

(19)



(11)

EP 3 874 530 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

15.05.2024 Bulletin 2024/20

(51) International Patent Classification (IPC):

G21F 9/02 ^(2006.01) **A62D 3/00** ^(2006.01)
G21F 9/16 ^(2006.01) **G21F 9/32** ^(2006.01)

(21) Application number: **19795208.8**

(52) Cooperative Patent Classification (CPC):

G21F 9/02; A62D 3/00; G21F 9/167; G21F 9/32

(22) Date of filing: **30.10.2019**

(86) International application number:

PCT/EP2019/079593

(87) International publication number:

WO 2020/089265 (07.05.2020 Gazette 2020/19)

(54) **SYSTEM FOR THERMALLY OXIDISING A WASTE GAS WITH HYDROCARBON COMPOUNDS INTO AN OXIDISED GAS AND USE THEREOF**

SYSTEM ZUR THERMISCHEN OXYDIERUNG VON KOHLENWASSERSTOFFVERBINDUNGEN ENTHALTENDEM ABFALLGAS IN OXYDIERTES GAS UND VERWENDUNG DESSELBEN

SYSTÈME POUR L'OXYDATION THERMIQUE DE GAS DE DÉCHET CONTENANT DES HYDROCARBURES DANS UN GAS OXYDÉ ET L'USAGE D'UN TEL SYSTÈME

(84) Designated Contracting States:

AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **31.10.2018 BE 201805759**

(43) Date of publication of application:

08.09.2021 Bulletin 2021/36

(73) Proprietors:

- **Belgoprocess**
2480 Dessel (BE)
- **ASX Investments B.V.**
5976 NG Kronenberg (NL)

(72) Inventors:

- **HANSEN, Jorgen**
3900 Overpelt (BE)
- **DECKERS, Jan**
9170 Sint-Gillis-Waas (BE)
- **FRANCKEN, René**
5801 KJ Venray (NL)

(74) Representative: **Gevers Patents**

De Kleetlaan 7A
1831 Diegem (BE)

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Description

Technical field

[0001] The present invention relates to a system for thermally oxidising a waste gas with hydrocarbon compounds into an oxidised gas. The waste gas is particularly the gasified material resulting from the pyrolysis.

Prior art

[0002] The nuclear industry annually produces an amount of waste that is classified as radioactively contaminated ion exchange media (i.e., resin), sludge and solvents. Resin is an organic material. The base is usually a styrene polymer to which are linked sulfonic acid and/or amine groups. The resin is therefore flammable, but when oxygen gas is supplied during combustion, sulphur and nitrogen oxides are formed which in turn must be somehow separated. In addition, the temperature rises sufficiently high during combustion to allow radioactive caesium to partially evaporate. The resulting gases and fly ashes can therefore be significantly contaminated as a result of the radioactivity of the resins to be processed, which requires a highly efficient filter system. Accordingly, both technical and economic problems are associated with combustion of ion exchange media.

[0003] An alternative processing method to combustion is pyrolysis as described in GB-B-1577383 and US-B-6084147. Pyrolysis takes place in an inert atmosphere at a temperature between 400°C to 850°C, whereby a decomposition of the molecules, i.e. a mineralisation, occurs. Due to the significantly lower temperature in comparison with combustion and the absence of oxygen, the residual products from the resins remain in the pyrolysis reactor. The transfer of various radioactive isotopes, for example caesium, to the exhaust gas is also significantly lower to non-existent.

[0004] A known method of processing medium into highly radioactive resins using pyrolysis comprises three sequential steps as described in GB-B-1577383. In the first phase, the resins are dried. Namely, it is usual for the resins to be transported as a suspension in water, typically in a 70/30 volume ratio of resin to water. After drying, the resins undergo pyrolysis, wherein the resins are usually subjected to a counter-current of superheated steam in a reactor vessel, which is carried out as a continuous process. This pyrolysis leads to a small volume of solid residue containing the vast majority of the radionuclides and pyrolysis gas. This pyrolysis gas then undergoes thermal post-combustion at temperatures between 800°C and 1100°C as described below.

[0005] WO-A-2005/106329 describes an afterburner for processing heavy fuel vapours that are the result of, among other things, the gasification of organic waste. The heavy fuel vapours are mixed with oxygen gas before or after the fuel vapours have arrived in the afterburner. The afterburner comprises an ignition portion and a lab-

yrinth portion which is formed by a number of partition walls which optimises the mixing of the oxygen gas and the fuel vapours and also extends the residence time within the afterburner so that it is 4 seconds. The oxygen-rich fuel vapours enter the afterburner, particularly the ignition portion, at a temperature of approximately 425°C. The ignition portion is provided with an electrical igniter for burning the oxygen-rich fuel vapours. The igniter reaches temperatures of 540°C to 870°C so that the fuel vapours burn. The heat released thereby results in the temperature inside the afterburner, particularly the labyrinth portion, rising to between 870°C and 950°C. In this way the legal obligations of a residence time of at least 2 seconds at a temperature of at least 800°C are met for the processing of heavy fuel vapours.

[0006] A disadvantage of the afterburner described in WO-A-2005/106329 is that an igniter is necessary for the correct operation of the afterburner. Namely, without an igniter, the required temperature for oxidation to take place is then not easily achieved. However, the use of an igniter in combination with flammable gases entails safety risks.

[0007] Moreover, the temperature in the labyrinth portion is almost exclusively determined by the energy generated by the combustion of the heavy fuel vapours. In other words, when the afterburner is started up, the labyrinth portion is not necessarily at the required temperature for processing the fuel vapours. Also, in case the supply of fuel vapours to the ignition portion is not sufficient, the resultant temperature in the labyrinth portion cannot be sufficiently high. In both cases, the legal requirements for oxidising the waste gas are not always met. Moreover, direct contact between the waste gas and the electric heating elements causes contamination thereof, which is not desirable.

Description of the invention

[0008] It is an object of the present invention to provide a system for oxidising a waste gas with hydrocarbons wherein a minimum temperature is always achieved during use.

[0009] This object is achieved by means of a system for thermally oxidising a waste gas with hydrocarbon compounds into an oxidised gas, which system comprises: an outer chamber with a front wall, a rear wall, a left wall, a right wall, an upper wall and a lower wall which are provided on their inside with electrical heating means, the outer chamber being provided with a first opening and a second opening, wherein a depth of the outer chamber is defined as a shortest distance between its front wall and its rear wall, wherein a width of the outer chamber is defined as a shortest distance between its left wall and its right wall and wherein a height of its outer chamber is defined as a shortest distance between its lower wall and its upper wall; and an inner chamber that is completely surrounded by the outer chamber and has a depth, a width and a height, each of which is at most

15%, particularly at most 10%, smaller than a respective one of the depth, the width and the height of the outer chamber, wherein the inner chamber is provided with: an inlet configured to connect, via the first opening in the outer chamber, to a supply device provided to supply a mixture of superheated oxygen gas and said waste gas to the inner chamber; an outlet configured to connect, via the second opening in the outer chamber, to a discharge device provided to discharge said oxidised gas from the inner chamber; and one or more partitions such that said mixture flows through one or more substantially U-shaped loops within the inner chamber.

[0010] By building the system (also known as an oxidiser) as an inner chamber for the oxidation of the waste gas in a heated outer chamber, the entire inner chamber is brought to the required temperature. There is therefore no risk that, for example during the start-up of the oxidation, an amount of waste gas was not exposed to a sufficiently high temperature. In addition, the electric heating elements do not require the combustion of an additional fuel, for example oil or gas, and are therefore less polluting. In addition, the volume of steam is more limited since no additional combustion air is required for the additional fuel. The combustion of gas and particularly oil also generate gases that must be further treated. An electric oxidiser thus results in a smaller oxidiser in comparison with existing afterburners that use an igniter and/or a burner for heating the afterburner, which must also have sufficient volume for the additional combustion air. Avoiding combustion air also means that a simpler waste gas treatment system can be used. In addition, there are also fewer safety risks associated with the electric heating elements in comparison with an oxidiser that uses an igniter.

[0011] The one or more partitions increase the residence time of the mixture in the inner chamber compared to an identically dimensioned chamber without partitions with the same inflow rate. In other words, the inner chamber, and therefore the outer chamber, can be made smaller by using one or more partitions to still obtain the same residence time for the same inflow speed. In addition, the one or more U-shaped loops, which are the direct result of the partitions, contribute to the mixing of the waste gas and the superheated oxygen gas.

[0012] The inner chamber can also be replaced in its entirety without compromising the structural integrity of the outer chamber, which normally does not come into direct contact with waste gas. In other words, in the case of contamination and/or damage to the inner chamber, it can easily be replaced or maintained.

[0013] Furthermore, the dimensions of the inner chamber are chosen in such a way compared to the outer chamber that there is as little volume as possible between the chambers without them being able to come into contact with each other considering the high temperatures to which the chambers are exposed.

[0014] In addition, the system is suitable for the processing of waste gas that is the result of pyrolysis of

organic waste, particularly radioactive waste, and more particularly radioactive resin or radioactive sludge or other organic waste.

[0015] In an embodiment of the present invention, one of the inner walls of the inner chamber and one side of one of said partitions are each provided with heat-resistant insulation panels for insulating a first section of the U-shaped loop closest to the inlet.

[0016] The portion of the inner chamber closest to the inlet provided with heat-resistant insulation panels provides an additional protection to the portion of the inner chamber that is exposed to the highest temperatures without having to drastically increase the design of the system as opposed to providing heat-resistant insulation panels on each wall within the inner chamber.

[0017] In an embodiment of the present invention, the outer chamber is further provided with a third opening and the inner chamber with a gas inlet configured to connect, via the third opening in the outer chamber, to a urea supply device provided for supplying urea to the inner chamber. Preferably, said gas inlet is provided after the U-shaped loop closest to the inlet.

[0018] The introduction of urea into the inner chamber during the processing of waste gas prevents the formation of nitrogen oxides. Adding the urea to the start of the system ensures that the formation of nitrogen oxides is avoided throughout substantially the entire inner chamber. In this way the oxidiser also acts as DeNOx installation.

[0019] In an embodiment of the present invention, the inner sides of the walls of the outer chamber are provided with ceramic elements in which the electrical heating means are incorporated, which elements are provided with heat-resistant insulation on their side facing the outer chamber.

[0020] The ceramic insulation panels make it possible to use the heat generated by the heating means more efficiently, i.e. the insulation panels limit the heat loss to the environment. The incorporation of the heating means into the insulation panels also limits the space required on the inner side of the outer chamber so that the inner chamber can be used at best.

[0021] In an embodiment of the present invention, said inner chamber is made entirely of heat-resistant metal.

[0022] In an embodiment of the present invention, an odd number of partitions are provided, wherein said inlet and said outlet are provided in the same wall of the inner chamber and wherein, preferably, said first opening and said second opening are provided in the same wall of the outer chamber.

[0023] The provision of an odd number of partitions makes it possible to provide the inlet and the outlet in the same wall, whereby the first and the second opening in the outer wall can also be provided in the same wall, whereby additional insulation around the openings can be limited to one wall.

[0024] In an embodiment of the present invention, fastening means are provided with which the inner chamber

is attached to the outer chamber, which fastening means are configured such that the inner chamber substantially does not contact with the inner side of the outer chamber. Preferably, said fastening means comprise one or more supporting elements positioned between the lower wall of the outer chamber and a lower wall of the inner chamber.

[0025] The provision of support elements between the lower walls of the outer and the inner chamber forms a very simple connection so that the inner chamber is not in direct contact with the outer chamber and wherein sufficient play can also be provided so that the inner chamber is not, even at high temperatures, in contact with the outer chamber.

[0026] In a preferred embodiment of the present invention, the system further comprises said supply device configured to supply said mixture into the inner chamber at a speed of at least 1 m/s and at most 5 m/s. Preferably, said U-shaped loops have a joint overall length such that the residence time of said waste gas in the inner chamber is at least 2 seconds. Preferably, said supply device comprises a superheater configured to superheat oxygen gas, particularly air, more particularly ambient air, to a temperature of at least 850°C, preferably at least 900°C and particularly to substantially 1000°C.

[0027] Superheating the supplied air, particularly the oxygen gas therein, limits the required residence time since the mixture substantially does not need to be heated further.

[0028] In a further preferred embodiment of the present invention, said supply device comprises a control mechanism configured to control an amount of oxygen gas in said mixture, which amount is at least 6 vol%. Preferably, said control mechanism comprises a control device in said discharge device, which control device is configured to determine the amount of oxygen gas in said oxidised gas, wherein the control mechanism is further configured to control the amount of oxygen gas in said mixture based on the determined amount of oxygen gas in said oxidised gas.

[0029] The control device allows at least 6 vol% oxygen gas to be present at all times in the waste gas mixture to be processed throughout the entire length of the inner chamber.

[0030] In an embodiment of the present invention, said partitions are alternately attached to opposite walls of the inner chamber, wherein, preferably, each partition has a length that is at most 95% of a shortest distance between said opposite walls.

[0031] Such an alternating attachment makes it possible in a simple manner to obtain the desired U-shaped loops for the flow of said mixture.

[0032] This object is also achieved by the use of an oxidiser as described above for thermally oxidising a waste gas, particularly a waste gas resulting from the pyrolysis of organic waste, particularly radioactive waste and more particularly comprising radioactive resin or radioactive sludge, with hydrocarbon compounds into an

oxidised gas.

Brief description of the drawings

[0033] The invention will hereafter be explained in further detail by way of the following description and the accompanying drawings.

Figure 1 shows a perspective view of a system for processing organic resin according to the present invention.

Figure 2 shows a perspective view of the pyrolysis portion of the system of Figure 1.

Figure 3 shows a front view of Figure 2.

Figure 4 shows a schematic representation of the system of Figure 1.

Figure 5 shows a perspective view of the mixing device.

Figure 6 shows a perspective view of the waste gas processing portion of the system of Figure 1.

Figure 7 shows a section through the oxidation portion of the system of Figure 1.

Embodiments of the invention

[0034] Although the present invention will hereinafter be described with respect to particular embodiments and with reference to certain drawings, the invention is not limited thereto and is only defined by the claims. The drawings shown here are merely schematic representations and are not limiting. In the drawings, the dimensions of some of the elements may be exaggerated and thus not drawn to scale for illustrative purposes only. The dimensions and the relative dimensions do not necessarily correspond to actual embodiments to practice of the invention.

[0035] In addition, terms such as 'first', 'second', 'third', and the like are used in the description and in the claims in order to make a distinction between similar elements and not necessarily in order to indicate a sequential or chronological order. The terms in question are interchangeable under appropriate circumstances and the embodiments of the invention can operate in other sequences than described or illustrated herein.

[0036] Moreover, terms such as 'top', 'bottom', 'above', 'under' and the like are used in the description and the claims for descriptive purposes. The terms thus used are interchangeable under appropriate circumstances and the embodiments of the invention can operate in other orientations than described or illustrated herein.

[0037] The term 'comprising', or its derivatives, as used in the claims, should not be interpreted as being restricted to the means listed thereafter; the term does not preclude other elements or steps. The term should be interpreted as specifying the stated features, integers, steps or components referred to, but does not preclude the presence or addition of one or more other features, integers, steps or components, or groups thereof. Thus, the scope of an

expression such as 'a device comprising means A and B' is not solely limited to devices consisting only of components A and B. In contrast, what is meant is that, with respect to the present invention, the only relevant components of the device are A and B.

[0038] As used herein, the term 'inert atmosphere' means an atmosphere in which less than 2% oxygen is present.

[0039] The present invention comprises a method and a system for decomposing organic waste, so that the volume and mass of the waste to be removed is considerably reduced relative to the initial volume and the original mass. The present invention also relates to the rendering harmless of those components of the processed waste that are released (e.g., exhaust gases) before they end up in the environment.

[0040] The present method will be described particularly with regard to radioactive waste, and in particular with regard to radioactive ion exchange resin, but other organic wastes may be processed in accordance with the following process and with the components of the system. The organic wastes that can be processed according to the present invention therefore comprise not only ion exchange resins, but also, among other things, cleaning solutions for steam generators, solvents, oils, decontamination solutions, antifreeze, dirt, sludge, nitrates, phosphates and polluted water.

[0041] An ion exchange resin is made from organic materials, usually styrene to which amino groups are linked to make anion resins or to which sulfone groups are linked to form cation resins. Since these resins are used to purify cooling water in a nuclear reactor, they accumulate up to about 7% iron, calcium, silica and small amounts of other metals and cations.

[0042] The method is based on pyrolysis in a closed reactor. The solid residue from the processing of the waste, namely an inorganic grain with a high metal oxide content, is packaged for subsequent storage for a period of 200 years to 300 years. The method can further use a conventional exhaust gas treatment (e.g., post-combustion), but also an oxidation of the waste gas as further described. Pyrolysis is the destruction of organic material with the aid of heat in the absence of a stoichiometric amount of oxygen, i.e. in an inert atmosphere. Hence, a reactor for use in the present invention should be substantially hermetically sealable.

[0043] In the present method, the organic components of the resin are destructively distilled by heating. Upon heating, the weak chemical compounds of the polymer resins break into compounds with lower carbon numbers, including carbon, metal oxides, metal sulphides, and pyrolysis gases, which in turn comprise carbon dioxide, carbon monoxide, water, nitrogen, and hydrocarbon gases. The small volume of solid residue that remains after pyrolysis contains the vast majority of the radionuclides.

[0044] Although pyrolysis can take place over a wide range of temperatures, the present method is a pyrolysis at low temperatures, generally about 300°C to 600°C, to

prevent radioactive metals from volatilizing in the ion exchange resins. These metals are therefore retained in the residue of the reactor. As a result, the low-active synthetic pyrolysis gases can then be converted at higher temperatures into carbon dioxide and water without concern for volatile radioactive metals such as caesium.

[0045] Oxidation of the waste gas, e.g., the pyrolysis gas comprising hydrocarbons, is the destruction of an organic gas at high temperatures, where a minimum amount of oxygen gas must be present. Typically, the hydrocarbon vapours are converted to carbon dioxide and water at a temperature of at least 850°C with a residence time of the gases of at least 2 seconds and an oxygen content of at least 6 vol%. This does not constitute combustion of the waste gas.

[0046] The system for processing the ion exchange resin comprises a frame 1 on which a collecting chamber 2 is mounted, in which the resin is transported by means of transport water, particularly via supply line (not shown) and inlet 3, which inlet can be closed via closing valve 9. Optionally, the transport water can be filtered from the collecting tank 1 and discharged via a discharge line (not shown). The separation of the transport water results in a dryer resin, which lowers the residence time in the pyrolysis chamber.

[0047] From the collecting chamber 2, the resin (including or excluding the transport water) is transported to the conical pyrolysis chamber 4 via line 5 (shown in Figure 2) and enter the housing 4 via inlet 6. In the pyrolysis chamber 4, the transport water is evaporated (if necessary) and the resin is dried and pyrolysed as described below. The waste gases generated by evaporation, drying and pyrolysis are discharged via gas outlet 7 connected to line 8. Due to gravity, the pyrolysed material falls down inside the housing 4 and leave it via outlet 12 which opens into a collection tray 10. In the embodiment shown, a sluice valve device 11 (shown in Figure 3) is also provided between the outlet 12 and the collection tray 10. Such a sluice valve is then closed during use so that non-pyrolysed material cannot yet end up in the collection tray 10. A similar sluice valve device 13 (also shown in Figure 3) is provided between the collection tray 2 and the inlet 6 of the pyrolysis chamber 4.

[0048] In order for the pyrolysis chamber 4 to be hermetically sealed, i.e. to ensure that substantially no oxygen is present inside the pyrolysis chamber 4, nitrogen gas is led from storage tanks 19 to each opening of the pyrolysis chamber 4. This nitrogen gas prevents oxygen gas from getting through one of the openings in the pyrolysis chamber 4 and thus disrupting the state of an inert atmosphere, causing an oxidation or combustion reaction which could lead to such high temperatures that the housing 4 could be damaged and/or an unsafe condition arises. It will be appreciated that the storage tanks 19 can also be replaced by another nitrogen supply, e.g. a nitrogen supply network.

[0049] As shown in Figure 4, the conical housing 4 on the side wall is provided with heating means 24, partic-

ularly electric heating means, for heating the side wall. In an advantageous embodiment, these heating means 24 are incorporated in ceramic elements which are directly attached to the conical housing 4 and are suitable for generating a temperature within the housing 4 of at least 200°C, particularly at least 300°C, more particularly at least 400°C and most particularly at least 500°C. The temperature that needs to be generated depends on the type of waste that needs to be processed and also on the phase the processing is in. For example, a temperature of 120°C may suffice during the evaporation of the transport water, while a temperature of approximately 300°C (depending on the type of resin) is required during the pyrolysis.

[0050] Inside the housing 4 a conical mixing body 25 is provided which is attached via cross connections 41 to a drive shaft 26 which extends through the upper side of the housing along said longitudinal direction with a first portion which is inside the housing 4 and a second portion which is outside the housing 4. The conical mixing body 25 is configured to fluidise waste inside the housing 4 by transporting it upwards along the side wall of the housing 4 by rotating the mixing body 25.

[0051] As shown schematically in Figure 4, the mixing body 25 does not touch the housing 4 and the mixing body 25 has a free bottom side at the underside of the housing 24, as described above, to avoid accumulation of waste at the bottom of the housing 4. Such a construction is possible because the second portion of the drive shaft 26 is bearing-mounted on the frame 1 and therefore no mounting is required inside the housing 24. Particularly, a double bearing is used when attaching the drive shaft 26 to the frame 1. As shown in Figure 4, the drive shaft 26 extends in the longitudinal direction 27 of the housing 4. The drive shaft 26 is driven by an electric motor 28 shown in Figure 1.

[0052] In an embodiment, the shortest distance between the mixing body 25 and the side wall of the housing 4 is at most 5% and particularly at most 3%, as described above, in order to avoid build-up of residue on the side wall.

[0053] The waste gas from the evaporation, drying and pyrolysis is supplied via line 8 to a supply line 14, which discharges into an inlet 33 of an oxidising device 15 (also known as an oxidiser). The supply line 14 is provided for supplying superheated oxygen gas, particularly superheated air (such as ambient air), which air was heated by means of a superheater 20 (shown schematically in Figure 4). The oxygen gas can be provided in a tank 21 and supplied via pump 22 as shown in Figure 4. The tank 21 is preferably the chamber in which the oxidiser 15 is located and the supplied air is hence ambient air. The pump 22 also determines how much oxygen gas is supplied and can also be used to control the speed (for example between 1 and 5 m/s) at which the mixture of oxygen gas and waste gas is supplied.

[0054] As shown in Figures 4 and 6, the oxidising device 15 comprises an outer chamber 16 and an inner

chamber 17. Electric heating means 23 (shown in Figure 7) are provided in the outer chamber 16 and heat the inner chamber 17 through which the mixture of waste gas and superheated air flows. This mixture is oxidised by the temperature so that an oxidised gas is discharged from the oxidising device 15 via outlet 32 and discharge line 18. The temperature of the superheated air (particularly at least 850°C, preferably at least 900°C and more preferably almost 1000°C) already ensures an initial heating of the waste gas such that the oxidation reaction already starts at the beginning of the inner chamber 17.

[0055] The outer chamber 16 is provided with a front wall, a rear wall, a left wall, a right wall, an upper wall and a lower wall, each of which are provided on their inner side with electric heating means 23 schematically shown in Figure 7, a depth of the outer chamber 16 being defined as a shortest distance between its front wall and its rear wall, a width of the outer chamber 16 being defined as a shortest distance between its left wall and its right wall and a height of its outer chamber 16 being defined as a shortest distance between its lower wall and its upper wall. The outer chamber 16 is further provided with a first opening 29 and a second opening 30, through which the supply line 14 and the discharge line 18 extend, respectively.

[0056] The inner chamber 17 is completely surrounded by the outer chamber 16 as shown in Figure 6 and has dimensions that are as close as possible to the dimensions of the outer chamber 16. Particularly, the height, depth and width are each at most 15%, particularly at most 10%, less than a respective one of the depth, width and height of the outer chamber 16. It has been found that such dimensions allow the inner chamber 16 to expand due to the high temperature, but also that the total volume of the outer chamber is as small as possible to form a compact oxidiser 15. As shown in Figure 7, the inner chamber 17 is supported on the outer chamber 16 by fastening means 31 so that direct contact between the two chambers 16, 17 is avoided. This avoids damage to the heating means 23.

[0057] It is clear that the atmosphere within inner chamber 17 is substantially completely sealed off from the atmosphere around the inner chamber 17 in the outer chamber 16. In this way the gas to be oxidised is prevented from coming into contact with the outer chamber 17, particularly with the heating means 23.

[0058] In an embodiment, the heating means 23 are designed as ceramic elements which are provided on their side facing the outer chamber 16 with heat-resistant insulation.

[0059] In order to limit the dimensions of the oxidiser 15, the inner chamber 17 is provided with mutually substantially parallel partitions 35 which increase the residence time inside the inner chamber 17 relative to an identically dimensioned chamber without partitions. Due to these partitions 35, the mixture must flow through a series of substantially U-shaped loops 36 which stimulate the mixing of the gases.

[0060] Preferably, the corners of the U-shaped loops are rounded to avoid a vortex flow that could temporarily retain a portion of the waste gas, thereby reducing the efficiency of the oxidiser 15.

[0061] In the embodiment shown, the length of each partition 35 is approximately 85% of the height of the inner chamber 17, but other lengths are also possible. In general, this length is preferably between 60% and 95% of the height (or of the width or length if the partitions are oriented according to the width or length direction). It has been found that this allows sufficient flow and also maximises the total distance that the mixture has to travel based on the ideally as low as possible dimensions of the inner chamber 17.

[0062] The number of partitions 35 and the dimensions of the inner chamber 17 are selected based on the desired residence time of the mixture. This residence time is preferably at least 2 seconds. The pump 22 can also be used to adjust the flow rate so that, given a certain total distance, the residence time is sufficient.

[0063] To prevent damage to the partitions 35, these can also be provided with insulation (not shown). This is especially advantageous with the first partition since this is the hottest zone due to the supply of the superheated air. In addition, this wall of the inner chamber 17 is also insulated.

[0064] In the embodiment shown, use is made of an odd number of partitions 35 so that the openings 29, 30 can be provided in the same wall of the outer chamber 16, on which optionally no heating means 23 are then provided, but preferably insulation is provided.

[0065] In the embodiment shown, a third opening 38 is also provided in the outer chamber 16 to which a urea supply device 37 is connected via gas inlet 40 positioned within the opening 38. As described above, the supply of urea leads to the avoidance of the formation of nitrogen oxides during the oxidation. As shown, the urea supply device 37 is connected to the nearest U-shaped loop 36 such that the supplied urea has a sufficient residence time.

[0066] In an embodiment, the outer chamber 16 is provided with a door 34 that forms a wall thereof. This is advantageous since it allows the inner chamber 17 to be replaced or cleaned in its entirety. This also makes it possible to perform maintenance on the heating means 23.

[0067] In the embodiment shown, a control device 39 is also provided which checks what volume percentage of oxygen gas is present in the oxidised gas. If this is too low, a control mechanism is activated that adjusts pump 22 so that more oxygen gas is supplied. In this way, the desired oxygen gas percentage (e.g. 6 vol%) can be obtained and maintained throughout the entire inner chamber 17.

[0068] Although certain aspects of the present invention have been described with respect to specific embodiments, it is clear that these aspects may be implemented in other forms within the scope of protection as defined

by the claims.

Claims

1. System for thermally oxidising a waste gas with hydrocarbon compounds into an oxidised gas, which system comprises:

- an outer chamber (16) with a front wall, a rear wall, a left wall, a right wall, an upper wall and a lower wall which are provided on their inside with electrical heating means (23), the outer chamber being provided with a first opening (29) and a second opening (30), wherein a depth of the outer chamber is defined as a shortest distance between its front wall and its rear wall, wherein a width of the outer chamber is defined as a shortest distance between its left wall and its right wall and wherein a height of its outer chamber is defined as a shortest distance between its lower wall and its upper wall; and

- an inner chamber that is completely surrounded by the outer chamber and has a depth, a width and a height, each of which is at most 15%, particularly at most 10%, smaller than a respective one of the depth, the width and the height of the outer chamber, wherein the inner chamber is provided with:

- an inlet (33) configured to connect, via the first opening (29) in the outer chamber, to a supply device (22) provided to supply a mixture of superheated oxygen gas and said waste gas to the inner chamber;

- an outlet (32) configured to connect, via the second opening (30) in the outer chamber, to a discharge device provided to discharge said oxidised gas from the inner chamber; and

- one or more partitions (35) such that said mixture flows through one or more substantially U-shaped loops (36) within the inner chamber.

2. System according to claim 1, wherein one of the inner walls of the inner chamber and one side of one of said partitions are each provided with heat-resistant insulation panels for insulating a first section of the U-shaped loop closest to the inlet.

3. System according to claim 1 or 2, wherein the outer chamber is further provided with a third opening (38) and the inner chamber with a gas inlet (40) configured to connect, via the third opening in the outer chamber, to a urea supply device (37) provided to supply urea to the inner chamber.

4. System according to claim 3, wherein said gas inlet is provided after the U-shaped loop closest to the inlet.

5. System according to any of the preceding claims, wherein the inner sides of the walls of the outer chamber are provided with ceramic elements in which the electrical heating means are incorporated, which elements are provided with heat-resistant insulation on their side facing the outer chamber.
6. System according to any of the preceding claims, wherein said inner chamber is made entirely of heat-resistant metal.
7. System according to any of the preceding claims, wherein an odd number of partitions are provided, wherein said inlet and said outlet are provided in the same wall of the inner chamber and wherein, preferably, said first opening and said second opening are provided in the same wall of the outer chamber.
8. System according to any of the preceding claims, wherein fastening means (31) are provided with which the inner chamber is attached to the outer chamber, which fastening means are configured such that the inner chamber substantially does not contact with the inner side of the outer chamber, wherein, preferably, said fastening means comprise one or more supporting elements positioned between the lower wall of the outer chamber and a lower wall of the inner chamber.
9. System according to any of the preceding claims, wherein the system further comprises said supply device configured to supply said mixture into the inner chamber at a speed of at least 1 m/s and at most 5 m/s.
10. System according to claim 9, wherein said U-shaped loops have a joint overall length such that the residence time of said waste gas in the inner chamber is at least 2 seconds.
11. System according to claim 9 or 10, wherein said supply device comprises a superheater (20) configured to superheat oxygen gas, particularly air and more particularly ambient air, to a temperature of at least 850°C, preferably at least 900°C and particularly to substantially 1000°C.
12. System according to any of claims 9 to 11, wherein said supply device comprises a control mechanism configured to control an amount of oxygen gas in said mixture, which amount is at least 6 vol%, wherein, preferably, said control mechanism comprises a control device (39) in said discharge device, which control device is configured to determine the amount of oxygen gas in said oxidised gas, wherein the control mechanism is further configured to control the amount of oxygen gas in said mixture based on the determined amount of oxygen gas in said oxidised

gas.

13. System according to any of the preceding claims, wherein said partitions are alternately attached to opposite walls of the inner chamber and wherein, preferably, each partition has a length that is at least 60%, particularly at least 75% and at most 95% of a shortest distance between said opposite walls.
14. System according to any of the preceding claims, wherein said waste gas is the result of the pyrolysis of organic waste, particularly radioactive waste, and more particularly comprising radioactive resin or radioactive sludge.
15. Use of a system according to any of the preceding claims for thermally oxidising a waste gas, particularly a waste gas resulting from the pyrolysis of organic waste, particularly radioactive waste, and more particularly comprising radioactive resin or radioactive sludge, with hydrocarbon compounds to an oxidised gas.

25 Patentansprüche

1. System zur thermischen Oxidation eines Abgases mit Kohlenwasserstoffverbindungen zu einem oxidierten Gas, wobei das System umfasst:
 - eine Außenkammer (16) mit einer Vorderwand, einer Rückwand, einer linken Wand, einer rechten Wand, einer oberen Wand und einer unteren Wand, die auf ihrer Innenseite mit elektrischen Heizmitteln (23) bereitgestellt sind, wobei die Außenkammer mit einer ersten Öffnung (29) und einer zweiten Öffnung (30) bereitgestellt ist, wobei eine Tiefe der Außenkammer als ein kürzester Abstand zwischen ihrer Vorderwand und ihrer Rückwand definiert ist, wobei eine Breite der Außenkammer als ein kürzester Abstand zwischen ihrer linken Wand und ihrer rechten Wand definiert ist und wobei eine Höhe seiner Außenkammer als kürzester Abstand zwischen ihrer unteren Wand und ihrer oberen Wand definiert ist; und
 - eine Innenkammer, die vollständig von der Außenkammer umgeben ist, und eine Tiefe, eine Breite und eine Höhe aufweist, von denen jede höchstens um 15%, besonders höchstens um 10%, kleiner als eine jeweilige von der Tiefe, der Breite und der Höhe der Außenkammer ist, wobei die Innenkammer bereitgestellt ist mit:
 - einem Einlass (33), der konfiguriert ist, über die erste Öffnung (29) in der Außenkammer mit einer Zuführungsvorrichtung (22) verbunden zu werden, die bereitgestellt ist, um der Innenkammer ein Gemisch aus überhitztem Sauerstoff-

- gas und dem Abgas zuzuführen;
 - einem Auslass (32), der konfiguriert ist, über die zweite Öffnung (30) in der Außenkammer mit einer Ablassvorrichtung verbunden zu werden, die bereitgestellt ist, um das oxidierte Gas aus der Innenkammer abzulassen; und
 - einer oder mehreren Trennwänden (35), so dass das Gemisch durch eine oder mehrere im Wesentlichen U-förmige Schleifen (36) innerhalb der Innenkammer fließt.
2. System nach Anspruch 1, wobei eine der Innenwände der Innenkammer und eine Seite von einer der Trennwände jeweils mit hitzebeständigen Isolierplatten zum Isolieren eines ersten Abschnitts der U-förmigen Schleife bereitgestellt sind, der dem Einlass am nächsten liegt.
 3. System nach Anspruch 1 oder 2, wobei die Außenkammer weiter mit einer dritten Öffnung (38), und die Innenkammer mit einem Gaseinlass (40) bereitgestellt ist, der konfiguriert ist, über die dritte Öffnung in der Außenkammer mit einer Harnstoffzuführungsvorrichtung (37) verbunden zu werden, die bereitgestellt ist, um Harnstoff zur Innenkammer zuzuführen.
 4. System nach Anspruch 3, wobei der Gaseinlass nach der U-förmigen Schleife, die dem Einlass am nächsten liegt, bereitgestellt ist.
 5. System nach einem der vorstehenden Ansprüche, wobei die Innenseiten der Wände der Außenkammer mit Keramikelementen bereitgestellt sind, in denen die elektrischen Heizmittel integriert sind, wobei die Elemente auf ihrer der Außenkammer zugewandten Seite mit einer hitzebeständigen Isolierung bereitgestellt sind.
 6. System nach einem der vorstehenden Ansprüche, wobei die Innenkammer vollständig aus hitzebeständigem Metall gefertigt ist.
 7. System nach einem der vorstehenden Ansprüche, wobei eine ungerade Anzahl an Trennwänden bereitgestellt ist, wobei der Einlass und der Auslass in derselben Wand der Innenkammer bereitgestellt sind, und wobei die erste Öffnung und die zweite Öffnung vorzugsweise in der gleichen Wand der Außenkammer bereitgestellt sind.
 8. System nach einem der vorstehenden Ansprüche, wobei Befestigungsmittel (31) bereitgestellt sind, mit denen die Innenkammer an der Außenkammer befestigt ist, wobei die Befestigungsmittel konfiguriert sind, sodass die Innenkammer die Innenseite der Außenkammer im Wesentlichen nicht berührt, wobei die Befestigungsmittel vorzugsweise ein oder mehrere Stützelemente umfassen, die zwischen der unteren Wand der Außenkammer und einer unteren Wand der Innenkammer positioniert sind.
 9. System nach einem der vorstehenden Ansprüche, wobei das System weiter die Zuführungsvorrichtung umfasst, die konfiguriert ist, das Gemisch mit einer Geschwindigkeit von mindestens 1 m/s und höchstens 5 m/s in die Innenkammer zuzuführen.
 10. System nach Anspruch 9, wobei die U-förmigen Schleifen eine gemeinsame Gesamtlänge aufweisen, so dass die Verweilzeit des Abgases in der Innenkammer mindestens 2 Sekunden beträgt.
 11. System nach Anspruch 9 oder 10, wobei die Zuführungsvorrichtung einen Überhitzer (20) umfasst, der konfiguriert ist, Sauerstoffgas, insbesondere Luft und ganz besonders Umgebungsluft, auf eine Temperatur von mindestens 850 °C, vorzugsweise mindestens 900 °C und insbesondere auf im Wesentlichen 1000 °C zu überhitzen.
 12. System nach einem der Ansprüche 9 bis 11, wobei die Zuführungsvorrichtung einen Steuermechanismus umfasst, der konfiguriert ist, eine Menge an Sauerstoffgas in dem Gemisch zu steuern, wobei die Menge mindestens 6 Vol.-% beträgt, wobei der Steuermechanismus vorzugsweise eine Steuervorrichtung (39) in der Ablassvorrichtung umfasst, wobei die Steuervorrichtung konfiguriert ist, die Menge an Sauerstoffgas in dem oxidierten Gas zu bestimmen, wobei der Steuermechanismus weiter konfiguriert ist, die Menge an Sauerstoffgas in dem Gemisch basierend auf der bestimmten Menge an Sauerstoffgas in dem oxidierten Gas zu steuern.
 13. System nach einem der vorstehenden Ansprüche, wobei die Trennwände abwechselnd an gegenüberliegenden Wänden der Innenkammer befestigt sind, und wobei jede Trennwand vorzugsweise eine Länge aufweist, die mindestens 60%, insbesondere mindestens 75 % und höchstens 95 % eines kürzesten Abstands zwischen den gegenüberliegenden Wänden beträgt.
 14. System nach einem der vorstehenden Ansprüche, wobei das Abgas das Ergebnis der Pyrolyse von organischem Abfall, insbesondere radioaktivem Abfall und ganz besonders radioaktives Harz oder radioaktiven Schlamm umfassend ist.
 15. Verwendung eines Systems nach einem der vorstehenden Ansprüche zur thermischen Oxidation eines Abgases, insbesondere eines Abgases, das aus der Pyrolyse von organischem Abfall, insbesondere radioaktivem Abfall, und ganz besonders radioaktives Harz oder radioaktiven Schlamm umfassend, resultiert, mit Kohlenwasserstoffverbindungen zu einem

oxidierten Gas.

Revendications

1. Système pour oxyder thermiquement un gaz résiduaire avec des composés hydrocarbonés en un gaz oxydé, lequel système comprend :

- une chambre extérieure (16) avec une paroi avant, une paroi arrière, une paroi gauche, une paroi droite, une paroi supérieure et une paroi inférieure qui sont pourvues à l'intérieur de moyens de chauffage électriques (23), la chambre extérieure étant pourvue d'une première ouverture (29) et d'une seconde ouverture (30), dans lequel une profondeur de la chambre extérieure est définie comme une distance la plus courte entre sa paroi avant et sa paroi arrière, dans lequel une largeur de la chambre extérieure est définie comme une distance la plus courte entre sa paroi gauche et sa paroi droite et dans lequel une hauteur de sa chambre extérieure est définie comme une distance la plus courte entre sa paroi inférieure et sa paroi supérieure ; et

- une chambre intérieure qui est complètement entourée par la chambre extérieure et qui présente une profondeur, une largeur et une hauteur dont chacune est au maximum 15 %, en particulier au maximum 10 %, plus petite qu'une respective parmi la profondeur, la largeur et la hauteur de la chambre extérieure, dans lequel la chambre intérieure est pourvue :

- d'une entrée (33) configurée pour se connecter, via la première ouverture (29) dans la chambre extérieure, à un dispositif d'alimentation (22) prévu pour alimenter la chambre intérieure en un mélange d'oxygène gazeux surchauffé et dudit gaz résiduaire ;

- d'une sortie (32) configurée pour se connecter, via la deuxième ouverture (30) dans la chambre extérieure, à un dispositif d'évacuation prévu pour évacuer ledit gaz oxydé à partir de la chambre intérieure ; et

- d'une ou plusieurs cloisons (35) de telle sorte que ledit mélange s'écoule à travers une ou plusieurs boucles sensiblement en forme de U (36) à l'intérieur de la chambre intérieure.

2. Système selon la revendication 1, dans lequel une des parois intérieures de la chambre intérieure et un côté de l'une desdites cloisons sont chacun pourvus de panneaux isolants résistant à la chaleur pour isoler une première section de la boucle en forme de U la plus proche de l'entrée.

3. Système selon la revendication 1 ou 2, dans lequel

la chambre extérieure est en outre pourvue d'une troisième ouverture (38) et la chambre intérieure d'une entrée de gaz (40) configurée pour se connecter, via la troisième ouverture dans la chambre extérieure, à un dispositif d'alimentation en urée (37) prévu pour alimenter en urée la chambre intérieure.

4. Système selon la revendication 3, dans lequel ladite entrée de gaz est prévue après la boucle en forme de U la plus proche de l'entrée.

5. Système selon l'une quelconque des revendications précédentes, dans lequel les côtés intérieurs des parois de la chambre extérieure sont pourvus d'éléments en céramique dans lesquels sont incorporés les moyens de chauffage électriques, lesquels éléments sont pourvus d'un isolant résistant à la chaleur sur leur côté tourné vers la chambre extérieure.

6. Système selon l'une quelconque des revendications précédentes, dans lequel ladite chambre intérieure est entièrement réalisée en métal résistant à la chaleur.

7. Système selon l'une quelconque des revendications précédentes, dans lequel un nombre impair de cloisons est prévu, dans lequel ladite entrée et ladite sortie sont prévues dans la même paroi de la chambre intérieure et dans lequel, de préférence, ladite première ouverture et ladite deuxième ouverture sont prévues dans la même paroi de la chambre extérieure.

8. Système selon l'une quelconque des revendications précédentes, dans lequel sont prévus des moyens de fixation (31), avec lesquels la chambre intérieure est fixée à la chambre extérieure, lesquels moyens de fixation sont configurés de telle sorte que la chambre intérieure n'entre sensiblement pas en contact avec le côté intérieur de la chambre extérieure, dans lequel, de préférence, lesdits moyens de fixation comprennent un ou plusieurs éléments de support positionnés entre la paroi inférieure de la chambre extérieure et une paroi inférieure de la chambre intérieure.

9. Système selon l'une quelconque des revendications précédentes, dans lequel le système comprend en outre ledit dispositif d'alimentation configuré pour alimenter la chambre intérieure en ledit mélange à une vitesse d'au moins 1 m/s et d'au plus 5 m/s.

10. Système selon la revendication 9, dans lequel lesdites boucles en forme de U présentent une longueur totale conjointe telle que le temps de séjour dudit gaz résiduaire dans la chambre intérieure est d'au moins 2 secondes.

11. Système selon la revendication 9 ou 10, dans lequel ledit dispositif d'alimentation comprend un surchauffeur (20) configuré pour surchauffer de l'oxygène gazeux, en particulier de l'air et plus particulièrement de l'air ambiant, à une température d'au moins 850 °C, de préférence d'au moins 900 °C et en particulier jusqu'à sensiblement 1000 °C. 5
12. Système selon l'une quelconque des revendications 9 à 11, dans lequel ledit dispositif d'alimentation comprend un mécanisme de contrôle configuré pour contrôler une quantité d'oxygène gazeux dans ledit mélange, laquelle quantité est d'au moins 6 % en volume, 10
dans lequel, de préférence, ledit mécanisme de contrôle comprend un dispositif de contrôle (39) dans lequel ledit dispositif d'évacuation, lequel dispositif de contrôle est configuré pour déterminer la quantité d'oxygène gazeux dans ledit gaz oxydé, dans lequel le mécanisme de contrôle est en outre configuré pour 15
contrôler la quantité d'oxygène gazeux dans ledit mélange sur la base de la quantité déterminée d'oxygène gazeux dans ledit gaz oxydé. 20
13. Système selon l'une quelconque des revendications précédentes, dans lequel lesdites cloisons sont 25
fixées en alternance aux parois opposées de la chambre intérieure et dans lequel, de préférence, chaque cloison présente une longueur qui fait au moins 60 %, en particulier au moins 75 % et au plus 30
95 % d'une distance la plus courte entre lesdites parois opposées.
14. Système selon l'une quelconque des revendications précédentes, dans lequel ledit gaz résiduaire est le 35
résultat de la pyrolyse de déchets organiques, en particulier de déchets radioactifs, et comprenant plus particulièrement une résine radioactive ou des boues radioactives. 40
15. Utilisation d'un système selon l'une quelconque des revendications précédentes pour oxyder thermiquement un gaz résiduaire, en particulier un gaz résiduaire résultant de la pyrolyse de déchets organiques, en particulier de déchets radioactifs, et comprenant plus particulièrement une résine radioactive ou des boues radioactives, avec des composés hydrocarbonés en un gaz oxydé. 45

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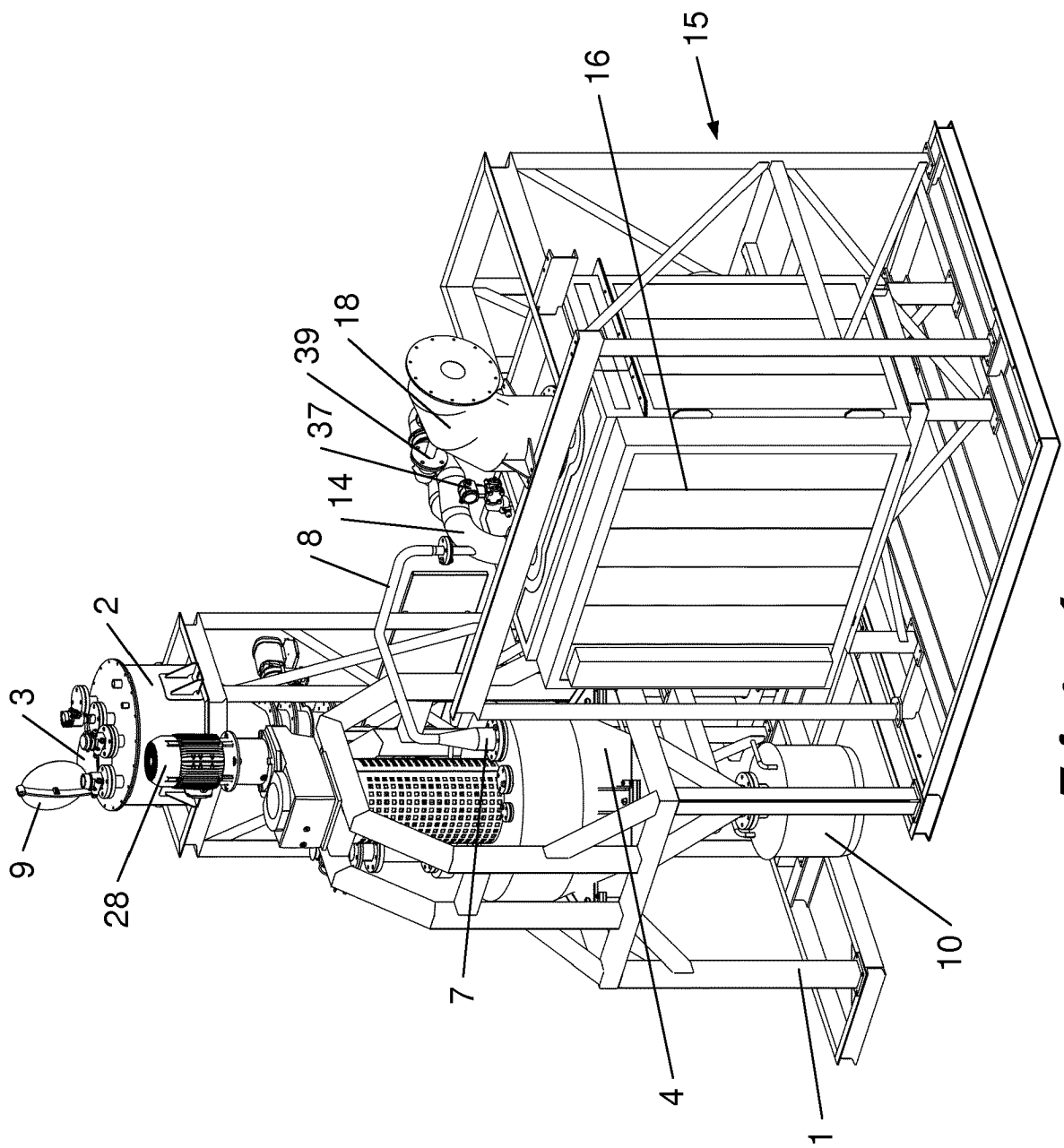


Fig. 1

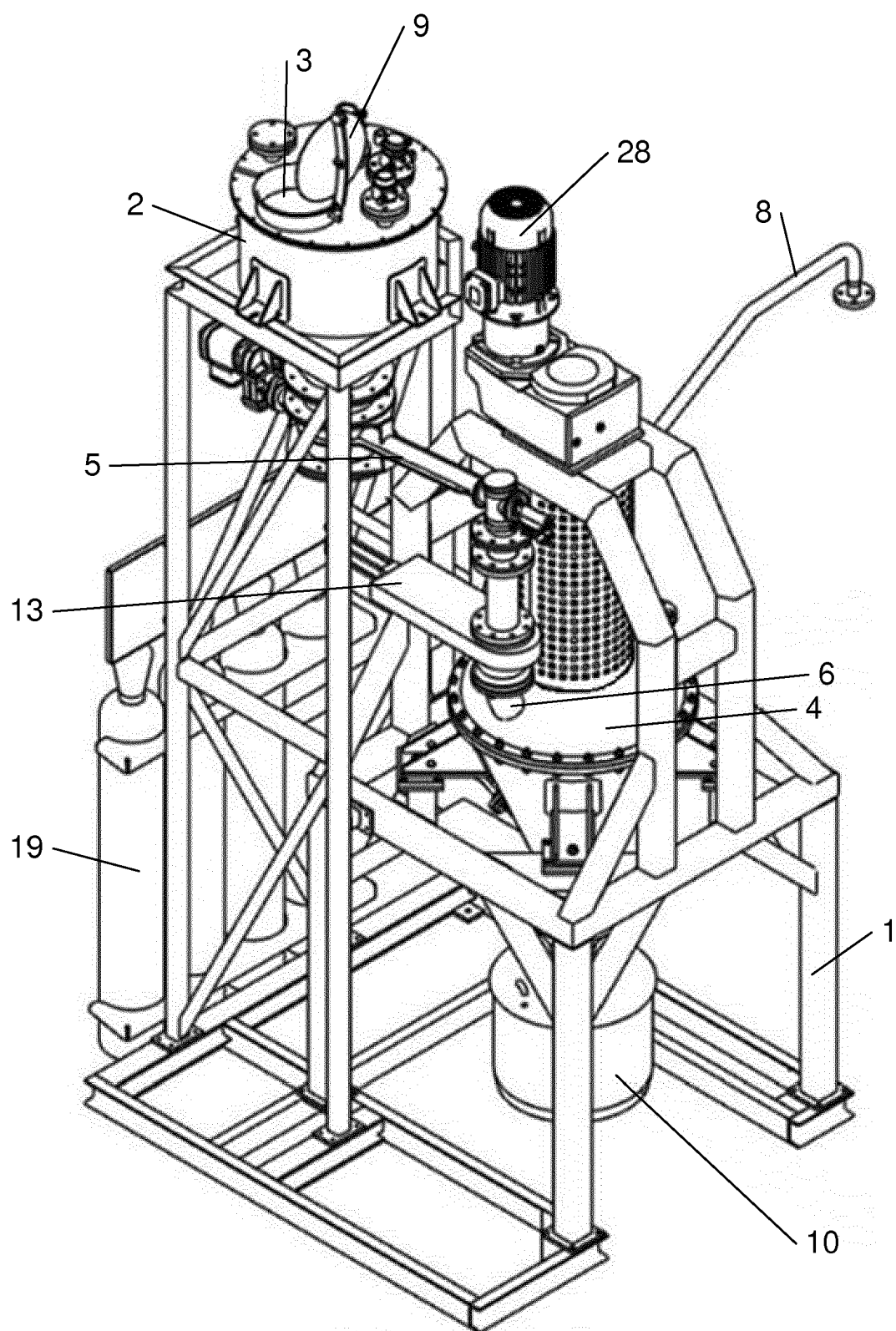


Fig. 2

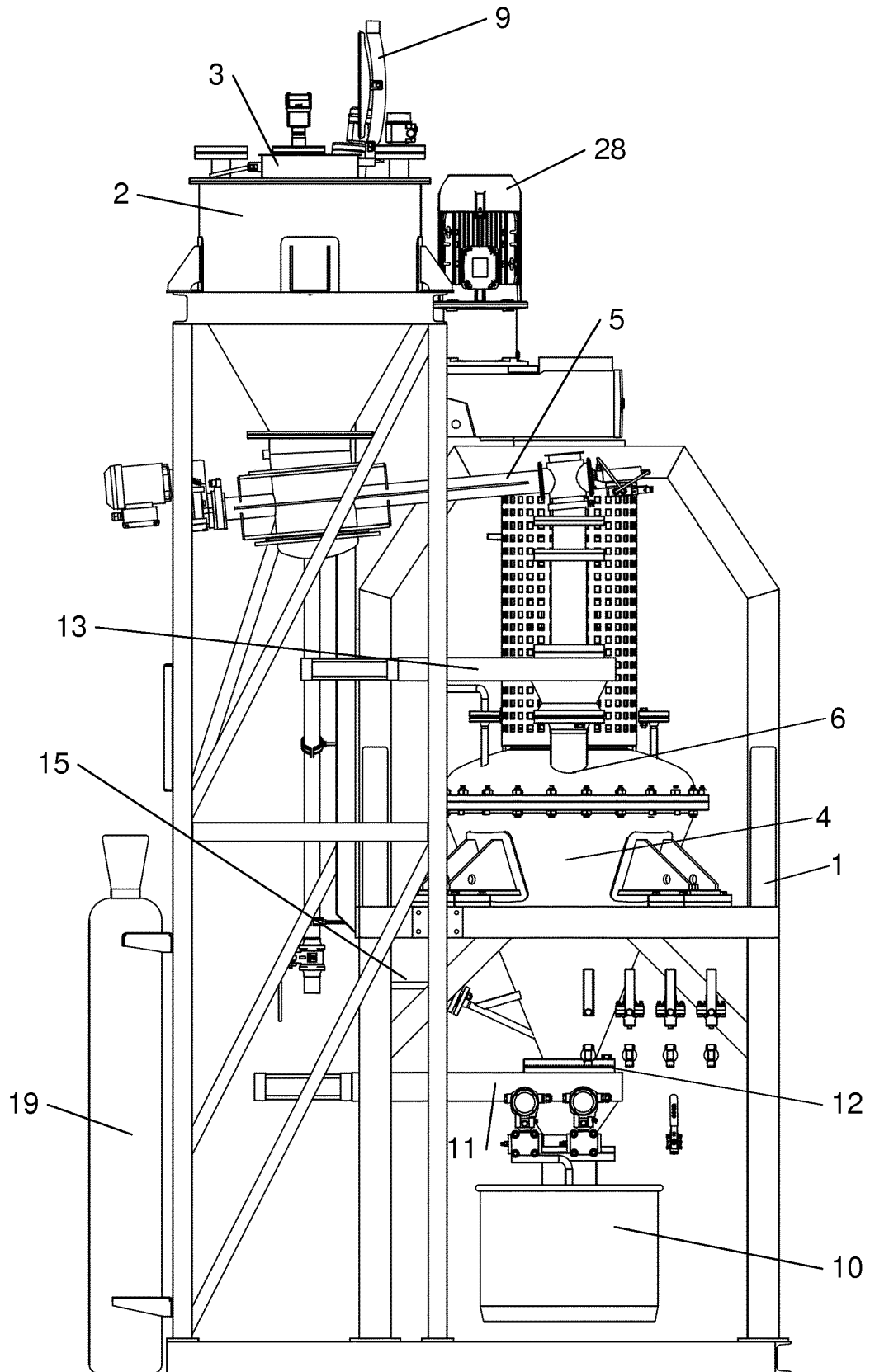


Fig. 3

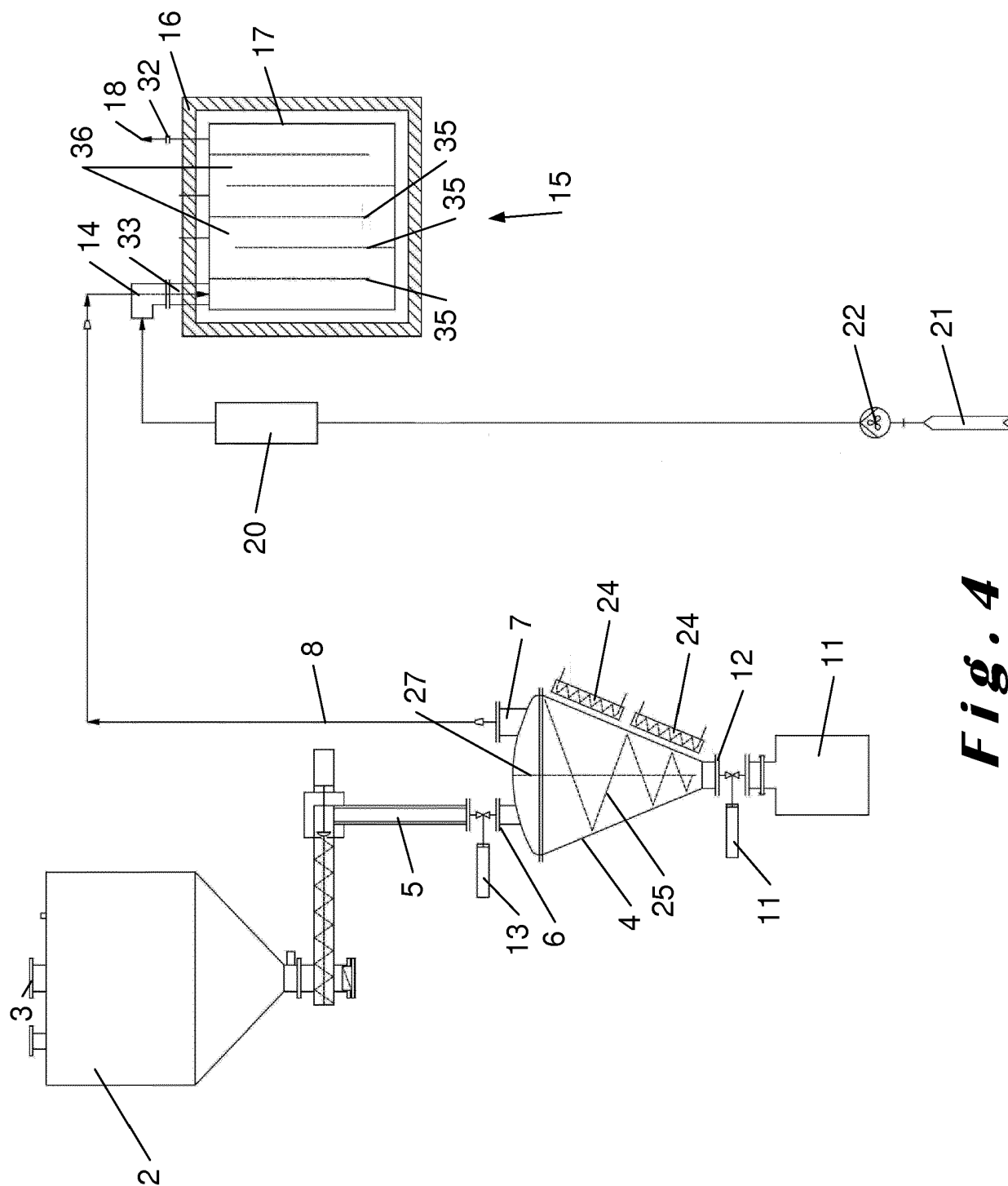
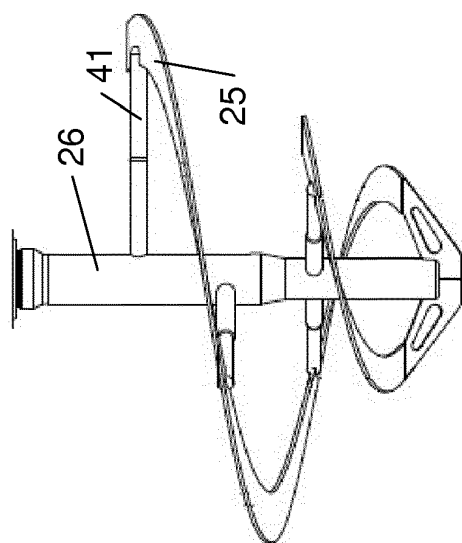
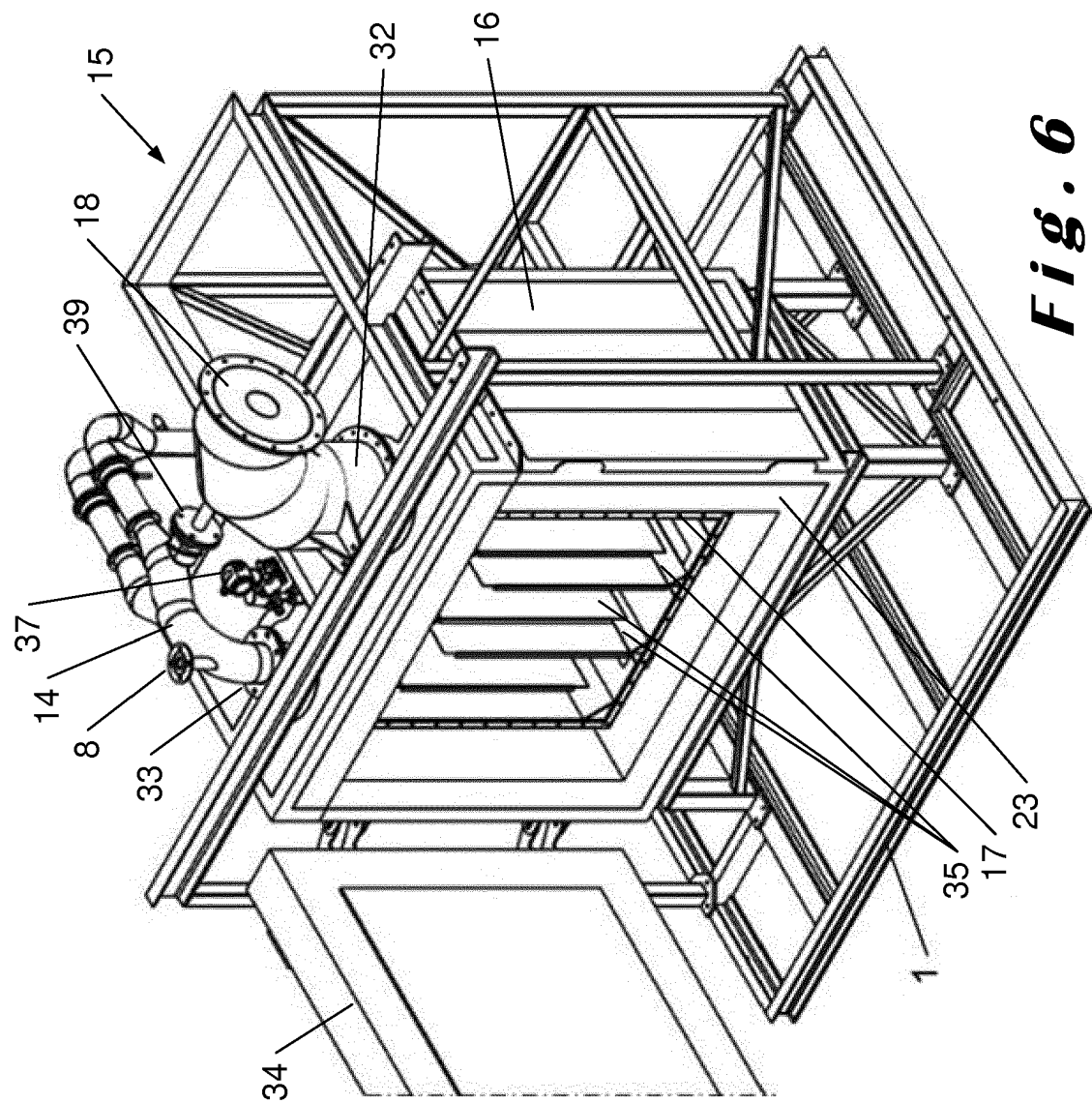
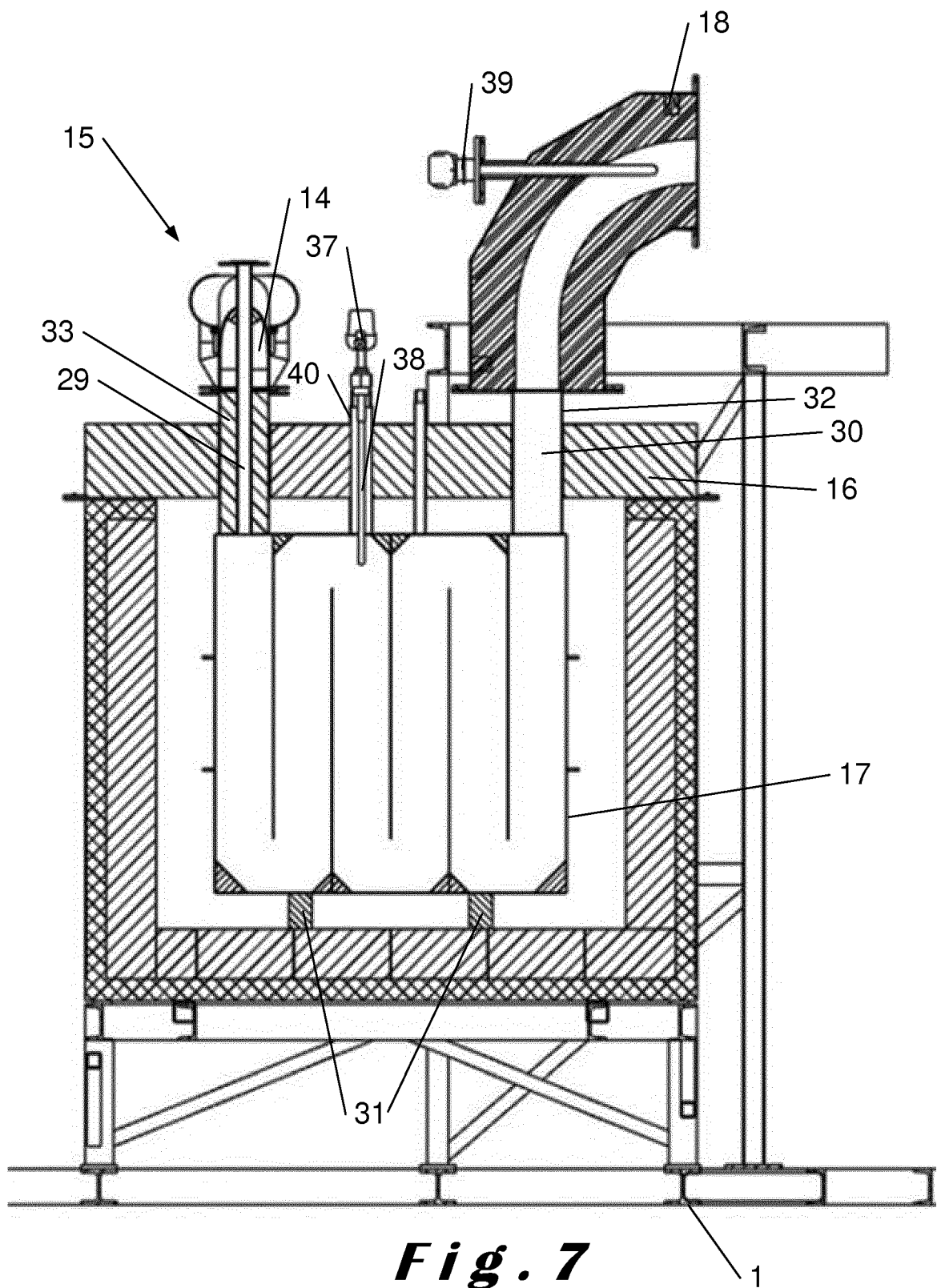


Fig. 4





REFERENCES CITED IN THE DESCRIPTION

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