



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.06.2016 Bulletin 2016/25

(51) Int Cl.:
F23D 11/10 (2006.01) **F23D 11/12** (2006.01)
F23D 11/24 (2006.01) **F23D 11/38** (2006.01)
F23D 17/00 (2006.01)

(21) Application number: **15200053.5**

(22) Date of filing: **15.12.2015**

(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
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **Dernjatin, Pauli**
00670 Helsinki (FI)
• **Savolainen, Kati**
02730 Espoo (FI)
• **Heinolainen, Antti**
00700 Helsinki (FI)

(30) Priority: **15.12.2014 FI 20146099**

(74) Representative: **Papula Oy**
P.O. Box 981
00101 Helsinki (FI)

(71) Applicant: **Fortum OYJ**
02150 Espoo (FI)

(54) **BIO OIL BURNER AND OIL NOZZLE**

(57) A bio oil burner comprises an oil lance, at the end of which there is an oil nozzle with spray holes for feeding atomized oil to a furnace of a boiler. The bio oil burner further comprises a first cylinder which together with the oil lance delimits an annular primary air flow channel; a second cylinder which together with the first cylinder delimits an annular secondary air flow channel, and a third cylinder which together with the second cylinder delimits an annular tertiary air flow channel. In addition, the bio oil burner comprises a primary air swirler annularly surrounding the oil nozzle and blocking at least part of an outlet of the primary air flow channel. The oil nozzle has 6 - 50 spray holes which are distributed on a slanting circumferential surface of the oil nozzle in such a way that said spray holes form at least two groups of spray holes in which the spray holes are located at a regular spacing from each other, and that between said groups of spray holes there are intermediate spaces in which no spray holes are present. A free end of the first cylinder is provided with a flame stabilizing ring which surrounds the outlet of the primary air flow channel and blocks part of an outlet of the secondary air flow channel. The outer diameter D_i of the primary air swirler is calculated by the formula $D_i = a \cdot D_{1ry}$, wherein a is 0.45 - 0.6 and D_{1ry} is the inner diameter of the first cylinder.

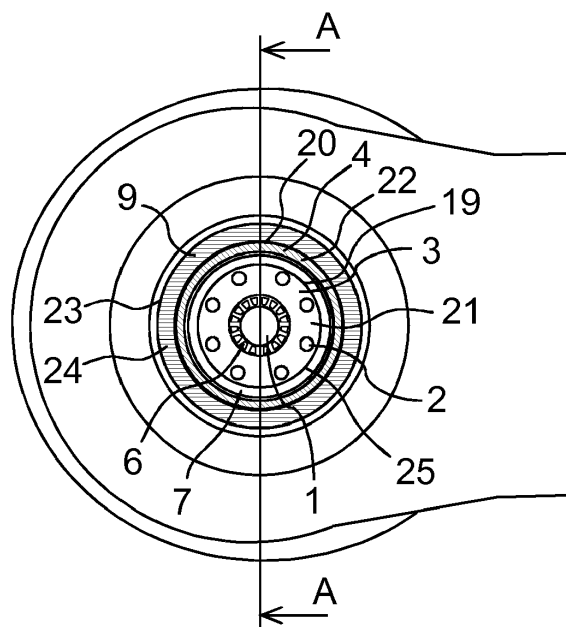


Fig. 5

Description

FIELD OF THE INVENTION

[0001] The invention relates to a bio oil burner which is suitable for burning bio-based pyrolysis oil in heat only boilers. The invention also relates to an oil nozzle for an oil burner.

BACKGROUND OF THE INVENTION

[0002] The burning of heavy fuel oil and natural gas is currently well known and commercial arrangements are numerous. However, as the emission standards for nitrogen oxides (NO_x) are becoming ever more stringent, there are pressures to make modifications, and technical improvements in devices are continuously required. In addition to NO_x emissions, also the emission standards for carbon dioxide (CO_2) will become more stringent. One way to reduce CO_2 emissions is to replace the heavy fuel oil with bio oil produced from bio-based material.

[0003] For burning gaseous, liquid and solid fuels, there are specific separate burners optimized for that specific type of fuel. In addition, there are hybrid burners suitable for burning two or more different types of fuel.

[0004] Typically, the heat power of the largest currently manufactured heavy oil burners is 40 - 60 MW, the oil flow fed to the burner then being 4 - 6 t/h (thousand kilograms per hour). A typical oil burner comprises an oil lance surrounded by a primary air feeding channel, a secondary air feeding channel and a tertiary air feeding channel. The oil can be atomized into droplets by steam or compressed air. The fuel is sprayed by means of an oil nozzle situated at the end of the oil lance to the hot furnace where it immediately ignites so as to form a flame at the mouth of the burner. Burning is enhanced by air flows which are fed around the flame and which are arrangeable under a rotating motion by air guiding devices provided to the air feeding channels.

[0005] The oil burner's requirements become different as the properties of the fuel change. Bio oil produced by pyrolysing bio mass may contain 20 - 40 weight-% of water. While the heating value of heavy fuel oil is approximately 40 MJ/kg, the heating value of bio oil is only approximately 10 - 15 MJ/kg. To reach the same heat power, bio oil must be fed to the boiler in a greater amount than heavy fuel oil. While the mass flow of the fuel to a heavy fuel burner, in the order of 40 - 60 MW is approximately 4 - 6 t/h, in a bio oil burner of the corresponding order the mass flow of the fuel must be approximately 10 - 12 t/h. Such a feed flow cannot be produced with the currently used heavy oil burners. The high water content of bio oil lowers the temperature of the flame and reduces its stability. Bio oil may have a high nitrogen content, for example 0.5 weight-%, which increases the NO_x emissions. In addition, acids are normally produced when pyrolysing biomass, and so bio oil is most often acidic. For example, bio oil produced from wood has a pH of approx-

imately 2-3. To prevent high-temperature corrosion of the boiler, it is important that the flame of the oil burner situated at the ceiling or on the wall of the furnace under no conditions contacts the surfaces of the boiling pipes of the boiler.

OBJECTIVE OF THE INVENTION

[0006] The objective of the invention is to provide an oil burner and an oil nozzle suitable for burning bio oil. In other words, the objective is a burner by which liquid fuel having a low heating value and low pH can be atomized and burnt.

[0007] Specifically, the objective is a bio oil burner by which it is possible, at the same time, to achieve the following objects or at least approach the following values: [1] the carbon monoxide (CO) content of the flue gas is below 100 ppm; [2] the proportion of incombustible carbon in the fly ash contained by the flue gas is below 5 weight-%; [3] the NO_x content of the flue gas is below 400 mg/ Nm^3 ; and [4] the flame does not extend to the walls of the furnace where it could cause high-temperature corrosion.

[0008] Since the potential means for achieving the above objects are partly conflicting with each other, it requires careful optimization of the structural properties of the oil burner to achieve all of the objects at the same time.

SUMMARY

[0009] A bio oil burner has now been proposed, comprising:

- an oil lance, at the end of which there is an oil nozzle with spray holes for feeding atomized oil to a furnace of a boiler,
- a first cylinder coaxially surrounding the oil lance and together with the oil lance delimiting an annular primary air flow channel which ends at an outlet of the primary air flow channel,
- a second cylinder coaxially surrounding the first cylinder and together with the first cylinder delimiting an annular secondary air flow channel which ends at an outlet of the secondary air flow channel,
- a third cylinder coaxially surrounding the second cylinder and together with the second cylinder delimiting an annular tertiary air flow channel which ends at an outlet of the tertiary air flow channel, and
- a primary air swirler annularly surrounding the oil nozzle and blocking at least part of the outlet of the primary air flow channel, the bio oil burner being characterized in that
- the oil nozzle has a slanting circumferential surface and 6 - 50 spray holes which are distributed on the slanting circumferential surface of the oil nozzle in such a way that said spray holes form at least two groups of spray holes in which the spray holes are

located at a regular spacing S1 from each other, and that between said groups of spray holes there are intermediate spaces in which no spray holes are present, and the circumferential length S2 of the intermediate spaces is greater than the circumferential spacing S1 between the spray holes within the group,

- the first cylinder has a free end at the outlet of the primary air flow channel, and the free end of the first cylinder is provided with a flame stabilizing ring surrounding the outlet of the primary air flow channel and blocking part of the outlet of the secondary air flow channel, and
- the outer diameter D_i of the primary air swirler is calculated by the formula $D_i = a \cdot D_{1ry}$, wherein a is 0.45 - 0.6 and D_{1ry} is the inner diameter of the first cylinder.

[0010] In addition, a bio oil burner has now been proposed, comprising:

- an oil lance, at the end of which there is an oil nozzle with spray holes for feeding atomized oil to a furnace of a boiler,
- a first cylinder coaxially surrounding the oil lance and together with the oil lance delimiting an annular primary air flow channel which ends at an outlet of the primary air flow channel,
- a second cylinder coaxially surrounding the first cylinder and together with the first cylinder delimiting an annular secondary air flow channel which ends at an outlet of the secondary air flow channel,
- a third cylinder coaxially surrounding the second cylinder and together with the second cylinder delimiting an annular tertiary air flow channel which ends at an outlet of the tertiary air flow channel, and
- a primary air swirler annularly surrounding the oil nozzle and blocking at least part of the outlet of the primary air flow channel, the bio oil burner being characterized in that
- the oil nozzle has a slanting circumferential surface and 10 - 50 spray holes which are distributed on the slanting circumferential surface of the oil nozzle in such a way that said spray holes form at least two groups of spray holes in which the spray holes are located at a regular spacing S1 from each other, and that between said groups of spray holes there are intermediate spaces in which no spray holes are present, and the circumferential length S2 of the intermediate spaces is greater than the circumferential spacing S1 between the spray holes within the group,
- the first cylinder has a free end at the outlet of the primary air flow channel, and the free end of the first cylinder is provided with a flame stabilizing ring surrounding the outlet of the primary air flow channel and blocking part of the outlet of the secondary air flow channel, and

- the outer diameter D_i of the primary air swirler is calculated by the formula $D_i = a \cdot D_{1ry}$, wherein a is 0.45 - 0.6 and D_{1ry} is the inner diameter of the first cylinder.

[0011] In addition, an oil nozzle for an oil burner has now been proposed, which oil nozzle has a slanting circumferential surface with spray holes, and which oil nozzle has 6 - 50 spray holes which are distributed on the slanting circumferential surface of the oil nozzle in such a way that said spray holes form at least two groups of spray holes in which the spray holes are located at a regular spacing S1 from each other, and that between said groups of spray holes there are intermediate spaces in which no spray holes are present, and the circumferential length S2 of the intermediate spaces is greater than the circumferential spacing S1 between the spray holes within the group.

[0012] In addition, an oil nozzle for an oil burner has now been proposed, which oil nozzle has a slanting circumferential surface with spray holes, and which oil nozzle has 10 - 50 spray holes which are distributed on the slanting circumferential surface of the oil nozzle in such a way that said spray holes form at least two groups of spray holes in which the spray holes are located at a regular spacing S1 from each other, and that between said groups of spray holes there are intermediate spaces in which no spray holes are present, and the circumferential length S2 of the intermediate spaces is greater than the circumferential spacing S1 between the spray holes within the group.

[0013] Due to the large number of spray holes in the oil nozzle, a greater mass flow of fuel can be conveyed through the oil nozzle than by a nozzle in which the number of spray holes is smaller. The spray holes are furthermore provided to the oil nozzle in two or more groups in such a way that between the groups of spray holes there are intermediate spaces. In one embodiment said spray holes form two, three or four groups of spray holes. Through the intermediate spaces, primary air is able to flow to the area of the center of the oil nozzle. The air flowing to the area of the center enhances the ignition of the flame in two ways. The air flowing to the area of the center enhances the mixing of air and oil droplets with each other, due to which the ignition of the fuel is more stable. The air flowing to the area of the center also pushes the oil particles formed in an outward direction, which furthers the ignition of the flame.

[0014] The spacing S1 is the circumferential spacing between the centers of two successive spray holes within the group B1, B2. The circumferential length S2 of the intermediate space is the circumferential distance between the centers of the outermost spray holes of adjacent groups B1, B2 of spray holes.

[0015] In one embodiment the diameter of the spray holes is 6 - 10 mm. In one embodiment the diameter of the spray holes is 7.5 mm. When the diameter of the spray holes is 7.5 mm, according to computer calculations a sufficient oil feed is obtained.

[0016] The flame stabilizing ring attached to the free end of the first cylinder is so located that primary air flows on one side of it and secondary air flows on the other side of it. The stabilizing ring blocks part of the outlet of the secondary air flow channel in such a way that part of the secondary air flow collides with the stabilizing ring, whereby the flow field of the air is changed. Behind the stabilizing ring in the secondary air flow channel a reduced pressure field is provided, which causes stabilization of the flame, or at least enhances the stability of the flame. In addition, the flame ignites better by means of the stabilizing ring than without the stabilizing ring. Furthermore, the flame stabilizing ring changes the flow field of the flame so as to keep the flame narrow, whereby the flame does not extend to the walls of the boiler and so does not cause high-temperature corrosion of the walls, or at least reduces high-temperature corrosion.

[0017] The primary air swirler blocks at least part of the outlet of the primary air flow channel so that at least part of the primary air flow collides with the swirler, whereby the flow field of the air is changed. Due to the primary air swirler according to the invention, the air flow discharged from the primary air flow channel moves more linearly toward the center of the boiler than in a burner wherein the outer diameter of the swirler is larger. The flame thus stays narrow and mainly does not extend to the walls of the boiler.

[0018] By means of the structure of the oil nozzle, the outer diameter of the swirler and the stabilizing ring, the flow field of the entire boiler and thereby of the area adjacent to the burner can be adjusted. As to the flow field of the area adjacent to the burner, it governs the local oxygen content and thus the formation of nitrogen oxide emissions.

[0019] By bio oil, it is meant liquid fuel produced by pyrolysing biomass. In one embodiment the bio oil is produced by pyrolysing wood mass. In one embodiment the bio oil is pyrolysis oil.

[0020] By atomization, it is meant that the oil is broken up into small droplets. In one embodiment the oil is broken up by means of a pressure medium. In one embodiment the pressure medium is steam. In one embodiment the pressure medium is compressed air. In one embodiment the oil is broken up by adjusting the oil pressure without the pressure medium.

[0021] The first cylinder coaxially surrounds the oil lance. The space between the inner surface of the first cylinder and the outer surface of the oil lance forms the primary air flow channel. The cross section of the primary air flow channel is annular.

[0022] The second cylinder coaxially surrounds the first cylinder. The space between the inner surface of the second cylinder and the outer surface of the first cylinder forms the secondary air flow channel. The cross section of the secondary air flow channel is annular.

[0023] The third cylinder coaxially surrounds the second cylinder. The space between the inner surface of the third cylinder and the outer surface of the second cylinder

forms the tertiary air flow channel. The cross section of the third cylinder is annular.

[0024] In one embodiment the oil nozzle has 6 - 20 or 6 - 14 or 6 - 12 or 8 - 20 or 8 - 14 or 8 - 12 or 10 - 20 or 10 - 14 or 10 - 12 spray holes. In one embodiment the oil nozzle has 6 - 20 spray holes. In one embodiment the oil nozzle has 6 - 14 spray holes. In one embodiment the oil nozzle has 6 - 12 spray holes. In one embodiment the oil nozzle has 8 - 20 spray holes. In one embodiment the oil nozzle has 8 - 14 spray holes. In one embodiment the oil nozzle has 8 - 12 spray holes. In one embodiment the oil nozzle has 10 - 20 spray holes. In one embodiment the oil nozzle has 10 - 14 spray holes. In one embodiment the oil nozzle has 10 - 12 spray holes.

[0025] The number and diameter of the spray holes are determined according to the capacity of the oil nozzle. In other words, the number and diameter of the spray holes depend on the amount of the mass flow of fuel to be conveyed through the oil nozzle per unit of time. In one embodiment the power of the oil burner is 10 MW, and the oil nozzle has 6 spray holes. In one embodiment the power of the oil burner is 50 MW, and the oil nozzle has 10 or 12 spray holes. The diameter of the oil nozzle is determined according to the number and diameter of the spray holes.

[0026] In one embodiment the oil nozzle has 10 - 50 spray holes.

[0027] In one embodiment the oil nozzle has 6 - 10 spray holes and the length of the spacing S1 is 15 - 40 mm or 20 - 35 mm or 25 - 30 mm. In one embodiment the oil nozzle has 6 - 8 spray holes and the length of the spacing S1 is 15 - 40 mm or 20 - 35 mm or 25 - 30 mm.

[0028] In one embodiment the oil nozzle has 15 - 40 spray holes. In one embodiment the oil nozzle has 20 - 25 spray holes.

[0029] In one embodiment the length of the spacing S1 is 15 - 40 mm or 20 - 35 mm or 25 - 30 mm. Between two successive spray holes, air is able to flow to the area of the center of the oil nozzle. When the spacing S1 is sufficiently long, a sufficient amount of air is able to flow between the successive spray holes to the area of the center of the oil nozzle and around each individual spray hole, which enhances the ignition of the flame.

[0030] In one embodiment the circumferential length S2 of the intermediate spaces is 2 - 4 times greater than the circumferential spacing S1 between the spray holes within the group. In one embodiment the circumferential length S2 of the intermediate spaces is 3 times greater than the circumferential spacing S1 between the spray holes within the group. In one embodiment the circumferential length S2 of the intermediate spaces is 1.3 - 4 times or 1.5 - 3 times greater than the circumferential spacing S1 between the spray holes within the group. Air is able to flow to the area of the center of the oil nozzle through the intermediate space, which enhances the ignition of the flame. The air flowing to the area of the center of the oil nozzle through the intermediate space also provides natural staging of the fuel and air at the nozzle and

thus reduces nitrogen oxides.

[0031] In one embodiment the spray holes are distributed on the slanting circumferential surface of the oil nozzle in two circumferential rows. In another embodiment the spray holes are distributed on two different slanting circumferential surfaces in two circumferential rows.

[0032] In one embodiment the stabilizing ring comprises an annular section widening in a direction away from the outlet of the primary air flow channel. Also, the stabilizing ring may comprise a number of tooth-like projections which radially extend into the primary air flow channel. In one embodiment the wall thickness of the widening annular section of the stabilizing ring is steadily reduced toward the free edge of the stabilizing ring. In one embodiment the free end of the first cylinder is thinned, and the stabilizing ring comprises a uniform annular section which can be fitted around the thinned end of the first cylinder and secured by a locking ring. In one embodiment the stabilizing ring is made of heat-resistant steel. The stabilizing ring may consist of one or more sections. Said tooth-like projections can be made of heat-resistant steel or heat-resistant ceramic material.

[0033] In one embodiment a is 0.5. In one embodiment the outer diameter of the swirler is 120 - 180 mm. In another embodiment the outer diameter of the swirler is 150 mm.

[0034] When the number of spray holes in the oil nozzle is 20 and the circumferential length $S2$ of the intermediate spaces is three times greater than the circumferential spacing $S1$ between the spray holes within the group, and a is 0.5 when calculating the outer diameter of the primary air swirler, according to computer calculations a stable and narrow flame not extending to the walls of the furnace is obtained. Similarly, with the above values, according to computer calculations a carbon monoxide content below 100 ppm and a NO_x content below 400 mg/Nm³ are obtained in the flue gas. In addition, with the above values, according to computer calculations the proportion of incombustible carbon in the fly ash contained by the flue gas is below 5 weight-%.

[0035] When the number of spray holes in the oil nozzle is 10, the circumferential spacing $S1$ between the spray holes within the group is 25 - 30 mm and the circumferential length $S2$ of the intermediate spaces is two times greater than the circumferential spacing $S1$ between the spray holes within the group, and a is 0.5 when calculating the outer diameter of the primary air swirler, according to computer calculations and practical test results a stable and narrow flame not extending to the walls of the furnace is obtained. Similarly, with the above values, according to computer calculations and practical test results a carbon monoxide content below 50 ppm and a NO_x content below 350 mg/Nm³ are obtained in the flue gas. In addition, with the above values, according to computer calculations the proportion of incombustible carbon in the fly ash contained by the flue gas is below 5 weight-%.

[0036] In one embodiment the bio oil burner is provided with gas lances located in the primary air flow channel

and allowing the burning of gaseous fuel. In another embodiment the bio oil burner is not provided with gas lances.

[0037] In one embodiment the bio oil burner has a heat power of 5 - 60 MW. In one embodiment the bio oil burner has a heat power of 10 - 55 MW. In one embodiment the bio oil burner has a heat power of 20 - 50 MW. In one embodiment the bio oil burner is used for burning bio oil in heat only boilers which produce only heat, or heat and steam, but no electricity. The bio oil burner can also be used in another type of a boiler. The same boiler may be provided with several bio oil burners.

[0038] In one embodiment the oil nozzle is designed for a bio oil burner.

[0039] The bio oil burner described herein provides significant advantages over the prior art. At least some of the embodiments described herein provide an oil burner which is suitable for burning bio oil and by which a sufficient amount of fuel can be fed to the boiler per unit of time, and by means of which, according to computer calculations, a sufficiently stable and narrow flame not subjecting the surfaces of the boiler to high-temperature corrosion (either at all or at least to a significant degree) is provided. The ignition of the flame is also enhanced. The bio oil burner according to at least some of the embodiments provides, according to computer calculations, a low content of nitrogen oxides so as to satisfy the official regulations taking effect in the EU in 2016 (Industrial Emission Directive, IED). Similarly, the bio oil burner according to at least some of the embodiments provides, according to computer calculations, a carbon monoxide content below 50 ppm in the flue gas and a proportion of incombustible carbon below 5 weight-% in the fly ash contained by the flue gas.

LIST OF FIGURES

[0040] The invention will now be described with reference to the accompanying figures which illustrate the embodiments by way of example. The invention is not limited to the embodiments of the figures.

Fig. 1 schematically shows a front view of a heavy oil burner,

Fig. 2 is a cross section A-A of the heavy oil burner of Fig. 1,

Fig. 3 shows a heavy oil nozzle in cross section,

Fig. 4 shows a front view of a heavy oil nozzle,

Fig. 5 schematically shows a front view of a bio oil burner according to one embodiment,

Fig. 6 is a cross section A-A of the bio oil burner of Fig. 5,

Fig. 7 shows the area of the mouth opening of one bio oil burner as an enlarged detail view,

Fig. 8 shows a bio oil nozzle according to one embodiment in cross section, and

Fig. 9 shows a front view of a bio oil nozzle according to one embodiment.

[0041] Fig. 1 and 2 show a heavy oil burner, the structure of which is not suitable as such for burning bio oil. The heavy oil burner is designed to be located at the ceiling or wall structures of a heat boiler in a way that the mouth opening of the burner opens toward the furnace. The heat boiler may normally have, depending on the power of the boiler, 1-5 oil burners.

[0042] The heavy oil burner according to Fig. 1 and 2 comprises an oil lance 13 annularly surrounded by a primary air flow channel 3, a secondary air flow channel 4 (indicated in diagonal lines) and a tertiary air flow channel 9 (indicated in horizontal lines). By means of the oil lance 13, fuel is fed in an atomized form to the furnace of the boiler, where it takes fire so as to form a flame in front of the mouth opening of the burner. Through the air flow channels 3, 4 and 9, air that is needed for burning is fed around the flame for providing a stable flame. In addition, the heavy oil burner comprises a number of gas lances 2 which are provided to the primary air flow channel 3. By means of the gas lances 2, natural gas or other gaseous fuel can be fed to the furnace of the boiler if necessary. The oil burner is further provided in a manner known per se with an igniter (not shown), by means of which the fuel is ignited when starting the burner, and with a flame controller (not shown).

[0043] Fig. 1 and 2 show a first cylinder 19, a second cylinder 20 and a third cylinder 23 coaxially located around the oil lance 13. The first, the second and the third cylinders 19, 20, 23 end at primary air, secondary air and tertiary air outlets 21, 22, 24. Fig. 2 further shows a free end 25 of the first cylinder 19.

[0044] In Fig. 1 and 2, the oil lance 13 comprises a pressure medium feeding channel 14, one or more fuel feeding channels 15 and an oil nozzle 1A where the fuel is atomized by means of the pressure medium before being fed to the furnace. For example steam or compressed air may be used as the pressure medium in atomization. Atomization may also be provided by adjusting the oil pressure without the pressure medium. The oil nozzle 1A shown in more detail in Fig. 4 and 6 comprises a number of spray holes 12 through which the fuel is fed as droplets to the furnace of the boiler. The fuel discharged from the oil nozzle 1A takes fire as it meets the air flow discharged from the primary air flow channel 3.

[0045] As illustrated in Fig. 1 and 2, the oil nozzle 1A is annularly surrounded by a primary air swirler 6A. The swirler 6A is located at the outlet 21 of the primary air flow channel 3 so that the swirler 6A blocks at least part of the outlet 21. The swirler 6A is secured around the oil nozzle 1A. The swirler 6A may be situated either inside or outside the flow channel 3, i.e. inside or outside the free end 25 of the first cylinder 19. The swirler 6A may comprise vanes, blades or another such structure which brings the air flow discharged from the primary air flow channel 3 under a rotating motion before it collides with the flame or the jet of fuel discharged from the oil nozzle 1A.

[0046] In the heavy oil burner of Fig. 1 and 2, also the secondary air flow channel 4 and the tertiary air flow channel 9 can be provided with means (not shown) for bringing this air flow under a tangential motion before the secondary air flow and the tertiary air flow, respectively, are conveyed around the flame.

[0047] Fig. 3 and 4 show the principles of the structure of the heavy oil nozzle 1A. The heavy oil nozzle typically has an outer diameter of 30 - 50 mm. The diameter of the spray holes of the heavy oil nozzle is typically approximately 3 - 5 mm. This nozzle is not suitable as such for use in a bio oil burner. The heavy oil nozzle 1A according to Fig. 3 and 4 comprises six spray holes 12 evenly distributed on a slanting circumferential surface 17 of the oil nozzle 1A.

[0048] The principles of the structure and operation of the oil nozzle will now be described. A cavity 14a is provided inside the oil nozzle 1A so as to be in flow communication with the pressure medium flow channel 14. A number of spray channels 12a open into the cavity 14a, each of them ending at the spray hole 12 on the slanting circumferential surface 17 of the oil nozzle 1A. The oil nozzle 1A also comprises a number of oil channels 15a in flow communication on the one hand with the fuel feeding channels 15 and on the other hand with the spray channels 12a and therethrough with the spray holes 12.

[0049] The pressure medium (steam or compressed air) is conveyed through the pressure medium flow channel 14 to the cavity 14a inside the oil nozzle 1A, and from there the pressure medium is discharged to the spray holes 12 through the spray channels 12a. The fuel is conveyed to the oil nozzle 1A through the fuel feeding channels 15 which end at the oil channels 15a provided to the oil nozzle 1A so as to be in flow communication with the spray channels 12a. When the pressure medium is discharged to the spray channels 12a from the cavity 14a, it at the same time draws fuel from the oil channels 15a, which fuel is mixed in the pressure medium as small droplets. According to the structure of the flow channels 12a and 15a, this nozzle arrangement is referred to as a Y nozzle. The angle of the flow channels 12a and 15a and of the slanting circumferential surface 17 to the central axis of the nozzle can be varied according to the application.

[0050] Fig. 5 and 6 show a bio oil burner according to the invention. The bio oil burner has an oil nozzle 1 differing from that of the heavy oil burner of Fig. 1-4. The bio oil burner has a swirler 6 with an outer diameter smaller than the outer diameter of the swirler 6A of the heavy oil burner 1A. In addition, the free end 25 of the first cylinder 19 is provided with a stabilizing ring 7.

[0051] The bio oil burner comprises an oil lance 13 annularly surrounded by a primary air flow channel 3, a secondary air flow channel 4 (indicated in diagonal lines) and a tertiary air flow channel 9 (indicated in horizontal lines). By means of the oil lance 13, the fuel is fed in an atomized form to the furnace of the boiler, where it takes fire so as to form a flame in front of the mouth opening

of the burner. Through the air flow channels 3, 4 and 9, air that is needed for burning is fed around the flame for providing a stable flame. In addition, the bio oil burner of Fig. 5 and 6 comprises a number of gas lances 2 provided to the primary air flow channel 3. By means of the gas lances 2, natural gas or other gaseous fuel can be fed to the furnace of the boiler if necessary. The oil burner is further provided in a manner known per se with an igniter (not shown), by means of which the fuel is ignited when the burner is being started, and with a flame controller (not shown).

[0052] Fig. 5 and 6 show a first cylinder 19, a second cylinder 20 and a third cylinder 23 coaxially located around the oil lance 13. The first, the second and the third cylinders 19, 20, 23 end at primary air, secondary air and tertiary air outlets 21, 22, 24. Fig. 6 shows a free end 25 of the first cylinder 19 provided with the flame stabilizing ring 7.

[0053] In Fig. 5 and 6, the oil lance 13 comprises a pressure medium feeding channel 14, one or more fuel feeding channels 15 and an oil nozzle 1 where the fuel is atomized by means of the pressure medium before it is fed to the furnace. For example steam or compressed air may be used as the pressure medium. Atomization may also be provided by adjusting the oil pressure without the pressure medium. The oil nozzle 1 shown in more detail in Fig. 8 and 9 comprises a number of spray holes 12 through which the fuel is fed as droplets to the furnace of the boiler. The fuel discharged from the oil nozzle 1 takes fire as it meets the air flow discharged from the primary air flow channel 3. The bio oil nozzle 1 has a diameter larger than the diameter of the heavy oil nozzle 1A of Fig. 1-4. The bio oil nozzle 1 also has a structure differing from the structure of the heavy oil nozzle of Fig. 1-4. The structure of the bio oil nozzle 1 will be described in more detail below with reference to Fig. 8 and 9. The diameter of the air feeding channels 3, 4, 9 surrounding the oil nozzle 1 does not necessarily have to be changed when replacing the heavy oil burner with the bio oil burner.

[0054] As illustrated in Fig. 5 and 6, the oil nozzle 1 is annularly surrounded by a primary air swirler 6. The swirler 6 is located at the outlet 21 of the primary air flow channel 3 so that the swirler 6 blocks at least part of the outlet 21. The swirler 6 is secured around the oil nozzle 1. The swirler 6 may be situated either inside or outside the flow channel 3, i.e. inside or outside the free end 25 of the first cylinder 19. The swirler 6 may comprise vanes, blades or another such structure bringing the air flow discharged from the primary air flow channel 3 under a rotating motion before it collides with the flame or the jet of fuel discharged from the oil nozzle 1.

[0055] In the bio oil burner according to Fig. 5 and 6, the outer diameter of the primary air swirler 6 is smaller than in the heavy oil burner according to Fig. 1 and 2. When the outer diameter of the primary air swirler 6 is reduced, the air flow discharged from the primary air flow channel 3 moves more linearly toward the center of the

boiler than in a burner wherein the outer diameter of the swirler is larger. As a result, the flame does not spread as widely as in a burner with a larger outer diameter of the swirler. While in 50 MW heavy oil burners the outer diameter of the swirler 6A is typically approximately 300 - 310 mm, in a burner according to one embodiment the outer diameter of the swirler 6 is approximately half of that. In one embodiment the outer diameter of the swirler 6 is approximately 120 - 180 mm. In another embodiment the heat power of the bio oil burner is approximately 50 MW and the diameter of the swirler is approximately 150 mm.

[0056] Also the secondary air flow channel 4 and the tertiary air flow channel 9 can be provided with means (not shown) for bringing this air flow under a tangential motion before conveying the secondary air flow and the tertiary air flow, respectively, around the flame.

[0057] In the bio oil burner of Fig. 5 and 6, the free end 25 of the first cylinder 19 at the outlet 21 of the primary air flow channel is provided with a flame stabilizing ring 7 in such a way that on its one side, primary air flows from the primary air flow channel 3 and on its other side secondary air flows from the secondary air flow channel 4. The stabilizing ring 7 blocks part of the outlet 22 of the secondary air flow channel 4 in such a way that part of the secondary air flow collides with the stabilizing ring. The purpose of the flame stabilizing ring 7 is to adjust the flow field of the flame so as to keep it sufficiently narrow and prevent the flame from extending to the walls of the furnace. Another purpose of the flame stabilizing ring 7 is to effectively ignite the bio oil flame and stabilize its burning.

[0058] The stabilizing ring 7 is directed outward and forward from the first cylinder 19, i.e. toward the center of the boiler and the walls of the boiler. The shape of the stabilizing ring 7 may be staggered in such a way that the end of the stabilizing ring 7 secured to the first cylinder 19 extends in parallel to the cross section of the first cylinder 19, and the stabilizing ring 7 takes a turn at a distance from its point of attachment toward the center and the walls of the boiler. The stabilizing ring 7 may be substantially truncated cone shaped, so as to open toward the center and the walls of the boiler. The stabilizing ring 7 may also have another shape, as long as it diverts the flow field of the flame to the desired direction.

[0059] Fig. 7 shows part of the structure of a bio oil burner according to one embodiment as an enlarged view. The new type of oil nozzle 1 is provided at the end of the oil lance 13 and is surrounded by the primary air swirler 6. The oil lance 13 is surrounded by the primary air flow channel 3, the secondary air flow channel 4 and the tertiary air flow channel 9. In this arrangement the oil nozzle 1 has a new structure, the outer diameter of the primary air swirler 6 is smaller than in the heavy oil burner of Fig. 1-4, and further, the oil burner is provided with the flame stabilizing ring 7. The stabilizing ring 7 comprises an annular section 26 widening in a direction away from the outlet 21 of the primary air flow channel.

[0060] Fig. 8 and 9 show the principles of the structure of a bio oil nozzle 1 according to one embodiment. The operation of the bio oil nozzle 1 is similar to that of the heavy oil nozzle 1A of Fig. 3 and 4. The operation has been described above with reference to Fig. 3 and 4. Also the structure of the bio oil nozzle 1 is similar to the structure of the heavy oil nozzle 1A described with reference to Fig. 3 and 4, except for the outer diameter of the nozzle 1 and the number and location of the spray holes 12, the spray channels 12a and the oil channels 15a. The diameter of the bio oil nozzle 1 according to Fig. 8 and 9 is larger than the diameter of the heavy oil nozzle 1A because a greater mass flow must be conveyed through the bio oil nozzle 1 than with the traditional fuels. While in the heavy oil nozzle 1A it suffices to have 6-8 oil spray holes 12 to feed the fuel, the number of spray holes 12 in the bio oil nozzle 1 may be 6 - 50 in one embodiment and 10 - 50 in another embodiment. In addition, these spray holes 12 are located differently in the bio oil nozzle than in the heavy oil nozzle 1A.

[0061] The bio oil nozzle 1 according to Fig. 8 and 9 comprises a total of 20 spray holes 12 located as two groups B1, B2 of spray holes on the slanting circumferential surface 17 of the oil nozzle 1. The spray holes 12 may also be present in another number, for example eight, ten or twelve. The number of spray holes depends on the amount of the mass flow of fuel to be conveyed through the oil nozzle per unit of time. In one embodiment the number of spray holes 12 is six, and the circumferential spacing S1 between the centers of two successive spray holes 12 is 15 - 40 mm. In the embodiment according to Fig. 8 and 9, each group B1, B2 of spray holes comprises ten spray holes 12 distributed at a regular spacing so that the spacing between the centers of two successive spray holes 12 is S1. The circumferential spacing S1 between the centers of two successive spray holes 12 is in one embodiment 15 - 40 mm or 20 - 35 mm or 25 - 30 mm. Between two groups B1, B2 of spray holes there is an intermediate space 16 having a length S2 greater than the spacing S1 between two successive spray holes 12 within the group B1, B2. By the length S2 of the intermediate space 16, it is meant the distance between the centers of the outermost spray holes 12 of adjacent groups B1, B2 of spray holes. The circumferential length S2 of the intermediate space 16 is in one embodiment 1.3 - 4 times or 1.5 - 3 times greater than the circumferential spacing S1 between the spray holes 12 within the group B1, B2. The diameter of the spray holes is 7.5 mm in the bio oil nozzle according to Fig. 8 and 9. The spray holes may also have another diameter depending on the amount of the mass flow to be conveyed through the oil nozzle per unit of time. It is also possible to divide the spray holes in the groups B1, B2 in two circumferential rows.

[0062] Air is able to flow through the intermediate spaces 16 to the area of the center 18 of the oil nozzle 1, where the air enhances the ignition of the flame in two ways. The access of air in the middle of the oil droplets

discharged from the spray holes 12 enhances the mixing of air in the oil droplets, which is important for stable ignition of the fuel. In addition, the air flowing to the area of the center 18 of the oil nozzle 1 spreads the oil particles formed in the outward direction, at the same time spreading the flame, which is also advantageous for the ignition of the flame. In the oil nozzle 1A with a regular distribution, the flame tends to narrow down and the air is poorly mixed, so that harmful incombustible soot and carbon monoxide are likely to be formed.

[0063] The new structure of the oil nozzle 1 allows large amounts of oil to be burnt by the bio oil burner according to the invention. The division of the spray holes 12 into two groups B1, B2 between which there are intermediate spaces 16 enhances the ignition and stabilizes burning.

[0064] The invention is not limited to the above examples but is modifiable within the scope of the accompanying claims.

Claims

1. A bio oil burner comprising:

- an oil lance (13), at the end of which there is an oil nozzle (1) with spray holes (12) for feeding atomized oil to a furnace of a boiler,
 - a first cylinder (19) coaxially surrounding the oil lance (13) and together with the oil lance (13) delimiting an annular primary air flow channel (3) which ends at an outlet (21) of the primary air flow channel (3),
 - a second cylinder (20) coaxially surrounding the first cylinder (19) and together with the first cylinder (19) delimiting an annular secondary air flow channel (4) which ends at an outlet (22) of the secondary air flow channel,
 - a third cylinder (23) coaxially surrounding the second cylinder (20) and together with the second cylinder (20) delimiting an annular tertiary air flow channel (9) which ends at an outlet (24) of the tertiary air flow channel, and
 - a primary air swirler (6) annularly surrounding the oil nozzle (1) and blocking at least part of the outlet (21) of the primary air flow channel (3),
- characterized in that**
- the oil nozzle (1) has a slanting circumferential surface (17) and 6 - 50 spray holes (12) which are distributed on the slanting circumferential surface (17) of the oil nozzle (1) in such a way that said spray holes (12) form at least two groups (B1, B2) of spray holes in which the spray holes (12) are located at a regular spacing (S1) from each other, and that between said groups (B1, B2) of spray holes there are intermediate spaces (16) in which no spray holes (12) are present, and the circumferential length (S2) of the intermediate spaces (16) is greater than the

- circumferential spacing (S1) between the spray holes (12) within the group (B1, B2),
 - the first cylinder (19) has a free end (25) at the outlet (21) of the primary air flow channel (3), and the free end (25) of the first cylinder (19) is provided with a flame stabilizing ring (7) surrounding the outlet (21) of the primary air flow channel (3) and blocking part of the outlet (22) of the secondary air flow channel (4), and
 - the outer diameter D_i of the primary air swirler (6) is calculated by the formula $D_i = a \cdot D_{1ry}$, wherein a is 0.45 - 0.6 and D_{1ry} is the inner diameter of the first cylinder (19).
2. The bio oil burner according to claim 1, **characterized in that** the oil nozzle (1) has 6 - 20 or 6 - 14 or 6 - 12 or 8 - 20 or 8 - 14 or 8 - 12 or 10 - 20 or 10 - 14 or 10 - 12 spray holes (12).
 3. The bio oil burner according to claim 1, **characterized in that** the oil nozzle (1) has 10 - 50 spray holes (12).
 4. The bio oil burner according to any one of claims 1 - 3, **characterized in that** the length of the spacing (S1) is 15 - 40 mm or 20 - 35 mm or 25 - 30 mm.
 5. The bio oil burner according to any one of the preceding claims, **characterized in that** the circumferential length (S2) of the intermediate spaces (16) is 2 - 4 times greater than the circumferential spacing (S1) between the spray holes (12) within the group (B1, B2).
 6. The bio oil burner according to any one of claims 1 - 4, **characterized in that** the circumferential length (S2) of the intermediate spaces (16) is 1.3 - 4 times or 1.5 - 3 times greater than the circumferential spacing (S1) between the spray holes (12) within the group (B1, B2).
 7. The bio oil burner according to any one of the preceding claims, **characterized in that** the stabilizing ring (7) comprises an annular section (26) widening in a direction away from the outlet (21) of the primary air flow channel.
 8. The bio oil burner according to any one of the preceding claims, **characterized in that** a is 0.5.
 9. An oil nozzle for an oil burner, the oil nozzle having a slanting circumferential surface (17) with spray holes, **characterized in that** the oil nozzle (1) has 6 - 50 spray holes (12) which are distributed on the slanting circumferential surface (17) of the oil nozzle (1) in such a way that said spray holes (12) form at least two groups (B1, B2) of spray holes in which the spray holes (12) are located at a regular spacing (S1) from each other, and that between said groups (B1, B2) of spray holes there are intermediate spaces (16) in which no spray holes (12) are present, and the circumferential length (S2) of the intermediate spaces (16) is greater than the circumferential spacing (S1) between the spray holes (12) within the group (B1, B2).
 10. The oil nozzle according to claim 9, **characterized in that** the oil nozzle (1) has 6 - 20 or 6 - 14 or 6 - 12 or 8 - 20 or 8 - 14 or 8 - 12 or 10 - 20 or 10 - 14 or 10 - 12 spray holes (12).
 11. The oil nozzle according to claim 9, **characterized in that** the oil nozzle (1) has 10 - 50 spray holes (12).
 12. The oil nozzle according to any one of claims 9 - 11, **characterized in that** the length of the spacing (S1) is 15 - 40 mm or 20 - 35 mm or 25 - 30 mm.
 13. The oil nozzle according to any one of claims 9 - 12, **characterized in that** the circumferential length (S2) of the intermediate spaces (16) is 2 - 4 times greater than the circumferential spacing (S1) between the spray holes (12) within the group (B1, B2).
 14. The oil nozzle according to any one of claims 9 - 12, **characterized in that** the circumferential length (S2) of the intermediate spaces (16) is 1.3 - 4 times or 1.5 - 3 times greater than the circumferential spacing (S1) between the spray holes (12) within the group (B1, B2).
 15. The oil nozzle according to any one of claims 9 - 14, **characterized in that** it is designed for a bio oil burner.

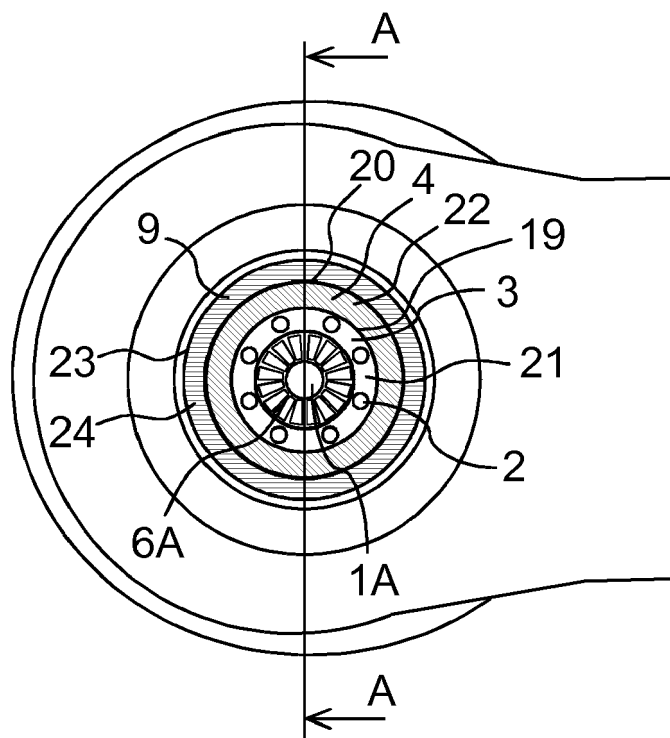


Fig. 1

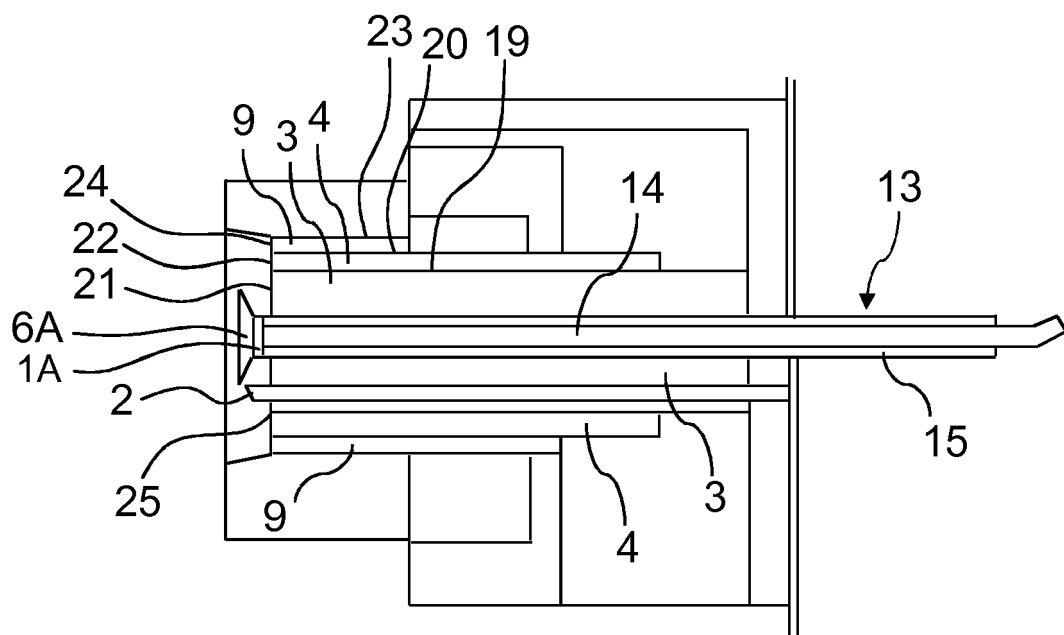


Fig. 2

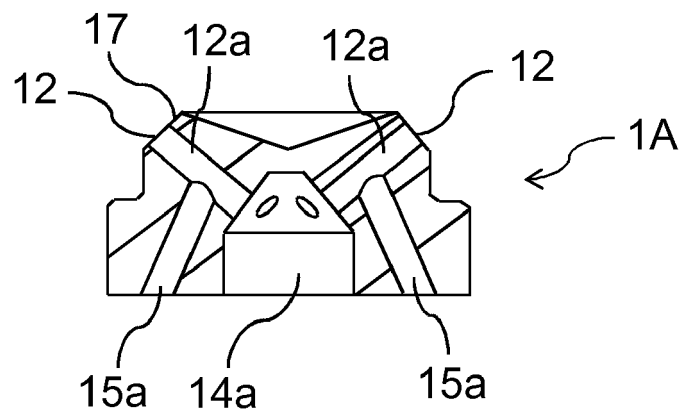


Fig. 3

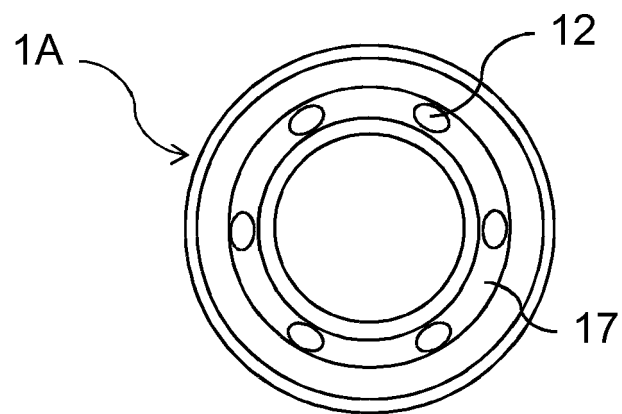


Fig. 4

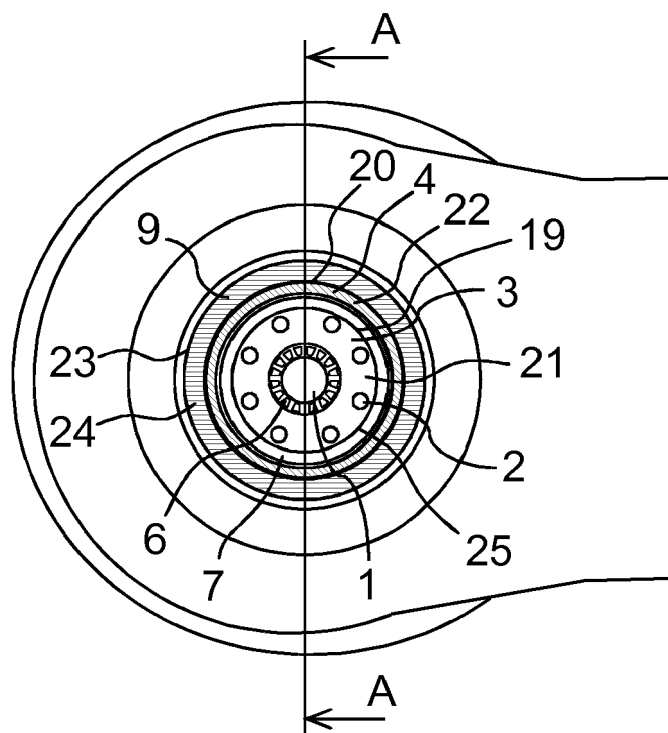


Fig. 5

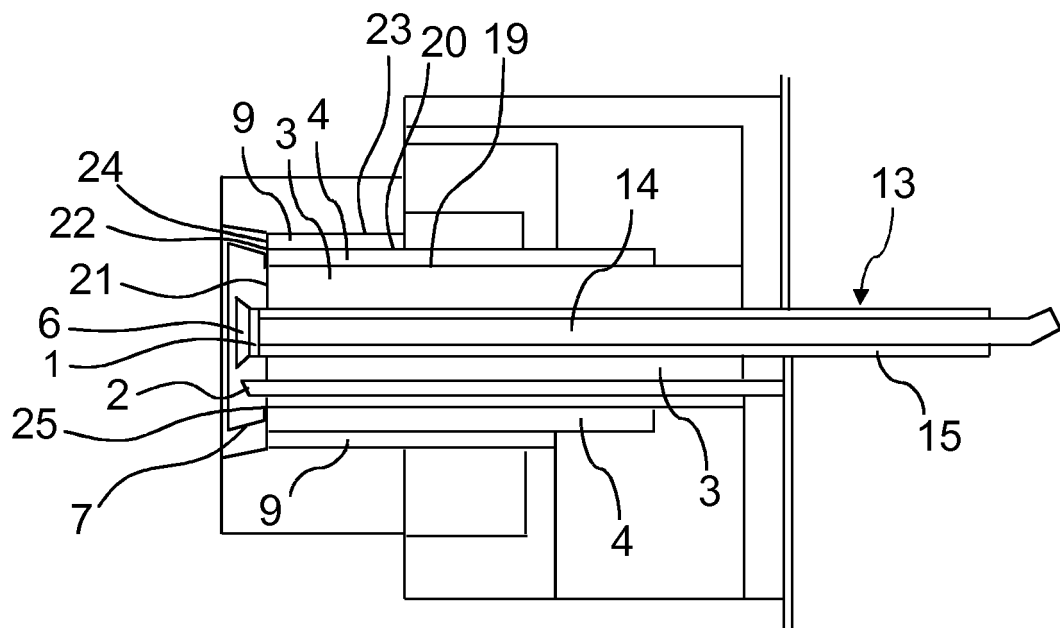


Fig. 6

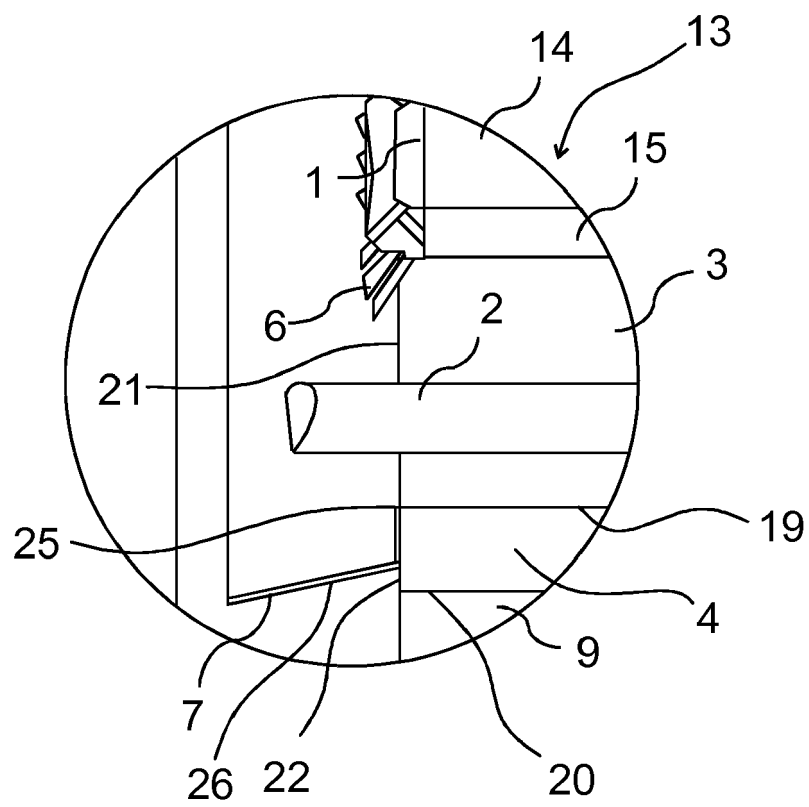


Fig. 7

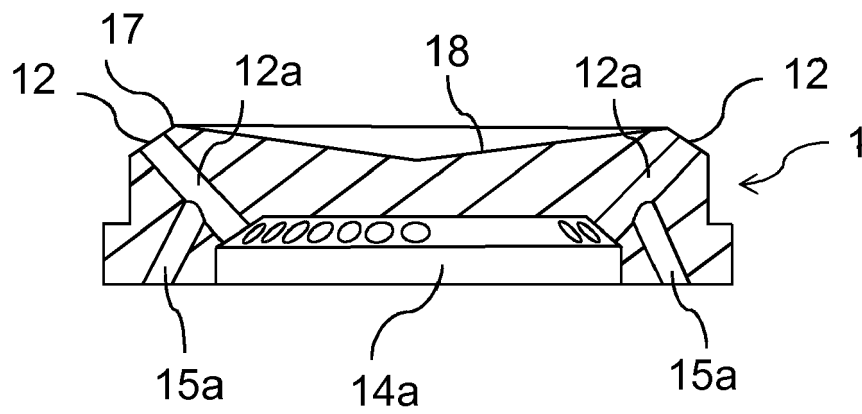


Fig. 8

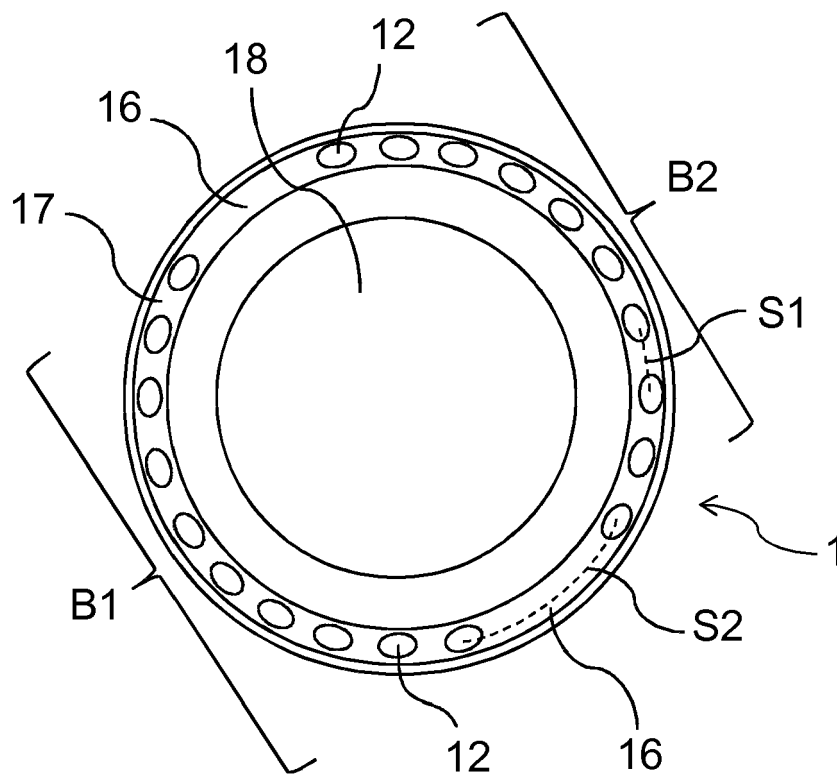


Fig. 9



EUROPEAN SEARCH REPORT

 Application Number
 EP 15 20 0053

5

10

15

20

25

30

35

40

45

50

55

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	JP H02 33506 A (BABCOCK HITACHI KK) 2 February 1990 (1990-02-02) * figures 2-4 and the relevant description *	9-14	INV. F23D11/10 F23D11/12 F23D11/24 F23D11/38 F23D17/00
X	JP S56 27814 A (MITSUBISHI HEAVY IND LTD) 18 March 1981 (1981-03-18) * figures 3, 4 and the relevant description *	9-14	
X	US 6 622 944 B1 (HURLEY JOHN F [US] ET AL) 23 September 2003 (2003-09-23) * column 7, line 65 - column 11, line 35 * * figures 1-3 *	9-14	
A	CN 102 230 623 A (CISDI IND FURNACE CO LTD) 2 November 2011 (2011-11-02) * figures 1-11 and the relevant description *	9-14	
A	US 2005/173566 A1 (VECCHIET FABIO [IT] ET AL) 11 August 2005 (2005-08-11) * page 2, paragraph 31 - page 3, paragraph 51 * * figures 1-4 *	9-14	TECHNICAL FIELDS SEARCHED (IPC) F23D
A	US 5 145 359 A (ANCONA GIUSEPPE [IT] ET AL) 8 September 1992 (1992-09-08) * the whole document *	1-8	
A	US 4 602 571 A (CHADSHAY ROMAN [US]) 29 July 1986 (1986-07-29) * the whole document *	1-8	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 April 2016	Examiner Rudolf, Andreas
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 15 20 0053

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-04-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H0233506 A	02-02-1990	NONE	
JP S5627814 A	18-03-1981	NONE	
US 6622944 B1	23-09-2003	AT 348980 T EP 1251309 A1 MX PA02003987 A US 6622944 B1	15-01-2007 23-10-2002 20-08-2003 23-09-2003
CN 102230623 A	02-11-2011	NONE	
US 2005173566 A1	11-08-2005	AT 412854 T AU 2003212374 A1 EP 1490631 A1 ES 2316731 T3 IT MI20020611 A1 US 2005173566 A1 WO 03081136 A1	15-11-2008 08-10-2003 29-12-2004 16-04-2009 22-09-2003 11-08-2005 02-10-2003
US 5145359 A	08-09-1992	DE 69005099 D1 DE 69005099 T2 EP 0452608 A2 ES 2047308 T3 IT 1238713 B US 5145359 A	20-01-1994 26-05-1994 23-10-1991 16-02-1994 01-09-1993 08-09-1992
US 4602571 A	29-07-1986	NONE	