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(54) **Post-firing burner for natural gas and lean gases with a high efficiency and a low emission of nitrogen oxides**

Nachverbrennungs-Brenner für Erdgas und niederkalorische Gase mit hoher Effizienz und geringen Stickstoffoxidemissionen

Brûleur de post-combustion pour gaz naturel et gaz pauvres avec une grande efficacité et une faible émission d'oxydes d'azote

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Description

Field of the invention

[0001] The present invention relates to a post-firing burner suitable for in-line installation in the feed duct of a heat recovery steam generator.

State of the art

[0002] Among the various possible uses of fuels for energy-related purposes, they can also be used to raise the temperature of effluent gases with a residual oxidising potential coming from other processes, such as the exhaust gases from a gas turbine that are normally heated immediately before they enter a heat recovery steam generator. This is done to obtain a better performance of the steam generator and/or to balance any reduction in the capacity the gas turbine due to high ambient temperatures typical of the summer season, which determines a reduction in the flow rate of the available steam.

[0003] At the end of the open-type gas cycle, in which the internal air (the process fluid) has been heated by means of its partial combustion, a gas turbine normally discharges high flow rates of exhaust gas downstream from the expander that still has a high heat content ($T = 650-900\text{ K}$) and, more importantly, a high oxygen content ($O_2 = 13-15\%$ vol.). If they were released directly into the atmosphere, these gases would constitute an energy loss for which the plant would pay in terms of efficiency.

[0004] Combined cycles are consequently used in power plants, i.e. in order to achieve a highly efficient thermodynamic cycle, the above-described gas cycle is used in association with the retrieval of the heat contained in the exhaust fumes by means of a "heat recovery steam generator" that processes a steam cycle. The presence of a steam cycle downstream of the gas cycle often also provides the opportunity to increment the power output and the efficiency of the steam generator by increasing the heat content of the effluent gases from the gas turbine by means of post-firing systems capable of using the same process exhaust as the combustion agent, either as is or, in some cases, suitably corrected. These systems can sometimes double the steam generator's output.

[0005] The known post-firing systems comprise one or more grids of post-firing burners that are normally installed inside the exhaust gas duct; in some cases, they may also be installed in a bypass duct. The burner is essentially a streamlined component capable of assuring the flame the necessary turbulence where, in given conditions of temperature, pressure and oxygen content in the combustion agent, the flame might be susceptible to severe instability phenomena. Given the particular features of the application, moreover, conditions of flame stability must be assured over a wide range of load variations.

[0006] The single post-firing burners are usually in-

stalled in line, one after the other, forming rows (arrays) of burners that pass right through the effluent duct, with the same cross-section and with reduced boundary effects. The burner is consequently modular in terms of both the length of the single row and of the repeatability of the numerous rows needed to cover the full cross-section of the duct and thus form a "grid" of post-firing burners. Thanks to their characteristic linear arrangement, their fuel rating is usually characterized by a factor Ps that defines the heat rating of the burner per unit length.

[0007] The flame produced as a result of this characteristic linear arrangement of the burner enables a gradual heat release in the cross-section of the duct so as to guarantee the achievement of homogeneous conditions of the fumes being produced - in terms of their chemical composition and, above all, of their temperature - in relatively limited spaces. On this issue, see US 4737100, US 4767319, US 6929470, US 6301875 and EP 1122494.

[0008] Over the years, the post-firing burner has undergone modifications relating not only to the primary need to guarantee a stable flame over a wide range of operating conditions, but also - like all new-generation burners - with a view to containing its environmental impact and particularly to reduce the NO_x emissions. Many combustion techniques have been applied, but the more in-depth studies have demonstrated that a stable flame can be guaranteed, ensuring a low output of NO_x and CO at the same time, by partially pre-mixing the fuel with the combustion agent. This ensures a more limited formation of thermal NO_x (the main path of NO_x formation) and, at the same time, a valid containment of the unburnt CO . There are known examples of premixing in-line burners, such as those described in US 5131836, US 4869665 and JP 59219612.

[0009] Other important industrial applications in which a post-firing system is required include the cogeneration plants serving processes using heat (e.g. production plants with thermal processes, such as for clinker baking or in the production of silicon): the gases used for the industrial process can be drawn more conveniently from the exhaust of engines used to generate electrical energy (e.g. a gas turbine), if a post-firing system is inserted to raise the temperature of the gas to the required level.

[0010] Post-firing burners, and flame stabilisers in particular, are generally manufactured from castings and are consequently characterized by relatively large thicknesses ($\sim 10-20\text{ mm}$). This technical solution is adopted to guarantee the body of the burner an adequate mechanical resistance to high temperatures. In fact, especially when the flow rate of the fuel is low, the flame is very close to the burner and temperatures even in excess of 1300 K may consequently be reached at the burner walls. Clearly, the problem of the nearness of the flame to the combustor is felt even more in the premix type configurations.

[0011] However, the use of relatively large thicknesses

negatively affects the working life of the burner, especially if the flow rate of fuel being processed varies with time. In fact, because the flame stabiliser is lapped by the gases coming from the gas turbine on one side and by the flame on the other, the resulting high temperature gradients will vary with time depending on any variations in the flow rate of the fuel being processed. This gives rise to dynamic stresses that facilitate the onset of cracking, which can propagate to the point of damaging the flame stabiliser. The same problem can occur on the body of the burner near the fuel injection holes, where the wall is again lapped by the fuel gas on one side and by the flame on the other.

[0012] It should be noted, moreover, that using burners made from castings makes it essential to restrict the burner's crosswise dimensions, because of the need to reduce their weight and keep the risk of crack propagation due to the dynamic stresses incurred as a result of the high temperature gradient in the metal to a minimum. Deflectors are often used to compensate for the limited crosswise dimensions of conventional burners. These deflectors are streamlined components that, as explained in the following paragraphs, are placed between adjacent rows of burners with a view to inducing a local pressure drop in the flow of combustion agent in the vicinity of the flame stabilisers of the adjacent burners, thus enabling the proper operation of the burners.

[0013] Furthermore, the use of elements made from castings also makes it practically impossible to exploit fuels delivered at low pressures because it would become necessary in such cases to use large-diameter feed ducts and consequently also burners with large crosswise dimensions - a solution that is clearly not feasible, for the above explained reasons, if castings have to be used.

[0014] US3649211 discloses a burner for placement in a gas stream with a low oxygen content, said burner having a fuel ejecting means disposed in the gas stream and adapted to direct the fuel in the downstream direction; adjacent the burner is placed an air duct to supply the burner with sufficient oxygen and permit ignition of the fuel.

[0015] US3732059 discloses a burner for promoting the combustion of a gaseous fuel in an oxidizing atmosphere which contains oxygen in an amount less than that of air and which atmosphere has appreciable and significant flow velocity, said burner comprising one or more baffle arrays mounted across the flow of said oxidizing atmosphere.

Summary of the invention

[0016] The general object of the present invention is to provide a post-firing burner suitable for in-line installation in a feed duct serving a heat recovery steam generator, and for combined cycle systems in particular, with a structural design that enables an effective thermal protection of the burner body while maintaining the position

of the flame virtually unchanged, irrespective of the flow rate of the fuel being processed, and anchored to streamlined elements of regular shape. This makes it possible to use sheet metal even in thicknesses below 2 mm to make the main parts of the burner, while preserving their geometrical features in the long term.

[0017] A particular object of the present invention is to provide a post-firing burner of the above-mentioned type wherein, thanks to the choice of a limited thickness for the main burner parts, said component parts can be manufactured by means of bending processes instead of having to use pieces obtained from castings.

[0018] Another object of the present invention is to provide a post-firing burner of the above-mentioned type wherein an increase in the crosswise dimensions of the burners enables an improvement to be achieved in the homogeneity of the fumes downstream from the burner thanks to an increase in the quantity of combustion agent involved in the recirculation regions.

[0019] Further object of the present invention is to provide a post-firing burner of the above-mentioned type that also guarantees the conditions needed to enable the fuel and the combustion agent to be mixed adequately so as to achieve a reduction in the emissions of unburnt gases and also of thermal NO_x thanks to the consequent attenuation of the temperature peaks.

[0020] Still another object of the present invention is to provide a post-firing burner of the above-mentioned type that enables an effective use of gaseous fuels of different types and that are difficult to burn.

[0021] These objects are achieved with a post-firing burner according to the present invention that comprises:

at least one fuel gas delivery pipe lying crosswise with respect to the flow of the oxidising gas in the feed duct of a heat recovery steam generator, and at least one row of fuel gas injector nozzles installed along said delivery pipe, the axis of said nozzles defining the axis (X) of the burner.

[0022] The burner also comprises:

first fuel gas deflector means for diverting the flow of the fuel gas coming from said injector nozzles in a direction substantially orthogonal to the axis of the burner, said first deflector means being fixed to said fuel gas delivery pipe in front of said injector nozzles, and

second deflector means for the oxidising gas extending around part of the delivery pipe and terminating at symmetrically opposite ends of the first deflector means, said second deflector means being suitable for dividing the flow of oxidising gas into a first fraction for mixing with the fuel gas flow coming from the first deflector means in at least one first mixing region inside the burner, where a premixed flow of the fuel gas and oxidising gas forms, and a second fraction for mixing with said premixed flow in at least one

second mixing region downstream of the burner.

[0023] Thanks to this configuration, the burner is streamlined so as to generate a first premixing step through the interaction of the first fuel gas flow deflector means with the second deflector means, that is capable of making the oxidising gas and the burnt gases recirculate. This first stage takes place inside the body of the burner and enables stable flames to be generated in the various burner operating conditions. This stage is followed by a second stage in which the oxidising gas or combustion agent and the premixed fuel gas are mixed. The second stage takes place outside the body of the burner and produces a flame tending to be compact and characterized by a perfect mixing of the gases, low nitrogen oxides and carbon oxide emissions, a very wide operating range, in terms of both thermal load and chemical composition of the combustion agent, and an effective thermal protection due to a film cooling effect.

[0024] According to a first aspect of the invention, the first deflector means comprise a front conveying wall fixed tangentially to the delivery pipe in line with the row of injector nozzles. Corresponding holes enabling the passage of the fuel gas are formed on the front wall. Parallel to said wall, a deflector plate is attached to the delivery pipe, the plate being spaced from the wall so as to define a duct running substantially orthogonal to the axis of the burner and being suitable for carrying the fuel gas towards two first mixing regions situated in symmetrically opposite positions on either side of said axis, where the premixing of the fuel gas with the oxidising gas takes place.

[0025] On the front wall, in line with the row of injector nozzles, there is advantageously an intermediate channel with tapered walls running parallel to the delivery pipe, while a recess of complementary shape is correspondingly formed in the deflector plate to define a sloping portion of the deflector duct.

[0026] According to another aspect of the invention, the second deflector means comprise a semi cylindrical screen substantially coaxial to the delivery pipe positioned on the side diametrically opposite the front fuel gas conveying wall. A pair of parallel plates extending from the axial sides of said screen are fixed to two sides of the front wall that are symmetrically opposite one another on either side of the axis of the burner. The front sides of the two plates are fitted with respective stabiliser wings so that they define a passage between the wings and the respective plates designed to divide the flow of oxidising gas in two fractions that flow, in substantially opposite radial directions, one towards the inside of the burner and the other towards the outside and downstream of the burner.

Brief description of the drawings

[0027] Further characteristics and advantages of the post-firing duct burner according to the present invention

will be apparent from the following description of an embodiment, given here as a non-limiting example with reference to the attached drawings, wherein:

figure 1 is a schematic axonometric view of a feed duct for a heat recovery steam generator, located downstream of a gas turbine, incorporating an array of post-firing burners according to the invention;
figure 2 is a partial axonometric view of the array of burners shown in figure 1;
figure 2a shows an enlarged view of a burner unit shown in figure 2;
figure 3 shows a further enlargement of a burner unit according to the present invention;
figure 4 is a partial exploded view of a detail of figure 3;
figure 5 shows the particular field of motion created in the flow of exhaust gas and fuel gas near the burner unit according to the invention.

Detailed description of the invention

[0028] With reference to figures 1, 2 and 2a, the numeral 1 indicates a feed duct of a heat recovery steam generator (not shown) and 2 indicates an array of identical post-firing burners installed in the duct 1, through which there is a flow F of gas coming from the exhaust of a gas turbine (not shown) and moving towards the inlet of the heat recovery steam generator. The array 2 comprises a number of rows of in-line burners, 3a, 3b, 3c, 3d, each row being fed by a respective fuel gas delivery pipe 4. Figures 1 and 2 show four rows of burners simply as an example.

[0029] The array 2 of post-firing burners comprises a frame 5, the shape of which is suitably adapted to the shape of the duct carrying the gases and the purpose of which is to support the row of burners. In particular, in the present embodiment of the invention, the frame is shown rectangular in shape.

[0030] Between the single rows of burners, and between the upper and lower rows and the respective inner walls of the duct 1, in the present embodiment of the invention, there are streamlined deflector elements 5a suitably shaped and positioned so as to create a significant local pressure drop and direct the flow of exhaust gases coming from the gas turbine towards the single rows of burners. The deflectors 5a (one of which is also partially visible in figure 5) usually consist of V-shaped plates with their tips pointing upstream with respect to the direction of the flow of oxidising gas and with said plates extending over the entire width of the frame 5.

[0031] As shown in figures 3 and 4, which show a burner unit according to the invention, each fuel gas delivery pipe 4 passes right through the array 2 and serves an entire row of burners, and a row of fuel gas injector nozzles 6 is distributed along the axis of the delivery pipe 4 and oriented downstream with respect to the direction of the flow F of oxidising gas.

[0032] The burner according to the invention comprises a front conveying wall 7 perpendicular to the flow direction F and attached to the pipe 4 by means of screws 8. The wall 7 is situated in front of the row of injector nozzles 6 so that it lies substantially tangent to the pipe 4 along said row. The wall 7 also has an intermediate channel 7a running parallel to the axis of the pipe 4 and formed with holes 9 axially aligned with the nozzles 6 to allow for the passage of the fuel gas.

[0033] In front of the front wall 7 and injector nozzles 6, there is a deflector plate 10 spaced from the wall 7 such that together they define a duct 11 extending in a direction substantially orthogonal to the direction in which the fuel gas is injected through the nozzles 6. The plate 10 thus serves the purpose of diverting the jets of fuel gas coming through the nozzles 6 at an angle of 90° with respect to the outflow direction of said gas. In particular, the plate 10 has an intermediate recess 10a with a profile substantially equal to that of the intermediate channel 7a in the wall 7 so that together they define a duct portion 11a, in correspondence with the nozzles 6, that slopes in the direction in which the fuel gas flows in order to make the change of direction of the gas flow less abrupt.

[0034] The plate 10 is attached to the fuel gas delivery pipe 4 by means of the same screws 8. The gap between the wall 7 and the plate 10 is assured by spacer bushes 12 attached to the wall 7 in line with through holes 13 for the screws 8. During assembly, the plate 10 is made to abut against the bushes 12 and against the shoulders 17, provided between the wall 7 and the plate 10 to close the sides of the duct 11.

[0035] The fuel gas delivery pipe 4 is contained in a casing, generally indicated at 14, that is lapped by the oxidising gas and is formed by a substantially semi cylindrical screen 15, coaxial to the pipe 4 and arranged on the side diametrically opposite the front fuel gas conveying wall 7, and by a pair of parallel plates 16 extending from the axial sides of the screen 15, and in particular tangentially to the cylindrical surface. The two plates 16 are fixed to the two symmetrically opposite sides of the wall 7 and to the shoulders 17.

[0036] Stabiliser wings 18 are provided on the front sides of the two plates 16. The wings 18 are anchored isostatically to the respective plates 16 to allow for thermal expansion. Between the wings 18 and the respective plates 16, a passage 19 for the oxidising gas is also provided, as shown in figure 5. In fact, the oxidising gas laps against the casing 14 and flows against the wings 18, and is divided into two flows F1 and F2 flowing in substantially opposite radial directions and directed respectively towards the inside of the burner and the plate 10, i.e. towards the axis of the burner (coinciding with the axes of the injector nozzles 6), and towards the outside of the burner on the downstream side.

[0037] The wings 18 can consist of flat or curved plates or, more in general, of any profile suitable for ensuring that a portion of the flow of oxidising gas be directed towards the axis of the burner. In particular, the distribu-

tion of the flow can be controlled by suitably inclining the wings 18 with respect to the plates 16.

[0038] With reference to figure 5, the combustion process takes place in two separate stages:

a) a first, pre-mixing stage that takes place in two regions of the burner, indicated as P, that extend symmetrically on either side of the plate 10 with respect to the axis X-X of the burner, their contours being delimited by the wall 7 and the plates 16. The premixing action is achieved in a "cold" swirl (clockwise or anticlockwise depending on whether reference is made to the upper or lower part of the burner in relation to its axis of symmetry X-X) with a "rich" stoichiometry that is not useful to produce a flame, but that is suitable for considerably diluting the fuel with the flow F1 of oxidising gas and for protecting the burner from overheating by means of a film cooling effect. This swirl is less strong in the event of operation with low flow rates, but still sufficient to induce the ignition of a particularly stable pilot flame within a confined space and protected against stripping by the external aerodynamics. In the case of a high fuel gas flow rates, on the other hand, the swirl fluid dynamics are such that the swirl is strongly reinforced and generates the best conditions for establishing a so-called "RQL" (Rich Quench Lean) combustion;

b) a second combustion stage, that takes place in the region immediately downstream of the burner, indicated as C, where the premixing swirl tends to reverse its direction of rotation and to become mixed with the swirls of combustion agent F2 turning in the opposite direction outside the burner. Good dilution conditions are rapidly established with a vast area of the oxidising fluid, giving rise to a flame that tends to be compact and bluish in colour.

[0039] The jet of fuel gas emerges from the burner in a direction lying crosswise to the burner's axis, through the duct 11 formed between the wall 7 and the deflector plate 10 in front of the wall, before the holes 9 and the corresponding nozzles 6 through which the fuel gas comes out from the delivery pipe 4. The plate 10 may be of various shapes, providing it serves the purpose of diverting the fuel gas in a direction crosswise to its axis. Said gas flow laps all over the flame side of the burner (i.e. the wall 7, the plate 10 and the plate 16), consequently exerting a film cooling effect on these components. The jet of gas also supports the formation of the swirls in the previously-mentioned regions P, which are consequently intensified in a manner proportional to the heat rating and which are responsible for the partial premixing of the combustion agent and the fuel gas required by the process.

[0040] Downstream of the stabiliser wings 18, an area of local recirculation is created (turning anticlockwise above the axis X-X and clockwise below said axis) that

guarantees a stable flame in any operating conditions. In fact, the flame produced is anchored to the wings, which represent its hot point, and the consequent thermal load on the wings is balanced by the heat extraction by the flow of gas that laps over them on the inside (cooling effect by impingement).

[0041] On the whole, it is evident that the main flame of the burner has two symmetrical origins starting from the two lateral hot points represented by the two stabiliser wings 18 placed symmetrically on either side of the axis of the burner.

[0042] The thermal protection afforded in this way affects the whole burner unit, with the exception of the deflector plate 10 (which is cooled on the inside, by impingement, by the jet of cold fuel gas) and the stabiliser wings 18 (which are also cooled by impingement on the inside), as explained later on. This thermal protection enables the component parts of the burner to be made of sheet metal bent by plastic deformation, so the design and manufacture of the burner's components can be rapidly adapted to the various potential applications, since there is no longer any need to construct dies in which to cast them. Moreover, the resulting burner is extremely lightweight and scarcely susceptible to temperature gradients inside the metal, or any consequent strain and cracking. The burner can thus be made in much larger dimensions than is the case when the components have to be obtained by casting, consequently enabling a reduction in the dimensions of the other parts involved in the assembly, e.g. the deflectors 5a used to produce the pressure drop required.

[0043] The smooth distribution of the fuel gas is assured mainly by the shape of the deflector plate 10, and its position inside the burner. This aspect contributes to a reduction in the temperature peaks and consequently in the emission of pollutants (CO and NOx).

[0044] The fuel gas is premixed very efficiently thanks to the formation of the two symmetrical swirls P revolving in opposite directions (see figure 5) supported by the jets of fuel gas and combustion agent, and contained between the two parallel plates 16, i.e. in the lower pressure zone created due to the effect of the volume of the burner inside the duct. The characteristics of this low pressure zone are suitably modified by the flow of the fuel gas that modulates the burner's capacity to feed a flow of combustion agent for premixing depending on the power involved, and consequently on the fuel's flow rate and velocity. In fact, the local pressure drop increases with the increase in the flow rate or velocity of the fuel gas. In this way, the burner achieves the particular feature that it can guarantee a wide range of adjustment because any increase in the flow rate of the fuel delivered corresponds to an increase in the flow rate of the combustion agent for premixing.

[0045] The burner according to the invention has the particular feature of synergically exploiting the pressure and velocity gradients of both the oxidising fluid and the fuel gas. In fact, thanks to the premixing stage, the

streamlining of the burner enables an efficient burning of different types of fuel gas, however difficult they may be. The limited availability of a fluid dynamic load in line with the burner is put to maximum advantage exploiting the majority of the natural swirls that form and containing as far as possible the losses that are not useful for the purposes of the aerodynamics essential to the process.

[0046] The pollutants emission, such as NOx and CO emissions, is kept to negligible levels in a range of rating variation in excess of 1:10.

[0047] In addition to the functional aspects of the combustion process relating to the heating of the fluid and to the environmental impact, no less important are the technological aspects of the strength and reliability of the components submitted to stress in a particularly aggressive environment. The development of the burner has duly borne these issues in mind, adapting both the process and the streamlined components to the need to contain the thermal stresses involved.

[0048] There may be variants and modifications of the post-firing burner according to the present invention without departing from the scope of the invention as set forth in the following claims.

Claims

1. A post-firing burner unit comprising:

- at least one fuel gas delivery pipe (4) lying crosswise to the flow (F) of oxidising gas in a feed duct (1) of a heat recovery steam generator,
- at least one row of fuel gas injector nozzles (6) formed along said delivery pipe (4), the axis of said nozzles corresponding to the axis (X) of the burner,
- first fuel gas deflector means (7,10) for diverting the fuel gas flow coming from said nozzles (6),
- second oxidising gas deflector means (14,18) extending around a part of said delivery pipe (4) and terminating at symmetrically opposite ends of said first deflector means (7,10),

said burner unit being **characterized in that:**

- said first deflector means (7,10) divert the fuel gas flow coming from said nozzles (6) in a direction substantially orthogonal to the burner axis (X), and are attached to said fuel gas delivery pipe (4) in front of said injector nozzles (6),
- said second deflector means (14,18) are designed to divide the flow of oxidising gas into a first fraction (F1) for mixing with the fuel gas flow coming from said first deflector means (7,10) in at least one first mixing region (P) inside the burner, where a premixed flow of fuel gas and oxidising gas is formed, and a second fraction

(F2) for mixing with said premixed flow in at least one second mixing region (C) downstream of the burner.

2. A burner unit according to claim 1, wherein said first deflector means comprise a front conveying wall (7) attached tangentially to said delivery pipe (4) in front of said row of injector nozzles (6), corresponding holes being formed in said wall to enable the passage of the fuel gas, and a deflector plate (10) attached to said delivery pipe (4) parallel to said wall (7) and spaced therefrom to define a duct (11) substantially orthogonal to the burner axis (X) for conveying the fuel gas towards two first mixing regions (P) located at symmetrically opposite positions with respect to the burner axis (X). 5 10 15
3. A burner unit according to claims 1 or 2, wherein an intermediate channel (7a) is formed on said wall (7), in front of said row of injector nozzles (6), said channel having sloping walls and being parallel to said delivery pipe (4), corresponding ribbing (10a) of complementary shape being formed on said deflector plate (10) to define a sloping portion (11a) of said duct (11). 20
4. A burner unit according to any of the previous claims, wherein spacer means (12) are inserted between said wall (7) and said deflector plate (10). 30
5. A burner unit according to claim 4, wherein said spacer means comprise bushes (12) installed coaxially to the holes (9) between said wall (7) and said plate (10). 35
6. A burner unit according to any of the previous claims, wherein said second deflector means comprise a semicylindrical screen (15) substantially coaxial to said delivery pipe (4) and arranged on the side diametrically opposite the front fuel gas conveying wall (7), a pair of parallel plates (16) extending from the axial sides of said screen (15) and attached to sides of the wall (7) that are symmetrically opposite one another with respect to the burner axis (X), respective stabiliser wings (18) being attached to the front sides of said two plates (16), a passage (19) being formed between said wings (18) and the respective plates (16) for distributing the flow of oxidising gas in said two fractions (F1,F2) flowing in radial directions substantially opposite one another, one towards the inside of the burner and the other towards the outside of the burner downstream thereof. 40 45 50
7. A burner unit according to claim 6, wherein said stabiliser wings (18) slope with respect to said parallel plates (16). 55
8. A burner unit according to any of the previous claims,

wherein its component parts are made of bent sheet metal.

9. A burner unit according to any of the previous claims, wherein said at least one fuel gas delivery pipe (4) is installed on a frame (5) lying crosswise inside said oxidising gas feed duct (1). 5
10. A burner unit according to any of the previous claims, **characterized in that** said at least one fuel gas delivery pipe (4) delivers fuel gas to a row of other identical burners aligned along the axis of said pipe (4), said frame (5) supporting several fuel gas delivery pipes (4) and corresponding rows (3a,3b,3c,3d) of parallel burners that together form an array (2) of burners. 10
11. A burner unit according to claim 10, wherein fluid dynamic deflector elements (5a) are installed between said rows (3a,3b,3c,3d) of burners. 15 20

Patentansprüche

- 25 1. Nachverbrennung-Brennereinheit, die enthält:

- wenigstens ein Brenngas-Zuführrohr (4), das quer zur Strömung (F) von Oxidationsgas in einer Versorgungsleitung (1) eines Dampfgenerators zur Wärmerückgewinnung liegt,
- wenigstens eine Reihe von Brenngas-Einspritzdüsen (6), die längs des Zuführrohrs (4) ausgebildet ist, wobei die Achse der Düsen der Achse (X) des Brenners entspricht,
- erste Brenngas-Ablenkeinrichtungen (7, 10) zum Ablenken der Brenngasströmung, die von den Düsen (6) kommt,
- zweite Oxidationsgas-Ablenkeinrichtungen (14, 18), die sich um einen Teil des Zuführrohrs (4) herum erstrecken und an symmetrisch entgegengesetzten Enden der ersten Ablenkeinrichtungen (7, 10) enden,

wobei der Brenner **dadurch gekennzeichnet ist, dass:**

- die ersten Ablenkeinrichtungen (7, 10) die Brenngasströmung, die von den Düsen (6) kommt, in eine Richtung im Wesentlichen orthogonal zu der Brennerachse (X) ablenken und an dem Brenngas-Zuführrohr (4) vor den Einspritzdüsen (6) angebracht sind,
- die zweiten Ablenkeinrichtungen (14, 18) ausgestaltet sind, um die Strömung des Oxidationsgases in eine erste Fraktion (F1) zur Vermischung mit der Brenngasströmung, die von den ersten Ablenkeinrichtungen (7, 10) kommt, in wenigstens einer ersten Vermischungsregion

- (P) innerhalb des Brenners, wo eine vorgemischte Strömung von Brenngas und Oxidationsgas gebildet wird, und eine zweite Fraktion (F2) zur Vermischung mit der vorgemischten Strömung in wenigstens einer zweiten Vermischungsregion (C) stromabwärts des Brenners teilt.
2. Brenneinheit nach Anspruch 1, wobei die ersten Ablenkeinrichtungen eine vordere Leitungswand (7), die tangential an dem Zuführrohr (4) vor der Reihe von Einspritzdüsen (6) angebracht ist, wobei entsprechende Löcher in der Wand ausgebildet sind, um den Durchgang des Brenngases zu gestatten, und eine Ablenkplatte (10) enthalten, die an dem Zuführrohr (4) parallel zu der Wand (7) angebracht ist und davon beabstandet ist, um eine Leitung (11) im Wesentlichen orthogonal zu der Brennerachse (X) zu definieren, um das Brenngas zu zwei ersten Vermischungsregionen (P) zu fördern, die an symmetrisch entgegengesetzten Positionen bezüglich der Brennerachse (X) liegen.
 3. Brenneinheit nach Anspruch 1 oder 2, wobei ein Zwischenkanal (7a) an der Wand (7) vor der Reihe von Einspritzdüsen (6) ausgebildet ist, wobei der Kanal geneigte Wände hat und parallel zu dem Zuführrohr (4) ist, wobei eine Riffelung (10a) von komplementärer Form an der Ablenkplatte (10) ausgebildet ist, um einen geneigten Teil (11a) der Leitung (11) zu bilden.
 4. Brenneinheit nach einem der vorhergehenden Ansprüche, wobei Abstandhaltereinrichtungen (12) zwischen der Wand (7) und der Ablenkplatte (10) eingesetzt sind.
 5. Brenneinheit nach Anspruch 4, wobei die Abstandhaltereinrichtungen Buchsen (12) enthalten, die koaxial zu den Löchern (9) zwischen der Wand (7) und der Platte (10) installiert sind.
 6. Brenneinheit nach einem der vorhergehenden Ansprüche, wobei die zweiten Ablenkeinrichtungen eine halbzyklindrische Abschirmung (15) enthalten, die im Wesentlichen koaxial zu dem Zuführrohr (4) ist und an der Seite diametral entgegengesetzt zu der vorderen Brenngas-Leitungswand (7) angeordnet ist, wobei ein Paar von parallelen Platten (16) vorgesehen ist, die sich von den axialen Seiten der Abschirmung (15) aus erstrecken und an Seiten der Wand (7) angebracht sind, die symmetrisch entgegengesetzt zueinander bezüglich der Brennerachse (X) sind, wobei entsprechende Stabilisierflügel (18) an den vorderen Seiten der zwei Platten (16) angebracht sind, wobei eine Passage (19) zwischen den Flügeln (18) und den entsprechenden Platten (16) ausgebildet sind, um in die zwei Fraktionen (F1, F2) die Strömung des Oxidationsgases zu verteilen, die in radialen Richtungen im Wesentlichen entgegengesetzt zueinander strömen, eine zur Innenseite des Brenners hin und eine zur Außenseite des Brenners hin stromabwärts davon.
 7. Brenneinheit nach Anspruch 6, wobei die Stabilisierflügel (18) bezüglich den parallelen Platten (16) geneigt sind.
 8. Brenneinheit nach einem der vorhergehenden Ansprüche, wobei seien Bestandteile aus gebogenem Blech hergestellt sind.
 9. Brenneinheit nach einem der vorhergehenden Ansprüche, wobei das wenigstens eine Brenngas-Zuführrohr (4) an einem Rahmen (5) installiert ist, der quer innerhalb der Oxidationsgas-Versorgungsleitung (1) liegt.
 10. Brenneinheit nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das wenigstens eine Brenngas-Zuführrohr (4) Brenngas zu einer Reihe anderer identischer Brenner liefert, die längs einer Achse des Rohrs (4) ausgerichtet sind, wobei der Rahmen (5) mehrere Brenngas-Zuführrohre (4) und entsprechende Reihen (3a, 3b, 3c, 3d) von parallelen Brennern trägt, die zusammen eine Anordnung (2) von Brennern bilden.
 11. Brenneinheit nach Anspruch 6, wobei Fluidodynamik-Ablenkelemente (5a) zwischen den Reihen (3a, 3b, 3c, 3d) von Brennern installiert sind.

Revendications

1. Une unité de brûleur post-combustion comportant :

- au moins un tuyau de distribution (4) de gaz combustible s'étendant en travers du flux (F) d'un gaz oxydant dans un conduit d'alimentation (1) d'un générateur de vapeur de récupération de chaleur,
- au moins une rangée des buses d'injection (6) de gaz combustible formée le long du dit tuyau de distribution (4), l'axe desdites buses correspondant à l'axe (X) du brûleur,
- des premiers moyens défecteurs (7, 10) de gaz combustible pour dévier le flux de gaz combustible provenant desdites buses (6),
- des seconds moyens défecteurs (14, 18) de gaz oxydant s'étendant autour d'une partie du dit tuyau de distribution (4) et se terminant à des extrémités symétriquement opposées desdits premiers moyens défecteurs (7, 10),

ladite unité de brûleur étant **caractérisée en ce**

que :

- lesdits premiers moyens déflecteurs (7, 10) dévient le flux du gaz combustible provenant desdites buses (6) dans une direction sensiblement orthogonale à l'axe du brûleur (X), et sont fixés au dit tuyau de distribution (4) de gaz combustible en regard desdites buses d'injection (6),
 - lesdits seconds moyens déflecteurs (14, 18) sont conçus pour diviser le flux du gaz oxydant en une première fraction (F1) pour la mélanger au flux de gaz combustible provenant desdits premiers moyens déflecteurs (7, 10) dans au moins une première région de mélange (P) à l'intérieur du brûleur, dans laquelle est réalisé un flux pré-mélangé de gaz combustible et de gaz oxydant, et en une seconde fraction (F2) pour la mélanger avec ledit flux pré-mélangé dans au moins une seconde région de mélange (C) en aval du brûleur.
2. Une unité de brûleur selon la revendication 1, dans laquelle lesdits premiers moyens déflecteurs comportent une paroi de guidage frontale (7) fixée tangentiellement audit tuyau de distribution (4) en face de ladite rangée de buses d'injection (6), des orifices correspondants étant réalisés dans ladite paroi pour permettre le passage du gaz combustible, et une plaque déflectrice (10) fixée audit tuyau de distribution (4) parallèle à ladite paroi (7) et espacée de celle-ci pour définir un conduit (11) sensiblement orthogonal à l'axe du brûleur (X) pour guider le gaz combustible vers les deux premières régions de mélange (P) situées dans des positions symétriquement opposées par rapport à l'axe (X) du brûleur.
 3. Une unité de brûleur selon l'une des revendications 1 et 2, dans laquelle un canal intermédiaire (7a) est réalisé sur ladite paroi (7), en face de ladite rangée de buses d'injection (6), ledit canal ayant des parois inclinées et étant parallèle audit tuyau de distribution (4), des nervures correspondantes (10a) de forme complémentaire étant réalisées sur ladite plaque déflectrice (10) pour définir une partie inclinée (11a) dudit tuyau (11).
 4. Une unité de brûleur selon l'une quelconque des revendications précédentes, dans laquelle sont insérés des moyens d'entretoise (12) entre ladite paroi (7) et ladite plaque déflectrice (10).
 5. Une unité de brûleur selon la revendication 4, dans laquelle lesdits moyens d'entretoise comportent des bagues (12) agencées entre ladite paroi (7) et ladite plaque (10) et de façon coaxiale aux orifices (9).
 6. Une unité de brûleur selon l'une quelconque des revendications précédentes, dans laquelle lesdits seconds moyens déflecteurs comportent un écran semi-cylindrique (15) sensiblement coaxial audit tuyau de distribution (4) et disposé sur le côté diamétralement opposé à la paroi (7) de guidage de gaz combustible frontale, une paire de plaques parallèles (16) s'étendant à partir des côtés axiaux dudit écran (15) et fixées aux côtés de la paroi (7) qui sont symétriquement opposés par rapport à l'axe (X) du brûleur, des ailettes de stabilisation respectives (18) étant fixées aux côtés avant desdites deux plaques (16), un passage (19) étant formé entre lesdites ailettes (18) et les plaques respectives (16) pour distribuer le flux du gaz oxydant dans lesdites deux fractions (F1, F2) s'écoulant dans des directions radiales sensiblement opposées, l'une vers l'intérieur du brûleur et l'autre vers l'extérieur du brûleur en aval de celui-ci.
 7. Une unité de brûleur selon la revendication 6, dans laquelle lesdites ailettes de stabilisation (18) sont inclinées par rapport auxdites plaques parallèles (16).
 8. Une unité de brûleur selon l'une quelconque des revendications précédentes, dans laquelle ses composants sont faits de tôles métalliques pliées.
 9. Une unité de brûleur selon l'une quelconque des revendications précédentes, dans laquelle ledit au moins un tuyau de distribution (4) de gaz combustible est installé sur un châssis (5) se trouvant en travers à l'intérieur dudit conduit d'alimentation (1) de gaz oxydant.
 10. Une unité de brûleur selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'**au moins un tuyau de distribution (4) de gaz combustible délivre du gaz combustible à une rangée d'autres brûleurs identiques alignés le long de l'axe du dit tuyau (4), ledit châssis (5) supportant plusieurs tuyaux de distribution (4) de gaz combustible et des rangées correspondantes (3a, 3b, 3c, 3d) de brûleurs parallèles qui forment ensemble une grille (2) de brûleurs.
 11. Une unité de brûleur selon la revendication 10, dans laquelle des éléments déflecteurs dynamiques (5a) sont installés entre lesdites rangées (3a, 3b, 3c, 3d) de brûleurs.

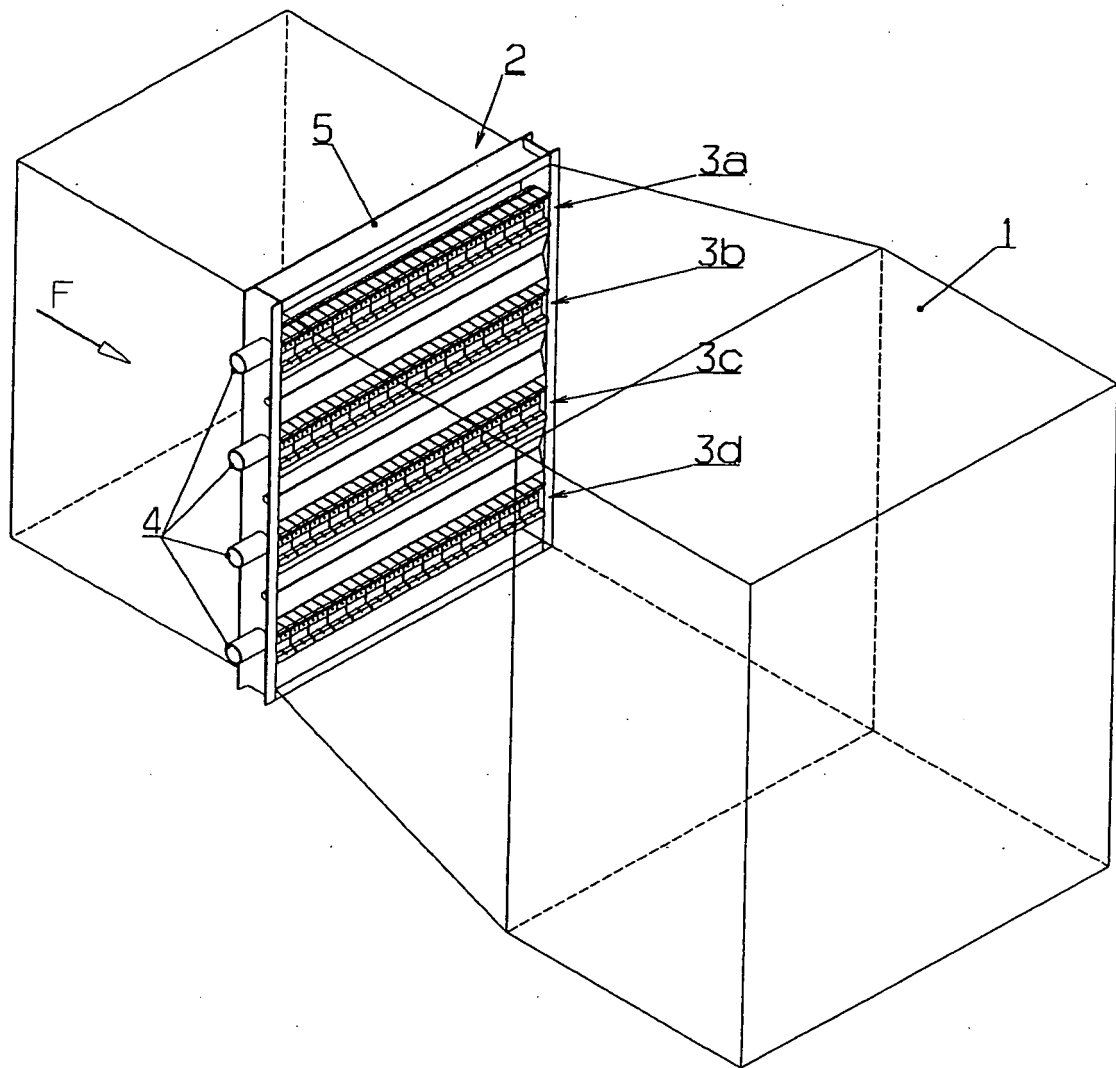


Fig. 1

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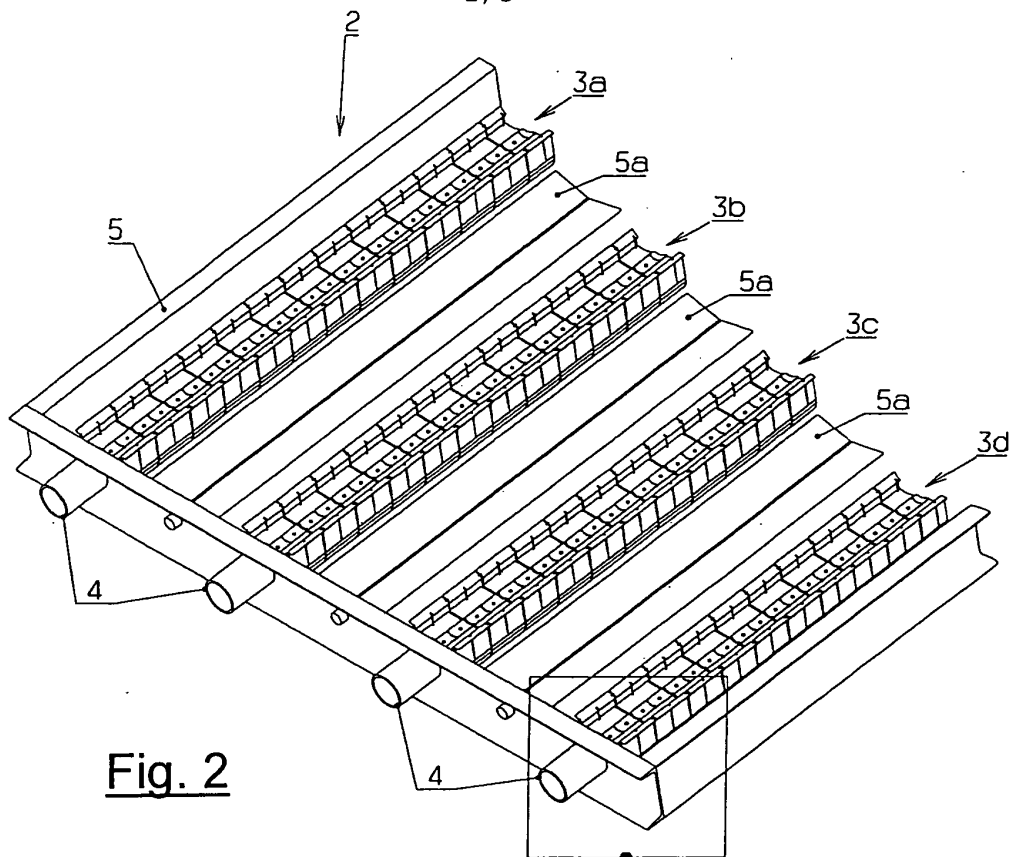


Fig. 2

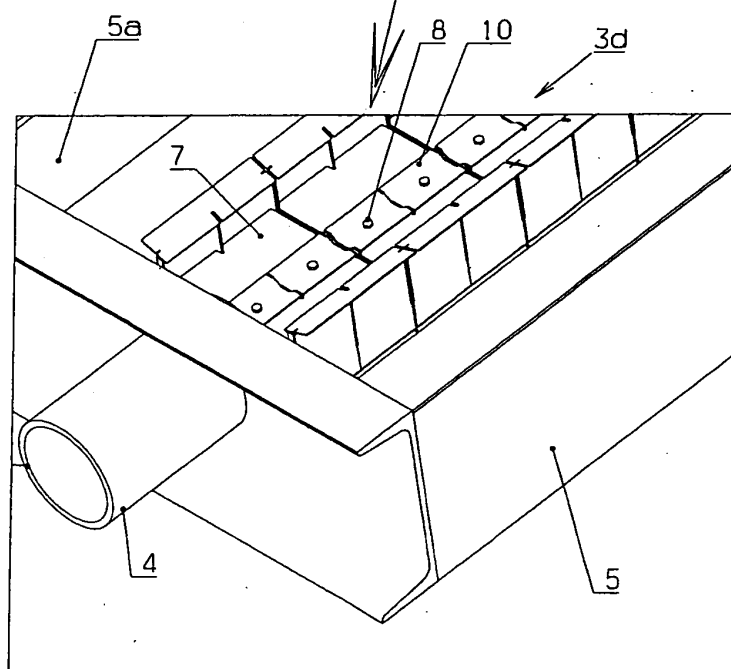


Fig. 2a

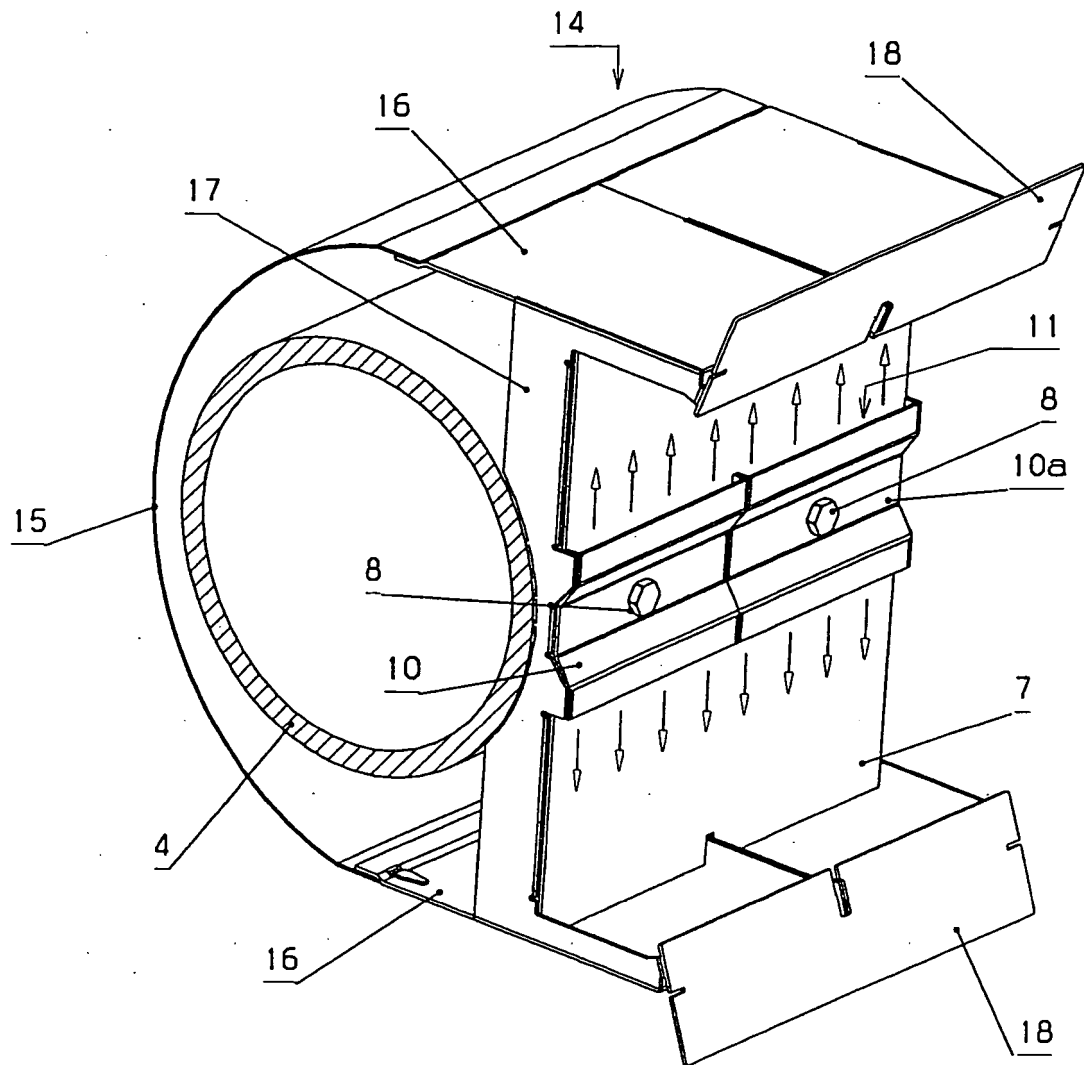


Fig. 3

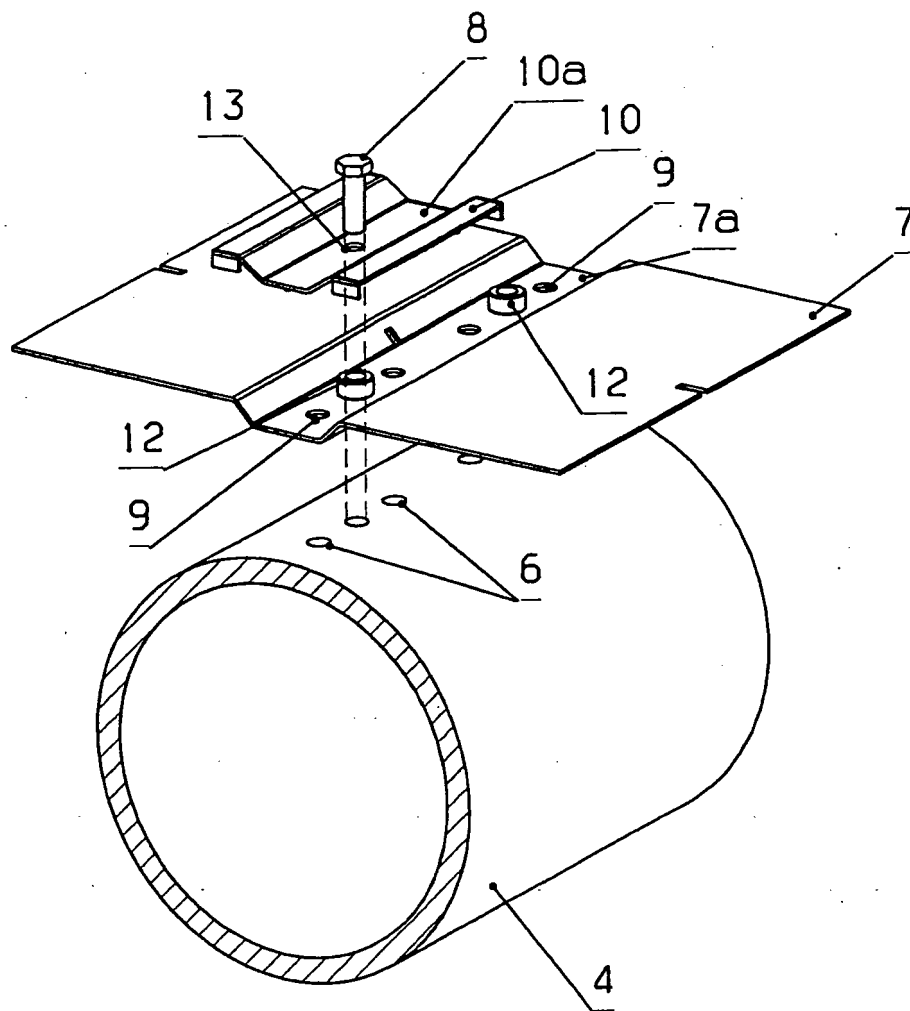


Fig. 4

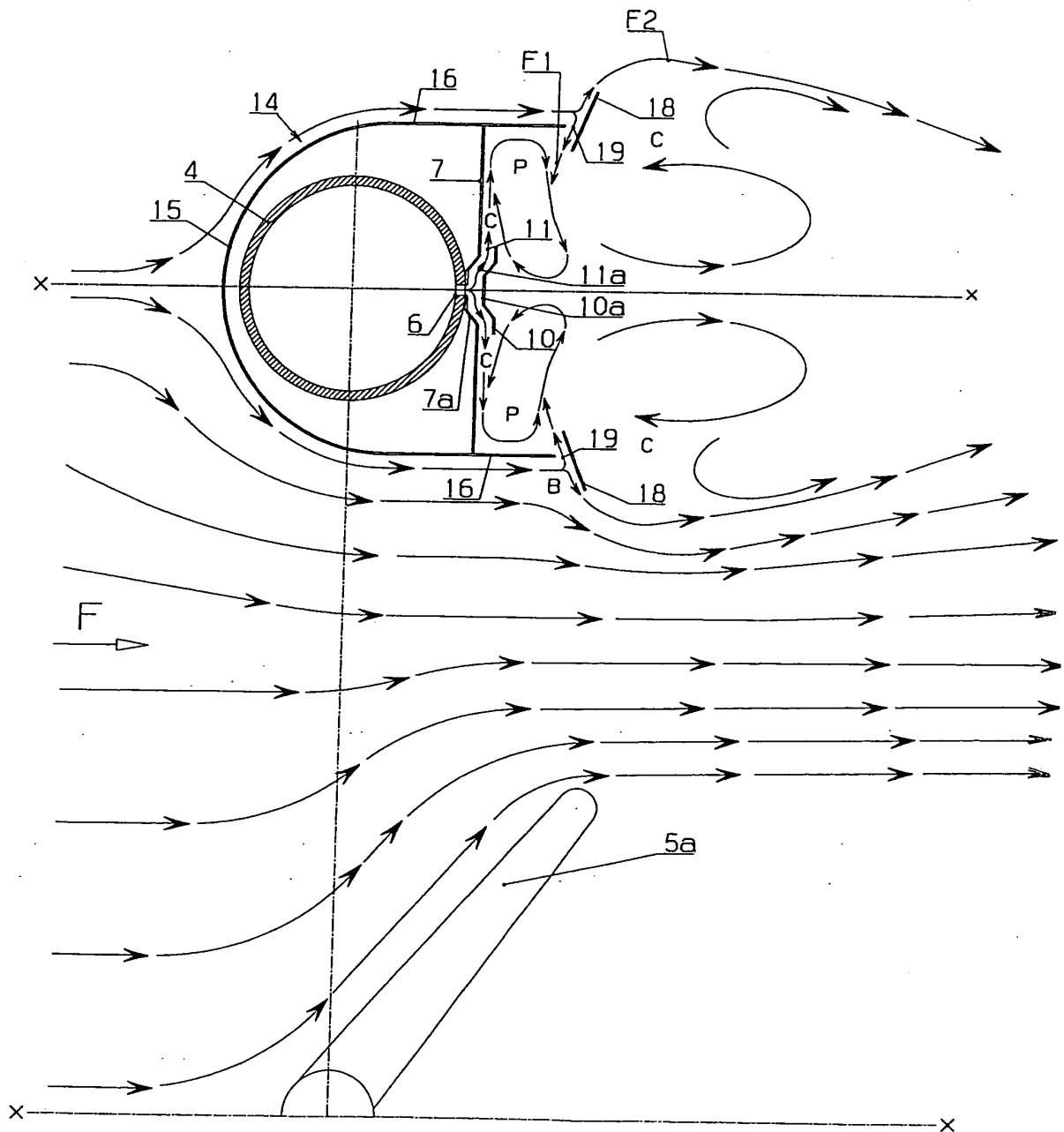


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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