600°C.

[0004] As is known, pyrolysis decomposes biomass into two parts: one gaseous and one solid. The gaseous part consists of a flammable mixture of gases, such as mainly carbon monoxide, hydrogen and methane, and a condensable compound, known to persons of skill in the art by the acronym TAR, while the solid part substantially consists of coal, known also by the term CHAR.

[0005] The mixture of gases derived from pyrolysis, which in this field is called "syngas", is ignited by ignition, and with the introduction of secondary air completes the combustion of the biomass, generating heat and a flame.

[0006] Known stoves, which are based on the pyrolysis process, have a brazier in which the biomass can be loaded, which can then be ignited. Primary air can be introduced into the brazier to create a so-called "flame cap" above the biomass.

[0007] When the stove is working, the heat of the combustion descends into the brazier in proximity to the still non-combusted biomass and causes the pyrolysis thereof. Then, to complete the combustion, secondary air is introduced into the brazier which ignites the combustible gases resulting from pyrolysis.

[0008] However, these known stoves have a series of disadvantages such as, for example, poor performance, poor versatility of use, difficult management of the power and speed of production of the combustible gases and discontinuous operation.

[0009] In fact, the combustion process occurs until the

loaded biomass is completely consumed by the pyrolysis process. When this process ends, because the biomass is finished, it is necessary to reload more biomass into the brazier and then restart the process by means of a new ignition. It is therefore quite clear that these operations require the intervention of an operator.

[0010] In addition, the introduction into the brazier of ambient air, having an oxygen component of approximately 23.3% by weight, contributes to a high production of polluting gases. In fact, biomass also includes nitrogen, generally bound with the carbon and hydrogen atoms present in it, and which, as is known, binds with the oxygen of the ambient air introduced into the brazier, producing nitrogen oxides which are very polluting.

[0011] Document DE 3718022 C1 is also known, which describes a biomass-fueled boiler, which comprises a brazier to contain the biomass, having a plurality of lateral entry apertures through which a mixture of air and fumes enters to trigger the pyrolysis of the biomass. Moreover, the brazier also comprises an exit aperture from which the combustible gases produced by the pyrolysis of the biomass exit. In correspondence with the exit aperture there are also air injection apertures to trigger the combustion of the combustible gases in a combustion chamber disposed directly downstream of the exit aperture of the brazier. The boiler also comprises a conduit that connects the combustion chamber disposed directly downstream of the exit aperture of the brazier to a post-combustion chamber comprising another air injection aperture to trigger the post-combustion of the fumes deriving from the first combustion, which took place in the combustion chamber disposed directly downstream of the exit aperture of the brazier.

[0012] Furthermore, in the boiler described in document DE 3718022 C1, the pyrolysis of the biomass is triggered by a mixture of air and fumes the oxygen content of which also induces the production of nitrogen oxides, which are very polluting. In fact, for this reason, the fumes from the combustion of the combustible gases produced by the pyrolysis of the biomass are conveyed to the post-combustion chamber to trigger a second combustion with the purpose of reducing the nitrogen oxides.

[0013] Lastly, the boiler described in document DE 3718022 C1 is fed in batches, that is, before inserting a new biomass into the brazier it is necessary to terminate the decomposition of the biomass already present inside and then to empty it, so it is particularly difficult to control and regulate the combustion.

[0014] Document WO 2014/064300 A1 is also known, which describes a vertical biomass-fueled boiler, with which comprises a first chamber into which the biomass is introduced from the top to the bottom, in the opposite direction with respect to a flow of primary air which is introduced into the first chamber from the bottom to the top. In the first chamber, that is, in the environment where the biomass is introduced, a first partial combustion of the biomass takes place with the primary air that can consist of a mixture of fumes and air arriving from the external

environment. The boiler of document WO 2014/064300 A1 also comprises a second chamber disposed directly above the first chamber to receive the fumes produced by the first combustion. Secondary air is introduced into the second chamber to complete the combustion of the fumes produced by the first partial combustion. In this case too, the second chamber is configured as a post-combustion chamber in which the combustion of the fumes produced in the first chamber is completed. Furthermore, it is also known that the introduction of biomass and primary air in opposite directions does not allow to completely separate the volatile components of the biomass and, therefore, the fumes generated by combustion from the first combustion chamber have a high polluting TAR content.

[0015] The document FR 2 752 915 A1 also shows a related heating apparatus.

[0016] There is therefore a need to provide a new and original heating apparatus that can overcome at least one, better all, the disadvantages of the state of the art.

[0017] One purpose of the present invention is to provide a heating apparatus that produces reduced pollutant emissions into the environment.

[0018] Another purpose of the present invention is to provide a heating apparatus that allows to regulate both the production speed of the combustible gases and also the calorific power generated.

[0019] Another purpose of the present invention is to provide a heating apparatus which also allows to obtain a continuous operation, that is, without interruptions and which, moreover, can be easily automated at least to allow automatic start up and switch off.

[0020] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0021] The present invention is set forth and characterized in the independent claims.

[0022] The dependent claims describe other characteristics of the present invention.

[0023] In accordance with the above purposes, a heating apparatus which overcomes the limits of the state of the art and eliminates the defects present therein, comprises a brazier configured to receive a biomass which functions as fuel and a first comburent and suitable to thermally decompose the biomass and produce at least one combustible gas.

[0024] According to the present invention, the brazier is of the type substantially closed with respect to the external environment and comprises a first entry aperture connected to an injection device configured to introduce, in a controlled, automatic, continuous and adjustable way, the biomass into the brazier, a second entry aperture for the first comburent to enter and an exit aperture for the at least one combustible gas to exit, the exit aperture

being disposed at a lower level than the one at which at least the second entry aperture is positioned.

[0025] According to the present invention, the entry apertures of the brazier are disposed at a higher level than the one at which the exit aperture is positioned, in such a way that the first comburent and the biomass enter the brazier with a concordant direction, from the top downward, and toward the exit aperture.

[0026] According to another aspect of the present invention, the heating apparatus also comprises a combustion chamber which is autonomous with respect to the brazier and has its own entry aperture configured to receive the combustible gas, and conveyor means interposed between the brazier and the entry aperture of the combustion chamber in order to convey the at least one combustible gas into the combustion chamber.

[0027] According to another aspect of the present invention, the heating apparatus also comprises a control unit configured to control the injection device in order to adjust the flow rate of the biomass introduced into the brazier.

[0028] According to another aspect of the present invention, the entry aperture of the combustion chamber is configured to receive a second comburent from the external environment. The apparatus also comprises both recirculation means to convey and/or draw the first comburent from the combustion chamber and convey the latter into the brazier, and also a fan connected to an evacuation aperture of the combustion chamber and configured to force the second comburent from the external environment toward the inside of the combustion chamber.

[0029] According to another aspect of the present invention, a heating method using the heating apparatus according to the invention comprises the following steps:

- providing the brazier;
- introducing, into the brazier, both the biomass and also the first comburent in order to thermochemically decompose the biomass and produce the at least one combustible gas.

[0030] According to another aspect of the present invention, the heating method also comprises the following steps:

- providing a combustion chamber autonomous with respect to the brazier;
- conveying the combustible gas into the combustion chamber; and
- drawing a second comburent from the external environment and conveying it into the combustion chamber; and
- igniting the combustible gas in order to develop heat by means of a flame.

[0031] According to another aspect of the present invention, the heating method also comprises the following

steps:

- drawing, from the combustion chamber, a first part of the fumes produced by the flame and introducing it into the brazier, whereby the first part of the fumes constitutes the first comburent; and
- drawing a second part of the fumes from the combustion chamber in order to evacuate it into the external environment.

[0032] According to another aspect of the present invention, the biomass is introduced into the brazier in a substantially continuous way.

[0033] According to the present invention, at least the first comburent is introduced into the brazier from the top downward.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] These and other aspects, characteristics and advantages of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a schematic block representation of a heating apparatus according to the present invention in accordance with a first embodiment;
- fig. 2 is a schematic block representation of a heating apparatus according to the present invention in accordance with a second embodiment;
- fig. 3 is a schematic block representation of a heating apparatus according to the present invention in accordance with a third embodiment;
- fig. 4 is a schematic block representation of a heating apparatus according to the present invention in accordance with a fourth embodiment;
- fig. 5 is a schematic block representation of a heating apparatus according to the present invention in accordance with a variant of the third embodiment;
- fig. 6 is a schematic block representation of a heating apparatus according to the present invention in accordance with a variant of the fourth embodiment;
- fig. 7 is a section lateral view of the heating apparatus of fig. 1;
- fig. 8 is a section along the line VIII-VIII of fig. 7;
- fig. 9 is a three-dimensional view of the heating apparatus of fig. 1, taken from the rear;
- fig. 10 is a three-dimensional view similar to that of fig. 9, but partly exploded;
- fig. 11 is a block electrical diagram of a control circuit of the heating apparatus of fig. 1.

[0035] We must clarify that in the present description and in the claims the term vertical, with its declinations, has the sole function of better illustrating the present invention with reference to the drawings and must not be in any way used to limit the scope of the present

invention itself, or the field of protection defined by the attached claims. For example, by the term vertical we mean an axis or a plane that can be either perpendicular to the line of the horizon, or inclined, even by several degrees, for example up to 20°, with respect to the latter.

[0036] Furthermore, the people of skill in the art will recognize that certain sizes or characteristics in the drawings may have been enlarged, deformed, or shown in an unconventional or non-proportional way in order to provide a version of the present invention that is easier to understand. When sizes and/or values are specified in the following description, the sizes and/or values are provided for illustrative purposes only and must not be construed as limiting the scope of protection of the present invention, unless such sizes and/or values are present in the attached claims.

[0037] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can be conveniently combined or incorporated into other embodiments without further clarifications.

DESCRIPTION OF SOME EMBODIMENTS OF THE PRESENT INVENTION

[0038] With reference to fig. 1, a heating apparatus 10 according to the present invention is of the pyrolysis type and, in accordance with a first embodiment, comprises thermochemical decomposition means M1 configured to receive a biomass C which functions as fuel and a first comburent F1, as will be explained below.

[0039] The thermochemical decomposition means M1 are suitable to thermally decompose the biomass C and produce, by means of pyrolysis, combustible gases S, for example consisting mainly of methane, hydrogen, carbon monoxide.

[0040] The heating apparatus 10 also comprises a combustion chamber 20 configured to receive both a second comburent A, different from the first comburent F1, and also the combustible gases S. The combustion chamber 20 is suitable to develop heat by means of a flame, fed by the combustible gases S and which produces fumes F, as will be explained below.

[0041] Furthermore, the heating apparatus 10, in accordance with one aspect of the present invention, comprises both conveyor means M2 interposed between the thermochemical decomposition means M1 and the combustion chamber 20 to convey the combustible gases S toward the latter, and also recirculation means M3 to convey at least a first part F1 of the fumes F, which constitutes the first comburent, from the combustion chamber 20 to the thermochemical decomposition means M1.

[0042] Furthermore, the heating apparatus 10 comprises heat exchange means M4, associated with the recirculation means M3 and configured to heat the sec-

ond comburent A, using the heat contained in the first comburent F1 before the second comburent A reaches the combustion chamber.

[0043] Hereafter, with reference to figs. 1 and from 7 to 11, the first embodiment of the heating apparatus 10 is described in more detail.

[0044] The thermochemical decomposition means M1 comprise a brazier 11 substantially closed with respect to the external environment and delimited by four lateral walls 12 and one upper wall 13. Furthermore, the brazier 11 is delimited at the bottom by a metal plate 14 provided with at least one exit aperture 15.

[0045] The exit aperture 15 of the brazier 11 is also configured to allow the combustible gases S to exit and the burnt and/or thermochemically decomposed biomass C to be discharged from the brazier 11.

[0046] The metal plate 14 can be selectively removable or openable, in any known way, to allow access to the brazier 11 from below, for example to carry out maintenance or cleaning thereof.

[0047] Furthermore, the brazier 11 has an entry aperture 16 for the biomass C to be introduced, comprising, for example, inconsistent wooden material such as chips, pellets or suchlike, and an entry aperture 18 from which the first comburent F1, which is of the aeriform type, can enter.

[0048] It should also be noted that according to the invention the brazier 11 does not have any apertures that allow the comburent air to enter directly from the external environment.

[0049] The entry apertures 16 and 18 of the brazier 11 are disposed in the upper part of the latter, that is, at a higher level than the one at which the exit aperture 15 is located. This configuration allows to introduce the biomass C and the first comburent F1 from the top downward.

[0050] It should be noted that the reciprocal position of the first aperture 16 and of the second aperture 18 may vary compared to that shown in the drawings, so that, for example, one or both can be disposed laterally, or one at a different level from the other.

[0051] In an alternative embodiment, not shown in the drawings and not according to the invention, the first aperture 16 of the brazier 11 can be disposed substantially level with the lower part thereof. In this configuration, the biomass C can be introduced into the brazier 11 from the bottom upward, or, alternatively, laterally, that is, in a substantially horizontal way. For example, the first aperture 16 can be disposed substantially level with the metal plate 14, in order to introduce the biomass C directly above the latter.

[0052] Furthermore, inside the brazier 11 there is an ignition device 19, configured to selectively trigger the combustion of the biomass C, for example when the heating apparatus 10 is switched on.

[0053] In the embodiment shown here, the ignition device 19 comprises an electrical resistance disposed in a lower zone of a lateral wall 12, that is, close to the

metal plate 14, for example in the same lateral wall 12 in which the first entry aperture 16 is made.

[0054] The ignition device 19 can be sized so as to come into contact, during use, with the biomass C present in the brazier 11. Alternatively, the ignition device 19 can be configured to ignite the biomass C indirectly, that is, by heating the air in contact with the latter.

[0055] The combustion chamber 20 is substantially closed and is in fluidic communication with the brazier 11 by means of a conveyor compartment 21, which is preferably hermetically sealed. In particular, the conveyor compartment 21 is interposed between the lower part of the brazier 11 and the lower part of the combustion chamber 20. Alternatively, the conveyor compartment 21 can be replaced by one or more conduits.

[0056] We must clarify that the combustible gas S exiting the exit aperture 15 of the brazier 11 flows directly into the conveyor means M2. The combustible gas S exiting the exit aperture 15 of the brazier 11 flows directly into the conveyor compartment 21, which defines the conveyor means M2.

[0057] We must also clarify that, in accordance with one aspect of the present invention, the brazier 11 and the combustion chamber 20 are autonomous, separated from each other and connected in a fluidic way by means of the conveyor compartment 21.

[0058] According to one aspect of the invention, the combustion chamber 20 is fluidically connected with the comburent entry aperture 18 of the brazier 11.

[0059] In particular, in the embodiment described here, the combustion chamber 20 is delimited by two lateral walls 22, by one upper wall 23, by one front wall 24, for example able to be opened, which functions as closing door, by one rear wall 25 and by one lower wall 26.

[0060] One or more recirculation apertures 27 are made on an upper part of the rear wall 25, each communicating with an upper end of a respective recirculation conduit 28, which is outside the combustion chamber 20 and has a lower end which, by means of a manifold 43, is connected to the intake of a first fan 29, the delivery of which is fluidically connected to the second entry aperture 18 of the brazier 11.

[0061] In addition or alternatively, the recirculation apertures 27 can be made in other walls of the combustion chamber 20.

[0062] Preferably, the recirculation conduits 28 are substantially parallel to each other and to the rear wall 25, and also detached from each other and from the rear wall 25, for example by between 1 and 3 cm.

[0063] The heating apparatus 10 also comprises a containing body 32, substantially box-shaped, on which two feed apertures 31 are made, which are in communication with the outside and through which the second comburent A can enter.

[0064] The containing body 32 is attached on the external surface of the rear wall 25 of the combustion chamber 20 creating, in cooperation with the latter, a containing compartment V in which the recirculation con-

duits 28 are disposed.

[0065] An entry aperture 33 is made in the bottom wall 26 of the combustion chamber 20, substantially in a central zone thereof, in said entry aperture 33 there being positioned a nozzle 30 having, in the example given here, a central conduit 34 disposed along a longitudinal axis X, substantially vertical, and a series of lateral through holes 35, which substantially lie on a substantially horizontal plane P disposed below the lower wall 26. The lateral holes 35 are in communication with the central conduit 34.

[0066] We must clarify that the conformation and disposition of the central conduit 34 and of the lateral holes 35 may differ, even considerably, compared to what is described here and represented in the attached drawings. For example, instead of the lateral holes 35, an aperture or a slot (not shown) of any suitable shape and size can be made.

[0067] The central conduit 34 is in communication with the conveyor compartment 21 and has the function of injecting the combustible gases S into the combustion chamber 20, while the lateral holes 35 have the function of conveying the second comburent A, coming from the containing compartment V. In particular, the second part V2 of the containing compartment V surrounds the portion of the nozzle 30 on which the lateral holes 35 are made, which are configured to receive the second comburent A coming from the second part V2 of the containing compartment V and to promote the mixing of the second comburent A with the combustible gases S in order to promote the combustion of the latter.

[0068] The feed apertures 31 are disposed below the lower ends of the recirculation conduits 28, that is, substantially level with the lower part of the combustion chamber 20.

[0069] Furthermore, a dividing wall, or partition, 37 is disposed inside the containing body 32, substantially dividing the containing compartment V into two parts, that is, into a first part V1, in which the recirculation conduits 28 are disposed, and into a second part V2, which laps both the rear wall 25 and also the lower wall 26 of the combustion chamber 20.

[0070] The first part V1 and the second part V2 of the containing compartment V are in communication with each other in correspondence with the upper part of the partition 37 which, preferably, is disposed in correspondence with the upper ends of the recirculation conduits 28, that is, where the latter are connected to the respective recirculation apertures 27.

[0071] Therefore, during use, the second comburent A enters from the feed apertures 31, passes through the first part V1 of the containing compartment V and heats up in contact with the recirculation conduits 28, until it reaches the top of the partition, 37. Then, the second comburent A enters the second part V2 of the containing compartment V from above and passes through it all, until it reaches the lateral holes 35 of the nozzle 30, lapping the rear wall 25 of the combustion chamber 20, heating up

further.

[0072] It should be noted that, thanks to this conformation, the containing body 32, in cooperation with the recirculation conduits 28 and the walls 25 and 27 of the combustion chamber 20, constitutes a counter-current heat exchanger, which corresponds to the heat exchange means M4 as above.

[0073] Furthermore, on each of the lateral walls 22 (fig. 8) of the combustion chamber 20 there are evacuation apertures 36, to each of which a respective evacuation pipe 38 is connected, outside the combustion chamber 20 and substantially vertical.

[0074] Each evacuation pipe 38 is fluidically connected to an evacuation chamber 40, in turn connected to the intake of a second fan 39 (fig. 7), the delivery of which communicates with the outside of the apparatus 10.

[0075] The heating apparatus 10 can optionally also comprise an external containing structure 41, substantially in the shape of a parallelepiped and comprising a second compartment 42, inside of which there are disposed, with ample clearance, both the evacuation pipes 38 and also at least a part of the combustion chamber 20, of the conveyor compartment 21 and of the evacuation chamber 40.

[0076] The external structure 41 has, in its lower part, an entry aperture 47, to which a third fan 45 is connected in order to selectively introduce ambient air R into the second compartment 42, and in its upper part an exit aperture 44 from which the same air R can exit in contact with the evacuation pipes 38.

[0077] The heating apparatus 10 also comprises an injection device 46, of any type known per se, to introduce the biomass C into the brazier 11 in a controlled way, whether intermittently or continuously.

[0078] In the example provided here, the injection device 46 comprises a container 48, substantially in the shape of a hopper, containing a biomass C load and an associated metering device 49, of a type known per se, having an exit connected to the entry aperture 16 of the brazier 11 and configured to meter the quantity of biomass C introduced into the brazier 11 in a way that is selective and proportional to certain electrical signals, under the control of a control unit 50 (fig. 11), as will be described in detail below.

[0079] Therefore, the biomass C lies in an autonomous and separate environment with respect to the brazier 11, and it is introduced therein in a selective, automatic and substantially continuous way by the injection device 49.

[0080] The metering device 49 (fig. 7) is of the type which comprises a rotating element 51 provided with radial blades 52 and connected to an electric motor 53 (fig. 11) controlled by the control unit 50. With each rotation, even partial, of the rotating element 51, a certain quantity of biomass C is introduced into the brazier 11, by means of an introduction conduit 54.

[0081] It is therefore clear that the quantity of biomass C introduced into the brazier 11, in a given unit of time, is a function of the rotation speed of the rotating element 51

(fig. 7).

[0082] In other embodiments, not shown in the drawings, the metering device 49 can comprise an auger.

[0083] The injection device 46 allows to introduce the biomass C into the brazier 11 in an automatic, controlled and continuous way, so as to allow to adjust the flow rate of biomass C introduced into the brazier 11.

[0084] The heating apparatus 10 also comprises a sensor 58 (figs. 7 and 11), also of a type known per se and for example consisting of a lambda probe, which is suitable to detect the quantity of oxygen present in the environment which surrounds it. In the example provided here, the sensor 58 is positioned downstream of the combustion chamber 20 and in particular inside the evacuation chamber 40.

[0085] In other embodiments, the sensor 58 can be disposed inside the evacuation pipes 38 and/or inside the recirculation conduits 28 in order to detect the quantity of oxygen in the fumes F.

[0086] The sensor 58 is connected to the control unit 50 and it is configured to transmit to the latter an electrical signal SP proportional to the quantity of oxygen detected by it.

[0087] The control unit 50 is configured to also control the first fan 29 and the second fan 39, and possibly also the third fan 45.

[0088] In addition, the control unit 50 is configured to command the operation of the recirculation means M2 in order to adjust the flow rate of the first comburent F1, and to command the operation of the injection device 46 in order to control the flow rate of the biomass C introduced into the brazier 11.

[0089] In particular, the control unit 50 can control the rotation speed of the first fan 29 and consequently the flow rate of the first comburent F1, the rotation speed of the second fan 39 and consequently the flow rate of the second comburent A, and the rotation speed of the rotating element 51 of the metering device 49 and consequently the flow rate of biomass C into the brazier 11.

[0090] In other embodiments not shown in the drawings, an element made of thermoconductive material, for example ceramic, can be attached at least to the lateral walls 22 of the combustion chamber 20, in order to increase the thermal inertia.

[0091] In other embodiments not shown in the drawings, one or more pipes for circulating water can be associated with at least the lateral walls 22 of the combustion chamber 20.

[0092] With reference to fig. 2, in a second embodiment, a heating apparatus 100 can comprise all the components of the heating apparatus 10 described above, except the heat exchange means M4. In this embodiment, the heating apparatus 100 can also comprise a second ignition device, not shown in the drawings, disposed substantially in proximity to the nozzle 30 and configured to trigger the combustion of the combustible gases S.

[0093] With reference to fig. 3, in a third embodiment, a

heating apparatus 200 can comprise all the components of the heating apparatus 10 described above, except the heat exchange means M4 and the first fan 29.

[0094] Also in this embodiment, the heating apparatus 200 can also comprise a second ignition device, not shown in the drawings, disposed substantially in proximity to the nozzle 30 and configured to trigger the combustion of the combustible gases S.

[0095] With reference to fig. 4, in a fourth embodiment, a heating apparatus 300 can comprise all the components of the heating apparatus 10 described above, except the first fan 29.

[0096] It should be noted that, in the third and fourth embodiments, the heating apparatus 200, 300 only comprises the second fan 39, connected to the combustion chamber 20 in order to draw the fumes F generated inside the latter.

[0097] Furthermore, in the third and fourth embodiments, a conduit connected downstream of the second fan 39 can be connected to the brazier 11 in order to function as a recirculation mean M3 to convey a first part F1 of the fumes F, which functions as a first comburent.

[0098] In other possible variants of the third and fourth embodiments, the conduit described above, which functions as a recirculation mean M3, can be disposed upstream of the second fan 39 and downstream of the combustion chamber 20 (figs. 5 and 6).

[0099] The operation of the heating apparatus 10 described heretofore, which corresponds to the method according to the present invention, comprises the following steps.

[0100] When the heating apparatus 10 is started, the control unit 50 drives the injection device 46 to introduce a certain quantity of biomass C into the brazier 11 and the ignition device 19 to ignite the biomass C in the brazier 11.

[0101] Furthermore, the control unit 50 drives the first fan 29 which takes a first comburent F1 from the combustion chamber 20 and introduces it into the brazier 11. We wish to clarify that, at start-up, substantially ambient air is present inside the combustion chamber 20.

[0102] The control unit 50 also drives the second fan 39 which draws the second comburent A from the external environment, through the feed apertures 31, and introduces the latter into the combustion chamber 20 through its entry aperture 33.

[0103] In this start-up step, the combustion between the biomass C inside the brazier 11 and the first comburent F1, which hereafter will be referred to as start-up combustion, is substantially of the reverse flame type, also called downdraft by the people of skill in the art, that is, by introducing the first comburent F1 into the brazier 11 from the top downward, in such a way that it passes, in this direction, through the biomass C disposed, during use, in the brazier 11 and consequently generating a flame which is also directed from the top downward, and fumes.

[0104] The fumes produced by the start-up combustion are conveyed into the combustion chamber 20 by means

of the conveyor compartment 21, thanks to the draw provided by the first fan 29 which, subsequently, re-introduces them into the brazier 11. Therefore, in this step, the first comburent F1 consists of a first part of the start-up combustion fumes.

[0105] In particular, a first part F1 of the start-up combustion fumes is drawn by the first fan 29 by means of the first recirculation apertures 27 and is re-introduced into the brazier 11 from its second aperture 18, functioning as first comburent F1, and a second part F2 of the start-up combustion fumes is drawn in by the second fan 39 by means of the evacuation apertures 36 and is expelled from the heating apparatus 10.

[0106] After a certain period of time, a steady state operating condition is reached, in which the first comburent F1 has a temperature and quantity of oxygen suitable to trigger the process of pyrolysis of the biomass C present in the brazier 11.

[0107] At this point, the first comburent F1 introduced into the brazier 11 is suitable to thermochemically decompose the biomass C inside the brazier 11 and produce combustible gases S.

[0108] It should be noted that the thermochemical decomposition of the biomass C also substantially occurs in downdraft, that is, by introducing the first comburent F1 into the brazier 11 from the top downward, in such a way that it passes, in this direction, through the biomass C which is disposed, during use, in the brazier 11. In this way, the combustible gases S produced by the thermochemical decomposition of the biomass C escape from the lower portion of the brazier 11.

[0109] This configuration is advantageous in that it forces the combustible gases S to pass through the biomass C contained in the brazier 11 and this allows to separate their volatile components, producing combustible gases S with less TAR.

[0110] Therefore, during steady state operation, it is no longer the fumes generated by the start-up combustion that exit from the exit aperture 15 of the brazier 11, but the combustible gases S generated by the thermochemical decomposition of the biomass C.

[0111] The method then provides to introduce the combustible gases S into the combustion chamber 20 by means of the conveyor compartment 21, thanks to the draw of the first fan 29. In fact, we wish to clarify that, when operating at steady state, only the combustible gases S pass through the conveyor means M2. In particular, in the example given here, when operating at steady state, only the combustible gases S that are introduced into the combustion chamber 20 pass through the conveyor compartment 21

[0112] The method then provides to oxidize, or ignite, the combustible gases S by means of the second comburent A introduced into the combustion chamber 20, producing a flame, fumes F and developing heat.

[0113] Optionally, the method can provide to heat the second comburent A, using the heat contained in the first comburent F1 before the second comburent A reaches

the combustion chamber 20. This heat exchange is preferably carried out in countercurrent.

[0114] It should be noted that, in this case, the ignition of the oxidation, or combustion, or fire, of the combustible gases S in the combustion chamber 20 occurs only by means of the "meeting" between the latter and the second heated comburent A. This is very advantageous, since it does not require the presence and use of additional ignition devices.

[0115] As before, a first part F1 of the fumes F generated, this time, by the combustion of the combustible gases S is drawn by the first fan 29 by means of the recirculation apertures 27 and is reintroduced into the brazier 11 from its comburent entry aperture 18, functioning as a first comburent F1, and a second part F2 of the fumes F is drawn by the second fan 39 by means of the evacuation apertures 36 and is expelled from the heating apparatus 10.

[0116] At this point, the first part F1 of the fumes F, reintroduced into the brazier 11, and which in fact functions as first comburent F1, has an oxygen component advantageously comprised between about 7% and about 12% by volume, which is smaller than that present in the ambient air. This is particularly advantageous since, by doing so, an anoxic environment is created in the brazier 11, that is, lacking in oxygen, which is present in a quantity sufficient to react mainly with the carbon present in the biomass C and generate the combustible gases.

[0117] Therefore, the production of polluting emissions such as, for example, nitrogen oxides, is significantly decreased since there is not a sufficient quantity of oxygen in the brazier 11 to bind with the nitrogen comprised in the biomass C.

[0118] Furthermore, when operating at steady state, the first part F1 of the fumes F, the moment it enters the brazier 11, has a temperature comprised between about 240°C and about 320°C, this is advantageous since at least part of the CO₂ present therein is re-converted into CO, that is, carbon monoxide, which is combustible. Another advantage is that the water present in gaseous phase in the first part F1 of the fumes F in the brazier 11 is converted into hydrogen, increasing the calorific value of the combustible gas S.

[0119] The control unit 50 can also control the injection device 46, the first fan 29 and the second fan 39 on the basis of the electrical signal received from the sensor 58. For example, the control unit 50 can modify the flow rate of the first comburent F1, of the second comburent A and/or of the biomass C in feedback, until the value detected by the sensor 58 reaches a predetermined target value. In fact, it should be noted that the injection device 46, the first fan 29 and the second fan 39 allow to manage the flow rate of the first comburent F1, of the second comburent A and/or of the biomass C in a coordinated way, so as to reduce the polluting emissions of the heating apparatus 10 and better manage the generation of heat thereby.

[0120] Optionally, the control unit 50 also drives the

third fan 45 to generate a flow of ambient air R which passes into the second compartment 42 in order to exchange heat with the evacuation pipes 38, heating up.

[0121] The heated ambient air R is then conveyed once again toward the external environment.

[0122] It is clear that modifications and/or additions of parts may be made to the heating apparatus 10 as described heretofore, without departing from the field and scope of the present invention as defined by the claims.

[0123] It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve equivalent forms of heating apparatus 10 within the scope of the present invention as defined in the claims.

[0124] In the following claims, the sole purpose of the references in brackets is to facilitate reading and they must not be considered as restrictive factors with regard to the field of protection defined by the claims.

Claims

1. Heating apparatus (10, 100, 200, 300), comprising a brazier (11) configured to receive a biomass (C) which functions as fuel and a first comburent (F1) and suitable to thermally decompose said biomass (C) and produce at least one combustible gas (S), wherein said brazier (11) is of the type substantially closed with respect to the external environment, such that the brazier (11) does not have any apertures that allow the comburent air to enter directly from the external environment, wherein said brazier (11) comprises a first entry aperture (16), connected to an injection device (46) which is configured to introduce, in a controlled, automatic, continuous and adjustable way, said biomass (C) into said brazier (11), wherein said brazier (11) comprises a second entry aperture (18) for said first comburent (F1) to enter and an exit aperture (15) for said at least one combustible gas (S) to exit, said exit aperture (15) being disposed at a lower level than the one at which at least said second entry aperture (18) is positioned, wherein said first and second entry apertures (16, 18) of said brazier (11) are disposed at a higher level than that on which said exit aperture (15) is located, in such a way that said first comburent (F1) and said biomass (C) enter said brazier (11) from the top downward and toward said exit aperture (15).
2. Heating apparatus (10, 100, 200, 300) as in claim 1, which also comprises a combustion chamber (20) autonomous with respect to said brazier (11) and having its own entry aperture (33) configured to receive said combustible gas (S), and conveyor means (M2) interposed between said brazier (11) and said entry aperture (33) of said combustion chamber (20) in order to convey said at least one combustible gas (S) into said combustion chamber (20).
3. Heating apparatus (10, 100, 200, 300) as in any claim hereinbefore, which also comprises a control unit (50) configured to control said injection device (46) in order to adjust the flow rate of said biomass (C) introduced into said brazier (11).
4. Heating apparatus (10, 100, 200, 300) as in claim 2 or 3, wherein said entry aperture (33) of said combustion chamber (20) is configured to receive a second comburent (A) from the external environment and wherein said heating apparatus (10, 100, 200, 300) also comprises both recirculation means (M3) to convey said first comburent (F1) from said combustion chamber (20) into said brazier (11), and also a fan (39) connected to an evacuation aperture (36) of said combustion chamber (20) and configured to force said second comburent (A) from the external environment toward the inside of said combustion chamber (20).
5. Heating method using a heating apparatus according to any claims hereinbefore, which comprises the following steps:
 - providing said brazier (11);
 - introducing, into said brazier (11), both the biomass (C) and also the first comburent (F1) in order to thermochemically decompose said biomass (C) and produce at least one combustible gas (S).
6. Heating method as in claim 5, which also comprises the following steps:
 - providing a combustion chamber (20) autonomous with respect to said brazier (11);
 - conveying said combustible gas (S) into said combustion chamber (20);
 - drawing a second comburent (A) from the external environment and conveying it into said combustion chamber (20); and
 - igniting said combustible gas (S) in order to develop heat by means of a flame.
7. Heating method as in claim 6, which also comprises the following steps:
 - drawing, from said combustion chamber (20), a first part (F1) of the fumes (F) produced by said flame and introducing it into said brazier (11), whereby said first part (F1) of said fumes (F) constitutes said first comburent (F1); and
 - drawing a second part (F2) of said fumes (F) from said combustion chamber (20) in order to

evacuate it into the external environment.

8. Heating method as in any claim from 5 to 7, wherein said biomass (C) is introduced into said brazier (11) in a substantially continuous way.

Patentansprüche

1. Heizvorrichtung (10, 100, 200, 300), die einen Brenner (11) umfasst, der so konfiguriert ist, dass er eine Biomasse (C), die als Brennstoff dient, und ein erstes Brennmittel (F1) aufnimmt und geeignet ist, die Biomasse (C) thermisch zu zersetzen und mindestens ein brennbares Gas (S) zu erzeugen, wobei der Brenner (11) von der Art ist, die gegenüber der äußeren Umgebung im Wesentlichen geschlossen ist, so dass der Brenner (11) keinerlei Öffnungen aufweist, durch die das luftartige Brennmittel direkt von der äußeren Umgebung eintreten kann, wobei der Brenner (11) eine erste Eintrittsöffnung (16) umfasst, die mit einer Einspritzvorrichtung (46) verbunden ist, die so konfiguriert ist, dass sie auf kontrollierte, automatische, kontinuierliche und einstellbare Weise die Biomasse (C) in den Brenner (11) einführt, wobei der Brenner (11) eine zweite Eintrittsöffnung (18) für den Eintritt des ersten Brennmittels (F1) und eine Austrittsöffnung (15) für den Austritt des mindestens einen brennbaren Gases (S) umfasst, wobei die Austrittsöffnung (15) auf einem niedrigeren Niveau angeordnet ist als dasjenige, auf dem zumindest die zweite Eintrittsöffnung (18) angeordnet ist, wobei die erste und zweite Eintrittsöffnung (16, 18) des Brenners (11) auf einem höheren Niveau angeordnet sind als dasjenige, auf dem die Austrittsöffnung (15) angeordnet ist, so dass das erste Brennmittel (F1) und die Biomasse (C) von oben nach unten und in Richtung der Austrittsöffnung (15) in den Brenner (11) eintreten.
2. Heizvorrichtung (10, 100, 200, 300) nach Anspruch 1, welche außerdem eine Brennkammer (20) umfasst, die in Bezug auf den Brenner (11) autonom ist und ihre eigene Eintrittsöffnung (33) aufweist, die so konfiguriert ist, dass sie das brennbare Gas (S) aufnimmt, sowie Fördermittel (M2), die zwischen dem Brenner (11) und der Eintrittsöffnung (33) der Brennkammer (20) angeordnet sind, um das mindestens eine brennbare Gas (S) in die Brennkammer (20) zu befördern.
3. Heizvorrichtung (10, 100, 200, 300) nach einem der vorhergehenden Ansprüche, welche außerdem eine Steuereinheit (50) umfasst, die so konfiguriert ist, dass sie die Einspritzvorrichtung (46) steuert, um die Durchflussmenge der in den Brenner (11) eingeführten Biomasse (C) einzustellen.

4. Heizvorrichtung (10, 100, 200, 300) nach Anspruch 2 oder 3, wobei die Eintrittsöffnung (33) der Brennkammer (20) so konfiguriert ist, dass sie ein zweites Brennmittel (A) aus der äußeren Umgebung aufnimmt, und wobei die Heizvorrichtung (10, 100, 200, 300) außerdem sowohl Rezirkulationsmittel (M3), um das erste Brennmittel (F1) aus der Brennkammer (20) in den Brenner (11) zu befördern, als auch ein Gebläse (39), das mit einer Evakuierungsöffnung (36) der Brennkammer (20) verbunden und so konfiguriert ist, dass es das zweite Brennmittel (A) aus der äußeren Umgebung in das Innere der Brennkammer (20) drückt, umfasst.
5. Heizverfahren, das die Heizvorrichtung gemäß irgendeinem der vorstehenden Ansprüche verwendet, wobei das Verfahren die folgenden Schritte umfasst:
 - Bereitstellen des Brenners (11);
 - Einführen sowohl der Biomasse (C) als auch des ersten Brennmittels (F1) in den Brenner (11), um die Biomasse (C) thermochemisch zu zersetzen und mindestens ein brennbares Gas (S) zu erzeugen.
6. Heizverfahren nach Anspruch 5, welches außerdem die folgenden Schritte umfasst:
 - Bereitstellen einer Brennkammer (20), die in Bezug auf den Brenner (11) autonom ist;
 - Zuführen des brennbaren Gases (S) in die Brennkammer (20);
 - Entnahme eines zweiten Brennmittels (A) aus der äußeren Umgebung und Befördern desselben in die Brennkammer (20); und
 - Zünden des brennbaren Gases (S), um mittels einer Flamme Wärme zu entwickeln.
7. Heizverfahren nach Anspruch 6, welches außerdem die folgenden Schritte umfasst:
 - Abziehen eines ersten Teils (F1) der von der Flamme erzeugten Abgase (F) aus der Brennkammer (20) und Einleiten derselben in den Brenner (11), wobei der erste Teil (F1) der Abgase (F) das erste Brennmittel (F1) bildet; und
 - Abziehen eines zweiten Teils (F2) der Abgase (F) aus der Brennkammer (20), um sie in die äußere Umgebung zu evakuieren.
8. Heizverfahren nach einem der Ansprüche 5 bis 7, wobei die Biomasse (C) im Wesentlichen kontinuierlich in den Brenner (11) eingeführt wird.

Revendications

1. Appareil de chauffage (10, 100, 200, 300), comprenant un brûleur (11) configuré pour recevoir une biomasse (C) qui fonctionne en tant que combustible et un premier comburant (F1), et approprié pour décomposer thermiquement ladite biomasse (C) et produire au moins un gaz combustible (S), dans lequel ledit brûleur (11) est du type sensiblement fermé par rapport à l'environnement extérieur, de sorte que le brûleur (11) ne présente pas de quelconques ouvertures qui permettent à l'air comburant d'entrer directement depuis l'environnement extérieur, dans lequel ledit brûleur (11) comprend une première ouverture d'entrée (16), reliée à un dispositif d'injection (46) qui est configuré pour introduire de manière commandée, automatique, continue et ajustable, ladite biomasse (C) dans ledit brûleur (11), dans lequel ledit brûleur (11) comprend une seconde ouverture d'entrée (18) pour que ledit premier comburant (F1) puisse entrer et une ouverture de sortie (15) pour que ledit au moins un gaz combustible (S) puisse sortir, ladite ouverture de sortie (15) étant disposée à un niveau inférieur à celui auquel au moins ladite seconde ouverture d'entrée (18) est positionnée, dans lequel lesdites première et seconde ouvertures d'entrée (16, 18) dudit brûleur (11) sont disposées à un niveau plus élevé que celui sur lequel ladite ouverture de sortie (15) est située, de telle manière que ledit premier comburant (F1) et ladite biomasse (C) pénètrent dans ledit brûleur (11) du haut vers le bas et vers ladite ouverture de sortie (15).
2. Appareil de chauffage (10, 100, 200, 300) selon la revendication 1, qui comprend également une chambre de combustion (20) autonome par rapport audit brûleur (11) et présentant sa propre ouverture d'entrée (33) configurée pour recevoir ledit gaz combustible (S), et des moyens de transport (M2) interposés entre ledit brûleur (11) et ladite ouverture d'entrée (33) de ladite chambre de combustion (20) afin de transporter lesdits au moins un gaz combustible (S) dans ladite chambre de combustion (20).
3. Appareil de chauffage (10, 100, 200, 300) selon l'une quelconque des revendications précédentes, qui comprend également une unité de commande (50) configurée pour commander ledit dispositif d'injection (46) afin d'ajuster le débit d'écoulement de ladite biomasse (C) introduite dans ledit brûleur (11).
4. Appareil de chauffage (10, 100, 200, 300) selon la revendication 2 ou 3, dans lequel ladite ouverture d'entrée (33) de ladite chambre de combustion (20) est configurée pour recevoir un second comburant (A) depuis l'environnement externe et dans lequel ledit appareil de chauffage (10, 100, 200, 300) comprend également des moyens de recirculation (M3) pour transporter ledit premier comburant (F1) depuis ladite chambre de combustion (20) jusque dans ledit brûleur (11), et également un ventilateur (39) relié à une ouverture d'évacuation (36) de ladite chambre de combustion (20) et configuré pour forcer ledit second comburant (A) depuis l'environnement externe vers l'intérieur de ladite chambre de combustion (20).
5. Procédé de chauffage utilisant un appareil de chauffage selon l'une quelconque des revendications précédentes, qui comprend les étapes suivantes consistant à :
 - fournir ledit brûleur (11) ;
 - introduire, dans ledit brûleur (11), à la fois la biomasse (C) et également le premier comburant (F1) afin de décomposer thermochimiquement ladite biomasse (C) et de produire au moins un gaz combustible (S).
6. Procédé de chauffage selon la revendication 5, qui comprend également les étapes suivantes consistant à :
 - fournir une chambre de combustion (20) autonome par rapport audit brûleur (11) ;
 - transporter ledit gaz combustible (S) jusque dans ladite chambre de combustion (20) ;
 - attirer un second comburant (A) depuis l'environnement externe et le transporter jusque dans ladite chambre de combustion (20) ; et
 - enflammer ledit gaz combustible (S) afin de développer de la chaleur au moyen d'une flamme.
7. Procédé de chauffage selon la revendication 6, qui comprend également les étapes suivantes consistant à :
 - attirer, depuis ladite chambre de combustion (20), une première partie (F1) des fumées (F) produites par ladite flamme et l'introduire dans ledit brûleur (11), ladite première partie (F1) desdites fumées (F) constituant ledit premier comburant (F1) ; et
 - attirer une seconde partie (F2) desdites fumées (F) depuis ladite chambre de combustion (20) afin de l'évacuer dans l'environnement extérieur.
8. Procédé de chauffage selon l'une quelconque des revendications 5 à 7, dans lequel ladite biomasse (C) est introduite dans ledit brûleur (11) d'une manière sensiblement continue.

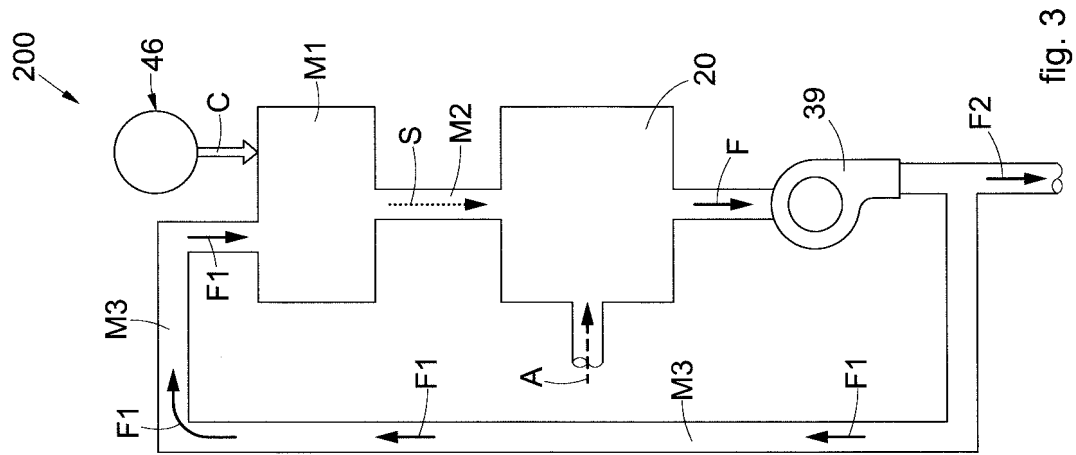


fig. 3

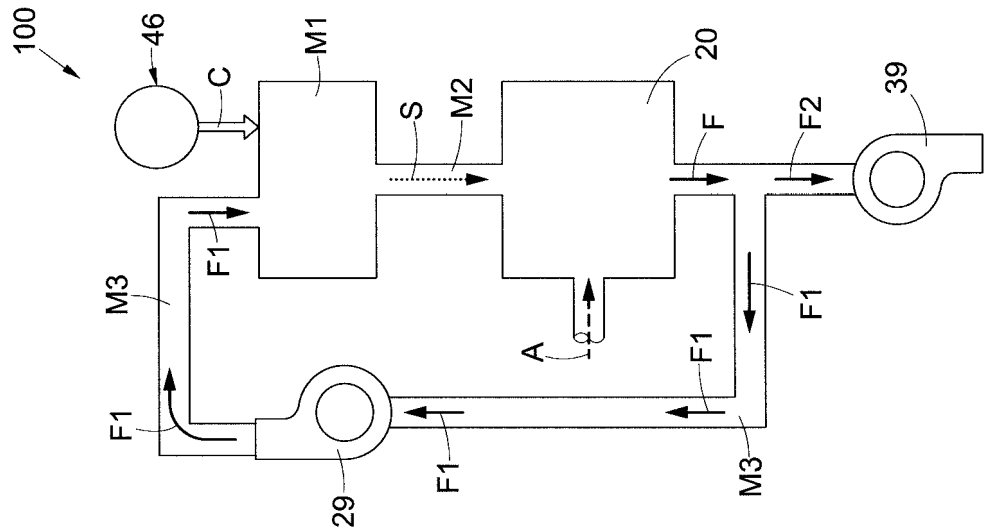


fig. 2

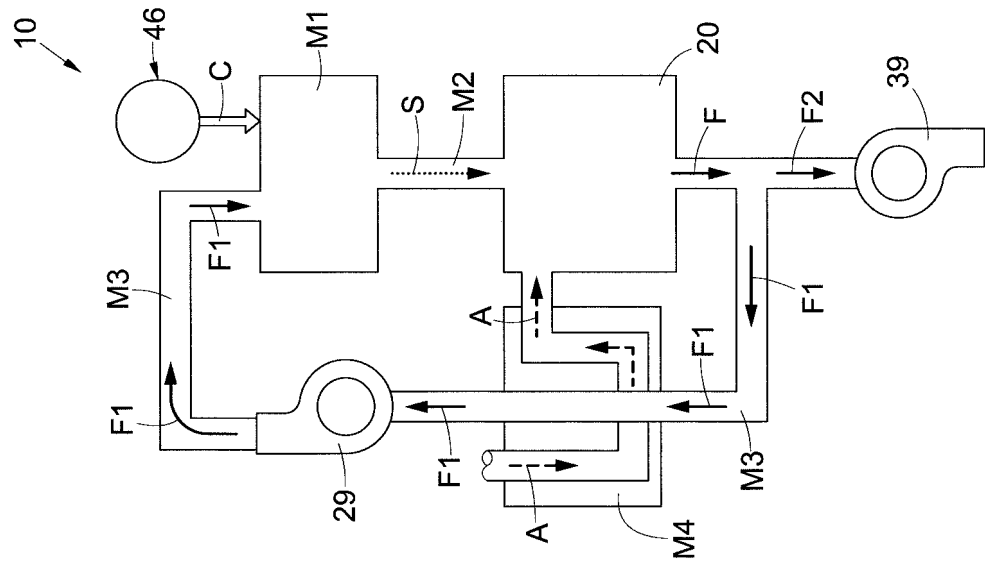
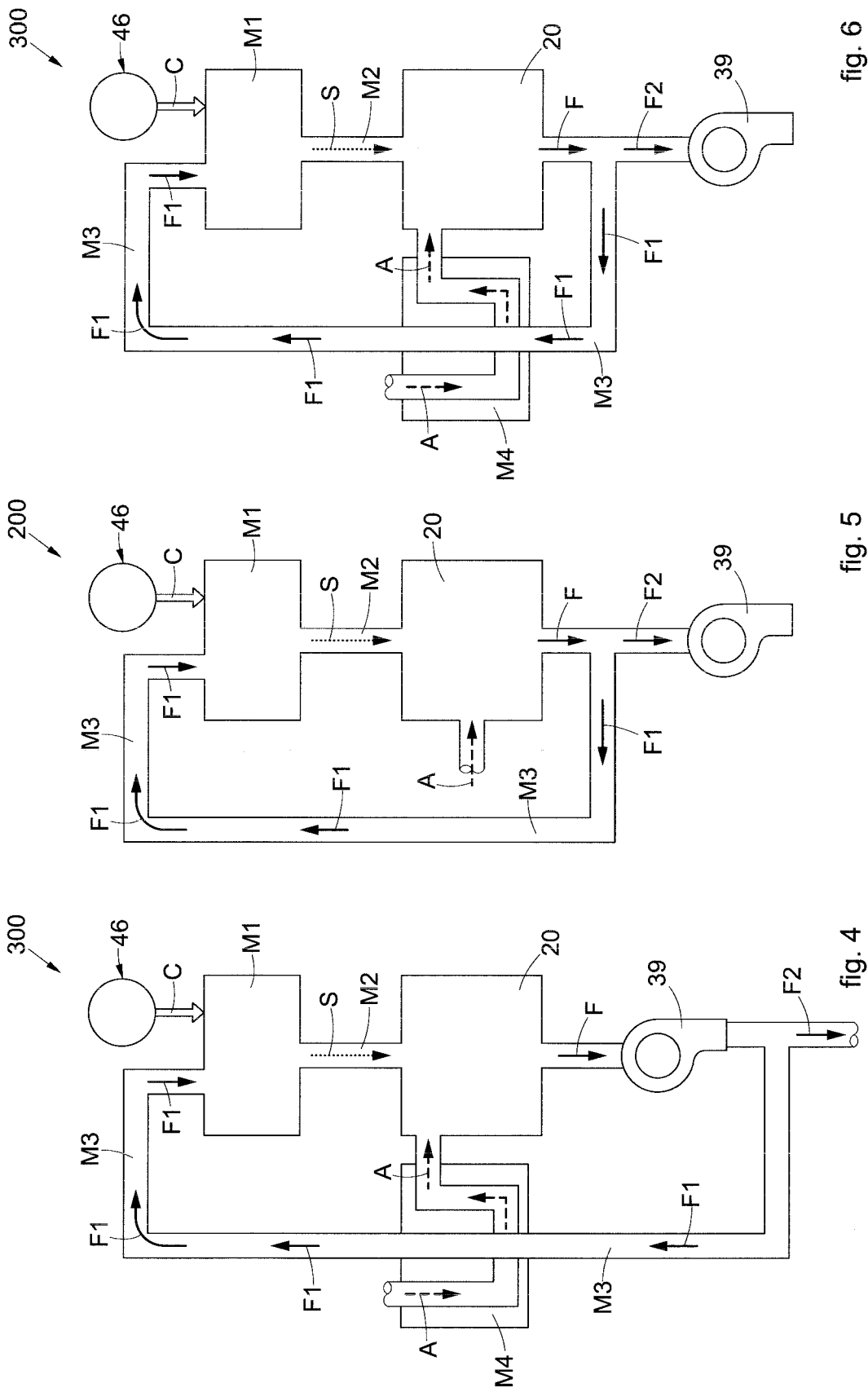


fig. 1



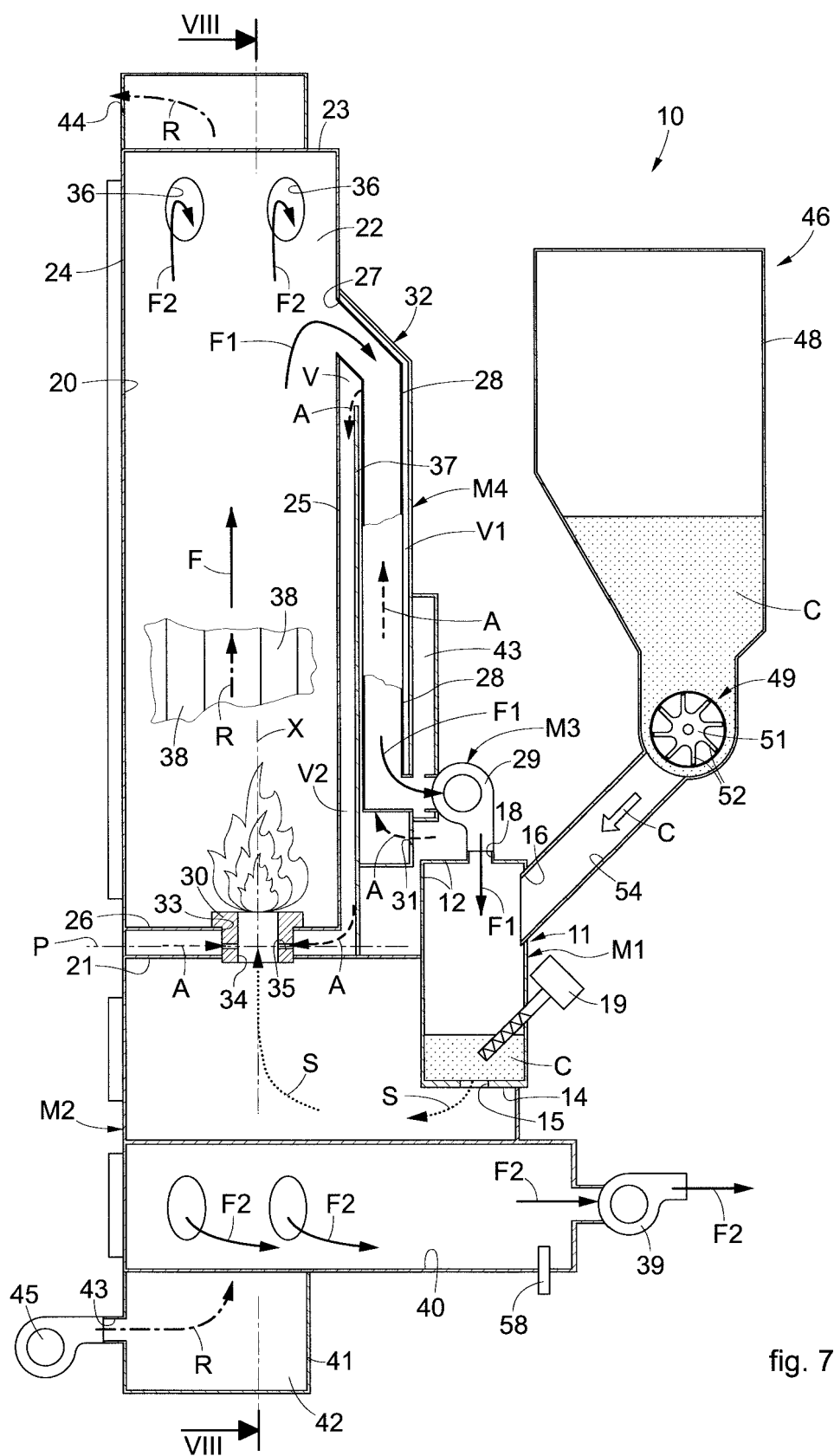


fig. 7

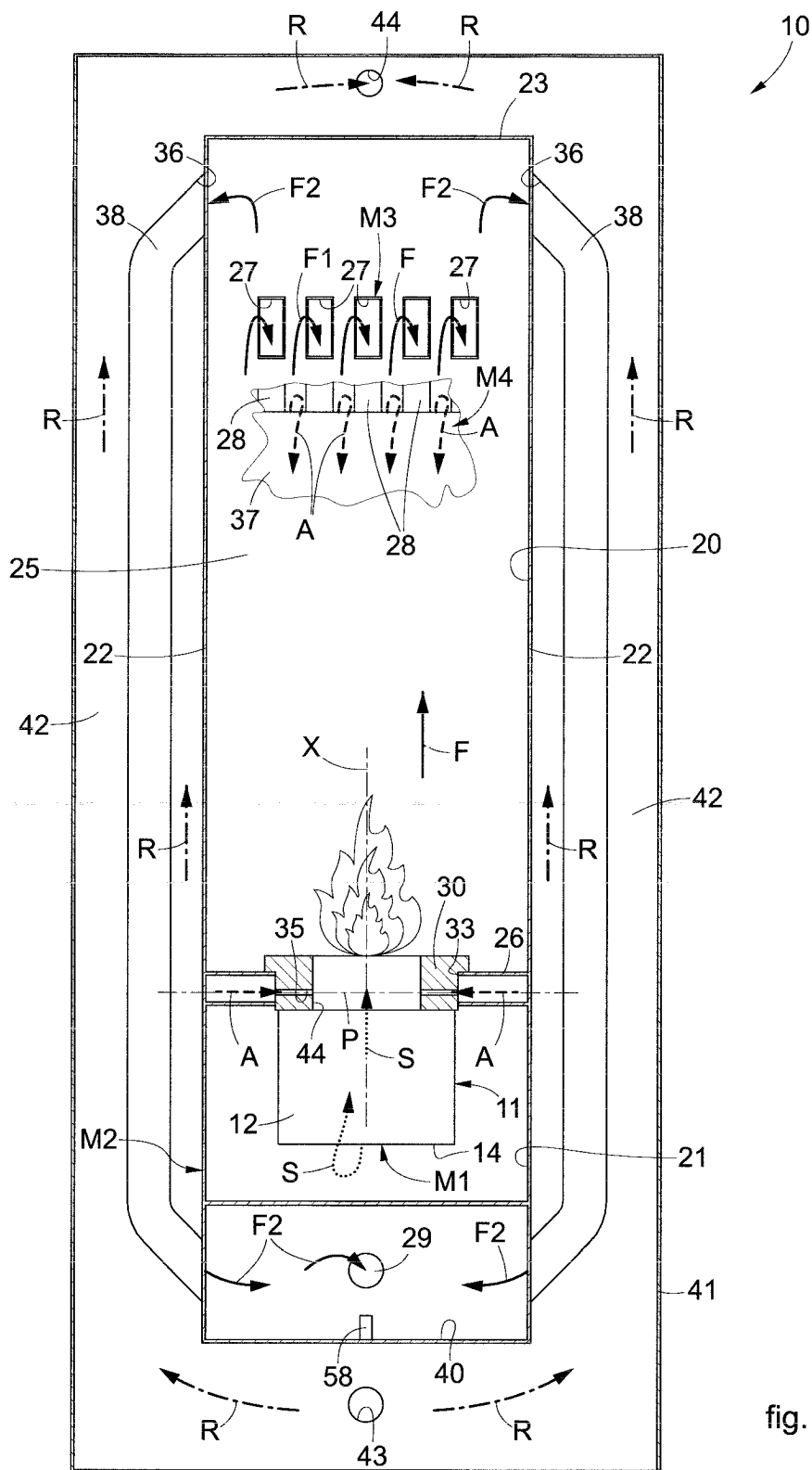
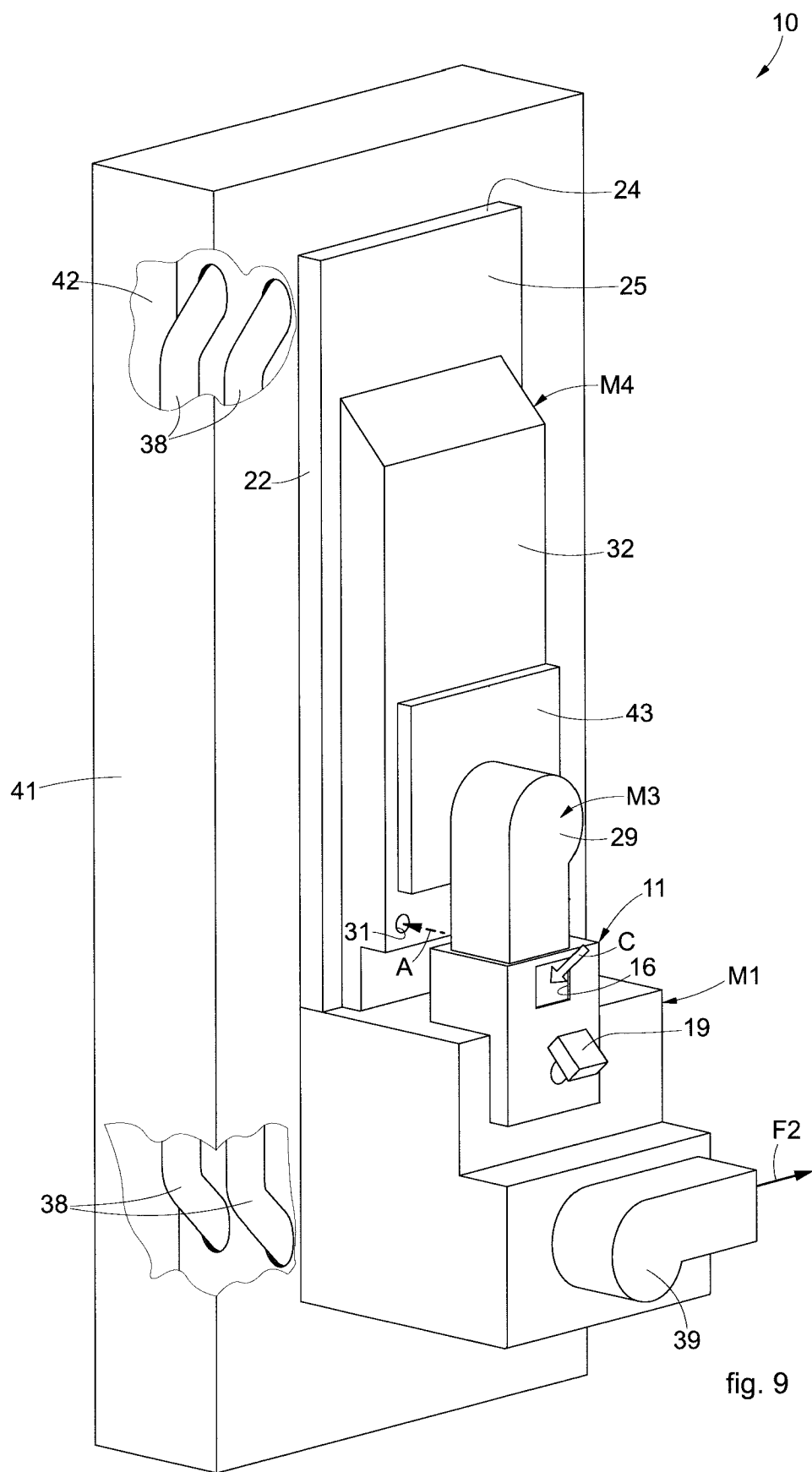


fig. 8



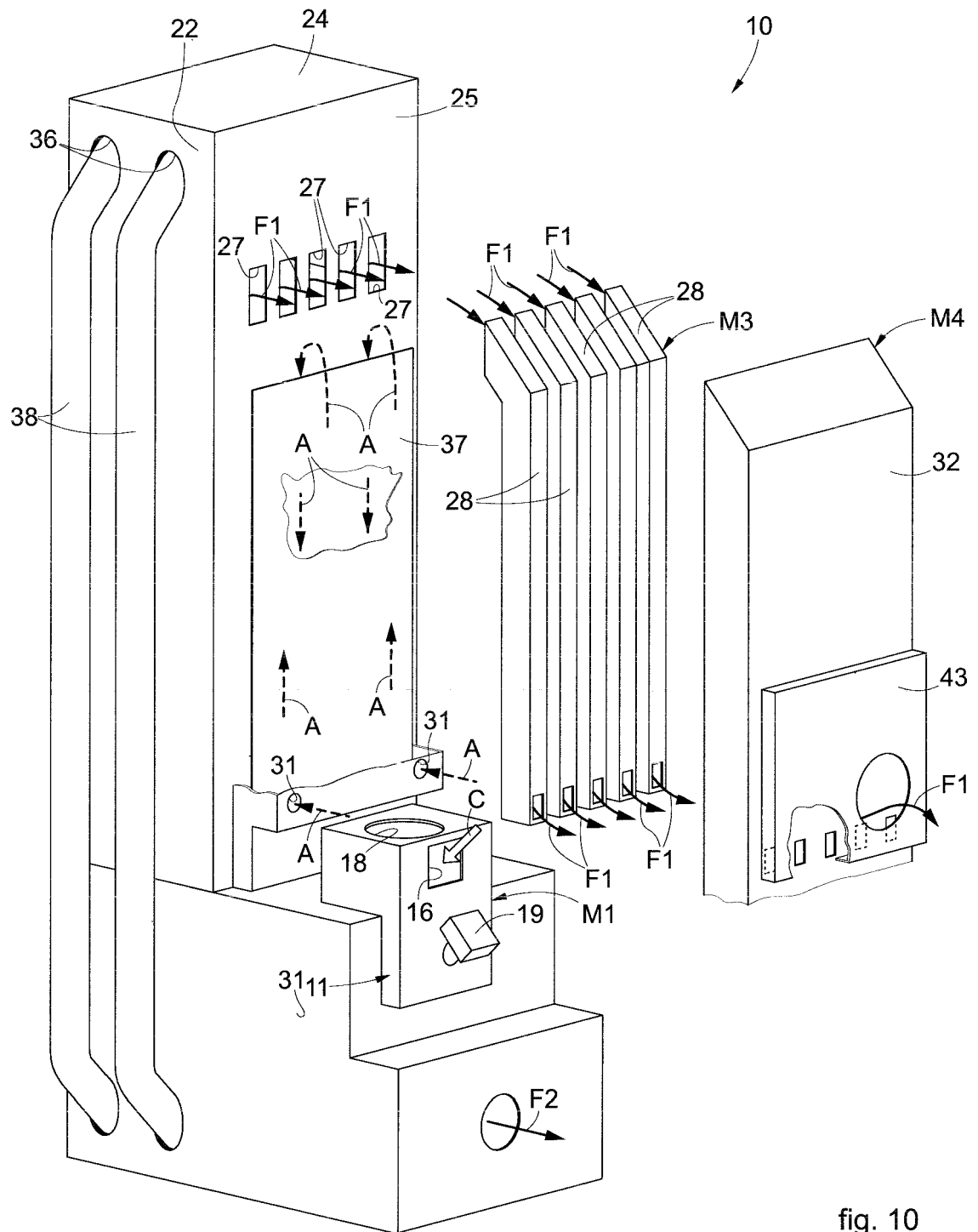


fig. 10

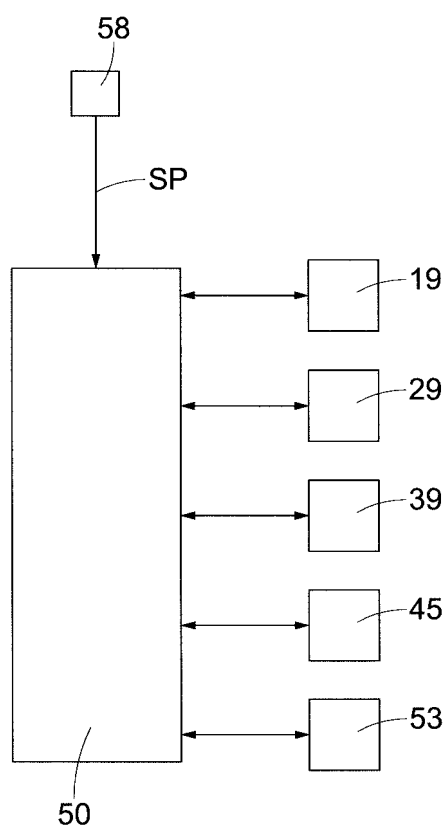


fig. 11

REFERENCES CITED IN THE DESCRIPTION

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