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(54) **ANCHORAGE OF LAMINAR FLAME OF FUEL-GAS**

VERANKERUNG EINER LAMINAREN GASFLAMME

ANCRAGE D'UNE FALMME LAMINAIRE DE COMBUSTIBLE GAZEUX

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## Description

FIELD OF THE INVENTION

**[0001]** The present invention relates to gaseous fuel combustion systems with either natural or forced draft, in particular to a method and apparatuses in accomplishment of same, for controlling the outflow of the air-gas mixture through the flame openings of burners, totally or partially premixed, in order to obtain: a stable flame, detached from the flame openings area, low emissions, in the most wide field of burner capacity modulation required in practice, even in feeding conditions with test gases foreseen from Standards for extreme conditions of use, in a so simple and practical way to be used also for apparatus with capacity of only few kW.

**[0002]** The gas combustion system is the assembly of the burner, with the combustion chamber, the heat exchanger, the means for the circulation of air and exhausts, if existing, as well as the control apparatus with its sensors; more elements of the assembly can form a sole body therefore a distinction is only possible considering the function of each element.

**[0003]** The gas combustion systems are the main functional assembly of domestic and industrial appliances as central heating boilers, water heaters, of two main types: instantaneous and storage water heater, room heater and furnaces, gas cookers etc.

**[0004]** For burner it is understood the functional assembly of parts which create the mixture of air (primary air) and fuel-gas (hereafter simply said mixture), making possible the flowing out of them in the combustion chamber through the flame openings.

**[0005]** The invention applies in particular to fuel-gas combustion systems, where:

- the mixture formed in the burner is from almost stoichiometric to strongly hyperstoichiometric ($0.95 < \lambda < 1.6$), $\lambda$ is the ratio between air actually present in the mixture and the air existing in the stoichiometric mixture of the same gas in the same conditions,
- the mixture flow in combustion chamber, out from the flame openings of the burners with substantially laminar flow, being the out flow velocity between 0.4 and 4.0 meter per second, velocity fairly higher to the flame speed,
- in the combustion chamber the mixture is ignited, at least initially, by suitable ignition devices,
- a laminar to wrinkled flame is generated, substantially detached from the area occupied by the flame openings, kept in stability conditions from a sort of anchorage system, acting at least in some points,
- said flame having big surface and minimum thickness, ratio surface-thickness is well over a value of ten, where the thickness magnitude order is a millimetre,
- the flame front, that is the surface where the combustion starts, coincides with the flame itself being the combustion monostadium for the presence of all the necessary oxygen since the ignition ,
- the premixed burner may be forced, where the air gas mixture is obtained, in the wanted flow and composition, with the help of auxiliary means (for example fans, or compressors), or atmospheric,
- both types of burners operate either with the presence of secondary air (called partially pre-mixed burners) or with only primary air (called totally premixed burners).

**[0006]** Slots obtained in sheet metal of thin thickness, so close to create an almost homogeneous sole jet of mixture, are considered as a single flame opening.

**[0007]** The front of flame is recognisable because it emits in the visible, even if the specific maximum emission, due to OH and CH ions, is respectively in the wavelength between 305 and 320 mm and around 431.5 and 438 mm.

BACKGROUND OF THE INVENTION

**[0008]** The apparatuses of the kind disclosed in the preamble of the claims arise when the burner capacity is modulating down therefore the mixture exit velocity reduce or when instead of the standard fuel-gas for which the apparatus is set, a fuel-gas from the same family as said standard fuel-gas but prone on flame blow-off or prone to flash back are fed. Specifically, the burner flame openings surface may attain critical temperature value, and in some other occasion, the flame may become unstable, resulting in poor combustion of fuel-gas. Generally said, the flame openings surface, which reach temperature up to 500°C, must be of costly materials and moreover the thermal stress reduces the possibility of flame openings design.

**[0009]** In 1979 Kawamura T. carried on experimental studies on a lamellar flame substantially detached from the area occupied by the flame openings using a burner designed for laboratory purpose, operating in free air, the outflow was forced through two parallel long slots punched in sheet metal.

**[0010]** The WO-A-8 901 116, of the same inventor, claims the following method: in an atmospheric burner, A) inside the burner it is sucked a quantity of primary air which is at least 80% of the air stoichiometrically necessary to the combustion; B) the secondary air, from the very first combustion steps, laps all sides of every single bladed small flame exiting from each group of slots foreseen on the burner diffuser, in such a way that the total air involved exceeds the stoichiometrical air value; C) the combustion starts and is completed within the bladed thickness of the flame,

**[0011]** The burners considered are only atmospheric, the only foreseen burner diffuser is in sheet metal with thickness of around 0.5 mm., the group of slots is defined "each group of slots being appropriately subdivided longitudinally into two subgroups of slots lying not so close together" to anchor the flame on the unpunched surface between subgroups of slots.

**[0012]** The PCT/IT 91/00056, perfecting the previous one, considers also the forced burners and the fully premixed burners with no need of secondary air, but it expects the sole use of sheet metal diffuser and of the sole anchorage of the flame on the flame openings surface.

**[0013]** The anchorage zone reaches high temperatures particularly in limit conditions, moreover the thermal stress, caused from temperature differences of 200-300°C in few millimetres, forces the use of costly materials and constrains special shape and arrangement of the slots which limits the specific capacity of said burner. Furthermore because the exit velocity is limited by the inefficacy of the flame anchorage, the specific capacity of the burner itself is again limited. The difficulty of the anchorage of this type of flame imposes also the introduction of more or less expensive regulation systems as per EP0606527A1 deposited on 16 August 1993. In other hyperstoichiometric burners the very low exit velocity of the mixture generates the flame in the proximity of the flame openings surface therefore such surface is water cooled to maintain temperature compatible with not too expensive materials, but the water cooling system doubles the cost of the burner and the absence of flame anchorage leaves the possibility of unstable conditions.

**[0014]** The PCT/GB 90/01485 Cafferty filed by BRAY BURNERS LIMITED considers a burner with a maximum primary aeration $\lambda$=0.7, "...enabling the issuance from the body of a curtain of said air-gas mixture, wall means adjacent the aperture means arranged so as to lie substantially parallel thereto and adjacent one side therefore...» the invention doesn't consider the hyperstoichiometric mixture with consequent flame of large surface and minimum thickness, doesn't consider the fluids dynamic obstacle immersed on the mixture flow and completely detached and down stream from the flame opening/s. Said invention doesn't solve the problems described previously particularly the difficulty to maintain the flame stable and the level (50 ppm) of emissions reached, originated by the inadequate premixture, which is not acceptable.

**[0015]** WO-A-9736135 (prior art under Article 54(3) EPC) describes and claims a method and apparatuses for the fulfilment of the same to maintain the flame, around an optimum position, regulating at least one of the three variable quantities of the mixture exiting the flame port/s: the value of the premixture rate $\lambda$, the outflow velocity, the temperature upstream the flame front. To obtain such results WO-A-9736135 uses modification of the fan speed, of the flame openings cross section and heat elements. Fluids dynamic obstacles are foreseen to create downstream a stagnation zone, anchorage of the flame, but not formed and positioned in a way to create downstream divergent fluids threads. The dilution of the mixture downstream the flame openings to locally reduce the flame speed is not foreseen

## DISCLOSURE OF INVENTION

**[0016]** The aim of this invention is to provide a method and apparatuses in fulfilment of same, to eliminate the aforesaid difficulties, to make possible the proper combustion in very compact combustion systems, even formed by a sole body, to reduce the emission to a very minimum, to maintain the temperature of the flame opening/s surface low to allow the use of steel, aluminium, and other inexpensive materials, all previously described goals must be achieved in all operating conditions caused by the capacity modulation or/and the use of limit gases. The feasibility must be so simple, to be used also for combustion systems of capacity of only few hundred watt.

**[0017]** This aim is reached by applying the method so that, in a gaseous fuel combustion system with either natural or forced draft, a premixed, atmospheric or forced burner form the fuel-gas air mixture, from almost stoichiometric to strongly hyperstoichiometric, which flows in combustion chamber from at least one flame opening with velocity, distribution such as to obtain a substantially laminar flow and velocity over 0.4 m/sec. An almost homogeneous single jet of mixture exits from each flame opening, whereby, immediately downstream of said opening, the gaseous content of the volume surrounding the jet is sucked into said jet and mixed therewith. The jet velocity is, in all operating conditions, higher than the combustion velocity of the mixture in said condition, at least for a distance equal to that of at least one fluids dynamic obstacle which is immersed in said jet, down stream the flame opening/s. Said obstacle is always completely detached from said flame opening/s, having such shape and dimensions to create down stream a stagnation zone, anchorage of the flame in all operating conditions, the distance of the down-stream side being at least big as the width of the at least one flame opening. The flow field, down stream and on the side of the obstacle, is almost laminar with progressively divergent fluids threads, to obtain a flame at the beginning ignited from a specific device, from laminar to wrinkled, characterised by a large surface and very low thickness anchored to the obstacle at least in some points by vortexes related to the stagnation zone, said flame doesn't touch at all the flame openings surface.

**[0018]** If the flame openings on the burner head are distributed close each other and disposed on a surface in an homogeneous way, the jets flowing out from different openings, join together after few to some ten mm. remaining the jet velocity over the combustion velocity at the given conditions of mixture and temperature; in this case mainly recycled mixture, is sucked into said jet/s just down stream the flame openings and the fluids dynamic obstacles, no longer related with the shape and arrangement of flame openings, may form a mesh net or, for instance, an assembly of parallel rods having centreline up to perpendicular to the axes of elongated flame openings.

**[0019]** If the flame openings are homogeneously distributed over a surface but spaced each other, the jets flowing out from different openings don't join together before the jet velocity becomes equal to the combustion velocity at the given conditions of mixture and temperature; in this case and in case of single mixture jet expressly supplied secondary air, pure or mixed with recycled mixture, is sucked into said jet/s just down stream the flame opening increasing locally the $\lambda$ of the mixture up to 30% and the fluids dynamic obstacle must closely follow the shape of the related opening.

**[0020]** In case of spaced flame openings, following the previously described criteria the body/s forming the obstacle need to have the centreline of the assembly or of the body in the centre, or slightly out of the centre (for instance when near the side walls of the combustion chamber) of the mixture jet in the observed point. The distance obstacle opening and its shape may vary along the opening length to follow flow-rate changes along said opening or to obtain particular flame shapes to comply with the heat exchanger. The position of said obstacles follow the flame openings surface.

**[0021]** It is possible to define the position of the flame as the distance between the barycentre of the flame front and the surface of at least one flame opening which generates this front, hereafter said quantity will be called flame distance.

**[0022]** If the temperature, the aeration ratio $\lambda$, of the mixture remain stable but flow-rate decreases (the exit velocity decreases), the flame distance decreases and vice-versa if the flow rate increases.

**[0023]** The flame distance optimum value can generally be predetermined arbitrary constant, but can have different values according to the fuel-gas flow rate; in any case, during the on periods on the combustion system, the instantaneous ratio, which is the detected flame distance/optimum flame distance, have the value -1- for the reached conditions considered as optimum, values over 1 show the tendency to the flame blow-off increasing as the ratio increases, values under 1 show the tendency to overheat the burner head (means the flame openings zone) increasing as the ratio decreases.

**[0024]** The instantaneous ratio: detected flame distance/optimum flame distance, will be hereafter called flame ratio.

**[0025]** To maintain the flame ratio near the optimum in all the operating conditions, the modification on the flame distance will cause a change of the cross section of the obstacle changing the flow conditions on the side of said obstacle and therefore shape of the flame, for example: bimetal or sealed bulbs filled with expansible fluid can be used.

**[0026]** Following the teaching of the Patent demand MI/96/A00058 of 23-03-96 of the same inventor, the outflow cross-section of the flame opening/s is varied according to the flame ratio, between a minimum and a maximum cross-section, causing a flame ratio > 1 an outflow section increase and vice versa, so as to maintain the flame ratio around a pre-fixed value, except for a different regulation during the transient periods, for example of starting, when needed.

**[0027]** By adopting the flame ratio, or any variable quantity which follows the same variation law, as control-parameter for the variation of the outflow cross-section of the flame opening/s, it is possible to reduce at the minimum the variation of the outflow velocity at the change of the burner capacity by maintaining the flame stable and low emissions.

**[0028]** For instance, the distance of a V shaped obstacle can be varied in such a way that the vertex of the V would enter the flame opening reducing the open surface.

**[0029]** By using any variant of the described method, the temperature of the mixture outflow zone of the burner head remains within acceptable limits (even below 200 °C), at any capacity condition of the burner, type of feeding gas, temperature of the inlet air; the flame remain stable; the harmful emissions are reduced to minima values.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0030]** In order to better understand the invention, its characteristic and the advantages it provides, few embodiments thereof are described hereinafter, by way of non limitative example and with the assistance of the appended drawings, in which

- Table 1/5 fig. 1 shows a combustion system with totally premixed forced burner, with the air-gas regulation and external obstacles with triangle cross section, fig. 2 shows a combustion system with totally premixed atmospheric burner, forced draft and external obstacles with V shaped cross section.
- Table 2/5 fig. 3 shows a combustion system with partially premixed atmospheric burner , natural draft, spaced flame openings with bimetallic V shaped external obstacles, fig. 4 shows a combustion system under natural draft, with partially premixed atmospheric burner, with flame openings very close together, totally covering the burner head, the obstacle is a mesh net
- Table 3/5 fig. 5 shows a burner of the tubular type in longitudinal view with a single flame opening, with variation of the outflow cross section according to the temperature of the exit area of the flame openings fig. 6 shows a vertical cross section of the burner of fig. 5, fig. 7 shows a burner similar to that of fig. 5, fig. 8 and fig. 9 show two cross sections of the tubular burner of fig. 6 in different operating conditions.
- Table 4/5 fig. 10, 11, 12, 13, 14, 15, 16 and 17 show different flame openings and their dispositions and correlation to external fluids dynamic obstacles.

- Table 5/5 fig. 15 shows a combustion system with atmospheric burner, forced draft, outflow velocity variation according to the flame ratio and/or according to the fuel gas flow rate; fig.18 is a front view, fig.19 a side view, fig. 20 a cross section of a flame opening.

DETAILED DESCRIPTION OF THE INVENTION

**[0031]** FIG. 1 shows, in vertical cross section, a combustion system 1 with a heat exchanger 2, a combustion chamber 3, a fan 4 for the air gas and exhausts circulation, put upstream the combustion chamber for which this is in over pressure compared to the outside of shell 5 representing the body of the combustion system, which, in this case, is a water cooled aluminium casting, whose inferior part forms the burner head 6 and the burner body 8, inside which a distributor 8C is installed; flame openings 7B obtained from the aluminium casting have lips, are lengthened, perpendicularly to the drawing surface. On the centre axe of the jet out flowing from said openings 7B, inside the combustion chamber 3, at a distance, from the flame openings surface, which can reach ten times the width of said openings, according to the exit velocity, coplanar with the jet flowing out, are disposed fluids dynamic obstacles 12A, made on small ceramic bars, with isosceles triangle cross section, having sharpest edge upstream and a side perpendicular to the jet axe downstream; the width of the obstacles cross section is of the same magnitude of the width of the openings, in this case between 2 and 4 mm., the height of the lips of the openings can vary between 7 and 20 mm., in the length the openings are interrupted every 25-50 mm.

**[0032]** The lamellar flame 19, ignited by a device not in the figure, generates and remains firmly anchored to triangle section obstacles 12A, downstream of the flame openings 7B, becoming alike a flying carpet, wave shaped because the openings are each other spaced so to create separate jets flowing out joining together only after the combustion for the expansion due to the reached temperature; a certain amount of exhaust gases is recycled from the doubled vortex formed between two flame openings and sucked inside the mixture jet just down stream the openings edges.

**[0033]** The process controller 15 according to the signals transmitted by the ionisation current sensor 14A operates the fuel gas valve 11 and the fan 4 speed.

**[0034]** FIG. 2 shows, in vertical cross section a combustion system operating in forced draft with the fan 4 mounted downstream the heat exchanger 2 so the inside of the shell 5 is in depression compared to the outside. The burner, the body 8 of which is the bottom part of the shell 5, is a fully premixed atmospheric one, the air-fuel gas mixture is obtained in a Venturi type tube 10 from the fuel gas exiting the injector 23 and the air from outside the shell 5 entering the mouth 9. Under the vacuum created by the fan in the combustion chamber 3 with respect to the region outside the shell 5 the mixture is drawn through the Venturi 10 and the mixing chamber to the flame openings 7A, better described in fig. 15, 16, obtained on the sheet metal, for example, of 0.4-0.6 mm thickness, of the burner head 6.

**[0035]** The flame openings 7A, each made of a row of slots, where the slots are 0.5 to 0.75 mm. width and 5 to 15 mm. long, parallel to each other on the long side with centre distance between 0.9 and 1.5 mm., rows are spaced centre to centre from 15 to 60 mm to obtain a flying carpet type lamellar flame 19 anchored to external obstacles 12B, made on stainless steel sheet metal, visible in V shaped cross section with upstream vertex and centreline of the V, perpendicular to the surface and in centre of the flame openings, parallel to the rows and distant to the slot surface from few to some ten mm according to the exit velocity of the mixture, V shaped obstacles of this type are better described in fig 7, 8, 9. The distance among flame openings and shape and position of the obstacles don't permit any recycling of exhaust gases, therefore the jets down stream the burner head surface suck only recycled air gas mixture.

**[0036]** The lamellar flame covers the plan of the combustion chamber 3, lying at level of the optical sensor 14B. The process controller, not shown, varies the gas flow through the valve 11, according to the heat request.

**[0037]** The optical device 14B, based on photo sensor/s, transmits a signal corresponding to the detected position of the flame to the process controller, not shown, which compares said position to a pre-fixed one (flame ratio), in order to change the fan speed.

**[0038]** FIG. 3 shows a natural draft combustion system 1, which employs a partially premixed atmospheric burner with body 8A of the extractable type; the secondary air is introduced from the inlet openings 18 on the shell 5. Flame openings 7A are formed of rows (perpendicularly lengthened to the drawing) of slots as in fig.2, 15, 16, punched on burner head 6; The external fluids dynamic obstacles have a V shaped cross section, as in fig.2, but made from bimetallic sheets cut and bent as described in fig.15, 16, 17. Being the centre distance among exits 7A big, the flame, ignited by a device not seen, divides itself in long separate V shaped lamellar flames 19A (perpendicularly lengthened to the drawing), at the same time the secondary air, introduced through the apertures 18, is sucked from the mixture jets just down stream the flame opening increasing the $\lambda$ of the mixture up to 30%.

**[0039]** At the same time, the external bimetallic sheet V shaped obstacle, according to the temperature reached changes their cross section, therefore changing the outflow velocity field so to favour the stability. For higher temperatures (continuous line) smaller cross section, the contrary (dashed line) for lower temperatures.

**[0040]** The ignition is obtained from the heat element 14 and the flame presence is controlled by a thermocouple not shown.

**[0041]** FIG.4 show a natural draft combustion system with partially premixed atmospheric burner, without any specific process control. The burner head 6 is of perforated sheet metal having the circular holes diameter from 2 to 5 mm. and lips from 1.5 to 7 mm. high.as better described in fig. 10, 11, uniformly positioned on the burner head as in fig. 11, so spaced each other to obtain a ratio open/total surface between 0.2 and 0.5 as to form a single substantially homogeneous mixture jet and to build a carpet shaped lamellar flame 19 anchored to a mesh net fluids dynamic obstacle 13 B, been the net made of wires of high nickel steel, regularly distributed to cover more/over the complete flame openings surface. Through calibrated passages 18 the outside and the inside of the shell 5 are in pressure balance, secondary air inlets only at the maximum capacity, at the ignition some air goes out. The presence of flame is detected from a combined device 14 A, which is an ionisation current sensor also capable to cause the spark ignition.

**[0042]** FIG. 5 shows an atmospheric burner with tubular body 8A with a sole flame opening 7B between two lips, with an external fluids dynamics obstacle having a triangle cross section positioned with the central line on centreplane of the burner at a distance from the flame opening edges up to 10 times the width of said flame opening with a cross dimension of the same magnitude of said width, anchoring the large V shaped flame. The fluid dynamics obstacle, of triangle section ceramic rod, is supported (the support is not shown) on the extremities leaving the possibility of expansion.

**[0043]** FIG. 6 shows the atmospheric burner of fig. 5 in vertical cross section to better understand the reciprocal dimension and position of the flame opening in this particular case.

**[0044]** FIG. 7 shows a tubular atmospheric burner with the body 8A forming a sole flame opening 7B with two mobile lips 7B2, which define the outflow cross section of it, moved by the deformation (temperature function of the flame opening edges) of two bimetallic sensors-actuators 17. The lips 7B2-a position full line drawn and 7B2-b the dashed drawn one correspond to two different conditions of the flame opening temperature obviously higher the one corresponding to the dashed line, the same for the position 17-a and 17-b of the bimetallic arches; the cross section of the burner body 8A is similar to that of fig.5 but the external obstacle have a V shaped cross section 12B.

**[0045]** FIG. 8 and 9, show the vertical cross sections of the tubular burner of fig. 7 in the two different operating conditions, shown with dashed and continuos lines for the same conditions represented there in the same way.

**[0046]** FIG. 10 shows, on plan view from the top, round holes having an external lip around, punched on sheet metal, arranged in groups of three holes in line, the groups parallel and so near to each other, forming a row which is one flame opening 7C, in fact the mixture exiting from all the slots of a row form a sole jet, the three rows shown have centre distance as in fig. 3 to obtain separate V shaped flames; dimensions of the holes are as defined in fig. 4. The projection of external trilobated elongated obstacles 12D are shown with dashed lines.

**[0047]** FIG. 11 shows, on plan view from the top, round holes having an external lip around, punched on sheet metal as those shown in fig.10 disposed regularly and close together, with a ratio open /total surface around 30%, jets flowing out from the flame openings are separate and join together around the level of the trilobated obstacles 12D, but because in this case the centre distance of said external fluids dynamic obstacles (projection is shown in dashed line), is big enough, a flame shaped alike a wave flying carpet is obtained, similar to that of fig. 1 obtained with a different lay out of flame openings and obstacles.

**[0048]** This fact demonstrate that when jets of air-gas mixture exiting from different flame openings join together before the external obstacle and maintain, there, a velocity higher than the combustion velocity for that mixture in that condition, the shape and position can be independent from that of the flame openings; the obstacles my assume various forms, parallel elongated rods, trilobe shaped 12D as here, V shaped 12B, triangular 12A, also round, nets of different construction and design as the mesh net 13B of fig. 4 and the laid on small rods 13C of fig. 14.

**[0049]** FIG.12 shows the vertical section of two aligned elongated openings so close together that a sole obstacle (12C), in this case a bimetallic V shaped one, the vertex is near the flame openings surface. Any variation of the form and or position of the flame cause a change of the cross section obstacle such to tend to re-establish the previous conditions, particularly at any increase of the flame distance causes an increase of the transversal dimension of the obstacle (12C) cross section, the opposite for a reduction. Also the flame and the wall design is visible.

**[0050]** FIG. 13 shows an enlarged plan view of the burner head in a first level where are visible slots parallel each other combined in groups of three and four, these said groups (the flame openings) been distributed in a check pattern to obtain a flying carpet shape lamellar flame 19 in the second level the external obstacle is visible formed of a net 13C made of parallel ceramic rods in one direction and wires perpendicularly, regularly covering the combustion chamber plan.

**[0051]** FIG. 14 shows the vertical section corresponding with the application of fig. 13 where the reciprocal position of openings, obstacle and flame are visible.

**[0052]** FIG. 15 shows the vertical section C-C of fig. 16 where the reciprocal position of openings, obstacle and flame are visible. In this case the composition of the gaseous content from the volume surrounding the jet sucked, immediately down stream the flame opening, inside said jet, is a mixture of secondary air and recycled exhaust gases in different ratio following different operating conditions.

**[0053]** FIG. 16 is a top view in two levels, of a part of the burner's head 6 of fig.3, two flame openings are represented, made of a row each of parallel slots having width from 0.5 to 0.75 and length from 5 to 15 mm. adjacent on the long side, spaced centre to centre from 0.9 to 1.5 mm., the external bimetallic obstacle 12C V shaped is visible on the left side on the second level.

**[0054]** FIG. 17 show the plan view of part of a sheet metal rectangle with alternate parallel cuts which bent would form the V shaped obstacle of fig.3, 12, 15, 16, the cuts are foreseen to prevent arc formed bending of the obstacle caused by the temperature distribution during the heating periods of the combustion system, if the sides of the V are longer than some mm. and the total length of the obstacle more than about 100 mm.

**[0055]** FIG.18 shows a forced draft combustion system, the burner, the body 8A of which is bottom part of the shell 5, the air-fuel gas mixture is obtained in a Venturi type tube 10 from the fuel gas exiting the injector 23 and the air from outside the shell 5 entering the mouth 9.

**[0056]** An optical device 14B is used to detect the flame ratio as to permit to the controller 15 the variation of the outflow velocity of the mixture according to said flame ratio using a step by step motor 25 moving up and down the obstacles 13A through an eccentric 28 as better described in fig 19 and 20. The flame openings 7B, lips formed, are lengthened, perpendicularly to the drawing surface; on the centre axe of the jet out flowing from said openings 7B, inside the combustion chamber 3, at a variable distance, from the flame openings surface, parallel to the openings, are disposed (displaced) fluids dynamic obstacles, V shaped made of stainless steel sheet metal 12Aa, supported each by a ceramic rod 12Ab,; the openings and the obstacles have the same length. The lamellar flame 19, ignited by a device not in the figure, generates and remains firmly anchored to obstacles 12B, downstream of the flame openings 7B becoming alike a wave shaped flying carpet because the openings are each other spaced about five times the openings width. No recirculation of exhaust gases is foreseen because the openings are too close to each other.

**[0057]** FIG. 19 shows the vertical section A-A of fig. 18, looks clear how the eccentric 28 moved by the motor 25 can push down the obstacles 12A against the springs 30 actuating the desired changes of the cross section of the flame openings 7B visible in fig. 18 and 20.

**[0058]** FIG. 20 shows a vertical section of lips formed flame opening 7B with movable obstacle 12B which modify the outflow cross-section of the flame opening and therefore the outflow velocity, according to the flame ratio, between a minimum and a maximum cross-section, causing a flame ratio > 1 an outflow section increase and vice versa, so as to maintain the flame 19A distance around a pre-fixed value, except for a different regulation during the transient periods, for example of starting, when needed. Two position of the obstacle and that correlate of the flame, are shown, with dashed line 12B-a the one for smaller outflow cross-section continuos line 12B-b those for higher.

## Claims

**1.** A method of combustion, in a gaseous fuel combustion system with either natural or forced draft with the following steps;

a- a premixed, atmospheric or forced burner forms a fuel-gas air mixture, from almost stoichiometric to strongly hyperstoichiometric,
b- the mixture flows, in to the combustion chamber, from at least one flame opening with velocity distribution such as to obtain a substantially laminar flow
c- an almost homogeneous single jet of mixture exits from each flame opening and immediately down-stream of said opening, the gaseous content, of the volume surrounding the jet is sucked into said jet and mixed therewith,
d- at least one fluids dynamic obstacle is immersed in the jet flowing out, down-stream at least one flame opening, is detached from said opening, in a position where the fuel-gas air mixture velocity in any point of the jet, is greater, at any operating condition, than the combustion velocity,
f- a stagnation zone is created, caused from the shape and dimensions of the obstacle, downstream this fluids dynamic obstacle,
g- a flow field almost laminar is generated with fluid threads progressively divergent on the side of the fluids dynamic obstacle
h- a laminar to wrinkled flame, which is at the beginning ignited by a specific device, is generated and anchored in all operating conditions, at least in some points, by the vortexes related to the stagnation zone; whereby

- the velocity of the mixture jet flowing out each flame opening remains over 0.4 m/sec. at any operating conditions,
- in case of single mixture jet or if the mixture jets do not join each other before the flame front, expressly supplied secondary air, pure or mixed with recycled mixture, is sucked into said jet/s just down stream the flame opening increasing locally the $\lambda$ of the mixture by up to 30%,
- if the mixture jets join together before the flame front, mainly recycled mixture, is sucked into said jet/s just down stream of the flame opening.
- the fluid threads of the almost laminar flow field are progressively divergent also

downstream the fluids dynamic obstacle/s, whereby

the generated flame from laminar to wrinkled, **characterised by** a large surface and a very low thickness, doesn't touch the flame openings surface at all.

**2.** Method as per claims 1, where the composition of the gaseous content sucked from the volume surrounding the jet, immediately down-stream the flame opening, inside said jet, is a mixture of secondary air and recycled air/gas mixture in different ratio following different operating conditions.

**3.** A burner head of a premixed, atmospheric or forced burner, including a specific ignition device, for performing the method of claims 1, or 2,

- having flame opening/s partially covering the surface of said burner head
- having at least one fluids dynamic obstacle with cross-section shape from circular to V formed, positioned down-stream of the at least one flame opening immersed in the out flowing mixture jet to create a downstream stagnation zone, causing anchorage of the flame under all operating condition,
- said fluids dynamic obstacle is always separate and completely detached from said at least one flame opening, the distance from said flame opening to the furthest point of the obstacle being at least big as the width of said flame opening,
- the width of the obstacle cross-section being of the same order of magnitude as the width of the nearest flame opening, the obstacle having a shape and dimensions to create a downstream stagnation zone, causing anchovage of the flame under all operating conditions.
whereby
- the area and shape of the flame opening/s is/are such that, in all operating conditions, the out flowing jet velocity is higher than 0.4 meter per second, at least for a distance equal to that of the at least one fluids dynamic obstacle,
- the area and shape of the at least one obstacle are such to obtain, combined with the flame opening surface and distribution (mixture jet speed and speed distribution), a flow field down-stream and on the side of the obstacle/s almost laminar with divergent fluids threads, obtaining a flame from laminar to wrinkled **characterised by** a large surface and a very low thickness which doesn't touch the flame openings at all, whereby the burner head is either
- of the fully premixed type, and the flame openings on the burner head are distributed close each other and disposed on a surface in an homogeneous way, the gaseous content from the volume surrounding the jet sucked inside said jet, immediately down-stream the flame opening, is mainly recycled air-gas mixture, or
- of the partially premixed type and secondary air passages are foreseen, the fluids dynamic obstacle/s closely follow the flame opening/s which are homogeneously distributed over a surface but spaced each other and, in this case, the gaseous content, sucked from the volume surrounding the jet immediately down-stream the flame opening inside said jet, is secondary air pure or mixed with recycled air-gas mixture.

**4.** burner head as per claim 3 **characterised by** the fact that the flame openings and fluids dynamic external obstacles are close each other and disposed in such an homogeneous way to obtain a sole flame covering all the surface detached from the flame openings.

**5.** burner head as per claim 4 **characterised by** the fact that the external obstacle is a mesh net regularly distributed over the entire surface of the flame opening/s following the shape of said surface.

**6.** burner head as per claim 4 **characterised by** the fact that the obstacle is made of rods regularly distributed over the entire surface of the flame opening/s.

**7.** burner head as per claim 3 **characterised by** the fact that the obstacle/s, is/are strictly related with the flame opening/s, following the shape of said flame opening/s.

**8.** burner head as per claim 7 **characterised by** the fact that the obstacle/s have in all points axis of symmetry in the centre line of the mixture jet flowing out in that point.

**9.** burner head as per claim 3 having a fluids dynamic external obstacle **characterised by** the fact that the cross section of the fluids dynamic obstacle has an edge even sharp up-stream edge to divide the mixture jet without generating stagnation.

**10.** burner head as per claims 3 to 9 **characterised by** the fact that any increase of the flame distance causes an increase of the traversal dimension of the obstacle cross section, the opposite for a reduction.

**11.** burner head following claim 9 and claim 10 **characterised by** the fact that the obstacle is an elongated sealed bulb, filled with expansible fluid.

**12.** burner head following claim 9 and claim 10 **characterised by** the fact that the obstacle is a V shaped bimetallic sheet metal rod.

**13.** burner head as per claim 3 **characterised by** the fact that the external fluids dynamic obstacle/s is/ are made of material heat resistant over 500°C.

**14.** method as per one or more of claims 1, 2, **characterised by** the fact that any variation of the flame ratio causes a change of the cross section of the flame opening, a flame ratio > 1 increasing the cross section, decreasing by flame ratio < 1 between a minimum and a maximum cross section coinciding with the minimum and the maximum of burner capacity.

**15.** burner head for performing the method of claim 14 **characterised by** the fact that the movement of the external fluids dynamic obstacle/s change/s the cross section of the flame opening/s.

## Patentansprüche

**1.** Ein Verbrennungsverfahren für ein für gasförmige Brennstoffe geeignete Verbrennungsystem mit atmosphärischem oder erzwungenem Zug das sich in den folgenden Phasen vollziehet;

a- in einem vorgemischten atmosphärischen oder mit erzwungenem Zug Brenner wird eine stöchiometrische Mischung von gasförmige Brennstoff und Luft erzeugt, die sich von stöchiometrischen bis zu stark überstöchiometrische Verhältnisse erstrecht ;
b- Die Mischung strömt in die Verbrennungskammer aus mindesten einer Flammenaustrittöffnung welche eine nahezu laminare Strömung erzeugt
c- Ein nahezu homogene Mischungsjet strömt aus jeder Flammenaustrittöffnung und unmittelbar stromabwärts von dieser wird das in dem Raum um die Mischungsjets enthaltene Gas in die Jet hinein angesaugt und dadurch den Jet zugemischt;
d- Mindesten ein gasdynamische Widerstandkörper ist, stromabwärts der ö in den ausströmenden Jet an einer Stelle angeordnet, wo die Geschwindigkeit der Brennstoff/Luft Mischung in jeder Jetstelle und in jeder Betriebsbedingung, größer als die Verbrennungsgeschwindigkeit ist;
e- Eine von der Form und Größe des gasdynamischen Widerstandskörper bestimmte Stauzone, wird sich stromabwärts des Widerstandskörper bilden,
f- ein nahezu laminares Strömungsfeld mit fortschreitend auseinander gehenden Strömungsfaden um die Seiten des gasdynamischen Widerstandskörper wird erzeugt;
g- Eine laminare bis faltigen Flamme, am Anfang mittels einer spezifischen Vorrichtung angezündet, erzeugt und in jeder Betriebsbedingung, mindesten an einigen Stellen durch die Wirbel der Stauzone verankert wird, Wobei

- die Geschwindigkeit der aus jeder Flammenaustrittöffnung abströmenden Mischungsjets in jeder Betriebsbedingung größer als 0.4 m/s bleibt
- in Falle eines einzigen Mischungsjet oder wenn die Mischungsjets nicht sich stromaufwärts des Flammenfront zusammenschließen, ein zu diesem Zweck erzeugter sekundärer Luftstrom in die genannten Jets hinein unmittelbar stromabwärts der Flammenaustrittöffnung angesaugt wird und dadurch wird das örtliche λ der Mischung um bis 30% gesteigert.
- In Falle die Mischungsjets sich stromaufwärts des Flammenfronts sich zusammenschließen , hauptsächlich eine verwirbelte Mischung, wird in die genannten Jets hinein unmittelbar stromabwärts der Flammenaustrittsöffnung angesaugt
- Die Strömungsfaden des nahezu laminaren Strömungsfeldes fortschreitend auch stromabwärts del gasdynamischen Widerstandskörpers auseinander gehen, wobei die laminare bis faltigen erzeugte Flamme durch eine große Oberfläche und eine geringe Dicke charakterisiert ist und in keinen Fall die Oberfläche der Flammenaustrittsöffnung berührt.

**2.** Verfahren dem Anspruch 1 entsprechend, wobei die Mischung des, aus dem Raum um die Jets umliegend, unmittelbar stromabwärts der Flammenaustrittsöffnung, in die Jets hinein angesaugten gasförmigen Stoffes, aus einer Mischung von sekundäre Luft und von verwirbelten Brennstoff/Luftmischung bestehet, deren Komposition und stöchiometrische Verhältnisse von den verschiedenen Betriebsbedingungen abhängen.

**3.** Ein Brennerkopf eines durch vorgemischten atmosphärischen oder erzwungenen Zug charakterisierten Brenners einschließlich eine spezielle Zündvorrichtung für die Durchführung des Verfahrens den Ansprüche 1, und 2, entsprechend

- mit Flammenaustrittsöffnung/(en) teilweise deckend die Oberfläche des genannten Brennerkopf.
- mit mindestens einem gasdynamischen Wider-

standkörper, durch einen rund bis V-förmige Querschnitt charakterisiert, stromabwärts der , zu mindesten einen, Flammenaustrittsöffnung in den abströmenden Mischungsjet angeordnet, welcher eine Stauzone erzeugt die eine Verankerung der Flamme in jede Betriebsbedingung versichert,

- das genannte gasdynamische Widerstandkörper ist stets von der genannten Flammenaustrittsöffnung getrennt und an einer Stelle angeordnet, deren Abstand von der Flammenaustrittsöffnung bis den entfernten Punkt des Widerstandkörper mindestens der Breite der Flammenaustrittsöffnung gleich ist;
- Die Breite des Widerstandkörperquerschnitts ist von derselben Größenordnung der Breite des anliegenden Flammenaustrittsöffnung und das Widerstandkörper hat eine Form und ein Ausmaß die angemessen sind um eine Stauzone stromabwärts zu erzeugen, welche die Verankerung der Flamme in jeder Betriebsbedingung versichert;

wobei
Die Fläche und die Form der Flammenaustrittsöffnung/(en) so ausgelegt sind daß in jeder Betriebsbedingung die Geschwindigkeit des abströmenden Jet, mindestens der Strecke entlang bis zu dem Widerstandkörper, den Wert 0,4 m/s übersteigt;
Der Querschnitt und die Form des Widerstandkörpers sind in einer geeigneten Wiese ausgelegt um bei Mitwirkung der Fläche und der Verteilung der Flammenaustrittsöffnung/en (Jets Geschwindigkeit und Geschwindigkeitsverteilung) ein laminare Strömungsfeld mit auseinander gehenden Stromfaden stromabwärts auf den Seiten des Widerstandkörpers zu erzeugen;

- Falls das Brennerkopf von der voll Vormischung Typ ist, und die Flammenaustrittsöffnungen auf dem Brennerkopf eng miteinander und regelmäßig auf die Oberfläche angeordnet sind, der in dem die Jets umgebenden Raum enthaltene und in die Jet hinein, unmittelbar stromabwärts der Flammenaustrittöffnungen angesaugte gasförmige Stoff hauptsächlich aus einer rezirkulierten Brennstoff/Luft Mischung besteht, oder
- Falls das Brennerkopf von der Teil-vormischung Typ ist , sind Öffnungen für sekundäre Luft vorgesehen und das/die gasdynamische Widerstandkörper neben den, regelmassig aber miteinander entfernt auf die Oberfläche angeordneten Flammenaustrittsöffnungen eingebracht, und der, in dem die Jets umgebenden Raum enthaltene, und in die Jet hinein unmittelbar stromabwärts del Flammenaustrittöffnungen angesaugten, gasförmige Stoff hauptsächlich aus reiner sekundärer Luft oder aus einer Mischung von sekundärer Luft mit der rezirkulierten Brennstoff/Luftmischung besteht.

**4.** Brennerkopf, dem N° 3 Anspruch entsprechend, der dadurch charakterisiert ist dass die Flammenaustrittsöffnungen und die gasdynamische Widerstandkörper eng miteinander und in einer Weise angeordnet sind das eine einzige Flamme gebildet wird, welche die ganze Flache stromabwärts der Flammenaustrittsöffnungen deckt.

**5.** Brennerkopf, dem Anspruch N° 4 entsprechend, der dadurch charakterisiert ist daß das externe Widerstandkörper aus einem regelmassig über die ganze Fläche der Flammenaustrittsöffnungen sich erstreckenden und an der Flächenform sich anpassenden Netz bestehet.

**6.** Brennerkopf, dem Anspruch N° 4 entsprechend, der dadurch charakterisiert ist daß das Widerstandkörper aus regelmäßig über die ganze Fläche der Flammenaustrittsöffnungen angeordneten Stäben bestehet.

**7.** Brennerkopf, dem Anspruch N°3 entsprechend, der dadurch charakterisiert ist daß das/die Widerstandkörper/s direkt von den Flammenaustrittsöffnung/en abhängt/en und sich an deren Form anpasst/en.

**8.** Brennerkopf, dem Anspruch N°7 entsprechend, der dadurch charakterisiert ist, daß der/die Widerstandkörper/s Symmetrie Achse in alle Punkten mit der Jet Symmetrie Achse überein stimmt.

**9.** Brennerkopf, dem Anspruch N°3 entsprechend, der dadurch charakterisiert ist daß der Querschnitt des gasdynamischen Widerstandkörper einen sogar scharfe Kante hat welcher den Mischungsjet ohne jegliche Stauzone aufteilen kann.

**10.** Brennerkopf, den Ansprüche N° 3 bis 9 entsprechend, der dadurch charakterisiert ist, daß jegliche Zunahme des Flammenabstandes eine Zunahme des Querausmaßes des Widerstandkörpers bestimmt, das Gegenteil bei einer Abnahme.

**11.** Brennerkopf, den Ansprüche N° 9 und 10 entsprechend, der dadurch charakterisiert ist daß das Widerstandkörper aus einem verlängerten mit einer ausdehnbaren Flüssigkeit gefüllten und dicht verschlossenen Flasche bestehet.

**12.** Brennerkopf, den Ansprüche N° 9 und 10 entsprechend, der dadurch charakterisiert ist daß das Widerstandkörper eine V-förmige aus zweimetallischen Platten bestehende Stab ist

**13.** Brennerkopf, dem Anspruch N° 3 entsprechend, der dadurch charakterisiert ist, daß die externen gasdynamische Widerstandkörper aus einem bis auf über 500 °C wärmebeständigen Stoff bestehen.

**14.** Verfahren, den Ansprüche N° 1, 2 entsprechend, die dadurch charakterisiert ist daß jegliche Änderung des Flammenverhältnis eine entsprechende Änderung der Flammenaustrittsöffnung bestimmt; bei einem Flammenverhältnis > 1 wird die Öffnung vergrößert, bei einem Flammenverhältnis < 1 wird die Öffnung reduziert wobei die Öffnungsgröße zwischen Öffnungswerte die der minimalen und maximalen Brennerbelastung entsprechen, eingestellt wird.

**15.** Brennerkopf der die in Anspruch 5 dargelegten Verfahren vollzieht und dadurch charakterisiert ist daß die Verstellung des/r externen gasdynamischen Widerstandkörper/se die Öffnungsgröße der Flammenaustrittsöffnung/en verändert.

**Revendications**

**1.** Méthode de combustion, dans un system de combustion soit a convection naturelle soit mécanique, avec les passages suivant:

a- un brûleur pré mélangé, atmosphérique or forcé réalise en mélange de air et gaz combustible de presque stçchiométrique a fortement iperstçchiometrique,
b- le mélange coule, dans la chambre de combustion, par au moins une ouverture de flamme avec une distribution de vitesse telle d'obtenir une écoulement substantiellement laminaire.
c- Un seul jet de mélange substantiellement homogène sorts de chaque sortie de flamme et, immédiatement en aval de cette sortie, le contenu gazeuse de la volume qui enveloppe le jet est absorbé dans cette jet et mélanger la dedans.
d- Au moins, une obstacle fluidodynamique est immerger dans le jet qui coule dehors, en aval d'au moins une ouverture de flamme, détacher de cette ouverture, dans une position où la vitesse de le mélange air gaz combustible est dans chaque point de le jet, plus grand que la vitesse de combustion, dans toutes les conditions du travail.
e- Une zone de stagnation est crée à cause de la forme est de les dimensions de l'obstacle, en aval de cette obstacle fluidodynamique.
f- Un écoulement presque laminaire est produit avec des filets fluides progressivement divergent à coté de l'obstacle fluidodynamique
g- Une flamme de laminaire à rider, laquelle est au début allumé par un appareil spécifique, est produit et ancré dans toutes les conditions de travail à cause des vorticelles liées à la zone de stagnation, au moins dans quelques points.

Par où

- La vitesse du jet de mélange coulant de chaque sortie de flamme restes supérieure à 0.4 m/sec dans toutes les conditions de travail,
- Dans le cas d'une seule jet de mélange ou dans le cas dont les différents jets de mélange ne se joindrent pas avant le front de flamme, de l'air secondaire, pure ou mélanger avec de mélange recyclé, est aspirer dans cette jet/s juste en aval de l'ouverture de flamme augmentant localement λ du mélange jusqu'à 30%.
- Si les jets de mélange joindrent ensemble avant le front de flamme, surtout le mélange recyclé, est aspiré dans cette jet/s, juste en aval de l'ouverture de flamme
- Les filets fluides du écoulement pratiquement laminaire sont progressivement divergents aussi en aval de l'obstacle fluidodynamiques,

Par où
• la flamme de laminaire à rider, **caractérisé par** un large surface et une épaisseur très bas, ne touche pas absolument la surface de la sortie de flamme.

**2.** Méthode suivant la revendication 1, où la composition du contenu gazeuse absorbé de la volume qui enveloppe le jet, est une mélange de air secondaire et air/gaz mélange recyclé, en pourcentage différent suivant les différents conditions de travail.

**3.** Tête d'une brûleur pré mélangé, atmosphérique or forcé, avec un appareil spécifique d'allumage, capable de réaliser la méthode de la revendications 1 ou 2,

- Laquelle a le/s ouverture/s de flamme qui couvrent partiellement la surface de cette tête de brûleur,
- Laquelle a au moins une obstacle fluidodynamiques avec une section de la forme circulaire à la forme V, positionné en aval de au moins une sortie de flamme immergé dans le jet de mélange qui sort pour créer en aval une zone de stagnation, laquelle cause l'anchorage de la flamme dans toutes les conditions de travail,
- Cette obstacle fluidodynamique est, dans tout les cas séparer et complètement détacher de cette au moins un sortie de flamme, la distance entre cette sortie et le point plus loin de l'obs-

tacle en étant au moins si grand que la largeur de la sortie de flamme,

- La largeur de la section de l'obstacle en étant de le même ordre de grandeur de la largeur de la sortie de flamme plus près, l'obstacle en étant forme et dimension capable de créer en aval une zone de stagnation qui cause l'anchorage de la flamme dans toutes les conditions de travail.
  Par où
- La surface et la forme de/s sortie/s de flamme sont tels que: dans toutes les conditions de travail, la vitesse du jet qui coule dehors est plus grand de 4m/sec, pour au moins une distance égale à celle d'au moins un obstacle fluidodynamique,
- La surface et la forme d'au moins un obstacle fluidodynamique, ensemble avec la surface et la distribution de la sortie de flamme (vitesse et distribution de la vitesse du jet), sont tels pour obtenir, une écoulement presque laminaire en avant filets fluides divergents en aval et à coté de l'obstacle/s, en obtenant une flamme de laminaire à rider qui ne touche pas du tout les sorties de flamme, **caractérisé par** une large surface et une épaisseur très bas.
  Dans le cas où
- La tête du brûleur est de type complètement pré mélangé et les sorties de flamme de la tête de brûleur sont distribuées l'une près de l'autre et distribuées d'une façon homogène, le contenu gazeuse de la volume qui enveloppe le jet immédiatement en aval de la sortie de flamme, aspiré dans cet jet, est surtout mélange air/gaz recyclé,
  Dans le cas où
- La tête du brûleur est de type partiellement pré mélangé et des passages d'air secondaire sont prévues, l'obstacle/s fluidodynamiques suive le/s sortie/s de flamme lesquelles sont homogènement distribuées sur la surface, mais dans cet cas élongées l'une l'autre, le contenu gazeuse de la volume qui enveloppe le jet immédiatement en aval la sortie de flamme, aspiré dans cet jet, est air secondaire pure ou mélangé avec mélange d'air/gaz recyclé.

**4.** Tête de brûleur suivant la revendication 3 **caractérisé** pour le fait que les sorties de flamme et les obstacles fluidodynamiques extérieurs sont près l'un à l'autre et distribués en façon homogène tel de obtenir une seule flamme détachée de les sorties de flamme, qui couvre toute la surface de celles.

**5.** Tête de brûleur suivant la revendication 4 **caractérisé** pour le fait que l'obstacle extérieur est une grillage régulièrement distribuée sur l'entier surface de les sortie/s de flamme suivant la forme de cette surface.

**6.** Tête de brûleur suivant la revendication 4 **caractérisé** pour le fait que l'obstacle est construit de tiges régulièrement distribuée sur l'entier surface de les sortie/s de flamme suivant la forme de cette surface.

**7.** Tête de brûleur suivant la revendication 3 **caractérisé** pour le fait que l'obstacle/s, est/sont strictement lié/es à la/les sortie/s de flamme, suivant la forme de cette/s sortie/s de flamme.

**8.** Tête de brûleur suivant la revendication 7 **caractérisé** pour le fait que l'obstacle/s ont tout les points l'axe de symétrie dans l'axe central de le jet de mélange qui coule dans cet point.

**9.** Tête de brûleur suivant la revendication 3 avant l'obstacle extérieur fluidodynamique **caractérisé par le fait que** la section de l'obstacle fluidodynamique a un arête même aiguisé en amont pour diviser le jet de mélange sans créer stagnation.

**10.** Tête de brûleur suivant la revendication 3 à 9 **caractérisé** pour le fait que chaque augmentation de la distance de la flamme cause une augmentation de la dimension transversale de l'obstacle, l'opposé pour une réduction.

**11.** Tête de brûleur suivant la revendication 9 et 10 **caractérisé** pour le fait que l'obstacle/s est une ampoule allongé étanche, rempli par une liquide expansible.

**12.** Tête de brûleur suivant la revendication 9 et 10 **caractérisé** pour le fait que l'obstacle/s est une profile bimétallique à forme V.

**13.** Tête de brûleur suivant la revendication 3 **caractérisé** pour le fait que l'obstacle/s extérieur est construit par une matériel résistante à une température supérieure à 500 degrés.

**14.** Méthode suivant une ou plusieurs de les revendications 1 et 2, **caractérisé par le fait que** chaque variation de la flamme ratio provoque le changement de la section de passage de la sortie de flamme, une augmentation pour flamme ratio >1, une diminution pour flamme ratio <1, entre un minimum et un maximum de section de passage qui coïncide avec le minimum et le maximum de la puissance de le brûleur.

**15.** Tête de brûleur suivant le méthode de la revendication 14 **caractérisé par le fait que** le mouvement de l'obstacle fluidodynamiques extérieur change la surface ouverte de la sortie de flamme.

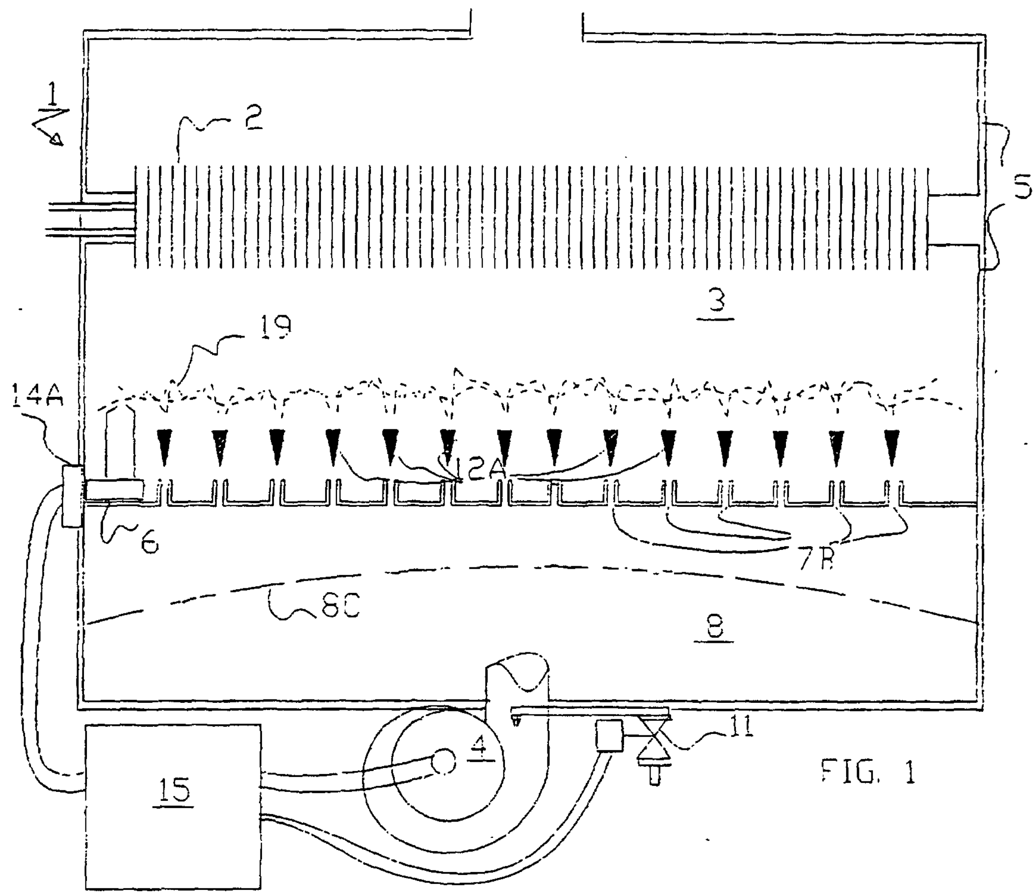



FIG. 1

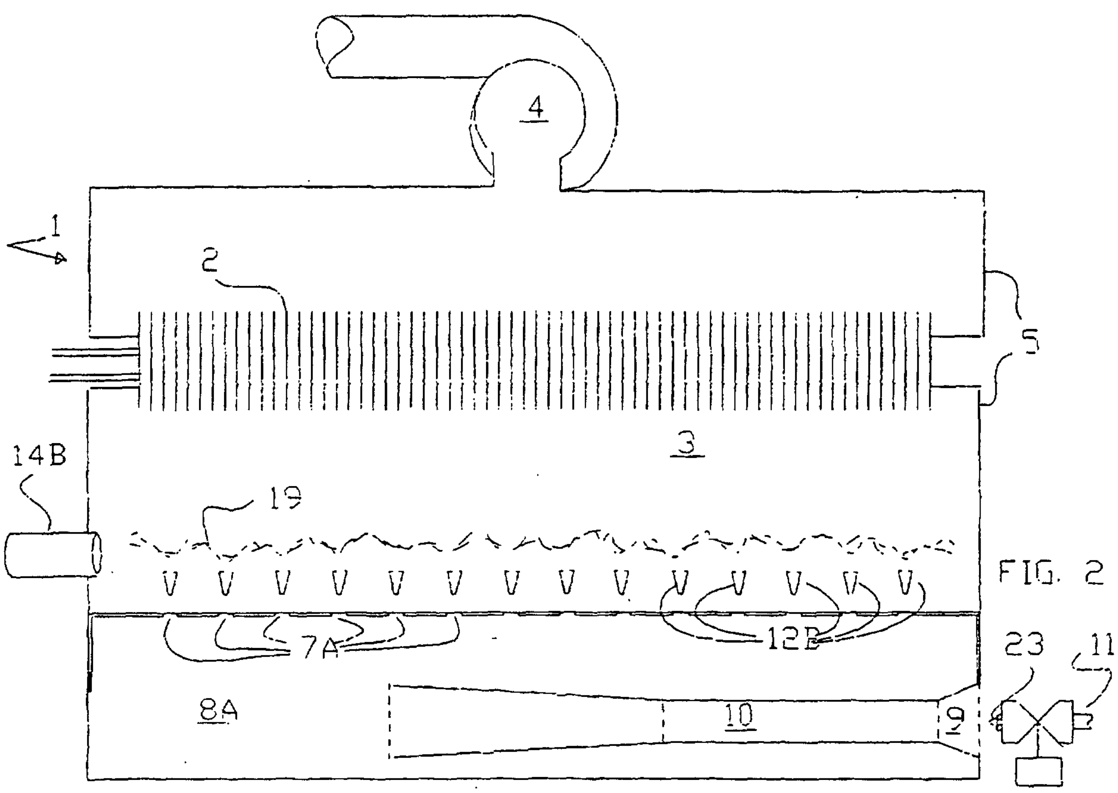



FIG. 2

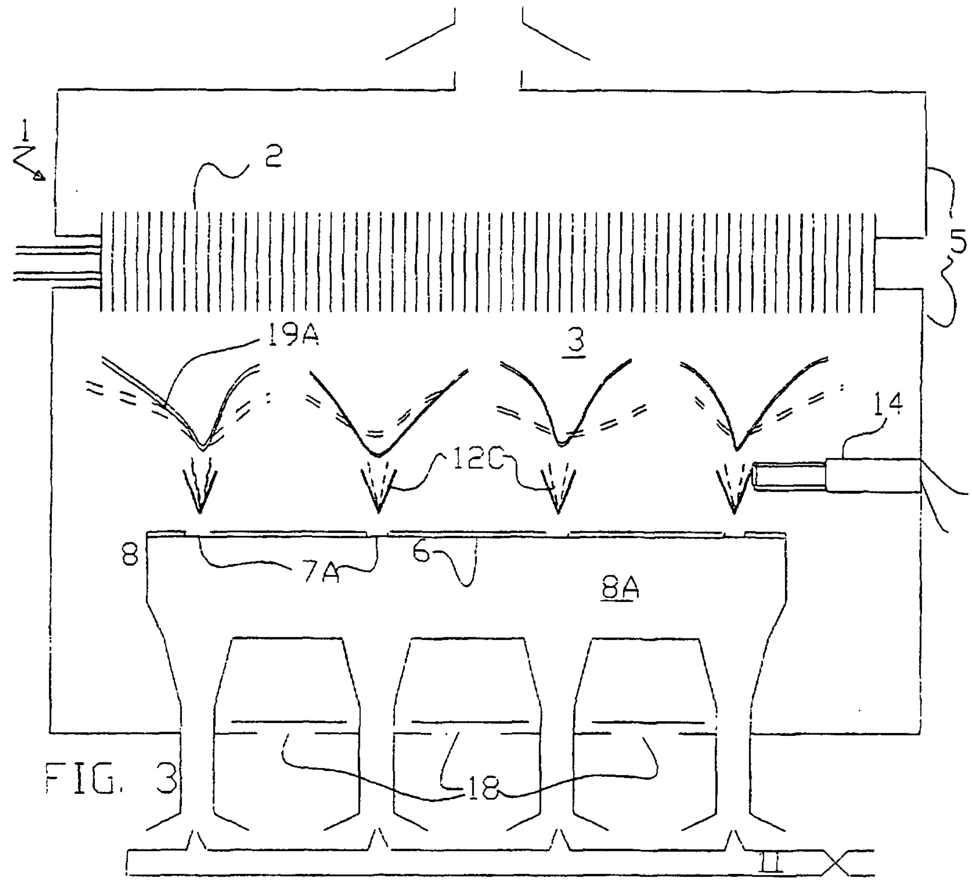



FIG. 3

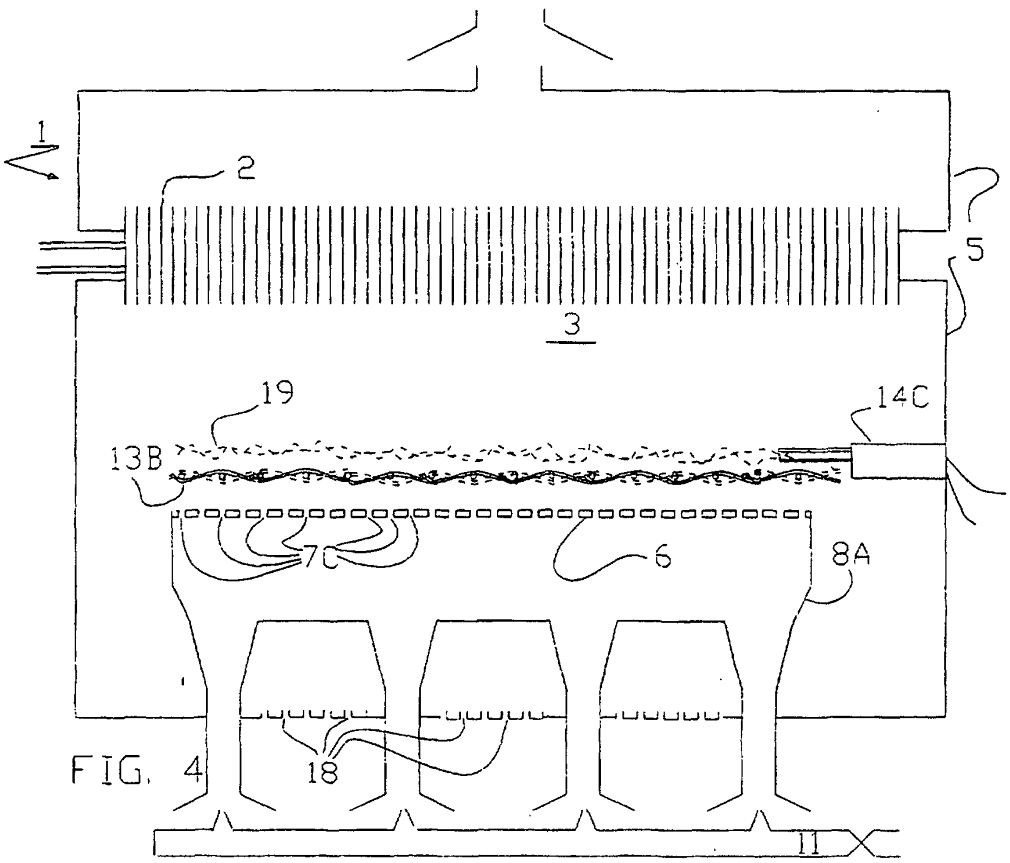
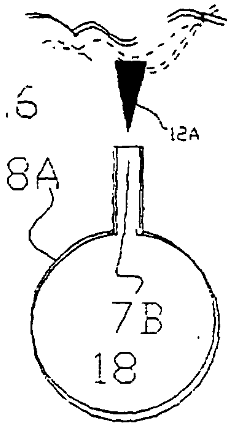



FIG. 4

FIG.6



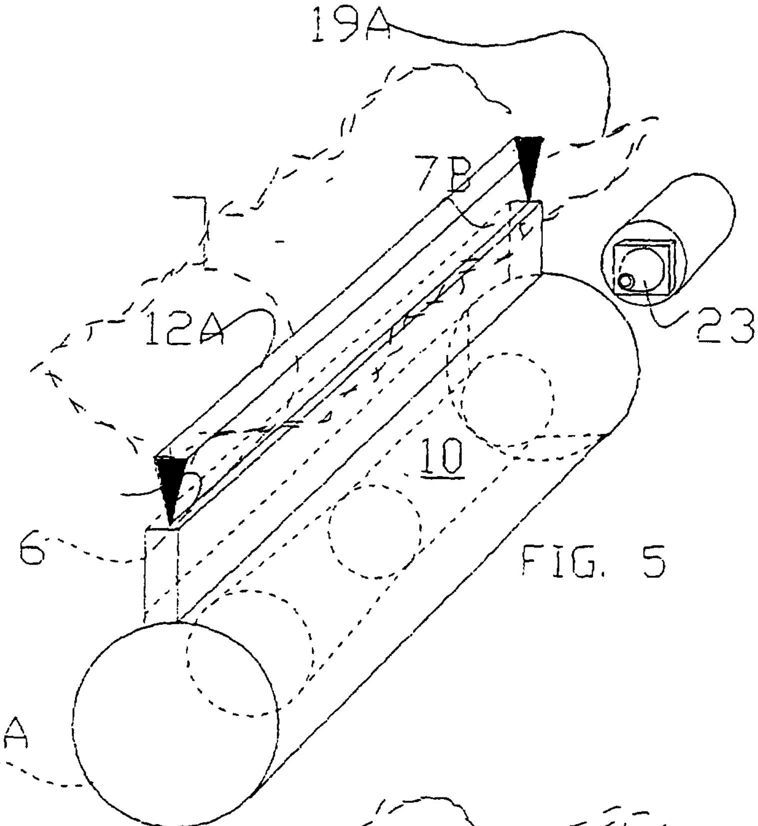
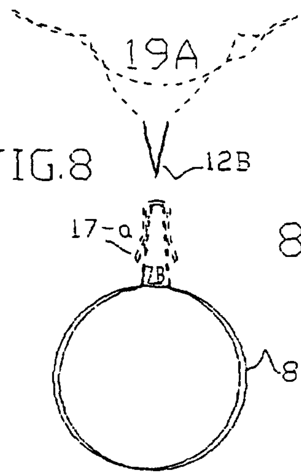




FIG. 5

FIG.8



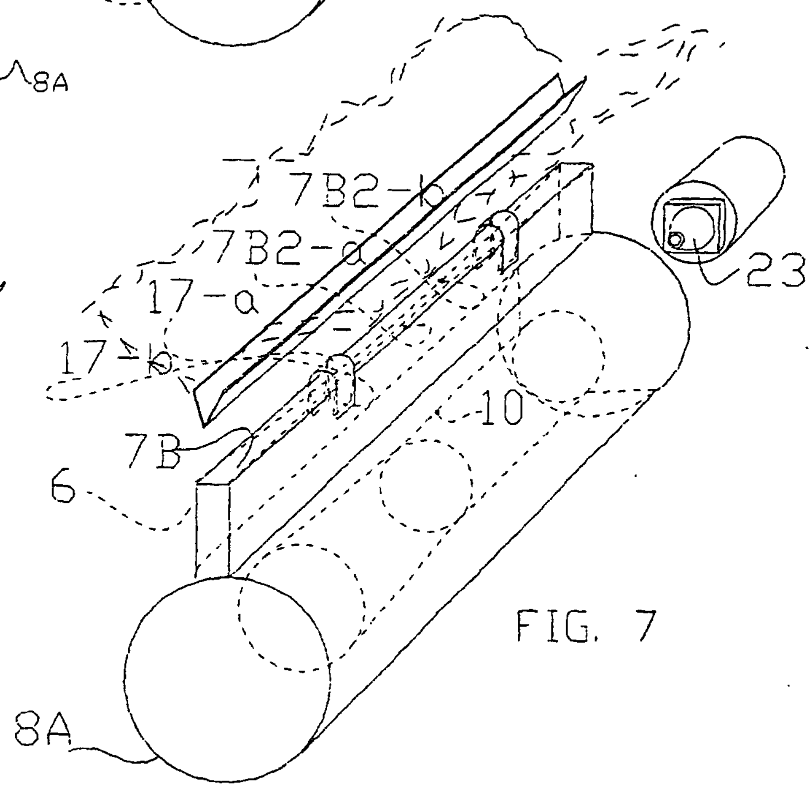




FIG. 7

FIG.9

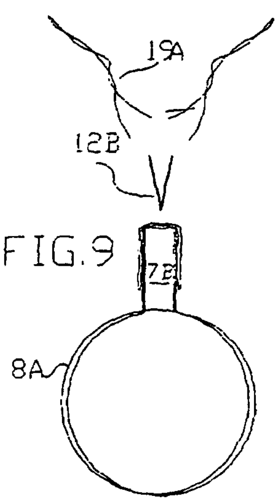


FIG.10

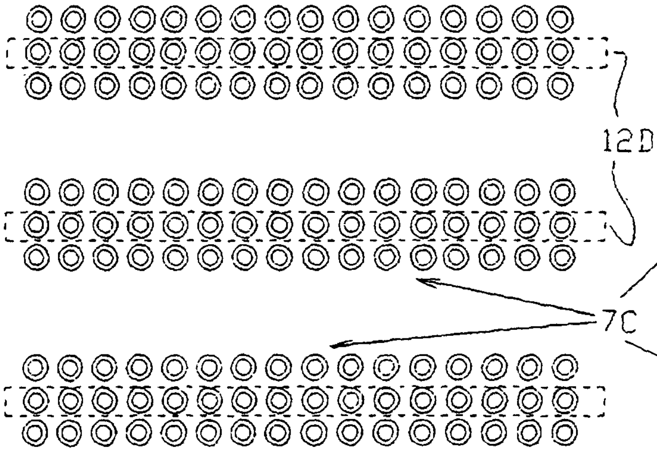



FIG.11

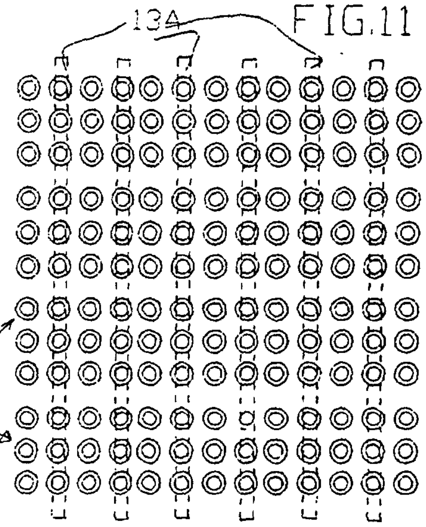
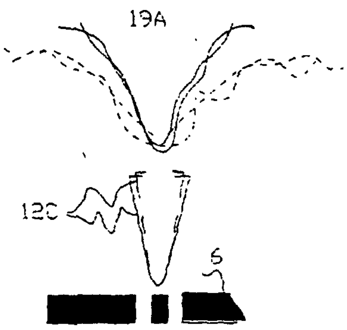



FIG.12



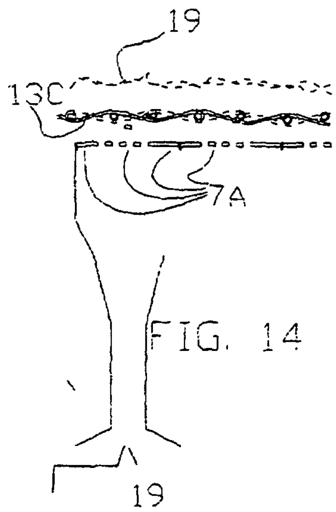




FIG. 14

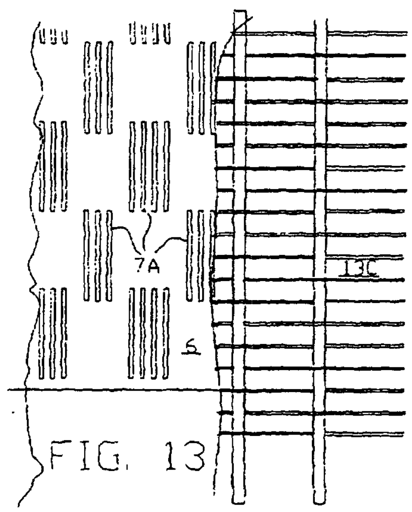



FIG. 13

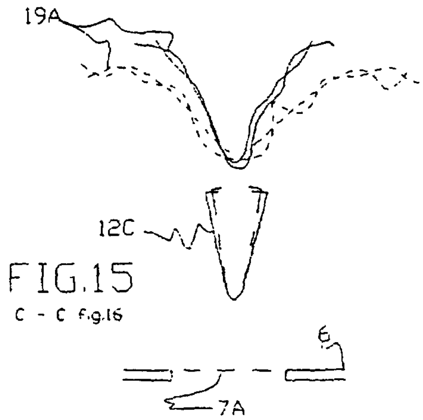
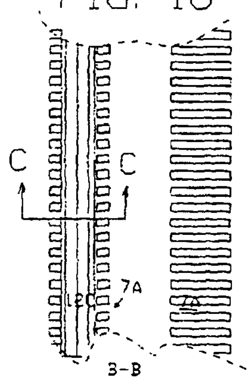



FIG.15
C - C F.g.16

FIG. 16



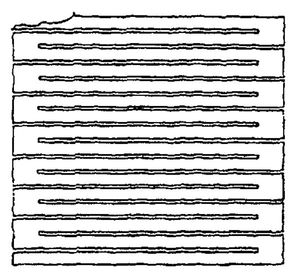



FIG.17

FIG.18

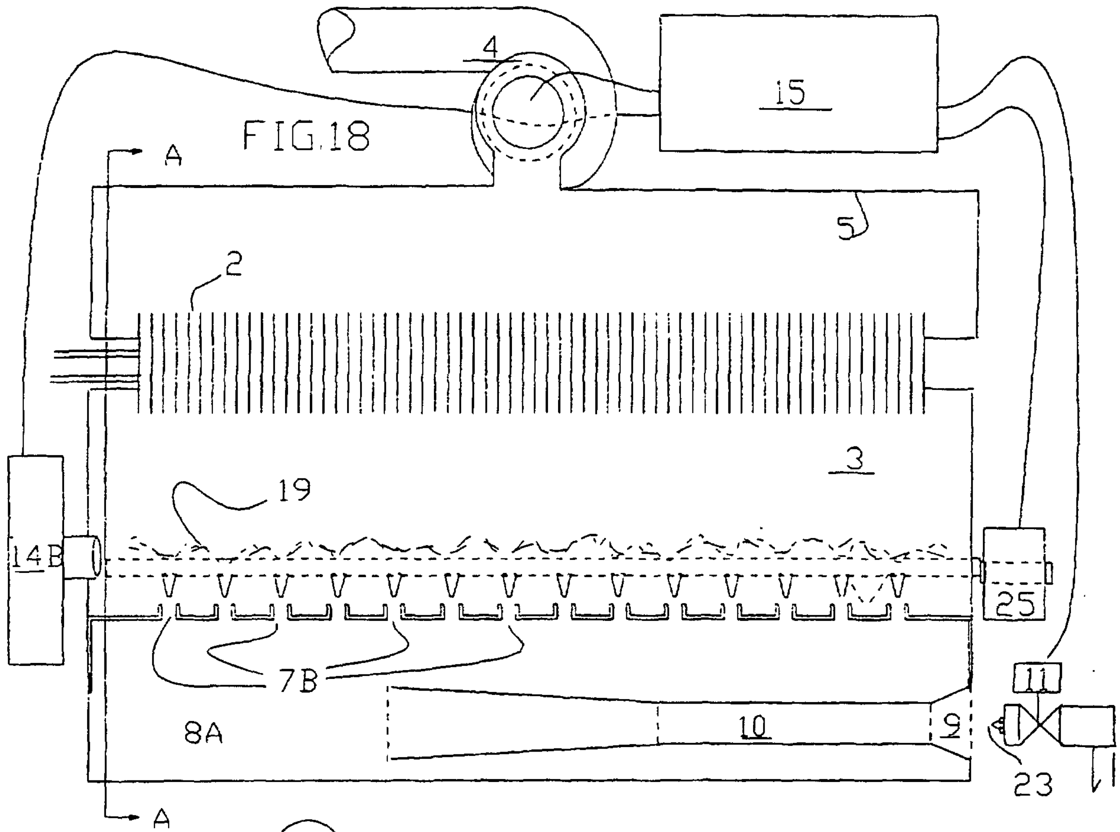
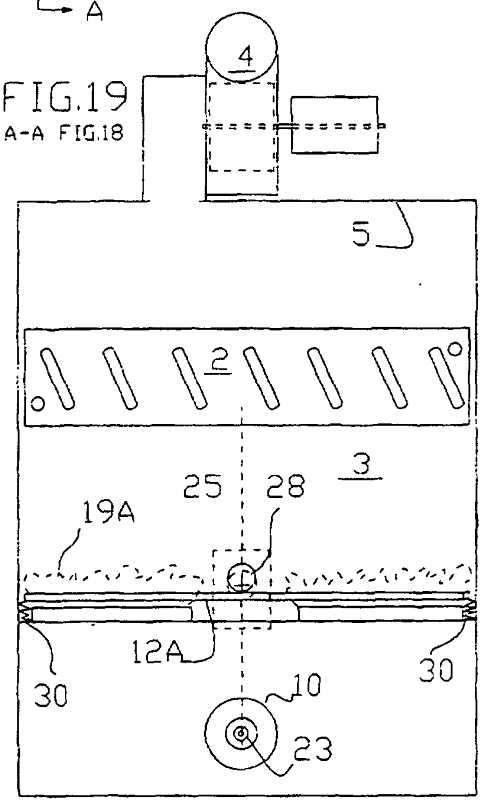



FIG.19
A-A FIG.18



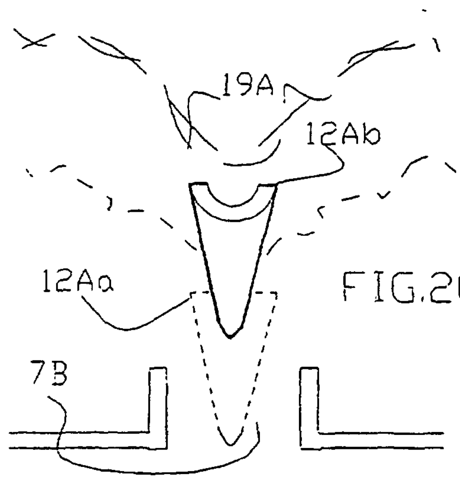




FIG.20