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(54) **A combustion system**

Verbrennungssystem

Système de combustion

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**Description**

## TECHNICAL FIELD

**[0001]** The present invention relates to a combustion system; in particular the invention refers to a combustion system that is part of a boiler, such as a boiler of a power plant for electric power generation.

## BACKGROUND

**[0002]** Boilers for electric power generation often have combustion systems with furnaces that are fired with solid fuel, such as coal, lignite, etc.; these combustion systems are usually provided with mills for pulverizing the fuel and ducting for supplying the pulverized fuel to burners of the furnace.

**[0003]** In these boilers, both fuel quality and achievable dust concentration influence operational flexibility, safe ignition, and flame stability.

**[0004]** In particular, in case of lignite fired boilers, fuel concentration is an important parameter to control, because of the very different features of different kinds of lignite, such that in order to maintain safe operation it is necessary to increase pulverized fuel concentration when the quality of the lignite lowers.

**[0005]** In order to increase fuel concentration it is common the use of the so called vapour separation systems; these systems separate the flow coming from the mill in a fuel rich flow and direct it to burners located at a lower zone of the furnace and a fuel lean flow (i.e. a vapour rich flow) and supply it to burners located at an upper zone of the furnace.

**[0006]** Different vapour separation systems have been proposed.

**[0007]** A first example of vapour separation system takes advantage of the non-homogeneous flow coming from the mill. In this case a branching in the duct that carries the flow from the mill causes separation of the flow in a fuel rich flow in one ducting and fuel lean flow in other ducting.

**[0008]** This vapour separation system proved to cause low pressure losses while ensuring good separation performances.

**[0009]** A different example of vapour separation system provides for an impeller that divides a homogeneous flow between different ducting; in particular the impeller forces separation of a fuel rich flow from a fuel lean flow and directs each flow in different ducting. For example, DE 293 35 28 discloses a vapour separation system of this kind.

**[0010]** This vapour separation system proved to be very effective in separation, but at the same time it causes high pressure losses.

**[0011]** Lignite fired boilers have to guarantee a broad operation load range but, because of the intrinsic features of the lignite, at low load (for example load below 50%, preferably 40%, more preferably 30%, and even more

preferably below 20%) the fuel concentration achievable with the known vapour systems and/or the pressure losses cannot guarantee safe operation.

**[0012]** US 2014/0065561 describes a single-fireball tangentially-firing boiler for the burning of anthracite. The combustion system of US 2014/0065561 is in accordance with the preamble of claim 1. FR 1352264 describes pulverised coal combustion with an enrichment device providing an air-pulverised coal mix.

## SUMMARY

**[0013]** An aspect of the invention includes providing a combustion system that is able to safely operate in a broad load range, in particular at low/very low load, without impairing or with a limited impairing of the operation at medium/high load, in particular when lignite is fired; other fuels are anyhow possible and in particular low quality fuels containing a large amount of humidity and ash.

**[0014]** These and further aspects are attained by providing a combustion system in accordance with the accompanying claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0015]** Further characteristics and advantages will be more apparent from the description of a preferred but non-exclusive embodiment of the combustion system, illustrated by way of nonlimiting example in the accompanying drawings, in which:

Figure 1 schematically shows a combustion system in an embodiment of the invention;

Figure 2 schematically shows a particular of figure 1; Figures 3 through 5 schematically show an impeller whose blades have different pitch angles.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

**[0016]** With reference to the figures, these show a combustion system 1 comprising a furnace 2 having an enclosure 3 defining a combustion chamber; preferably the furnace 2 is part of a boiler, in this case the enclosure 3 is made of tubed walls, for a cooling medium such as water to pass through the tubed walls and evaporate.

**[0017]** The furnace 2 further has burners 4a, 4b, 4c having different elevation. The burners can be of different types known in the art; they are arranged to supply solid fuel such as lignite and/or vapour containing solid fuel; they can be all equal or they can be different from one another.

**[0018]** The combustion system 1 further comprises a mill 6 for milling solid fuel such as lignite to be supplied to the burners 4a, 4b, 4c. The mill 6 is connected to a vapour separation system 7.

**[0019]** The vapour separation system 7 receives a non-

homogeneous flow of vapour and pulverized fuel and comprises a branching area 9 between first ducting 10 and second ducting 11; the non-homogeneous flow is divided at the branching 9 between the ducting 10 and 11 such that a fuel rich flow passes through the first ducting 10 and a fuel lean flow passes through the second ducting 11.

**[0020]** In addition, the first ducting 10 comprises an impeller 12 at a position downstream the branching area 9 with reference to the flow F of vapour and pulverized fuel coming from the mill 6.

**[0021]** The figures show an example of an impeller 12 with a body 12a and fixed impeller blades 12b extending therefrom. The flow passes through the impeller 12 such that the impeller 12 defines (through the blades 12b) a fuel concentrated content flow FC and a fuel reduced content flow FR.

**[0022]** The combustion system 1 further has ducting 15 for supplying the fuel concentrated content flow FC to first burners 4a of the burners having a lower elevation, and ducting 16 for supplying the fuel reduced content flow to second burners 4b of the burners having a lower elevation.

**[0023]** For example, as shown in the figures, the ducting 16 has an end inserted in the ducting 15, at an elbow thereof.

**[0024]** Advantageously the second burners 4b have a higher elevation than the first burners 4a and preferably the second burners 4b are located above the first burners 4a, such that the flame generated by the first burners 4a can contribute to maintain the flame generated by the second burners 4b in case of excessively lean fuel reduced content flow.

**[0025]** The impeller 12 can have blades 12b with adjustable pitch angle and, in this respect, the blades 12b can be connected to an electro-mechanical or hydraulic-mechanical mechanism 19.

**[0026]** In addition, the furnace 2 can also have a controller 20 to control the position of the blades 12b in accordance with a signal indicative of the load of the mill or flame stability or pulverized fuel content in the fuel concentrated content flow and/or fuel reduced content flow or other control signals.

**[0027]** The mill 6 provides a non-homogeneous flow F of vapour and pulverized fuel. Typically, the design of a beater wheel mill for lignite generates a non-homogeneous flow.

**[0028]** The operation of the combustion system is apparent from that described and illustrated and is substantially the following.

**[0029]** The mill 6 is supplied with solid fuel 25 such as lignite and carrier and drying gas 26, such as recirculated flue gas from the furnace 2.

**[0030]** At the mill 6 the lignite is milled and a flow F of vapour and pulverized fuel (lignite) moves from the mill 6 to the vapour separation system 7. This flow F is non-homogeneous, such that at the branching area 9 the fuel rich flow is separated from the fuel lean flow, because of

the greater inertia of the pulverized fuel than the vapour or light fuel particles that are entrained by vapour.

**[0031]** The fuel lean flow is supplied to the burners 4c having the higher elevation and is combusted (for example without flame, but this depends on the particular conditions) in the furnace 2.

**[0032]** The fuel rich flow passes through the impeller 12 that imparts the fuel a swirl that in turn by centrifugal forces defines the fuel concentrated content flow FC with an annular configuration (i.e. over the walls of the pipes of the first ducting 10) and the fuel reduced content flow FR within the annular fuel concentrated content flow FC.

**[0033]** The fuel concentrated content flow FC is thus supplied via the ducting 15 to the burners 4a of the lower burners and is combusted; the fuel reduced content flow FR is supplied via the ducting 16 to the burners 4b of the lower burners and is also combusted.

**[0034]** The fuel concentrated content flow FC has a high concentration that allows safe operation of the furnace 2 and flame stability also at low load or very low load.

**[0035]** The fuel from the burners 4b has a lower concentration than the fuel from the burners 4a, but this reduced concentration does not impair the furnace operation, because the flame generated by the fuel concentrated content flow from the burner 4a can stabilize when needed the flame from the fuel reduced content flow from the burner 4b. This stabilisation effect is particularly effective when the burners 4b are located above the burners 4a as shown in figure 2 (i.e. vertically aligned or substantially vertically aligned).

**[0036]** During operation the pitch angle of the blades 12b of the impeller 12 can be advantageously adjusted, as indicated by reference 27. This can for example be done in accordance with a parameter such as the load of the mill or a parameter indicative thereof or other parameters.

**[0037]** The pitch angle is the angle between the blade cord and the impeller rotation plane; the cord is the line between leading and trailing edge.

**[0038]** Figure 3 shows an example in which the pitch angle is 0. In this case the impeller 12 practically does not cause any separation between fuel concentrated content flow and fuel reduced content flow and likewise the pressure drop caused by the impeller 12 is minimum and typically negligible. This configuration can be used at medium/high load, when the vapour separation achieved at the branching area 9 is sufficient to obtain safe and stable operation of the furnace 2.

**[0039]** Figure 4 shows an example in which the pitch angle is 30 degree. In this case the impeller 12 causes separation of fuel concentrated content flow FC and fuel reduced content flow FR with some pressure losses; the separation and the pressure losses are anyhow not the largest achievable, i.e. the separation can be further increased by further increasing the pitch angle but this causes more pressure drop. This configuration can be used at low/medium load.

**[0040]** Figure 5 shows an example in which the pitch

angle is 45 degree; in this configuration the separation and the drop pressure are theoretically the largest; this configuration can be used at very low/low load.

**[0041]** Thus the adjustment of the pitch angle of the blades 12b advantageously allows to reduce the pitch angle in order to reduce pressure losses when separation of fuel concentrated content flow and fuel reduced content flow is not needed or is needed only to a limited extent to guarantee safe and stable operation of the furnace 2 and vice versa, i.e. increase the pitch angle when separation is needed to guarantee safe and stable operation of the furnace 2.

**[0042]** In practice the materials used and the dimensions can be chosen at will according to requirements and to the state of the art.

#### REFERENCE NUMBERS

#### [0043]

1 combustion system  
 2 furnace  
 3 enclosure  
 4a,b,c burners  
 6 mill  
 7 vapour separation system  
 9 branching area  
 10 first ducting  
 11 second ducting  
 12 impeller  
 12a body  
 12b impeller blades  
 15 ducting  
 16 ducting  
 19 mechanism  
 20 controller  
 25 solid fuel  
 26 carrier gas  
 27 adjustment of pitch angle  
 F flow of vapour and pulverized fuel  
 FC fuel concentrated content flow  
 FR fuel reduced content flow

#### Claims

1. A combustion system (1) comprising a furnace (2) with an enclosure (3) and burners (4a, 4b, 4c) having different elevation, a mill (6) for milling solid fuel to be supplied to the burners (4a, 4b, 4c), a vapour separation system (7) for receiving a non-homogeneous flow of vapour and pulverized fuel and providing a fuel rich flow through first ducting (10) to burners (4a, 4b) having a lower elevation, and a fuel lean flow through second ducting (11) to burners (4c) having a higher elevation, the first ducting (10) and the second ducting (11)

branching from a branching area (9), **characterised in that**

the first ducting (10) comprises an impeller (12) at a position downstream the branching area (9) with reference to the flow (F) of vapour and pulverized fuel, the impeller (12) defining a fuel concentrated content flow (FC) and a fuel reduced content flow (FR), and **in that** the combustion system (1) further comprises ducting (15) for supplying the fuel concentrated content flow (FC) to at least one first burner (4a) of the burners having a lower elevation and ducting (16) for supplying the fuel reduced content flow (FR) to at least one second burner (4b) of the burners having a lower elevation,

wherein the at least a second burner (4b) has a higher elevation than the at least a first burner (4a).

2. The combustion system (1) of claim 1, **characterised in that** the at least a second burner (4b) is located above the at least a first burner (4a).

3. The combustion system (1) of claim 1, **characterised in that** the impeller (12) has blades (12b) with adjustable pitch angle.

4. The combustion system (1) of claim 3, **characterised in that** the blades (12a) are connected to an electro-mechanical or hydraulic-mechanical mechanism.

5. The combustion system (1) of claim 3 or 4, **characterised by** comprising a controller (20) to control the position of the blades (12b) in accordance with a signal indicative of the load of the mill or flame stability or pulverized fuel content in the fuel concentrated content flow (FC) and/or fuel reduced content flow (FR).

6. The combustion system (1) of claim 1, **characterised in that** the mill (6) is arranged to provide a non-homogeneous flow (F) of vapour and pulverized fuel.

7. The combustion system (1) of claim 1, **characterised in that** it is part of a boiler.

#### Patentansprüche

1. Verbrennungssystem (1), das aufweist:

einen Ofen (2) mit einer Einhausung (3) und Brennern (4a, 4b, 4c) mit unterschiedlicher Höhenlage,  
 eine Mühle (6) zum Mahlen von Festbrennstoff, der den Brennern (4a, 4b, 4c) zugeführt werden soll,  
 einem Dampftrennsystem (7) zur Aufnahme einer inhomogenen Strömung aus Dampf und pul-

verisiertem Brennstoff und Lieferung einer brennstoffreichen Strömung durch ein erstes Leitungssystem (10) zu Brennern (4a, 4b) mit einer niedriger Höhenlage und einer brennstoffarmen Strömung durch ein zweites Leitungssystem (11) zu Brennern (4c) mit einer höheren Höhenlage,

wobei das erste Leitungssystem (10) und das zweite Leitungssystem (11) von einem Verzweigungsbereich (9) abzweigen,

**dadurch gekennzeichnet, dass**

das erste Leitungssystem (10) ein Flügelrad (12) an einer Position stromabwärts des Verzweigungsbereiches (9) in Bezug auf die Strömung (F) von Dampf und pulverisiertem Brennstoff aufweist, wobei das Flügelrad (12) eine Strömung (FC) mit konzentriertem Brennstoffgehalt und eine Strömung (FR) mit reduziertem Brennstoffgehalt definiert, und dass

das Verbrennungssystem (1) ferner ein Leitungssystem (15) zur Zuführung der Strömung (FC) mit konzentriertem Brennstoffgehalt zu wenigstens einem ersten Brenner (4a) der Brenner mit einer niedrigeren Höhenlage und ein Leitungssystem (16) zur Zuführung der Strömung (FR) mit reduziertem Brennstoffgehalt zu wenigstens einem zweiten Brenner (4b) der Brenner mit einer niedrigeren Höhenlage aufweist, wobei der wenigstens eine zweite Brenner (4b) eine höhere Höhenlage als der wenigstens eine erste Brenner (4a) aufweist.

2. Verbrennungssystem (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** der wenigstens eine zweite Brenner (4b) oberhalb des wenigstens einen ersten Brenners (4a) angeordnet ist.
3. Verbrennungssystem (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** das Flügelrad (12) Schaufeln (12b) mit einstellbarem Neigungswinkel aufweist.
4. Verbrennungssystem (1) nach Anspruch 3, **dadurch gekennzeichnet, dass** die Schaufeln (12a) mit einem elektromechanischen oder hydraulisch-mechanischen Mechanismus verbunden sind.
5. Verbrennungssystem (1) nach Anspruch 3 oder 4, **dadurch gekennzeichnet, dass** es eine Steuereinrichtung (20) zur Steuerung der Position der Schaufeln (12b) entsprechend einem Signal aufweist, das die Last der Mühle oder die Flammenstabilität oder den Gehalt an pulverisiertem Brennstoff in der Strömung (FC) mit konzentriertem Brennstoffgehalt und/oder der Strömung (FR) mit reduziertem Brennstoffgehalt anzeigt.
6. Verbrennungssystem (1) nach Anspruch 1, **dadurch**

**gekennzeichnet, dass** die Mühle (6) eingerichtet ist, um eine inhomogene Strömung (F) aus Dampf und pulverisiertem Brennstoff bereitzustellen.

- 5 7. Verbrennungssystem (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** es Teil eines Kessels ist.

## Revendications

- 10 1. Système de combustion (1), comprenant :

un four (2) comportant une enceinte (3) et des brûleurs (4a, 4b, 4c) situés à des hauteurs différentes,

un broyeur (6) destiné à broyer du combustible solide devant être fourni aux brûleurs (4a, 4b, 4c),

un système de séparation de vapeur (7) destiné à recevoir un flux non homogène de vapeur et de combustible pulvérisé, et à fournir un flux riche en combustible, via une première conduite (10), aux brûleurs (4a, 4b) situés à une hauteur plus faible, et un flux pauvre en combustible, via une deuxième conduite (11), aux brûleurs (4c) situés à une hauteur plus élevée, la première conduite (10) et la deuxième conduite (11) partant d'une zone d'embranchement (9),

**caractérisé en ce que**

la première conduite (10) comprend une roue (12) à une position située en aval de la zone d'embranchement (9) par rapport à l'écoulement (F) de vapeur et de combustible pulvérisé, la roue (12) définissant un flux à teneur concentrée en combustible (FC) et un flux à teneur réduite en combustible (FR), et **en ce que** le système de combustion (1) comprend en outre :

une conduite (15) destinée à acheminer le flux à teneur concentrée en combustible (FC) à au moins un premier brûleur (4a) parmi les brûleurs situés à une hauteur plus faible, et

une conduite (16) destinée à acheminer le flux à teneur réduite en combustible (FR) à au moins un deuxième brûleur (4b) des brûleurs situés à une hauteur plus faible, sachant que le deuxième brûleur (4b), au nombre d'au moins un, se situe à une plus grande hauteur que le premier brûleur (4a), au nombre d'au moins un.

- 50 2. Système de combustion (1) selon la revendication 1, **caractérisé en ce que** le deuxième brûleur (4b), au nombre d'au moins un, se situe au-dessus du premier brûleur (4a), au nombre d'au moins un.

3. Système de combustion (1) selon la revendication 1, **caractérisé en ce que** la roue (12) présente des aubes (12b) à angle de calage réglable.
4. Système de combustion (1) selon la revendication 3, **caractérisé en ce que** les aubes (12a) sont reliées à un mécanisme électromécanique ou hydraulique-mécanique. 5
5. Système de combustion (1) selon la revendication 3 ou 4, **caractérisé en ce qu'il** comprend un dispositif de commande (20) pour commander la position des aubes (12b) en fonction d'un signal indiquant la charge du broyeur ou la stabilité de la flamme ou la teneur en combustible pulvérisé dans le flux à teneur concentrée en combustible (FC) et/ou dans le flux à teneur réduite en combustible (FR). 10 15
6. Système de combustion (1) selon la revendication 1, **caractérisé en ce que** le broyeur (6) est agencé pour fournir un flux non homogène (F) de vapeur et de combustible pulvérisé. 20
7. Système de combustion (1) selon la revendication 1, **caractérisé en ce qu'il** fait partie d'une chaudière. 25

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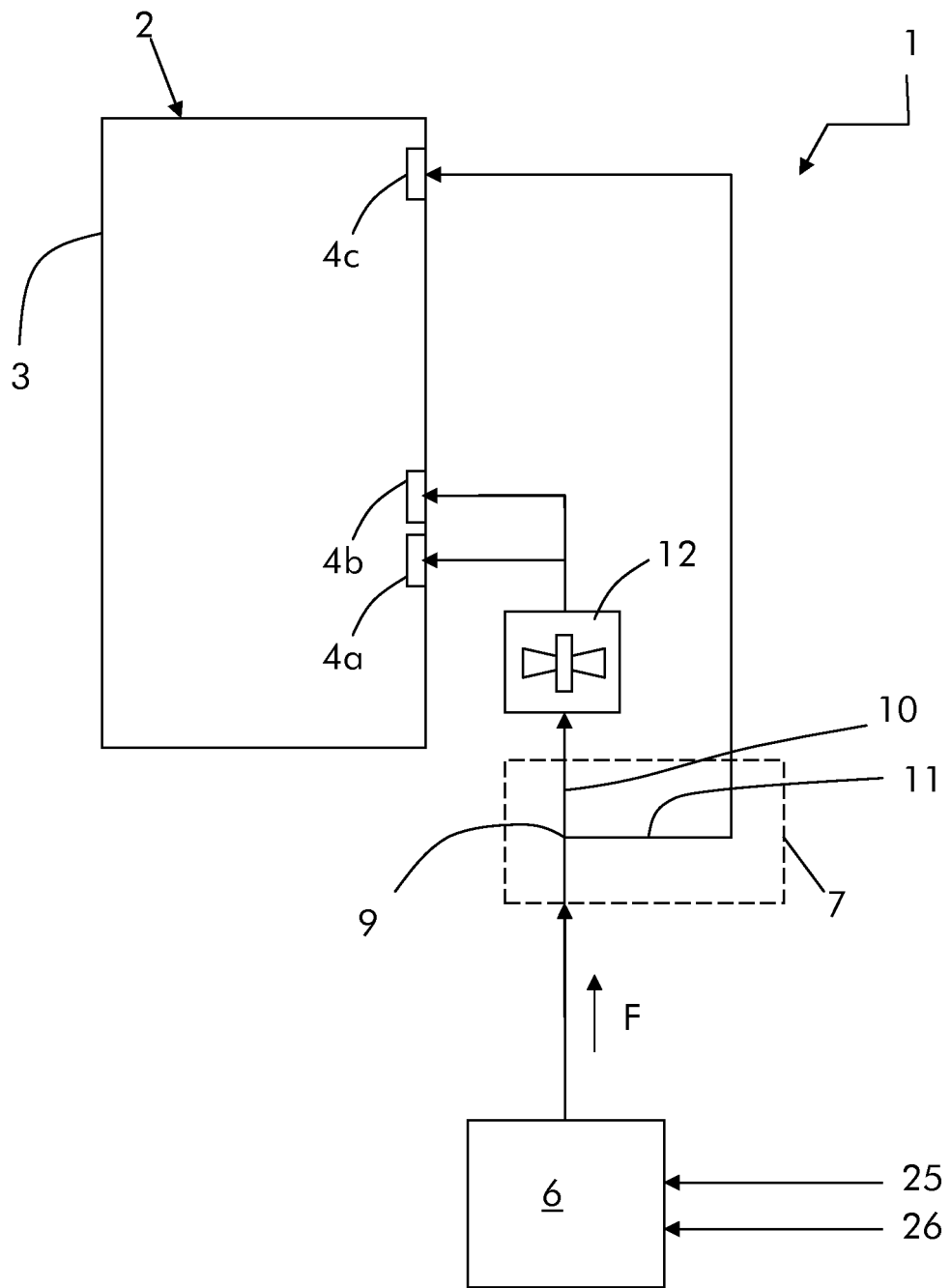


Fig. 1

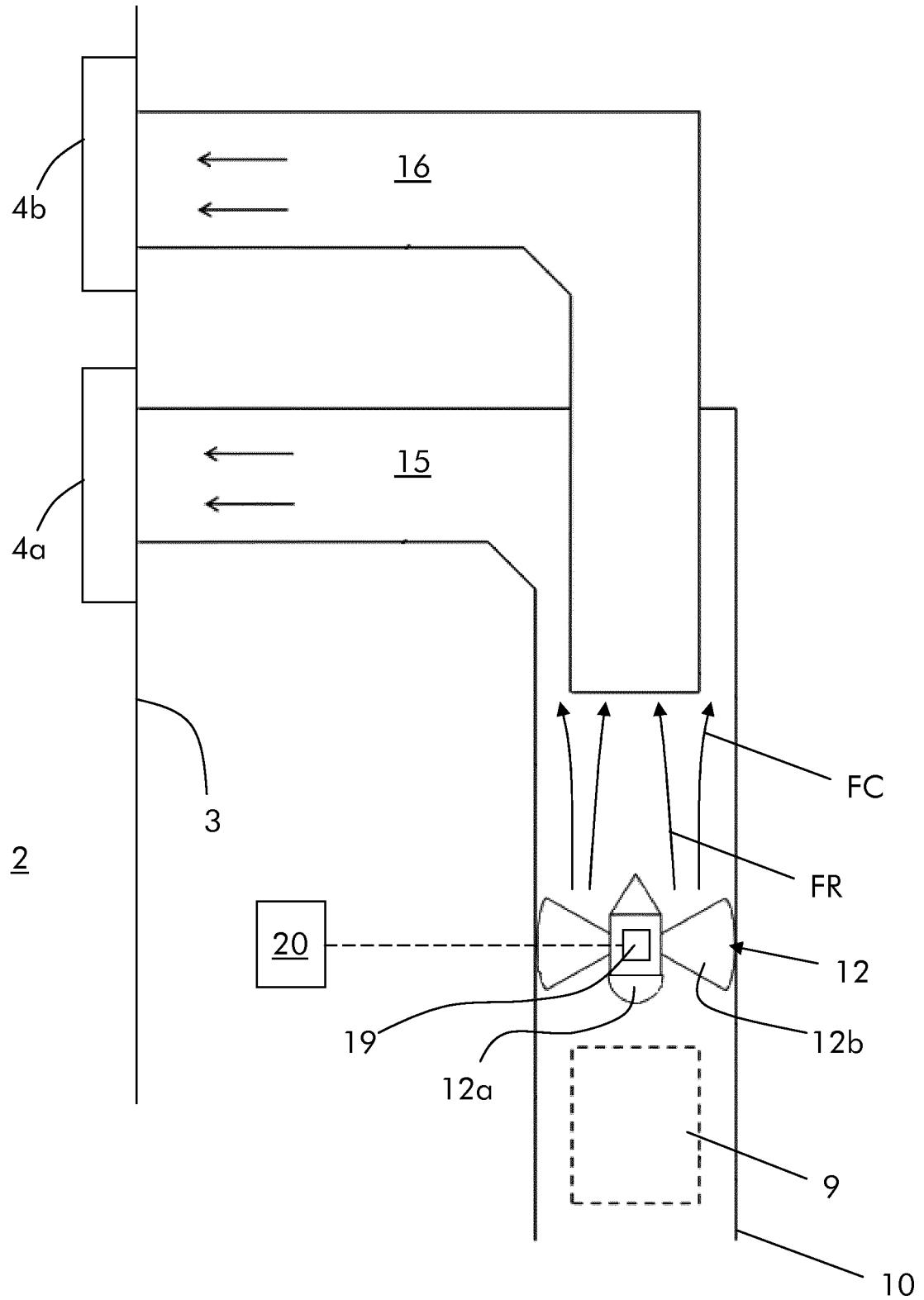


Fig. 2



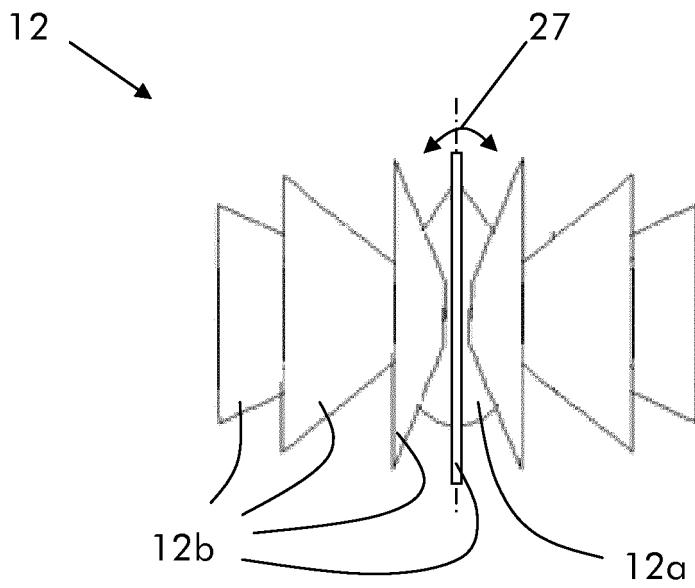


Fig. 3

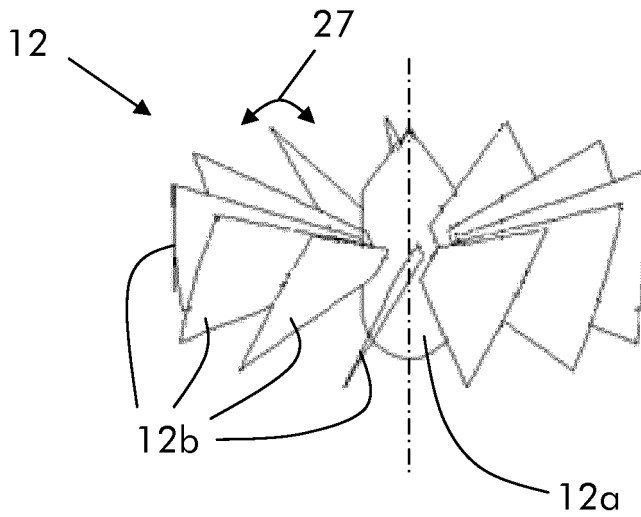


Fig. 4

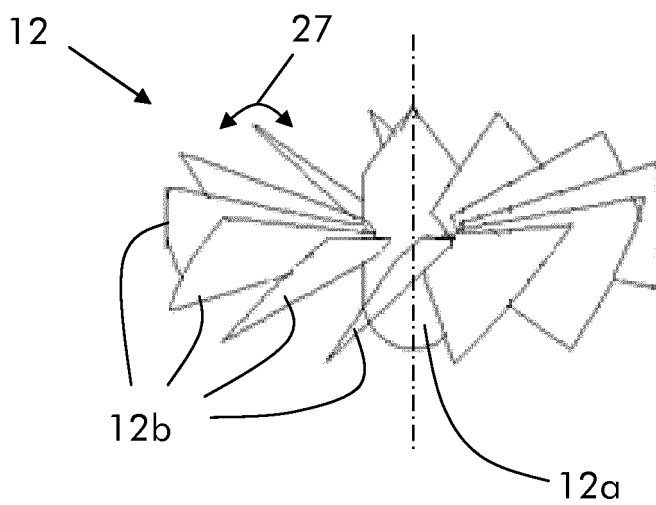


Fig. 5

**REFERENCES CITED IN THE DESCRIPTION**

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