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(54) **Low NOx burner for liquid and gaseous fuels**

Brenner mit niedrigem NOx-Gehalt für flüssige und gasförmige Brennstoffe

Brûleur à faible taux de NOx pour combustibles liquides et gazeux

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Description

[0001] The present invention relates to a novel low NOx burner for liquid and gaseous fuel. More precisely the invention relates to a low/medium capacity burner designed to equip steam or hot water generators both for civil purposes (for example remote location heating plants) and for industrial purposes (for example, boilers for steam generation for machinery, industrial laundries, etc.).

[0002] Low/medium capacity burners of the prior art generally comprise a duct for the combustion air, which can be whirled by means of an adjustable radial register or by means of a tangential inlet (volute inlet), and a large perforated and/or finned disk, placed at the outlet of the duct, for the stabilization of the flame. The burners of this kind are considerably simple in structure and construction, but have a low ability to reduce the nitrogen oxides emissions and very high aerodynamic pressure drops (in the range of several thousands of Pa). On the other side, for large size plants (such as thermoelectric power plants) there are known burners in which the combustion air is split into several streams, generally three streams, in such a way to control the reaction stoichiometry and the flame temperature. This system, named stage combustion, consists in suitably dosing the air and the fuel within the combustion system, in such a way to form a fuel-rich zone, in which the fuel pyrolysis processes take place and NOx reduction processes are activated, and a fuel-poor zone where the remaining portion of combustion air mixes with the fuel to complete the combustion. Burners of this type, however, are not suitable for low/medium capacity plants, both for cost reasons and the difficulties of reproducing their geometry on a lower scale.

[0003] EP 0536556 A1 discloses a burner for oil and gas fuels comprising a primary air duct and a secondary air duct coaxial to the primary air duct, oil/gas fuel supplying means extending in the primary duct, means for controlling the flowrate of the primary and the secondary air duct and means for creating vorticity in the combustion air comprising moving swirlers at the outlet side of the primary and secondary air ducts. US 3367385 A discloses a burner wherein the primary air duct is provided with an axially slidable radial swirler at its inlet side.

[0004] The object of the present invention is to provide a liquid and gaseous fuel burner suitable of performing a stage combustion typical of the "three airs" burners, with all the related advantages in term of reduced NOx production, but with a more simple structure with respect to this type of burners, thus being fit for installation in low/medium capacity steam/hot water generation plants.

[0005] Another object of the present invention is to provide a burner of the above-mentioned type, suitable to equip the combustion units of new steam and hot water generators, as well as to be mounted on existing plants.

[0006] The above objects are achieved by the burner of the invention, by virtue of the division of the combustion air into two streams, called primary and secondary air stream, as well as of a suitable geometry of the burner outlet and by means of the use of a turbulence generator (primary swirler) on the primary air with a radial flow divider and a controllable turbulence generator (secondary swirler) on the secondary air. Thanks to the above simplified structure of the burner it is possible to achieve a lower unit cost and lower air side pressure drop with the same capacity and pollutant emissions.

[0007] The features and advantages of the burner according to the present inventions will be clearer from the following description of an exemplifying and not limiting embodiment thereof with reference to the following drawings wherein:

- Figure 1 is a schematic view of a longitudinal section of the burner according to the invention;
- Figures 2a, 2b schematically show, in a side section and in front view, a primary swirler with flat blades of the burner according to the invention;
- Figures 3a, 3b schematically show, in front and rear perspective views, a variation of the primary swirler with variable section blades of the burner according to the invention;
- Figures 4a, 4b schematically show, in a side section and in front view, a variation of the primary swirler with a double-blade configuration of the burner according to the invention;
- Figures 5a, 5b, 5c schematically show, in a longitudinal perspective sectional view, the burner of the invention with the secondary swirler in the backward, intermediate and forward operating positions respectively.

[0008] With reference to Figure 1, it has been indicated at 1 a burner mounted in correspondence of a conical opening 2 of an inner wall 3 of a combustion chamber 4. Opening 2 is formed in the shape of a throat diverging toward combustion chamber 4. Combustion air is fed through a windbox 5 and split into two streams, called primary air stream A1 and secondary air stream A2 through respective primary air duct 11 and secondary air duct 17 coaxially arranged on longitudinal axis X-X of the burner.

[0009] The burner comprises a liquid fuel lance 6 connected to a flange 7 at the outer end and having an atomizer 8, of the known type, for converting the fuel into a fine spray at the inner end inside combustion chamber 4. Lance 6 is centrally arranged on the longitudinal axis X-X of the burner and a plurality of lances 9 for feeding gaseous fuels are arranged in parallel relation around it. Gas lances 9 extend from a toroidal header 10 located outside of flange 7 up to combustion chamber 4. Therefore, the burner can handle liquid fuel, gaseous fuel or both of them.

[0010] Primary air duct 11 extends coaxially to liquid

fuel lance 6 and houses gas lances 9. It is connected to flange 7 at its outer end and communicates with combustion chamber 4 at the inner one. A plurality of radial windows 12 for feeding the air from windbox 5 are formed on primary air duct 11 close to flange 7 and a cylindrical damper 13 axially slidable by means of a pair of rods 14 (only one shown in figure 1) extending outside of flange 7 is provided inside primary duct 11 in correspondence to windows 12.

[0011] Secondary air duct 17 extends coaxially to primary air duct 11 from a flange 18 radially extending from duct 11 and outflows in combustion chamber 4. A plurality of radial windows 19 for feeding air from windbox 5 are formed on secondary air duct 17 close to flange 18. A cylindrical damper 20 axially slidable by means of a pair of rods 21 (only one shown in figure 1) is provided in correspondence to windows 19 on the outer side of secondary air duct 17. The axial sliding of cylindrical dampers 13 and 20 allows for a continuous adjustment of the respective inlet sections of primary and secondary air ducts and, by this way, the partitioning of the flowrate of the combustion air. The adjustment can be carried out both by manual operation of respective rods 14 and by motorized operation. The primary and secondary air ducts can be fed either by the same windbox 5, as shown, or by different windboxes.

[0012] A primary swirler 15 formed by a plurality of fixed blades 15a is arranged in primary air duct 11 in correspondence to the outlet end at combustion chamber 4. A radial flow divider 16, conically shaped and coaxial to axis X-X of the burner, is provided at the outlet of primary swirler 15. The blades 15a of primary swirler 15 have a fixed inclination defined as a function of the application. The blades can be flat (figures 2a, 2b), in the case in which the outlet angle is the same over the whole radius of the primary air duct, or they can have a variable section. The section can be varied in a continuous way so as to have an outlet angle of the primary air flow variable with the radius, as shown in figures 3a, 3b, or in a discontinuous way by making each blade of two differently inclined blade-portions connected to each other, as shown in figures 4a, 4b.

[0013] Radial flow divider 16, arranged on the side of primary swirler 15 facing toward combustion chamber 4, divides swirler 15 into two concentric annuli, of which the external one has flowing section 2-3 times greater than the inner one.

[0014] A movable swirler 22, formed by a plurality of inclined blades, is arranged at the inner side of secondary air duct 17 in correspondence to windows 19.

[0015] Swirler 22 is made axially slidable between two end positions, a first one completely downstream of windows 19 and a second one, shown with discontinuous line in figure 1, completely upstream of windows 19, the sliding of movable swirler 22 being controlled by rods 23 extending outside of flange 7. As also shown schematically in figures 5a, 5b, 5c, depending on the position of movable swirler 22 with respect to air inlet windows

19, the air vorticity can be controlled in such a way that it will be null when swirler 22 is in the backward position, i.e. the second position and the combustion air does not pass through it (fig. 5a), medium when the swirler is in the intermediate position (fig. 5b), and maximum when the swirler 22 is in the forwardly extended position, i.e. the first position (fig. 5c). The vorticity control is obtained by placing the swirler in one of the possible intermediate positions. A venturi 24 is placed downstream of movable swirler 22 in correspondence to the outlet of secondary air duct 17. Furthermore a radial flow divider 25 is arranged at the outlet of secondary air duct 17 in the combustion chamber 4.

[0016] Flow divider 25 has a frusto-conical shape and extends from the outlet cage of primary air duct 11 thus delimiting the primary air stream from the secondary air stream.

[0017] The primary swirler 15 placed on the primary air stream at the outlet of the burner allows to obtain a field of motion typical of a low-NOx burner with low pressure drop without the risk of moving backward the flame front, in any operating condition, and fouling or damaging burner parts. The blades are so shaped as to increase the amount of air passing through the central zone. If a structure with a double series of blades such as that shown in figures 4a, 4b is used, the same purpose is achieved and further the whirling, i.e. the vorticity of the part of primary air passing through the outer annulus, can be increased. An equivalent effect can be obtained by using, instead of a double-bladed swirler, a swirler with single blades shaped so as to have an outlet angle variable with the radius, such as that shown in figures 3a, 3b. Radial flow divider 16 on the primary air stream has the purpose of separating the two flow regimes created by the blade shaping and stabilizing the flame. If the flow divider is combined with a double-bladed swirler, the diameter of the flow divider at the outlet of the swirler is equal to the diameter of separation of the annuli defined by the different inclinations of the series of blades.

Claims

1. A low-NOx burner for liquid and gaseous fuels, comprising a primary air duct (11) and a secondary air duct (17) coaxial to said primary air duct for supplying a primary air stream (A1) and, respectively, a secondary air stream (A2) for combustion, means (6,9) for supplying said fuels for combustion extending along or parallel to the longitudinal axis (X-X) of said primary air duct (11), control means for the combustion air comprising dampers (13,20) at the inlet side of said primary and secondary air ducts (11, 17), means for creating vorticity in the combustion air comprising a fixed swirler (15) at the outlet side of said primary air duct (11), **characterized in that** said means for creating vorticity in the combus-

tion air further comprise an axially movable swirler (22) arranged axially at the inlet of the air in said secondary air duct for generating a vorticity which is a function of its position with respect to said inlet and in that said dampers (13, 20) are axially sliding.

2. The burner according to claim 1, wherein a radial flow divider (16) is provided at the outlet side of said primary air duct (11) for dividing said swirler in two concentric annuli, the ratio between the cross sections of the inner annulus to the outer annulus being comprised between 1:2 and 1:3.
3. The burner according to claim 2, wherein said primary swirler (15) is formed by blades (15a) having constant inclination.
4. The burner according to claim 2, wherein said primary swirler (15) is formed by blades having different inclination for each annulus, said flow divider (16) having a frusto-conical shape with diameter of the lower section equal to the diameter of said inner annulus.
5. The burner according to claim 2, wherein said primary swirler (15) is formed by blades (15a) having a continuously radially variable inclination.
6. The burner according to the previous claims, wherein a second radial flow divider (25) is provided at the outlet side between the primary air duct (11) and the secondary air duct (17).
7. The burner according to the previous claims, wherein a venturi (24) is provided at the outlet section of said secondary air duct (17).
8. The burner according to the previous claims, wherein said primary air duct (11) and secondary air duct (17) are formed with respective radial windows (12, 19) through which the combustion air flows, a respective cylindrical damper (13, 20) being provided in correspondence to the windows of each duct for the flowrate partitioning.

Patentansprüche

1. Niedrig-NO_x-Brenner für flüssige und gasförmige Brennstoffe, enthaltend eine Primärluftleitung (11) und eine Sekundärluftleitung (17) koaxial zur Primärluftleitung zum Zuführen eines Primärluftstroms (A1) bzw. eines Sekundärluftstroms (A2) zu Verbrennung, Einrichtungen (6, 9) zum Zuführen der Brennstoffe zur Verbrennung, verlaufend längs oder parallel zur Längsachse (X-X) der Primärluftleitung (11), Steuereinrichtungen für die Verbrennungsluft, enthaltend Dämpfer (13, 20) auf der Ein-

laßseite der Primär- und Sekundärluftleitungen (11, 17), Einrichtungen zum Erzeugen einer Verwirbelung in der Verbrennungsluft, enthaltend einen fixierten Drallkörper (15) an der Auslaßseite der Primärluftleitung (11), **dadurch gekennzeichnet, daß** die Einrichtungen zum Erzeugen einer Verwirbelung in der Verbrennungsluft ferner enthalten einen axial beweglichen Drallkörper (22), der axial an dem Einlaß der Luft in der Sekundärluftleitung angeordnet ist zum Erzeugen einer Verwirbelung, die eine Funktion seiner Position bezüglich des Einlasses ist, und daß die Dämpfer (13, 20) axial beweglich sind.

2. Brenner nach Anspruch 1, wobei ein Radialströmungsteiler (16) vorgesehen ist an der Auslaßseite der Primärluftleitung (11) zum Teilen des Drallkörpers in zwei konzentrische Ringe, wobei das Verhältnis zwischen den Querschnitten des Innenrings zum Außenring enthalten ist zwischen 1:2 und 1:3.
3. Brenner nach Anspruch 2, wobei der Primärdrallkörper (15) durch Blätter (15a) gebildet ist, die eine konstante Neigung haben.
4. Brenner nach Anspruch 2, wobei der Primärdrallkörper (15) durch Blätter gebildet ist, die für jeden Ring verschiedene Neigungen haben, welcher Strömungsteiler (16) eine kegelstumpfförmige Form mit einem Durchmesser des unteren Querschnittes gleich dem Durchmesser des Innenrings hat.
5. Brenner nach Anspruch 2, wobei der Primärdrallkörper (15) durch Blätter (15a) gebildet ist, die eine kontinuierlich radial variable Neigung haben.
6. Brenner nach den vorhergehenden Ansprüchen, wobei ein zweiter Radialströmungsteiler (25) auf der Auslaßseite zwischen der Primärluftleitung (11) und der Sekundärluftleitung (17) vorgesehen ist.
7. Brenner nach den vorhergehenden Ansprüchen, wobei ein Drosselkegel (24) am Auslaßquerschnitt der Sekundärluftleitung (17) vorgesehen ist.
8. Brenner nach den vorhergehenden Ansprüchen, wobei die Primärluftleitung (11) und die Sekundärluftleitung (17) mit jeweiligen radialen Fenstern (12, 19) ausgebildet sind, durch welche die Verbrennungsluft strömt, wobei ein jeweiliger zylindrischer Dämpfer (13, 20) entsprechend den Fenstern jeder Leitung für die Strömungsratenpartitionierung vorgesehen ist.

Revendications

1. Brûleur à faible taux de NO_x pour combustibles liquides et gazeux, comprenant un conduit d'air primaire (11) et un conduit d'air secondaire (17) coaxial au dit conduit d'air primaire pour fournir un flux d'air primaire (A1) et, respectivement, un flux d'air secondaire (A2) pour la combustion, des moyens (6, 9) pour approvisionner en dits combustibles pour leur combustion s'étendant le long de ou parallèlement à l'axe longitudinal (X-X) du dit conduit d'air primaire (11), des moyens de contrôle de l'air de combustion comprenant des soupapes de réglage (13, 20) à l'entrée des dits conduits d'air primaire et secondaire (11, 17), des moyens pour créer un mouvement tourbillonnaire dans l'air de combustion comprenant un générateur de tourbillon (15) fixé à la sortie du conduit d'air primaire (11), **caractérisé en ce que** lesdits moyens pour créer le mouvement tourbillonnaire dans l'air de combustion comprennent en outre un générateur de tourbillon (22) mobile agencé axialement à l'entrée de l'air dans ledit conduit d'air secondaire pour créer un tourbillon qui est une fonction de sa position par rapport à ladite entrée, et **en ce que** lesdites soupapes de réglage (13, 20) sont montées axialement coulissantes.

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2. Brûleur selon la revendication 1, dans lequel un diviseur de flux (16) radial est prévu à la sortie du dit conduit d'air primaire (11) pour diviser le générateur de tourbillon en deux zones annulaires concentriques, le rapport entre la section transversale de la zone annulaire intérieure et celle de la zone annulaire extérieure étant compris entre 1/2 et 1/3.

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3. Brûleur selon la revendication 2, dans lequel ledit générateur de tourbillon primaire (15) est constitué d'ailettes (15a) ayant une inclinaison constante.

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4. Brûleur selon la revendication 2, dans lequel ledit générateur de tourbillon primaire (15) est constitué d'ailettes ayant une inclinaison différente pour chaque zone annulaire, ledit diviseur de flux (16) ayant une forme tronconique dont le diamètre de plus faible section est égal au diamètre de la zone annulaire intérieure.

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5. Brûleur selon la revendication 2, dans lequel ledit générateur de tourbillon primaire (15) est constitué d'ailettes (15a) ayant une inclinaison variable radialement de façon continue.

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6. Brûleur selon les revendications précédentes, dans lequel un second diviseur de flux radial (25) est prévu à la sortie entre le conduit d'air primaire (11) et le conduit d'air secondaire (17).

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7. Brûleur selon les revendications précédentes, dans lequel un venturi (24) est prévu à la section de sortie du dit conduit d'air secondaire (17).

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8. Brûleur selon les revendications précédentes, dans lequel lesdits conduits d'air primaire (11) et d'air secondaire (17) sont respectivement formés d'ouvertures radiales (12, 19) à travers lesquelles s'écoule les flux d'air de combustion, une soupape de réglage cylindrique (13, 20) étant respectivement agencée en correspondance avec les ouvertures de chaque conduit pour ajuster le taux de flux.

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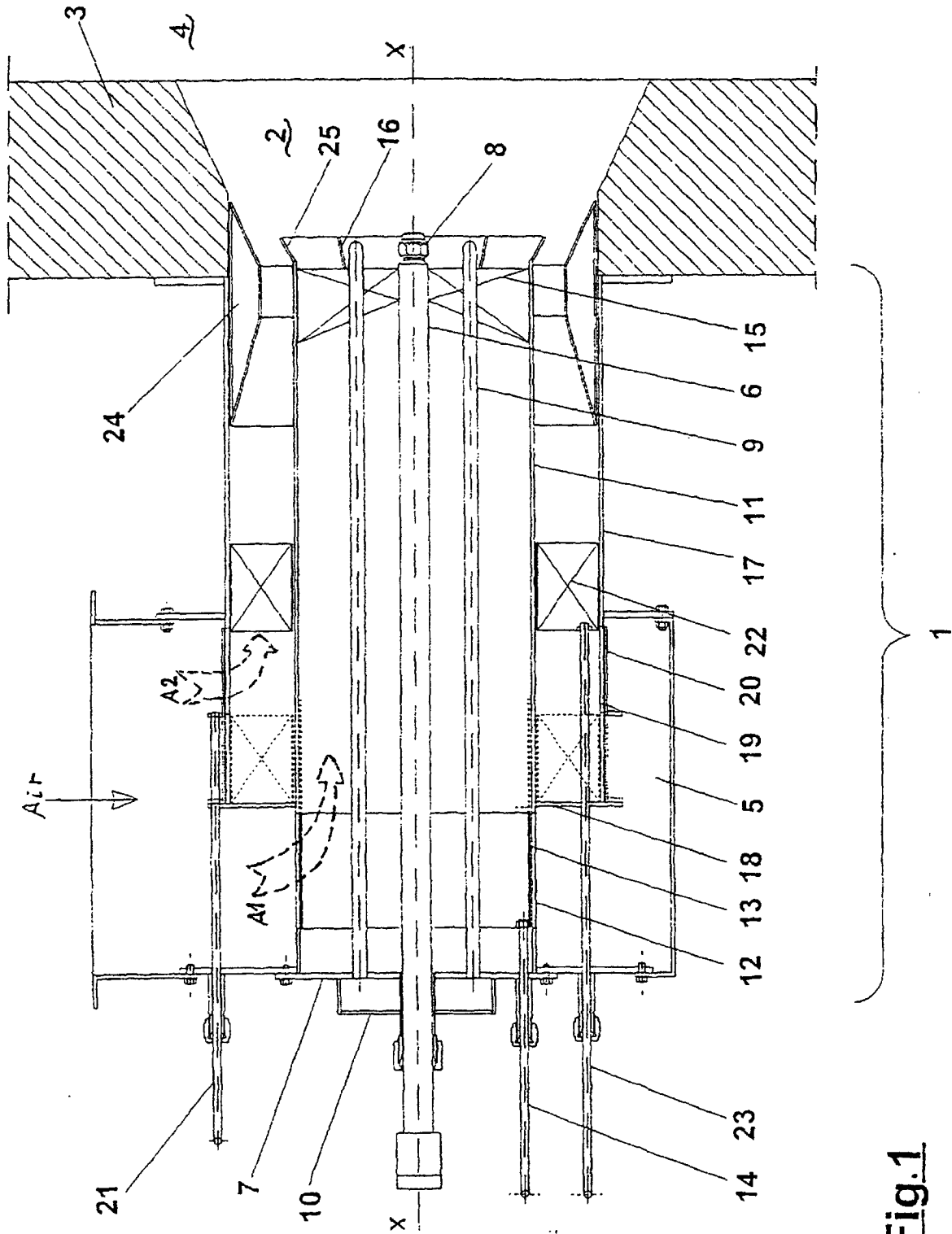
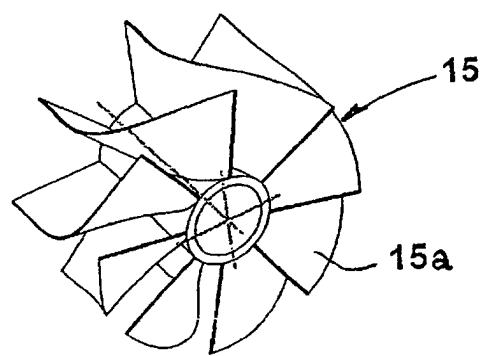
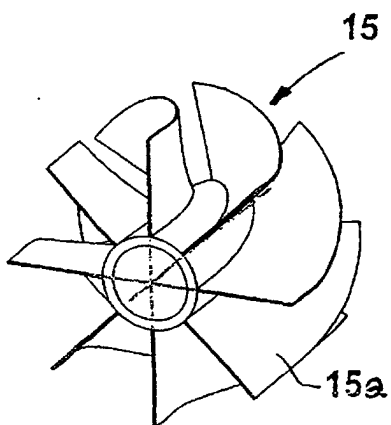
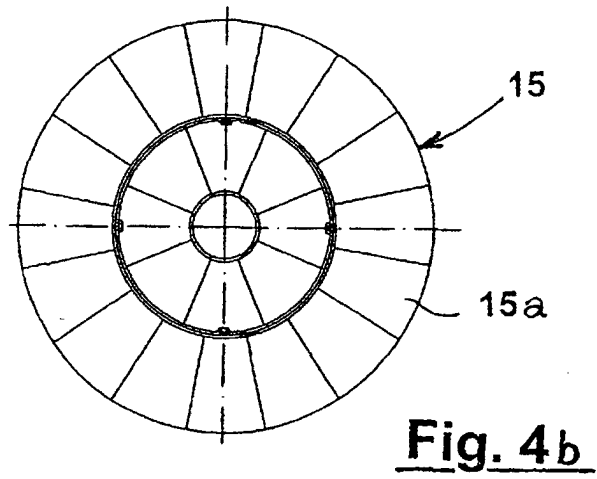
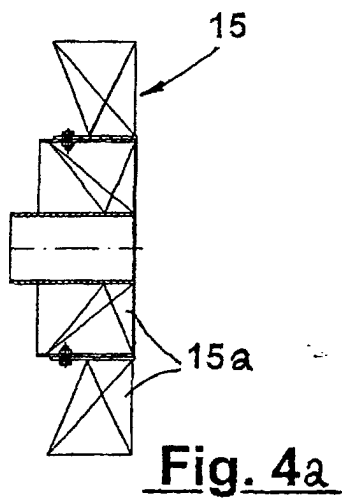
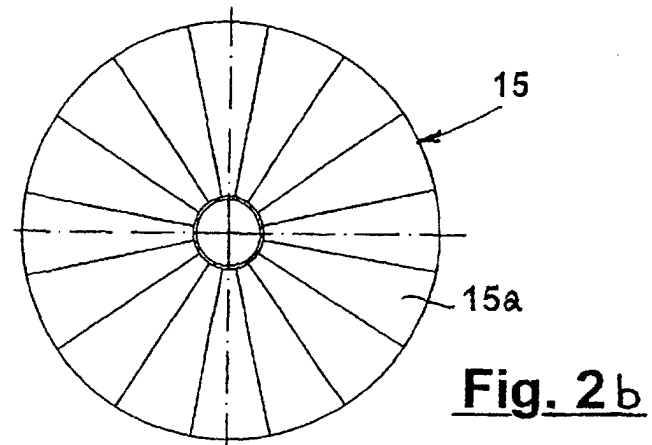
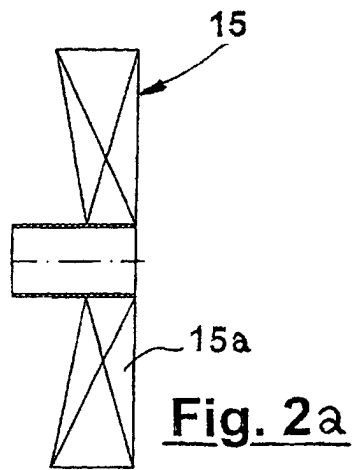


Fig.1



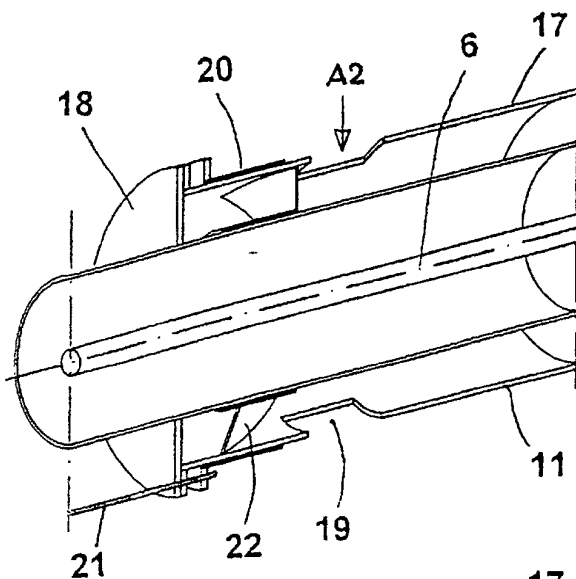


Fig. 5a

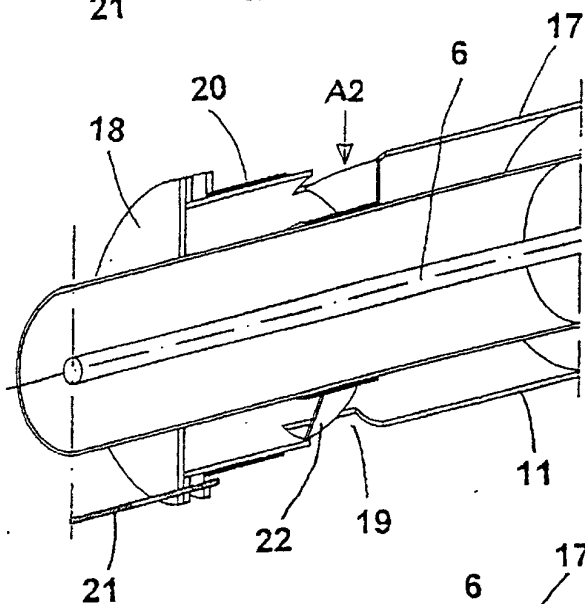


Fig. 5b

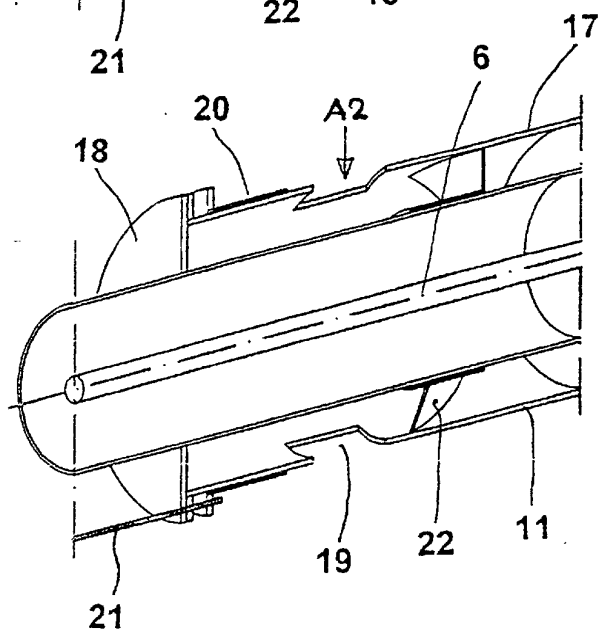


Fig. 5c