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(54) **PULSE SOOT BLOWER**

(57) A pulse soot blower for removing soot, ash and slag deposits from internal surfaces in fuel combustion facilities comprises (a) a mixture chamber connectable to sources of a combustible gas and an oxidizer; the mixture chamber configured for receiving and mixing the combustible gas and the oxidizer; (b) a passage of flame propagation fillable with the combustible gas-oxidizer

mixture fed from the mixing chamber; (c) an ignition assembly generating a deflagration wave within the passage; (d) a pulse generator configured for receiving the deflagration wave from the passage and generating a detonation wave therewithin. The pulse soot blower further comprises a first precompression chamber fluidly interconnecting the passage and the pulse generator

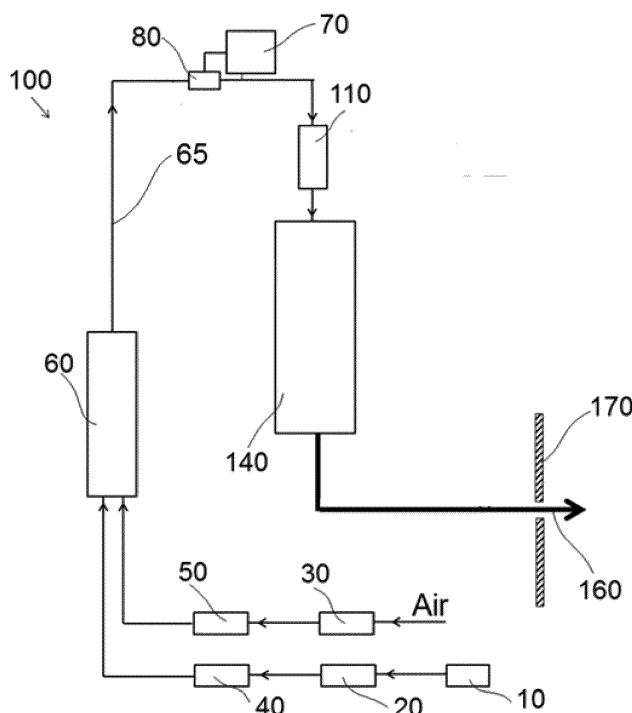


Fig. 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a gas pulse blower for removing soot, ash and slag deposits from external surfaces of internal elements in fuel combustion facilities, and, more specifically, to a gas pulse blower provided with at least one pre-compression chamber.

BACKGROUND OF THE INVENTION

[0002] Proper maintenance of fuel combustion facilities generally includes removal of undesired soot deposits on external surfaces of internal elements within an exhaust path of combustion products.

[0003] EP 2329191 discloses a gas impulse blower for cleaning a surface within a vessel fillable with a combustion gas-oxidizer mixture. The blower comprises: (a) a combustion assembly configured to generate a deflagration wave; and (b) an impulse generator having an inlet and an outlet and adapted to receive the deflagration wave into said inlet and eject the detonation wave from said outlet onto a surface to be cleaned. The impulse generator has a compartmentalized housing comprising at least two serially-connected compartments. The compartments are configured for being fed with said gas-oxidizer mixture by the combustion assembly in an individual manner so as to conduct the wave to the outlet.

[0004] A detonation wave generated by the gas pulse blowers known in the art depends on a mass of a combustible gas-oxidizer mixture which is defined by a length of a passage filled with the combustible gas-oxidizer mixture where the deflagration wave propagates. Augmentation of the generated detonation wave results in increase in dimensions of the gas pulse blower. In addition, amount of combustible gas-oxidizer mixture within the passage cannot be adjustable regarding a desirable impact force to be generated. Thus, there is a long-felt and unmet need for providing an effective device characterized by adjustability of the generated impact force and compactness.

SUMMARY OF THE INVENTION

[0005] It is hence one object of the invention to disclose a pulse soot blower for removing soot, ash and slag deposits from external surfaces of internal elements in fuel combustion equipment. The aforesaid pulse soot blower comprises (a) a mixture chamber connectable to sources of a combustible gas and an oxidizer; the mixture chamber configured for receiving and mixing the combustible gas and the oxidizer; (b) a passage of flame front propagation fillable with the combustible gas-oxidizer mixture fed from the mixing chamber; (c) an ignition assembly generating flame front within the passage; (d) a pulse generator configured for receiving the flame front from the passage and generating a detonation wave there-

within.

[0006] It is a core purpose of the invention to provide the pulse soot blower further comprising a first pre-compression chamber fluidly interconnecting the passage and the pulse generator.

[0007] Another object of the invention is to disclose the combustible gas selected from the group consisting of hydrogen, acetylene, propane, butane, methane or any combination thereof.

10 [0008] A further object of the invention is to disclose the oxidizer selected from the group consisting of oxygen and air.

[0009] A further object of the invention is to disclose the pre-compression chamber comprising at least one 15 turbulator.

[0010] A further object of the invention is to disclose the pulse generator comprising at least one turbulator.

[0011] A further object of the invention is to disclose the turbulator which is ovoid-shaped.

20 [0012] A further object of the invention is to disclose the combustible gas fed into the mixing chamber by a first compressor.

[0013] A further object of the invention is to disclose the oxidizer fed into the mixing chamber by a second 25 compressor.

[0014] A further object of the invention is to disclose the at least one of the first and second compressors which is an electrical-lightening-in-water compressor.

[0015] A further object of the invention is to disclose the pulse soot blower comprising at least one second 30 pre-compression chamber interconnecting the passage and the pulse generator in parallel with the first pre-compression chamber.

[0016] A further object of the invention is to disclose the pulse soot blower comprising a bypass interconnecting 35 the passage and the pulse generator.

[0017] A further object of the invention is to disclose the pulse soot blower comprising at least one first normally open valve located in a location selected from the 40 group consisting of an inlet of the first pre-compression chamber; the at least one second pre-compression chamber, bypass and any combination thereof.

[0018] A further object of the invention is to disclose the pulse soot blower comprising at least one second 45 normally closed valve configured for operating in an ultrafast manner; the second normally closed valve is located in a location selected from the group consisting of an outlet of the first pre-compression chamber; the at least one second pre-compression chamber, an outlet of 50 the pulse generator and any combination thereof.

[0019] A further object of the invention is to disclose the pulse soot blower soot comprising bombarding means configured for inserting ballistic bodies into said detonation wave.

55 [0020] A further object of the invention is to disclose a method of removing soot, ash and slag deposits from external surfaces of internal elements in fuel combustion equipment. The aforesaid method comprises steps of:

(a) providing a pulse soot blower further comprising: (i) a mixture chamber connectable to sources of a combustible gas and an oxidizer; the mixture chamber configured for receiving and mixing the combustible gas and the oxidizer; (ii) a passage of flame front propagation fillable with the combustible gas-oxidizer mixture fed from the mixing chamber; (iii) an ignition assembly generating flame front propagation within the passage; (iv) a pulse generator configured for receiving the flame front propagation from the passage and generating a detonation wave therewithin; the pulse soot blower further comprises at least one pre-compression chamber fluidly interconnecting the passage and the pulse generator; the pulse soot blower further comprises at least one first normally open valve located at an inlet of any one of the at least two pre-compression chambers in parallel therebetween; the pulse soot blower further comprises at least one second normally closed valve configured for operating in an instant manner; the at least one second normally closed valve is located in a location selected from the group consisting of an outlet of the at least one pre-compression chamber, outlet of the pulse generator and any combination thereof; (b) filling the passage, the at least one pre-compression chamber and pulse generator with the combustible gas-oxidizer mixture; (c) igniting the combustible gas-oxidizer mixture within the passage by ignition assembly and forming flame front within ignition assembly; (d) synchronically to the step of igniting the combustible gas-oxidizer mixture and opening the normally closed second valves; (e) propagating the flame front via at least one pre-compression chamber into the pulse generator; (f) transiting the flame front to a detonation wave within the pulse generator; and (g) blowing off the detonation wave into an interior of the heat-generating facilities.

[0021] A further object of the invention is to disclose the method comprising a step of turbulizing the gas-oxidizer mixture in the at least one pre-compression chamber by at least one turbulator.

[0022] A further object of the invention is to disclose the method comprising a step of turbulizing the gas-oxidizer mixture in the pulse generator by at least one turbulator.

[0023] A further object of the invention is to disclose the method comprising a step of feeding the combustible gas into the mixing chamber by a first compressor.

[0024] A further object of the invention is to disclose the method comprising a step of feeding the oxidizer into the mixing chamber by a second compressor.

[0025] A further object of the invention is to disclose the method comprising a step of providing a bypass interconnecting the passage and the pulse generator; the bypass is provided with the first valve thereon.

[0026] A further object of the invention is to disclose the step filling the passage, the at least one pre-compression chamber and pulse generator with the combustible gas-oxidizer mixture comprises successively executable sub-steps of filling the pulse generator with the

combustible gas-oxidizer mixture up to a first pressure thereof via the bypass, closing the first normally open valve located at the bypass, filling the at least one pre-compression chamber up to a second pressure; the first pressure is lower than the second pressure.

[0027] A further object of the invention is to disclose the method comprising steps of filling the pulse generator with air via the bypass up to a third pressure, closing the first normally open valve located at the bypass and generating a pneumatic shock onto the internal surfaces in heat-generating facilities by fast opening the second normally closed second valve located at the outlet of the pulse generator.

[0028] A further object of the invention is to disclose a valve driven by an electric discharge in water. The aforesaid valve comprises: (a) a housing; (b) a first passage configured for conducting a fluid flow to be controlled; (c) a member movable in a reciprocative manner; the member configured for releasably blocking the fluid flow within the passage.

[0029] It is a core purpose of the invention to provide the housing comprising an electric discharge chamber filled with water and provided with a pair of heteropolar electrodes immersed in the water. The pair of heteropolar electrodes is connectable to a high-voltage power supply configured for energizing the pair of heteropolar electrodes. The member is movable within a second passage between first and second positions corresponding open and closed positions of the valve, respectively; the second passage is in fluid connection with the electric discharge chamber such that gases and steam generated by the electric discharge in water move in an instant the member from the first position to the second position and vice versa.

[0030] A further object of the invention is to disclose the first and second passages intersecting each other. The member comprises a through bore; coincidence of the through bore with the first passage corresponds to the first position. No coincidence corresponds to the second position.

[0031] A further object of the invention is to disclose the member provided with a piston reciprocatively movable within a piston chamber in an airtight manner.

[0032] A further object of the invention is to disclose the piston chamber provided with a labyrinth channel providing resistance for an air flow vented from said piston chamber and so that the impact generated by rise in the internal pressure is cushioned. A vacuum breaker configured for filling said piston chamber with ambient air.

[0033] A further object of the invention is to disclose the electric discharge chamber which is in fluid connection with ambient air via a labyrinth channel and a drain trap.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] In order to understand the invention and to see how it may be implemented in practice, a plurality of em-

bodiments is adapted to now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which

Fig. 1 is a schematic diagram of a first embodiment of a pulse soot blower;

Fig. 2 is a schematic diagram of a second embodiment of a pulse soot blower;

Figs 3a and 3b are schematic diagrams of a first embodiment of a pump for feeding a combustible gas/air at phases of filling and ejection, respectively;

Figs 4a and 4b are schematic diagrams of a first embodiment of a pump for feeding a combustible gas/air at phases of filling and ejection, respectively; and

Fig. 5a and 5b are schematic diagrams of an ultra-fast valve in closed and open positions, respectively.

DETAILED DESCRIPTION OF THE INVENTION

[0035] The following description is provided, so as to enable any person skilled in the art to make use of said invention and sets forth the best modes contemplated by the inventor of carrying out this invention. Various modifications, however, are adapted to remain apparent to those skilled in the art, since the generic principles of the present invention have been defined specifically to provide a pulse soot blower for removing soot, ash and slag deposits from internal surfaces in heat-generating facilities and a method of doing the same.

[0036] The present invention is based on generation of a flame front wave within a combustible gas-oxidizer mixture and transiting the aforesaid flame front wave to a detonation wave. The present invention is applicable to cleaning the external surfaces of different types of tubes (pipes, tube bundles, fin tubes etc.) or other surfaces in steam generators (boilers) and other fuel burning equipment. The soot pulse blower is also usable for preventing accumulation of sedimentations, bridging or build-ups of any kind of powders in industry as well.

[0037] Cleaning contaminations like ash, soot, slug, etc. on different heat transfer surfaces in boilers, furnaces, heaters and incinerators or other fuel burning equipment such as combustion chambers, pipe bundles, economizers, super heaters, air preheaters, heaters and filters which are exploited at power stations, chemical plants, petrochemical, oil refinery plants, waste-to-energy plants, pulp and paper industry etc. are also in the scope of the present invention.

[0038] Reference is now made to Fig. 1 presenting first embodiment 100 of the present invention. The operational principle, as mentioned above, is based on ignition of a combustible gas-oxidizer mixture and creating a flame front wave which on its path transmits to a detonation

wave (not shown). Use of hydrogen, acetylene, propane, butane, methane or any other combustible gas is in the scope of the present invention. Numeral 10 refers to a source of a combustible gas such as a gas cylinder or bottle, a gas producer unit or alike. The combustible gas is pumped from source 10 via receiver chamber 40 to mixture chamber 60 by gas pump 20. Oxygen of air is used as an oxidizer. Therefore, atmosphere air is fed to mixture chamber 60 via receiver chamber 50 by pump 30. A combustible gas-air mixture obtained in mixture chamber 60 then flows into passage 65, pre-compression chamber 110 and pulse generator 140. Ignitor 80 is embedded into a wall of passage 65 and controlled by ignition control unit 70. A flame front wave initiated by a spark generated by ignitor 80 propagates along passage 65 via pre-compression chamber 110 and reaches pulse generator 140. The purpose of introduction pre-compression chamber 110 into the soot pulse blower is to increase a mass of deflagrated gas mixture and boost a deflagration wave force. It should be emphasized that a flame front of the deflagration wave generated within pre-compression chamber propagating into pulse generator 140 acts like a piston within a combustion engine at the phase of compression. The flame front pushes the combustible gas-air mixture located in front of it into the pulse generator 140. In other words, the flame front when it propagates along its path increases pressure of the combustible gas-air mixture and finally a shock force. When the flame front reaches pulse generator 140, deflagration-to-detonation transition occurs. To show schematically operation of the soot pulse blower, outlet 160 is inserted into an opening in wall 170 of a heat-generating facility.

[0039] Reference is now made to Fig. 2 presenting second embodiment 100a of the present invention. Pre-compression chambers 90 and 110 interconnect passage 65 and pulse generator 140 in a parallel manner. Any number of pre-compression chambers is in the scope of the present invention. Second embodiment 100a comprises normally open valves 120, 123 and 125 and normally closed valves 130, 133 and 135. The latter normally closed valves 130, 133 and 135 are controlled by ignition control unit 70 and openable synchronically with ignition of the combustible gas-air mixture by ignitor 80. According to one embodiment of the present invention, bypass 67 is parallel to pre-compression chambers 90 and 110.

[0040] An exemplary operating procedure is the following. A combustible gas and air are mixed in mixture chamber 60. Then, passage 65, at least one of pre-compression chambers 90 and 110 and pulse generator 140 are filled with the combustible gas-air mixture at initial pressure. Any one of pre-compression chambers 90 and 110 will not be filled with the combustible gas-air mixture if corresponding normally open valves 120 or 123 is closed. It should be emphasized that embodiment 100a provides adjustability of the generated detonation wave by means of change in pressure of the combustible gas-air mixture accommodated in pre-compression chambers 90 and 110 and pulse generator 140. Specifically, at the step of

initial filling, valves 120, 123 and 125 are open while valves 130, 133 and 135 are closed. After the aforesaid step of initial filling, valve 125 is closed and the pressure in the passage 65 is increased by pumps 20 and 30. Therefore, pre-compression chambers 90 and 110 are filled with the combustible gas-air mixture at elevated pressure. Filling pre-compression chambers in an individual manner is also in the scope of the present invention.

[0041] At the step of ignition of the combustible gas-air mixture accommodated in the soot pulse blower, a spark of ignitor 80 generates a flame front (not shown) which propagates along passage 65 and pre-compression chambers 90 and 110. As mentioned above, normally closed valves 130, 133 and 135 are controlled by ignition control unit 70. Aforesaid valves 130, 133 and 135 are opened synchronically with ignition of the combustible gas-air mixture. Therefore, the deflagration wave of improved force reaches pulse generator 140 where deflagration-to-detonation transition occurs.

[0042] According to one embodiment of the present invention, the soot pulse blower is provided with bombarding means 150 configured for inserting ballistic bodies 155 into the detonation wave generated within pulse generator 140.

[0043] According to one embodiment of the present invention, any one of pre-compression chambers or pulse generator is provided with at least one turbulator therewithin (not shown), for example, an oloid.

[0044] The innovation implemented in the present invention provides a compact apparatus with an adjustable wave force of the generated shock.

[0045] Reference is now made to Figs 3a and 3b presenting first exemplary embodiment of pump 20/30 in Figs 1 and 2. Figs 3a and 3b depict positions 200a and 200b corresponding to pumping-in and pumping-out phases. The operational principle of pump is based on an electric discharge in water. Specifically, housing 260 includes electric discharge chamber 230 and heteropolar electrodes 210 and 220. The latter electrodes are connectable to a high-voltage power supply (not shown). The pump comprises piston 270 reciprocally movable within chamber 280. High voltage applied to electrodes 210 and 220 generates an electric breakdown in water accommodated in chamber 230. Rise in internal pressure moves piston 270 from a lower position in Fig. 3a to an upper position in Fig. 3b. The rise in the internal pressure is caused by heating the water resulting in steam generation. A pause after an electric voltage pulse brings about to steam condensation, drop in the internal pressure and return of piston 270 into the lower position. It should be mentioned that chamber 230 is in fluid connection with ambient air via a labyrinth channel 240 and a drain trap 250. Combustible gas or air is pumped into pump chamber 280 via labyrinth channel 290 and pumped out into outlet pipe 310 via check valve 300.

[0046] Reference is now made to Figs 4a and 4b presenting second exemplary embodiment of pump 20/30

in Figs 1 and 2. Figs 4a and 4b depict positions of 400a and 400b corresponding to pumping-in and pumping-out phases. Summarizing the technical features discriminating between the first and second embodiments, contrary to a piston arrangement in the first embodiment, in the second embodiment, flexible membrane 410 is a driving element. Specifically, at the electric discharge phase (Fig. 4a), rise in internal pressure in electric discharge chamber 230 due to generation of steam therewithin arches flexible membrane 410. At the pause phase, flexible membrane 410 returns to the initial position.

[0047] Reference is now made to Figs 5a and 5b presenting exemplary embodiments 500a and 500b of the second valve which comprises a housing 530 having first passage 520 configured for conducting a fluid flow to be controlled. Numerals 523 and 525 refer to inlet and outlet of first passage 520. Member 510 is reciprocally movable within second passage 513. As mentioned above, the second valve is normally closed (Fig. 5a). Member 510 is provided with through bore 515. At the electric discharge phase, member 510 is movable upwards due to rise in the internal pressure in chamber 230 such that through bore 515 coincides with first passage 520. Coincidence of through bore 515 and first passage 520 corresponds to the open position of the second valve (Fig. 5b). Similar to the pumps described above, member 510 returns to its initial position (closed position) at the pause phase. It should be mentioned that piston chamber 505 here functions as a pneumatic damper absorbing an impact force generated by rise in the internal pressure in chamber 230. Specifically, at the phase valve opening, the air accommodated in chamber 505 is vented to atmosphere via labyrinth channel 550. The aforesaid labyrinth channel 550 provides resistance for the vented air flow and so that the impact generated by rise in the internal pressure in chamber 230 is cushioned. At the pause phase of steam condensation, ambient air can be sucked into chamber 230 via vacuum breaker 550.

Claims

1. A pulse soot blower for removing soot, ash and slag deposits from internal surfaces in fuel burning equipment; said pulse soot blower comprising
 - a. a mixture chamber connectable to sources of a combustible gas and an oxidizer; said mixture chamber configured for receiving and mixing said combustible gas and said oxidizer;
 - b. a pipe-shaped passage fillable with said combustible gas-oxidizer mixture fed from said mixing chamber; said pipe-shaped passage configured for flame front propagation;
 - c. an ignition assembly generating a flame front wave within said passage;
 - d. a pulse generator chamber being in fluid connection with pipe-shaped passage; said pulse

generator configured for receiving said flame front wave from said passage and generating a detonation wave therewithin;

wherein said pulse soot blower further comprising a first pre-compression chamber said passage downstream to said ignition assembly and upstream to said pulse generator; said first pre-compression chamber is configured for forming a detonation wave therewithin.

2. The pulse soot blower according to claim 1 wherein said combustible gas is selected from the group consisting of hydrogen, acetylene, propane, butane, methane or any combination thereof.

3. The pulse soot blower according to claim 1, wherein said oxidizer is selected from the group consisting of oxygen and air.

4. The pulse soot blower according to claim 1, wherein said pre-compression chamber comprises at least one turbulator.

5. The pulse soot blower according to claim 1, wherein said pulse generator comprises at least one turbulator.

6. The pulse soot blower according to claims 4 or 5, wherein said at least one turbulator is oloid-shaped.

7. The pulse soot blower according to claim 1, wherein said combustible gas is fed into said mixing chamber by a first compressor.

8. The pulse soot blower according to claim 1, wherein said oxidizer is fed into said mixing chamber by a second compressor.

9. The pulse soot blower according to claim 1 comprising at least one second pre-compression chamber interconnecting said passage and said pulse generator in parallel with said first pre-compression chamber.

10. The pulse soot blower according to claim 1 comprising a bypass interconnecting said passage and said pulse generator.

11. The pulse soot blower according to claims 1, 9 or 10 comprising at least one first normally open valve located in a location selected from the group consisting of an inlet of said first pre-compression chamber; said at least one second pre-compression chamber, bypass and any combination thereof.

12. The pulse soot blower according to claims 1, 9 or 10 comprising at least one second normally closed

valve configured for operating in an ultrafast manner; said second normally closed valve is located in a location selected from the group consisting of an outlet of said first pre-compression chamber; said at least one second pre-compression chamber, an outlet of said pulse generator and any combination thereof.

13. The pulse soot blower according to claim 1 comprising bombarding means configured for inserting ballistic bodies into said detonation wave.

14. A method of removing soot, ash and slag deposits from internal surfaces in heat-generating facilities; said method comprising steps of:

a. providing a pulse soot blower further comprising:

i. a mixture chamber connectable to sources of a combustible gas and an oxidizer; said mixture chamber configured for receiving and mixing said combustible gas and said oxidizer;

ii. a pipe-shaped passage fillable with said combustible gas-oxidizer mixture fed from said mixing chamber; said pipe-shaped passage configured for flame front propagation;

iii. an ignition assembly generating a flame front within said passage;

iv. a pulse generator chamber being in fluid connection with pipe-shaped passage; said pulse generator configured for receiving said flame front from said passage and generating a detonation wave therewithin;

said pulse soot blower further comprises at least one pre-compression chamber disposed on said passage downstream to said ignition assembly and upstream to said pulse generator; each of said pre-compression chambers is configured for forming a detonation wave therewithin; said pulse soot blower further comprises at least one first normally open valve located at an inlet of any one of said at least two pre-compression chambers in parallel therebetween; said pulse soot blower further comprises at least one second normally closed valve configured for operating in an ultrafast manner; said at least one second normally closed valve is located in a location selected from the group consisting of an outlet of said at least one pre-compression chamber, outlet of said pulse generator and any combination thereof;

b. filling said passage, said at least one pre-compression chamber and pulse generator with said combustible gas-oxidizer mixture;

- c. igniting the combustible gas-oxidizer mixture within the passage by ignition assembly and forming flame front within ignition assembly;
- d. synchronically to said step of igniting said combustible gas-oxidizer mixture and opening said second normally closed second valves; 5
- e. forming a flame front deflagration wave within said at least one pre-compression chamber;
- f. transiting a combustion mode from deflagration to detonation; 10
- g. propagating the flame front from at least one pre-compression chamber into the pulse generator;
- h. detonating said combustible gas-oxidizer mixture accommodated within said pulse generator; 15
- and
- i. blowing off said detonation wave into an interior of said heat-generating facilities.

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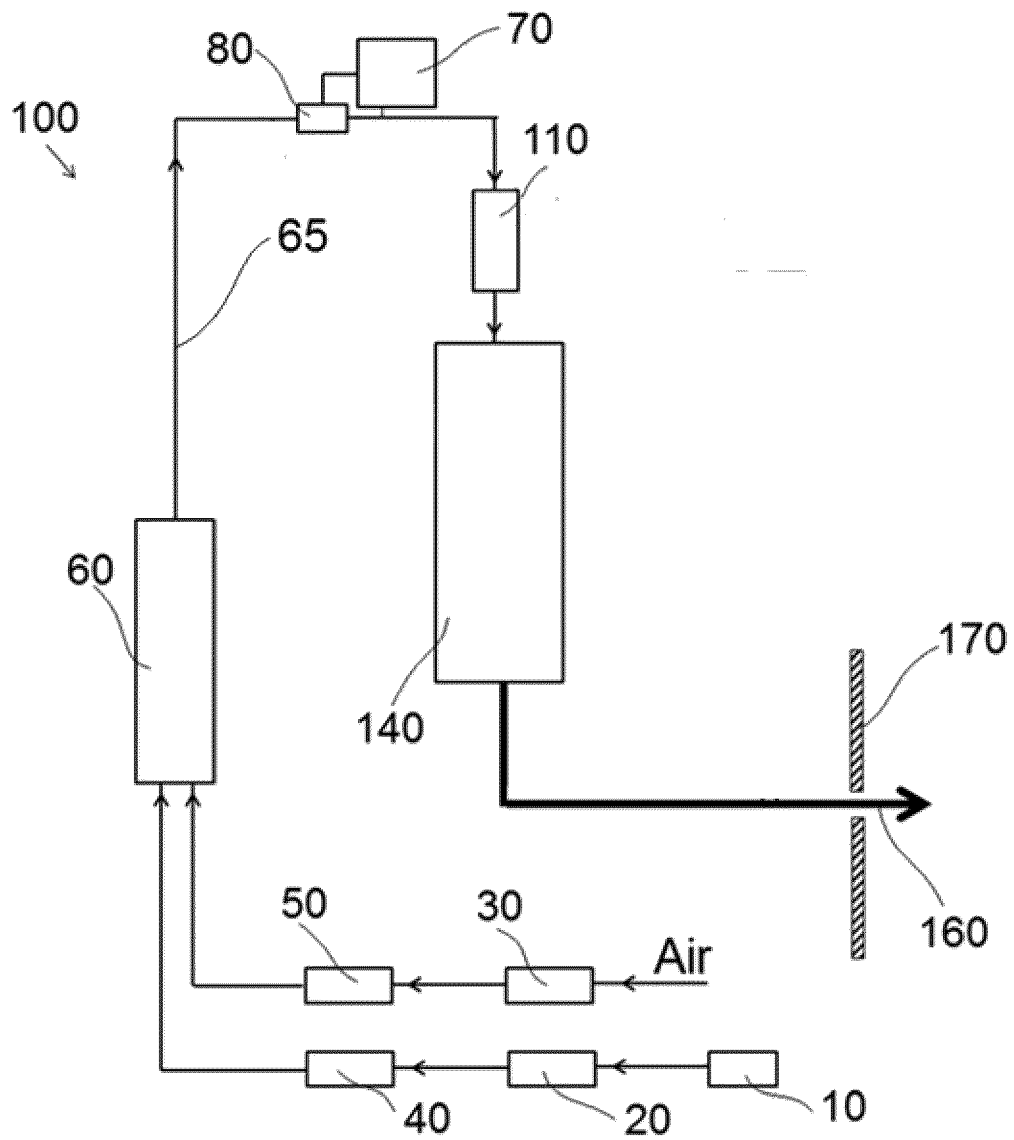


Fig. 1

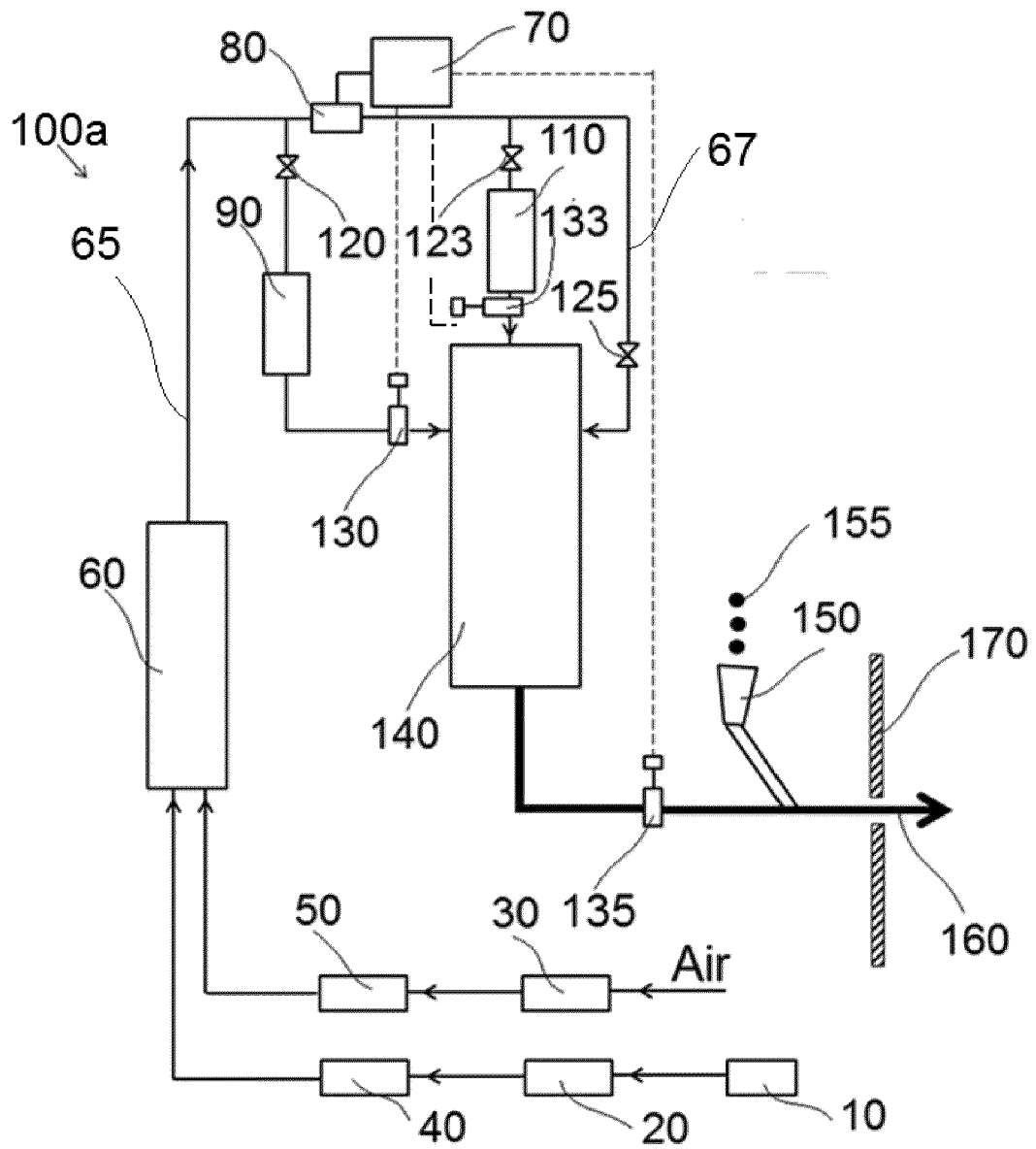


Fig. 2

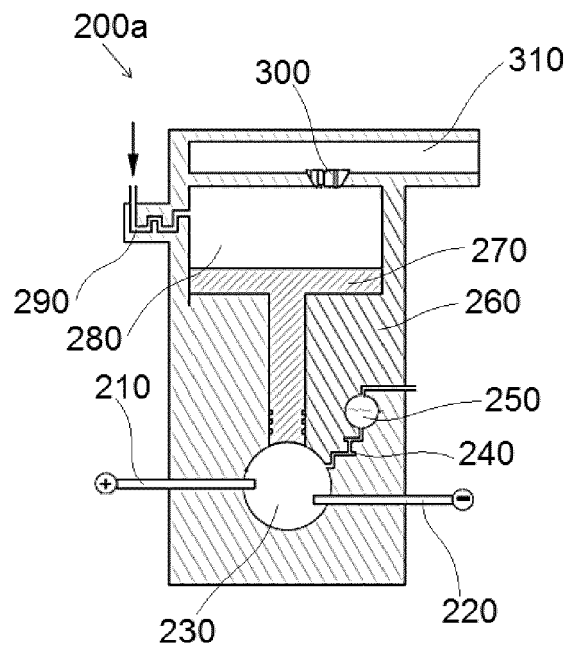


Fig. 3a

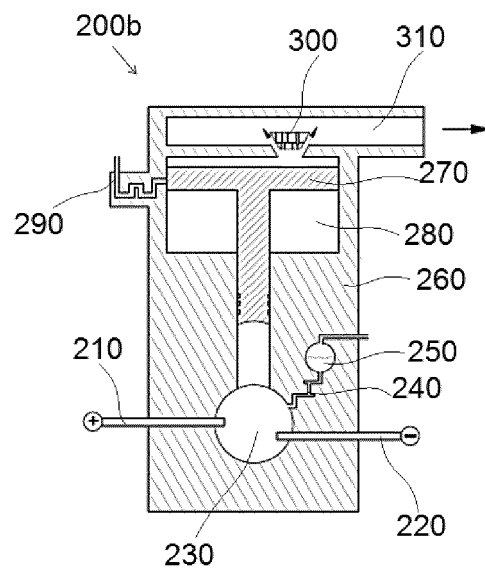


Fig. 3b

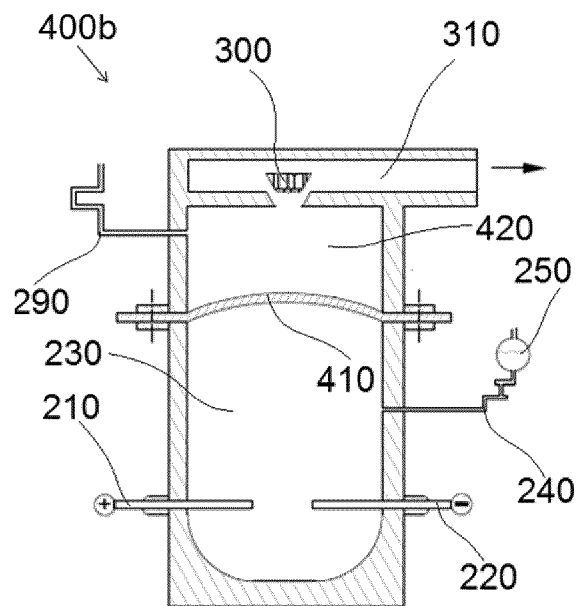


Fig. 4a

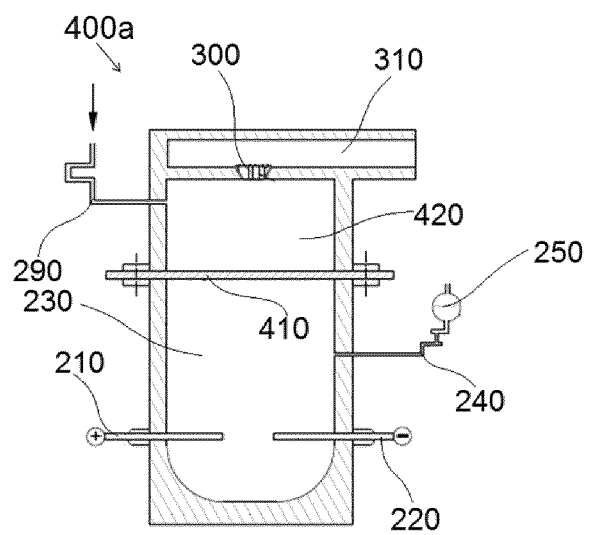


Fig. 4b

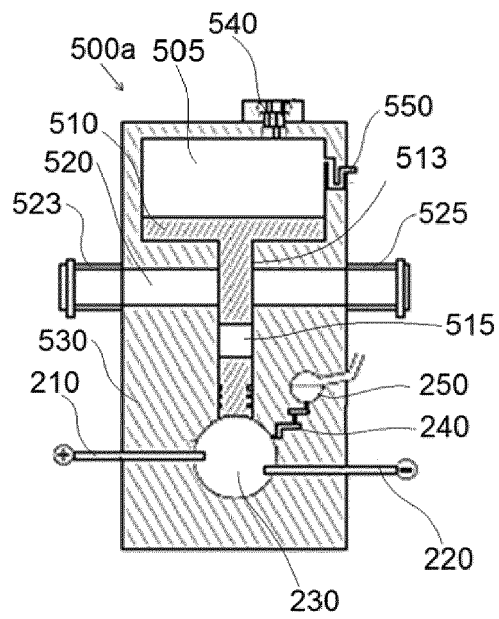


Fig. 5a

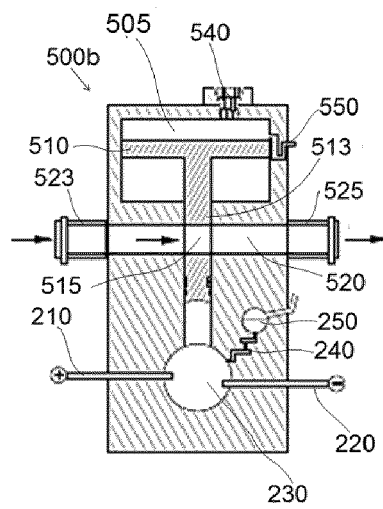


Fig. 5b



EUROPEAN SEARCH REPORT

Application Number
EP 20 16 2631

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 July 2020	Examiner Theis, Gilbert
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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REFERENCES CITED IN THE DESCRIPTION

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