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(54) **METHOD AND APPARATUS FOR OPERATING A BURNER**

(57) The invention proposes a method of operating a burner (110) of a sulphur recovery furnace (112) during an operation period, in which the furnace (112) has a temperature (135) below a predefinable first temperature threshold, comprising feeding (115) a first fluid (1) comprising at least one combustible constituent to the burner (110), feeding (115) a second fluid (2) containing a predefinable relative amount of oxygen to the burner (110), providing a turbulence provoking member (120) within a flow path (10, 20) of the first (1) and/or the second (2) fluid, igniting (140) the mixture formed from the first (1) and second (2) fluids within the burner (110) upstream and/or downstream the turbulence provoking member (120), and retracting (125) the turbulence provoking member (120) from within the flow paths (10, 20) of the first (1) and the second (2) fluids when the furnace (112) has a temperature (135) above a second temperature threshold. Further the invention proposes a corresponding apparatus (100).

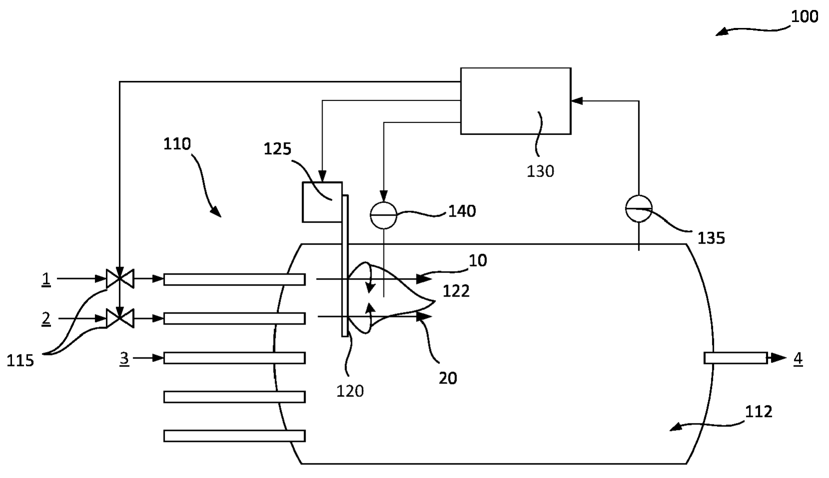

Fig. 1

Description

[0001] The invention relates to a method of operating a burner of a sulphur recovery furnace and a corresponding apparatus.

Background

[0002] Gas streams containing hydrogen sulphide (herein also referred to as "acid gas streams") are particularly formed in oil refineries and natural gas processing units, e.g. in connection with "sweetening" natural gas. Such streams cannot be vented directly to the atmosphere because hydrogen sulphide is poisonous. Furthermore, sulphur may represent a valuable resource.

[0003] A conventional method of treating an acid gas stream is by the well-known Claus process. In this process, a part of the hydrogen sulphide content of the acid gas stream is combined with an oxidant gas such as air and is subjected to combustion in a furnace so as to form sulphur dioxide. The sulphur dioxide then reacts in the furnace with residual hydrogen sulphide so as to form sulphur vapor. Thus, the hydrogen sulphide is effectively partially oxidized. The reaction between hydrogen sulphide and sulphur dioxide does not go to completion. The effluent gas stream from the furnace is cooled and sulphur is extracted, typically by condensation, from the cooled effluent gas stream. The resulting gas stream, still containing residual hydrogen sulphide and sulphur dioxide, passes through a train of stages in which catalysed reaction between the residual hydrogen sulphide and the sulphur dioxide takes place. The sulphur vapor produced is condensed downstream of each stage.

[0004] Sulphur recovery furnaces in the meaning of the present disclosure comprise furnaces with a simple burner geometry, i.e. without complex flow diverting (or fluid mixing) elements provided within the furnace chamber. For example, such furnaces may comprise a substantially empty furnace chamber, particularly with a circular cross section, with axially and/or radially and/or tangentially arranged fluid inlets and outlets for feeding combustible and/or oxidizing fluids to the furnace chamber and withdrawing product fluids from the furnace chamber. However, sulphur recovery furnaces according to this disclosure may also comprise more complex furnace geometries than the one described above.

[0005] Axially or longitudinally fired burners mounted on the back wall of a furnace may be used in a Claus process. Such burners are known e.g. from EP 0 315 225 A1 and from GB 2 467 930 A. EP 3 553 378 A1 discloses a method of combusting hydrogen sulphide with oxygen by means of a burner and such a burner, the outlet of which being connected to a furnace which is heated by a burner flame, said method including the step of preheating the furnace, wherein during the preheating step, a first fuel gas is supplied through a first port of the burner, the first port being connected to a plurality of first tubes extending to the burner outlet, a first oxidant gas is supplied through a second port of the burner, the second port being connected to a plurality of second tubes spaced from and coaxial with the first tubes, and a second oxidant gas or second fuel gas is supplied through a third port of the burner, the third port being connected to a plurality of third tubes spaced from and coaxial with the second tubes, and wherein during the normal operation of combusting hydrogen sulphide with oxygen, a third fuel gas is supplied through the first port and the first tubes, a third oxidant gas is supplied through the second port and the second tubes, and a fourth fuel gas is supplied through the third port and the third tubes.

[0006] Air, or more efficiently, commercially pure oxygen or oxygen-enriched air can be used as an oxidant gas to support the combustion of hydrogen sulphide in the initial part of the Claus process. However, if commercially pure oxygen or oxygen-enriched air having a mole fraction of oxygen above 0.65 is used as an oxidant gas, there may be a relatively high risk of damage to the refractory lining of the furnace due to the resulting high flame temperature. The degree of this risk will also depend on the composition of the Claus feed gas.

[0007] Possible ways of treating a feed gas stream comprising hydrogen sulphide are disclosed in US 6,893,620 B2 and in US 6,919,059 B2 where two furnaces are employed to support combustion of part of the hydrogen sulphide content of a feed gas stream with oxygen or oxygen-enriched air.

[0008] As the normal operation of combusting hydrogen sulphide with oxygen typically takes place at high temperatures in the furnace, especially when using pure oxygen or oxygen-enriched air, in order to avoid thermal stresses on the refractory lining of the furnace, preheating of the furnace is necessary. The preheating process may be done by a pilot burner which is installed separately from the main burner and typically close to the main burner in the furnace. With the pilot burner a dry-out and warm-up process typically having a thermal energy rate of 50 K/h is performed until the inner of the furnace reaches a temperature of more than about 1000 degrees Celsius. Before taking the main burner into operation, the pilot burner has to be removed or pulled out of the furnace after completion of the preheating process as due to the high temperatures of the main burner flame, there is a risk of damaging the pilot burner.

[0009] It is an object of the present invention to provide a method and a burner for combusting hydrogen sulphide with oxygen (generally an oxidant gas) including the step of preheating the furnace which is fired by the burner, where the disadvantages of using a pilot burner are reduced or overcome.

Disclosure of the invention

[0010] The invention is based on a turbulence provoking member being retractably positioned within a flow path of the combustible fuel fluid and/or the oxidizing fluid during the preheating phase of furnace operation in order to stabilize a flame during this operation period.

[0011] In detail, according to the invention, a method of operating a burner of a sulphur recovery furnace during an operation period, in which the furnace has a temperature below a predefinable first temperature threshold, comprises feeding a first fluid comprising at least one combustible constituent to the burner, feeding a second fluid containing a predefinable relative amount of oxygen to the burner, providing a turbulence provoking member within a flow path of the first and/or the second fluid, igniting the mixture formed from the first and second fluids within the burner upstream and/or downstream the turbulence provoking member, and retracting the turbulence provoking member from within the flow path of the first and the second fluids when the furnace has a temperature above a second temperature threshold. This stabilizes the flame during the preheating operation while protecting the turbulence provoking member from damage during standard operation of the furnace, in which the furnace temperature may well exceed a design temperature of the turbulence provoking member.

[0012] In at least one embodiment, the first fluid comprises one or more of hydrogen, natural gas, an alkane, an alkene, an alkyne and a derivative of any of the foregoing. These are particularly favourable combustibles for delivering a substantial amount of heat while allowing controlled combustion.

[0013] In at least one embodiment, the predefinable relative amount of oxygen is less than 50%, less than 30%, less than 25% or less than 22%, each case in relation to volume, particularly wherein the second fluid comprises at least 75%, at least 90% or at least 95% of one or more of air, synthetic air and dried air. This allows for controlled combustion without raising the risk of forming explosive mixtures of the first and second fluids.

[0014] In at least one embodiment, the first and second fluids are fed in such relative amounts to the burner that the oxygen constitutes less than 99%, less than 98% or less than 96% of the stoichiometrically required amount for entirely oxidizing the at least one combustible constituent. This protects downstream equipment from contact with oxidizing constituents, particularly oxygen, which would otherwise potentially cause negative effects for the equipment and/or products produced during standard operation (i.e. in an operation period following the preheating phase).

[0015] In at least one embodiment, the turbulence provoking member comprises a substantially flat element comprising one or more metallic and/or ceramic and/or refractory and/or amorphous material. Those are typically options which are economically favourable due to low cost and/or high durability in the relevant operating conditions. For example, the turbulence provoking member may be produced from a sheet metal, particularly an iron-based metal, and may optionally be coated with a ceramic coating, for instance.

[0016] In at least one embodiment, the turbulence provoking member has a shape with a circular or elliptical or rectangular or square or triangular or polygonal or star shaped or flower shaped or regular or partially regular or irregular contour line. Those shapes are relatively easy to manufacture and/or provide excellent turbulating performance.

[0017] Particularly, the shape may be chosen according to expected flow velocities and/or viscosity and/or density of the first and/or second fluids.

[0018] In at least one embodiment, the turbulence provoking member comprises holes configured to allow fluids to pass therethrough. This may enhance the turbulating properties of the turbulence provoking member and, therefore, aid the flame stabilizing effect.

[0019] In at least one embodiment, the second temperature threshold is equal to or lower than the first temperature threshold, particularly wherein the first and the second temperature threshold differ by less than 300°C, less than 200°C, less than 100°C or less than 50°C. Typically, with increasing temperature, flame stability also increases. Therefore, the turbulence provoking member may be retracted already before the preheating period is finished in order to protect it from overheating. However, this retraction should only be performed when the flame is sufficiently sustained by the already reached furnace temperature.

[0020] In at least one embodiment, the first temperature threshold is higher than 500°C, higher than 750°C, higher than 900°C or higher than 1000°C and/or lower than 2000°C, lower than 1500°C or lower than 1250°C. Those are particularly relevant temperature regimes.

[0021] According to the invention, an apparatus comprising a sulphur recovery furnace comprising a burner is configured to perform a method according to any one of the embodiments disclosed hereinbefore. Such an apparatus profits from the same advantages as the respective method.

[0022] In at least one embodiment, the apparatus comprises a turbulence provoking member configured to be retractably positionable within a flow path of the first and/or the second fluid when the apparatus is used to perform a method according to any of the embodiments disclosed hereinbefore. It is particularly advantageous if the turbulence provoking member is provided directly as a part of the apparatus such that there is no need to provide it separately.

[0023] In at least one embodiment, the apparatus comprises a motor element connected to the turbulence provoking member and configured to effect positioning within and/or retracting from the flow path of the first and/or second fluids. This allows for automation and/or remote and potentially more precise control of the apparatus, since no manual operation of the turbulence provoking element is required.

[0024] In at least one embodiment, the apparatus comprises control means configured to automatically control the turbulence provoking member to be retracted when a temperature within the sulphur recovery furnace exceeds the second temperature threshold. This reduces the requirements for surveillance of the preheating operation, since the turbulence provoking member in such an embodiment bears a substantially lower risk of being damaged by overheating due to belated retraction.

[0025] Particularly, the control means comprises a control unit, configured to issue control signals to control the turbulence provoking member to be retracted, and at least one temperature sensor configured to measure a temperature of the sulphur recovery furnace and to communicate information concerning the measured temperature to the control unit. Thereby, all the relevant information for deciding and controlling the retraction timing lies within the influence sphere of the control means.

[0026] In the following, further aspects and advantages of the invention are described with reference to particular embodiments and in relation to the appended drawings.

Brief description of the drawing

[0027]

Figure 1 schematically depicts an apparatus according to an embodiment of the present invention.

Figure 2 exemplarily depicts a turbulence provoking member useable in an apparatus according to the invention.

Embodiment(s) of the invention

[0028] In Fig. 1 an apparatus according to an embodiment of the invention is schematically depicted and collectively referred to with 100.

[0029] The apparatus 100 comprises a sulphur recovery furnace 112 fired by a burner 110. During an operating period in which the furnace has a temperature below a first temperature threshold, for example below 750°C, the burner 110 is supplied with a first fluid 1 comprising a combustible constituent, particularly natural gas, and a second fluid 2 containing oxygen. The second fluid 2 may be air, for example. A turbulence provoking member 120 is provided within flow paths 10, 20 of the first 1 and second 2 fluids, respectively. The presence of the turbulence provoking member 120 induces turbulences 122 downstream the turbulence provoking member 120, aiding thorough mixing of the first and second fluids 1, 2 and thereby results in flame stabilization.

[0030] In Figure 2 a turbulence provoking member 120 usable in embodiments of the invention is exemplarily depicted in a viewing direction substantially corresponding to the direction of the flow paths 10, 20 of fluids 1, 2 as shown in figure 1. The turbulence provoking member 120 as shown in figure 2 has a complex irregular contour line 210. In particular, this contour line comprises convex portions 212, concave portions 214 and sharp edges 216 (in this example in a concave configuration, although sharp edges may also be used in convex configuration). In the example shown, the turbulence provoking member 120 comprises two holes 220 which allow fluid to pass through the turbulence provoking member 120. In the example shown, the holes 220 are substantially elliptical in shape although different hole shapes (for example circular, rectangular, or any other regular, partially regular or irregular shape) as well as different numbers (for example one, three, four, five, ten, fifty, one hundred, one thousand or any other integer) and relative special arrangements (for example, randomly positioned or in an ordered array or any other relative spatial arrangement) of the holes are also conceivable. The turbulence provoking member 120 further comprises an engagement portion 230 via which it may be connected or mounted to other components of an apparatus according to an embodiment of the invention.

[0031] An ignition device 140, for example a spark igniter, is used to ignite the mixture resulting from the first 1 and second 2 fluids. In the example shown, the ignition device 140 is provided downstream the turbulence provoking member 120. The temperature of the furnace 112 may be monitored by a temperature sensor 135, particularly a thermocouple, communicatively connected to a control unit 130. The control unit 130 controls the ignition device 140 and a motor 125 which is functionally connected to the turbulence provoking member 120. Particularly, the motor 125 may be mechanically or magnetically connected to the engagement portion 230 of the turbulence provoking member 120.

[0032] For example, the control unit can control the ignition device 140 to ignite the mixture of the first 1 and second 2 fluids, monitor the resulting increase in furnace temperature via sensor 135 and control the motor 125 to retract the turbulence provoking member 120 from the flow paths 10, 20 of the first and second fluids 1, 2 when the temperature of the furnace 112 exceeds a second temperature threshold, e.g. 500°C. the second temperature threshold can be chosen according to the positioning of the temperature sensor and a material parameter of the turbulence provoking member, for example. Particularly the second temperature threshold may be lower than the first temperature threshold such that the turbulence provoking member 120 may be retracted before the preheating period of the furnace 112 is completed. As already explained, the combustion flame becomes more stable with increasing temperature such that the turbulence provoking member 120 may not be necessary for flame stabilization anymore, once the second temperature threshold is exceeded.

[0033] The first and second fluids 1, 2, in the example shown, are provided to the burner 110 via valves 115, particularly independently controllable valves controlled by control unit 130 associated with the apparatus 100. The valves 115 may particularly be controlled to provide the first 1 and second 2 fluids in such relative amounts to ensure a slightly sub-stoichiometric amount of oxygen for the combustion of the combustible constituent in order to prevent oxygen from contaminating the furnace 112 and/or equipment arranged downstream the furnace

112. In an example, the amount of oxygen may represent 95% of the stoichiometrically required oxygen amount for the total combustion of the combustible constituent. The relative and/or absolute amounts of the first 1 and second 2 fluids may also be adjusted in dependence of the temperature of the furnace 112 as measured by sensor 135. The first 1 and second 2 fluids may be provided to the burner using separate pipes or a pipe-in-pipe configuration, for example.

[0034] Once the control unit 130 detects that the furnace temperature exceeds the first temperature threshold, it may control the valves 115 to cut off at least the first fluid 1 and may control a third fluid 3 to be provided to the burner. The third fluid may particularly contain a combustible sulphur compound. By combusting at least a part of the sulphur compound and then reacting the resulting combustion product 4 with more of the combustible sulphur compound, elemental sulphur may be obtained.

Claims

1. Method of operating a burner (110) of a sulphur recovery furnace (112) during an operation period, in which the furnace (112) has a temperature (135) below a predefinable first temperature threshold, comprising feeding (115) a first fluid (1) comprising at least one combustible constituent to the burner (110),

   feeding (115) a second fluid (2) containing a predefinable relative amount of oxygen to the burner (110),
   providing a turbulence provoking member (120) within a flow path (10, 20) of the first (1) and/or the second (2) fluid,
   igniting (140) the mixture formed from the first (1) and second (2) fluids within the burner (110) upstream and/or downstream the turbulence provoking member (120), and
   retracting (125) the turbulence provoking member (120) from within the flow paths (10, 20) of the first (1) and the second (2) fluids when the furnace (112) has a temperature (135) above a second temperature threshold.

2. Method according to claim 1, wherein the first (1) fluid comprises one or more of natural gas, an alkane, an alkene, an alkyne and a derivative of any of the foregoing.

3. Method according to claim 1 or 2, wherein the predefinable relative amount of oxygen is less than 50%, less than 30%, less than 25% or less than 22%, each case in relation to volume, particularly wherein the second fluid (2) comprises at least 75%, at least 90% or at least 95% of one or more of air, synthetic air and dried air.

4. Method according to any one of the preceding claims, wherein the first (1) and second (2) fluids are fed (115) in such relative amounts to the burner (110) that the oxygen constitutes less than 99%, less than 98% or less than 96% of the stoichiometrically required amount for entirely oxidizing the at least one combustible constituent.

5. Method according to any one of the preceding claims, wherein the turbulence provoking member (120) comprises a substantially flat element comprising one or more metallic and/or ceramic and/or refractory and/or amorphous material.

6. Method according to any one of the preceding claims, wherein the turbulence provoking member (120) has a shape with a circular or elliptical or rectangular or square or triangular or polygonal or star-shaped or flower-shaped or regular or partially regular or irregular contour line (210).

7. Method according to any one of the preceding claims, wherein the turbulence provoking member (120) comprises one or more holes (220) configured to allow fluids (1, 2) to pass therethrough.

8. Method according to any one of the preceding claims, wherein the second temperature threshold is equal to or lower than the first temperature threshold, particularly wherein the first and the second temperature threshold differ by less than 300°C, less than 200°C, less than 100°C or less than 50°C.

9. Method according to any one of the preceding claims, wherein the first temperature threshold is higher than 500°C, higher than 750°C, higher than 900°C or higher than 1000°C and/or lower than 2000°C, lower than 1500°C or lower than 1250°C.

10. Apparatus (100) comprising a sulphur recovery furnace (112) comprising a burner (110) and configured to perform a method according to any one of the preceding claims.

11. Apparatus (100) according to claim 10 comprising a turbulence provoking member (120) configured to be retractably positionable within a flow path (10, 20) of the first (1) and/or the second (2) fluid when the apparatus (100) is used to perform a method according to any one of claims 1 to 9.

12. Apparatus (100) according to claim 11 comprising a motor element (125) connected to the turbulence provoking member (120) and configured to effect positioning within and/or retracting from the flow path (10, 20) of the first (1) and/or second (2) fluids.

13. Apparatus (100) according to claim 11 or 12 comprising control means (130) configured to automatically control the turbulence provoking member (120) to be retracted when a temperature within the sulphur recovery furnace (112) exceeds the second temperature threshold.

14. Apparatus (100) according to claim 13, wherein the control means comprises a control unit (130), configured to issue control signals to control the turbulence provoking member (120) to be retracted, and at least one temperature sensor (135) configured to measure a temperature of the sulphur recovery furnace (112) and to communicate information concerning the measured temperature to the control unit (130).

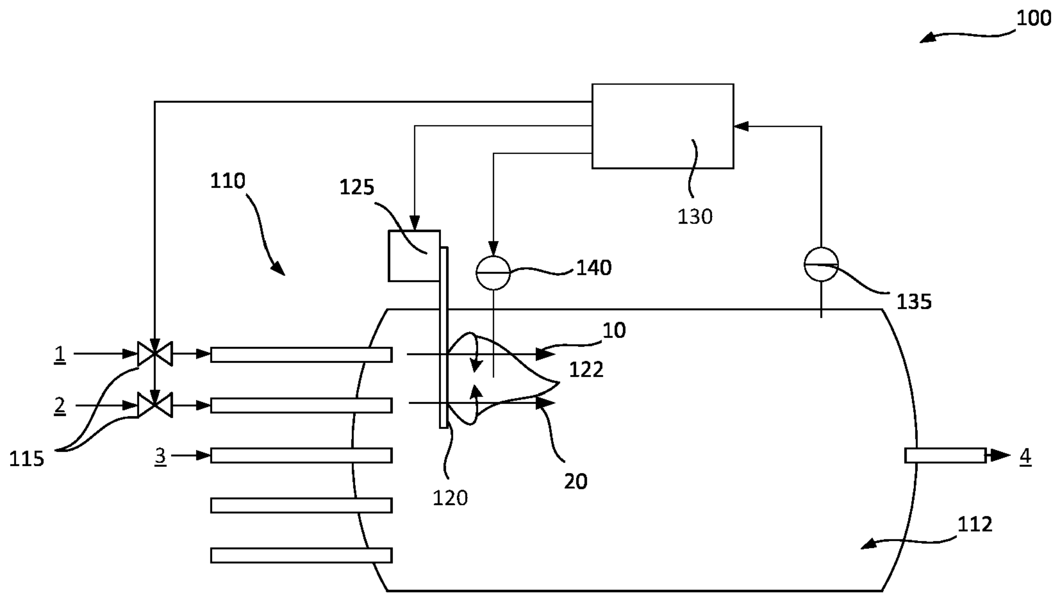

Fig. 1

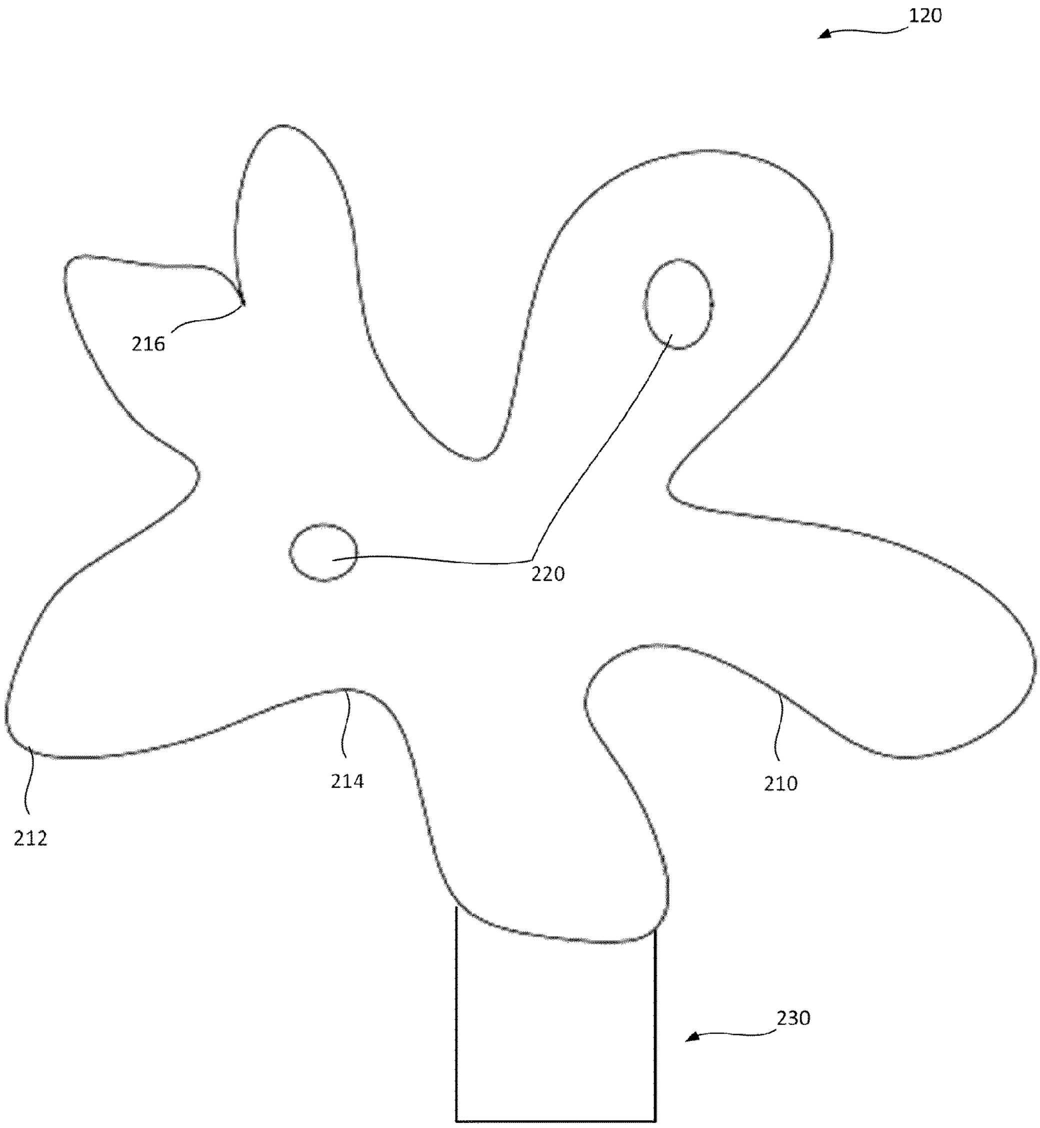

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 23 02 0217

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	CN 115 264 506 A (HENAN FANGYUAN INDUSTRIAL FURNACE DESIGN AND MFG CO LTD) 1 November 2022 (2022-11-01) * figures 1-3 and the relating passages of the description * -----	1-4,8-14 5-7	INV. F23D14/22 F23D14/70
A	US 4 123 220 A (BOND DESMOND H ET AL) 31 October 1978 (1978-10-31) * column 3, line 51 - column 15, line 57 * * figures 1-8 * -----	1-14	
A	US 2022/302683 A1 (AL-SHAMMARI KHAIR ALLAH SAYER [SA] ET AL) 22 September 2022 (2022-09-22) * page 2, paragraph 18 - page 4, paragraph 38 * * figures 1-4 * -----	1-14	
A	CN 202 993 205 U (NO 11 RES INST OF NO 6 ACADEMY CHINA AEROSPACE SCIENCE & TECHNOLOGY GR) 12 June 2013 (2013-06-12) * figures 1-3 and the relating passages of the description * -----	1-14	TECHNICAL FIELDS SEARCHED (IPC) F23D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	27 October 2023	Rudolf, Andreas

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 02 0217

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27-10-2023

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
CN 115264506	A	01-11-2022	NONE	
US 4123220	A	31-10-1978	NONE	
US 2022302683	A1	22-09-2022	NONE	
CN 202993205	U	12-06-2013	NONE	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0315225 A1 **[0005]**
- GB 2467930 A **[0005]**
- EP 3553378 A1 **[0005]**
- US 6893620 B2 **[0007]**
- US 6919059 B2 **[0007]**