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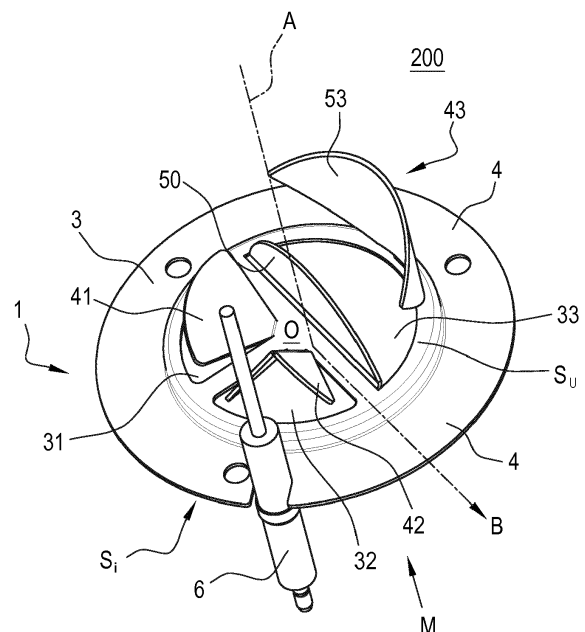
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(54) **VARIABLE CROSS-SECTION DISTRIBUTOR DEVICE FOR A PREMIXING BURNER AND BURNER COMPRISING SUCH DISTRIBUTOR**

(57) A variable cross-section distributor for a premix burner is provided with a plurality of openings and deflector elements which are located proximate thereto on an output surface and which have guide surfaces for directing the flow of an air and gas mixture in a plurality of directions. A first deflector element is configured to direct a part of the flow permanently in a first direction towards an ionisation sensor. A movable deflector element, capable of adopting, as a function of the pressure exerted on it by the mixture, a position that is variable relative to the output surface, is used to vary the cross section of the distributor through which the mixture flows and to minimise the load losses; the movable deflector directs a part of the flow in a second variable direction. At least one further, fixed deflector is configured to direct a part of the flow permanently in a second direction, different from the first direction, and to regulate the fluid dynamic distribution output from the distributor.

FIG. 3C



Description

[0001] This invention relates to a distributor device provided with openings for inputting a mixture of fuel and oxidant into a premix burner; the invention also relates to a premix burner comprising this distributor device.

[0002] A distributor device of this kind and a premix burner comprising the distributor are known from European patent EP 2 037 175 B1 to this applicant. The burner described in that document comprises: a cylindrical body made from perforated sheet metal and provided with an inlet at one end; a sheet metal base plate welded to one end of the cylindrical body in order to close it; and a disc-shaped distributor, preferably formed as one piece with a fixing flange for attaching the burner to the boiler. The distributor is located at the inlet of the cylindrical body and is provided with openings for inputting into the body a mixture of gas (fuel) and air (oxidant) whose combustion produces a flame on the external surface of the cylindrical body.

[0003] Some embodiments of the distributor described in patent EP 2 037 175 B1 comprise guide surfaces disposed around the openings of the distributor to guide the flow of mixture into the burner so as to create a desired fluid dynamic distribution. The configuration described in patent EP 2 037 175 B1 improves the thermo-acoustic behaviour and the thermal insulation of the burner.

[0004] As is known, the formation of the flame produced by combustion of numerous gases in the presence of an oxidant - air, for example - is accompanied by an ionisation process whereby ions are formed. The presence of the ions may be quantitatively detected using suitable sensors.

[0005] Measuring the ionisation signal of a flame provides information on the combustion process, such as, for example, the ratio (typically denoted by the Greek letter λ) between the quantities of air and gas involved in the process, and is commonly used in the prior art to regulate the combustion process.

[0006] European patent application EP 1 036 984 A1, filed by G. Kromschöder AG, describes for example a premix burner provided with a sensor for measuring the ionisation signal produced by the flame following combustion of an air and gas mixture; this signal is used in a feedback control circuit to control the operating regime of a fan in order to keep the value of the air-gas ratio at a predetermined optimum level.

[0007] In application EP 1 036 984 A1, the sensor comprises an electrode located proximate to a distributor of the mixture inside the burner. On its lateral surface, the internal distributor is provided with holes through which the mixture flows out and is distributed and the electrode is located in proximity to a zone of the distributor where the holes are more densely packed - that is to say, which is more porous: thus, in this porous zone, the intensity of the ionisation signal increases locally. This feature allows increasing the intensity of the ionisation signal detected, because the flame produced in the region with

the higher density of holes is more intense than on the rest of the lateral surface, thanks to the larger amount of mixture flowing in this region. This feature is of particular importance when the burner is operating in regimes of low generated thermal power: in effect, it is known that the ionisation signal decreases considerably in this operating regime, reaching values that are too low to be used to control the operation of the burner through a control circuit.

[0008] It may be inferred from the above that the solution described in application EP 1 036 984 A1 uses a conventional distributor that is not capable of directing the flow of mixture in the burner towards a well-delimited region or in a preferred direction. When the burner described in application EP 1 036 984 A1 works in regimes of low thermal flow and produces a less intense flame, the intensity of the ionisation signal is reduced in proportion to the reduction in flame intensity even in the porous region: as a result, the signal may drop below the minimum required for correct operation of the burner control circuit.

[0009] Another problem with the solution described in application EP 1 036 984 A1 is due to the higher mechanical stresses the burner is subjected to on account of the high temperatures reached by the sheet metal in the most porous region. This problem is made worse by the use of an internal distributor, which is also a source of thermoacoustic instability.

[0010] Unlike application EP 1 036 984 A1, this applicant's patent EP 2 037 175 B1, as already mentioned, describes a distributor whose openings are provided with deflectors capable of directing the flow of mixture towards the inside of the burner in a preferred direction. The deflectors are, however, all identical and therefore can only create a uniformly directed flow: as a result, the burner of patent EP 2 037 175 B1 does not allow the intensity of the ionisation signal and the fluid dynamic distribution of the mixture to be separately and independently optimized.

[0011] The need to optimize the ionisation signal independently is felt particularly strongly in modern heating systems, which are required to operate in a wide range of thermal flows without being switched off: in other words, modern systems must be capable of continuously modulating the thermal power generated according to the variable requirements of users in order to reduce energy consumption and emissions caused by repeatedly switching the heating system on and off and during power-on transients. It is therefore essential to be able to regulate the level of the ionisation signal independently of the control of other parameters such as, for example, the fluid dynamic distribution of the mixture inside the burner.

[0012] Similar drawbacks are also shared by the burner described in European patent EP 3 006 826 B1 to Worgas Bruciatori S.r.l., relating to a burner of the type having an internal distributor of the mixture and equipped, at the base of it, with a perforated disc provided with

guides, all identical in shape and size, for deflecting the mixture towards the inside of the burner along its central axis.

[0013] Lastly, European patent application EP 2 177 830 A1, filed by Siemens Building Technologies HVAC, describes a premix burner of the type with an internal distributor and provided with an ionisation electrode for detecting the flame ionisation signal, located in a region of the internal cavity of the burner separated from the rest of the cavity by a dividing panel.

[0014] That way, the pressure in the region with the ionisation electrode is higher than in the rest of the cavity in any operating regime, thus ensuring a higher ionisation signal over the full operating range of the burner.

[0015] The burner described in application EP 2 177 830 A1 has a certain number of drawbacks.

[0016] First of all, the dividing panel and the internal distributor worsen the thermoacoustic behaviour of the burner, make it more complicated and expensive to manufacture and are easily subject to mechanical stress and failure.

[0017] Secondly, the burner needs an internal distributor to distribute the mixture effectively and is thus subject to microcracking and thermoacoustic instability.

[0018] Lastly, patent application EP 2 918 912 A2 describes a premix burner provided with an input section for feeding a mixture of air and gas into a flame region. The input section has two separate ducts; each duct is connected to a different portion of the flame region, one of which has an ionisation electrode mounted inside it. In addition, each duct is equipped with a valve provided with a deflector hinged to the walls of the duct; each valve may close the respective duct or rise to allow the mixture to flow through it. The deflector connected to the flame region in which the ionisation electrode is located is lighter than the other deflector and ensures that for low thermal flows there is a sufficient supply of mixture to the ionisation electrode.

[0019] The burner described in application EP 2 918 912 A2, although it is capable of separately regulating the quantity of mixture directed to the ionisation electrode, is constructionally complex because the valve provided with the heavier deflector requires the use of a permanent magnet; moreover, this valve does not allow controlling the spatial distribution of the mixture since it only regulates the quantity of mixture flowing in the duct.

[0020] The aim of this invention is to provide a distributor device provided with openings for inputting a mixture of fuel and oxidant into a premix burner, capable of overcoming the abovementioned drawbacks of the prior art.

[0021] More specifically, this invention has for an aim to provide a distributor provided with openings for inputting a mixture of fuel and oxidant into a premix burner and also to provide a burner comprising such a distributor, capable of ensuring that the ionisation signal is stable and sufficiently intense in any operating regime and, at the same time, able to minimise burner load losses in any operating regime.

[0022] More specifically, the aim of this invention is to provide a distributor for a premix burner and a burner comprising the distributor, capable of ensuring in a constructionally simple and inexpensive manner that the ionisation signal is sufficiently intense during transients from the maximum to the minimum thermal power and vice versa.

[0023] A further aim of this invention is to propose a distributor for a premix burner and a burner of this kind, capable of guaranteeing an ionisation signal of sufficiently high intensity even in low thermal flow regimes so as to allow the operation of the burner to be controlled over a wide range of thermal flows.

[0024] A yet further aim of this invention is to provide a distributor and a premix burner comprising the distributor allowing the value of the λ ratio between the amount of air and the amount of gas in the mixture to be regulated reliably over the full operating range of the burner.

[0025] A further aim of this invention is to provide a distributor and a premix burner comprising the distributor and capable of reaching high values of modulation ratio, generally greater than 1:10. By way of non-limiting example, the modulation ratio may be equal to 1:20.

[0026] Lastly, this invention has for an aim to provide a distributor and a premix burner comprising the distributor, capable of controlling the fluid dynamic distribution of the mixture inside the burner and, at the same time, optimizing the load losses and the detectable ionisation signal.

[0027] These aims are fully achieved by the distributor and the burner of this invention as characterized in the appended claims.

[0028] The distributor device according to this invention comprises a distribution element having an axis along which the mixture propagates and provided with a first surface for inputting the mixture into the distribution element and a second surface for outputting the mixture. The first and the second surface are located opposite each other along the axis of propagation so that the axis is normal to both surfaces at the respective points where the axis crosses them. In a preferred embodiment, the first and the second surface have a centrally symmetrical geometrical shape about the axis of propagation of the mixture.

[0029] The distribution element also comprises a plurality of openings which put the first surface into communication with the second surface so as to allow the passage of the mixture through the distribution element. The openings are mutually separated and distributed angularly about the axis A of propagation in such a way that the position of each opening on the second surface is defined uniquely by a respective azimuth angle measured relative to a second reference axis perpendicular to the axis of propagation of the mixture. In other words, the openings are arranged around the axis of propagation and their positions on the output surface are distinct and uniquely defined by a different azimuth angle for each of the openings. For example, in the preferred case of a flat

output surface, the surface forms a plane (called azimuth plane) and, fixed to a reference axis lying in that plane and orthogonal to the axis of propagation of the mixture (which by definition is orthogonal to the input and output surfaces at one point), the position of each opening is uniquely identified by an angle measured relative to the second reference axis, in the azimuth plane.

[0030] The distribution element also comprises a set of deflector elements distributed on the second surface, each located proximate to a respective opening and provided with a guide surface positioned above that opening. Each guide surface is configured in such a way as to direct the mixture output from the second surface in at least one deflection direction which forms an angle of deflection with the propagation axis; the projection of the deflection direction of each guide surface on the output surface is also oriented in such a way as to form with the second reference axis defined above, the same azimuth angle that identifies the opening associated with the same guide surface.

[0031] Since each guide surface is oriented in a direction that differs in azimuth angular orientation from that of the other guide surfaces, each deflector element can direct a part of the mixture in a different direction.

[0032] The set of deflector elements of the distributor according to the invention comprises at least one first fixed deflector element whose guide surface is oriented in such a way as to direct the mixture in a direction which forms with the axis of symmetry a first angle of deflection that is fixed and not null.

[0033] The set of deflector elements also comprises a movable deflector element whose guide surface is oriented in such a way as to direct the mixture in at least one second direction that is variable and different from the first direction. To vary the second direction, the guide surface of the movable deflector element is provided with means for varying the second direction by moving the guide surface towards or away from the output surface. The movement towards or away is performed as a function of the pressure exerted on the guide surface of the movable deflector element by the mixture output from the respective opening.

[0034] In a preferred embodiment, the means for varying the second direction comprise a joint, by which a first end of the guide surface of the movable deflector is connected to the output surface; a second end of the guide surface, located at the end opposite the connected end, is free to move.

[0035] The joint, which may be embodied, for example, by a hinge, allows the deflector element to rotate by effect of the pressure exerted on the guide surface by the mixture flowing out of the opening below: that way, the free end moves away from the second surface and allows the guide surface of the movable deflector element to be oriented in such a way as to direct the mixture in at least one second direction which forms with the axis of propagation of the mixture, a second angle that is variable as a function of the pressure of the mixture.

[0036] The distributor device according to the invention is therefore characterized in that the distribution element comprises a fixed deflector element, whose guide surface is oriented in such a way as to direct a part of the flow of mixture in a first fixed direction, defined by the azimuth angle of the opening near which the guide surface is located, and by the first fixed angle of deflection. The distributor according to the invention also has a second movable deflector element, which directs a part of the mixture in a second direction and is free to rotate about a joint by effect of the pressure of the mixture flowing through the opening proximate to the movable element, in such a way that the total cross section of the distributor through which the mixture can flow changes as a function of the pressure of the mixture. Since all the deflectors direct the mixture output from the respective openings in directions that differ at least in azimuth orientation, the second direction in which the movable deflector directs the mixture is always different from the first direction in which the mixture is deflected by the first fixed deflector. The second direction is also variable because the angle of deflection that this direction forms with the axis of propagation of the mixture is adjustable as a function of the pressure of the mixture.

[0037] When the fixed deflector is oriented in a first direction, a part of the mixture flowing through the distributor device may be conveyed towards a well-delimited region of the space, distinct from the region in which the rest of the flow is directed and distributed. Using a distributor comprising a fixed deflector oriented in this way in combination with a sensor for detecting the ionisation of the flame produced by the combustion of the mixture makes it possible, by suitably positioning the sensor, to obtain an ionisation signal of high intensity under any working conditions.

[0038] Thanks to the movable deflector element, whose extent of opening (that is, of displacement from the output surface) is determined by the pressure of the mixture, which is in turn determined by the rpm of the fan, the distributor according to the invention can automatically regulate the mixture flow as a function of the operating regime of the fan and can reduce the total load losses, compared to a distributor with a fixed cross section. In other words, the movable deflector element thus configured ensures auto-regulated mixture distribution inside the burner based on the flow that strikes the movable element.

[0039] This technical effect is obtained by hinging the deflector element to the output surface of the distribution element by means of a joint which allows rotating the movable deflector above the opening proximate to it. In the absence of mixture or for values of mixture flow below a threshold value, the weight of the movable deflector (that is, its weight force) causes the movable deflector to close the opening; as the flow of the mixture increases as a function of the operating regime of the fan, the pressure exerted by the mixture output from the opening below progressively increases until exceeding the weight

force of the movable deflector, thus causing the movable deflector to turn about the joint by which it is hinged to the distribution element. As a result, the movable deflector is displaced from the opening, the extent of opening or of displacement being a function of the pressure of the mixture, and adopts a position and orientation which are variable as a function of that pressure. The movable deflector of the distributor according to the invention is thus able to modify the flow cross section of the distributor through which the mixture is free to pass as a function of the input flow of the mixture.

[0040] These and other features will become more apparent from the following detailed description of some preferred embodiments, illustrated by way of non-limiting example in the accompanying drawings, in which:

- Figure 1A shows a perspective view of a distributor element according to a first embodiment of the invention, in a first operating condition of the distributor;
- Figure 1B shows a plan view of the distributor element of Figure 1A;
- Figure 1C shows a perspective view of the distributor element according to the first embodiment, in a second operating condition;
- Figure 1D shows a plan view of the distributor element of Figure 1C;
- Figure 2A shows a burner comprising the distributor element according to the first embodiment, in the first operating condition;
- Figure 2B shows a burner comprising the distributor element according to the first embodiment, in the second operating condition;
- Figure 3A shows a perspective view of a distributor element according to a further embodiment of the invention, in a first operating condition;
- Figure 3B shows a plan view of the distributor element of Figure 3A;
- Figure 3C shows a perspective view of the distributor element according to the further embodiment, in a second operating condition;
- Figure 3D shows a plan view of the distributor element of Figure 3C;
- Figure 4A shows a burner comprising the distributor element according to the further embodiment, in a first operating condition;
- Figure 4B shows a burner comprising the distributor element according to the further embodiment, in a second operating condition;
- Figure 5 is a graph showing the trend of the ionisation signal as a function of the thermal flow for a burner according to the invention provided with a distributor according to the first embodiment shown in Figure 1A (bold solid line) and according to the further embodiment shown in Figure 3A (thin solid line), as well as the ionisation signal for a burner provided with a distributor according to patent EP 2 037 175 B1 (dashed line) for low thermal flow values;

- Figure 6 is a graph showing the trend of the ionisation signal as a function of the thermal flow over the full operating range for a burner according to the first configuration of the invention shown in Figure 1A (bold solid line) and for a burner according to patent EP 2 037 175 B1 (dashed line);
- Figure 7 is a graph showing the trend of the thermal flow as a function of the fan rpm at high thermal flows for a burner provided with a distributor according to the second embodiment, shown in Figure 3A (thin solid line) and for a burner according to patent EP 2 037 175 B1 (dashed line);
- Figure 8 is a graph showing the trend of the ionisation signal as a function of the thermal flow for a burner provided with a distributor according to the first embodiment of Figure 1A (bold solid line) and for a burner according to patent EP 2 037 175 B1;
- Figure 9 is a graph showing the trend of the opening angle of the movable deflector element of a burner according to the invention as a function of the flow of the mixture.

[0041] Figures 1A and 1C show two perspective views of a distributor element according to a first embodiment of this invention in a first operating condition 100 and a second operating condition 200, respectively, discussed in detail below. Figures 1B and 1D illustrate the same distributor element as Figures 1A and 1C in plan views, in the first operating condition 100 and in the second operating condition 200, respectively.

[0042] The distributor, denoted by the numeral 1, comprises a distribution element, which is substantially flat and circular in shape, denoted by the numeral 3. The distribution element 3 has a first surface or input surface Si, for receiving a mixture M, preferably gas and air, and a second surface or output surface Su to allow the mixture to be output and then input into a burner coupled with the distribution element. Generally speaking, the mixture M is composed of a fuel and an oxidant.

[0043] Figure 2A illustrates the burner, denoted by the reference numeral 2 and preferably of the premix type, coupled to the distributor 1 by a fixing flange 4 provided with holes for the fastening screws; Figure 2A relates to the first operating condition 100. Figure 2B illustrates the same burner 2 in combination with the distributor 1 in the second operating condition 200. In the example of Figures 1A-1D, the flange is 1 mm thick; the distribution element 3, including the flange 4, is 140 mm in diameter; the circular region without the flange is 69.15 mm in diameter.

[0044] In the example illustrated, the distribution element 3 has a centrally symmetrical geometrical shape about an axis A passing through its centre O and along which the mixture propagates. The shape of the distribution element 3 may be different: for example, the distribution element 3 may have a polygonal shape - hexagonal or octagonal, for instance - instead of circular. The invention is not, however, limited to the use of centrally

symmetrical distribution elements: in other words, shape symmetry is not essential for achieving the technical effects of the invention. It is also evident that propagation of the mixture, although it occurs predominantly along the axis A, is not limited exclusively to that direction because, on account of fluid dynamic turbulences which inevitably arise during operation of the burner, the flow of the mixture is not strictly rectilinear along the direction of the axis A.

[0045] In the embodiment illustrated, the distributor 1 is provided with two openings, labelled 32 and 33 in Figures 1A-1D and distributed around the axis of propagation A passing through the centre O of the distribution element 3. As may be seen in the plan view of Figure 1D, the opening 33 has, in the example, the shape of a semicircle and extends on one half of the output surface Su; the opening 32 has an elongate shape and extends on the other half of the output surface Su between the centre O and the peripheral region in which the fixing flange 4 is located.

[0046] The openings 32 and 33 allow the mixture M of air and gas to flow through the distribution element 3 from the input surface Si to the output surface Su, thus ensuring that the mixture M is input into the burner (as illustrated in Figures 2A and 2B, where the burner is labelled 2).

[0047] The distributor also comprises deflector elements 42 and 43 disposed on the output surface Su, in proximity to the respective openings 32 and 33 around the axis of propagation A of the distributor itself. This axis, in the complete burner illustrated in Figures 2A and 2B, coincides with the longitudinal axis of the burner.

[0048] The function of the deflector elements 42 and 43 is to direct the flow of mixture M flowing out of the openings 32 and 33 below in a first and a second direction: for this purpose, the deflectors 42 and 43 each have a surface that is shaped in such a way as to guide the flow of mixture. These surfaces are labelled 52 and 53 and are hereinafter called "guide surfaces".

[0049] The guide surface 52 of the first deflector element 42 extends above the opening 32 and has a progressively increasing height in the radial direction: that is, in the direction from the central point O to the periphery of the distributor. In the embodiment illustrated in Figures 1A-1D and 2A-2B, the guide surface 52 is formed by two vertical walls, approximately triangular in shape, and a vaulted surface which surmounts the two walls and forms a channel therewith. This channel is connected to the output surface Su at a first end of the guide surface 52 coinciding with the central point O, and is open at a second end, directed towards the flange 4. The mixture M flowing through the opening 32 below is confined by the walls and vault and is guided from the first to the second end of the guide surface 52. The shape of the guide surface 52 may be different from that illustrated in the drawings, provided always that it is able to channel and direct the mixture according to what is set out above: for example, the guide may be formed by two panels joined to

form a cusp.

[0050] The direction in which the mixture is directed by the guide surface 52 of the first deflector element 42 is determined by the orientation of the surface relative to the axis of propagation A, or equivalently, relative to the output surface Su. The guide surface 52 of the first deflector element 42 is configured in such a way as to permanently direct the mixture output flowing in a first direction D1 which forms with the axis of symmetry A a first angle, hereinafter denoted by the reference label $\beta 1$. The direction D1 also forms an azimuth angle $\phi 1$ with the axis B, orthogonal to the axis A.

[0051] The angle $\beta 1$ which the direction D1 forms with the axis is hereinafter called "inclination angle"; the complementary angle, hereinafter called "angle of deflection", denotes the inclination of the guide surface relative to the output surface Su. In the embodiment illustrated in Figures 1A-1D and 2A-2B, the inclination angle of the guide surface 52 is equal to 43 degrees. Since this angle and the first direction D1 are fixed, the first deflector is hereinafter called first fixed deflector. As explained in more detail below, the function of the first fixed deflector is to permanently direct a part of the flow of mixture to a peripheral region of the burner in which an ionisation sensor 6 is located, as illustrated in Figures 2A and 2B, in such a way as to ensure that an ionisation signal (associated with the flame produced by combustion of the mixture is sufficiently intense to be detected by the sensor 6 under any working conditions).

[0052] The deflector element 43 is also provided with a guide surface 53 which has a first and a second end. At its first end, the guide surface 53 is connected to the output surface Su of the distribution element 3 by a joint 43a, embodied preferably in the form of a hinge; the second end of the surface 53 is positioned opposite the first end and is free: that is to say, it is not connected to the surface Su. In the embodiment illustrated in Figures 1A-1D, 2A and 2B, the guide surface 53 of the deflector 43 has the shape of a half dome; the second end of the guide surface 53 is located above the output surface Su at a height h of 23.45 mm, measured from the surface Si. In the operating condition illustrated in Figures 1A and 1B, in which the deflector 43 closes the opening 33 below it, the guide surface 53, under the weight of the deflector 43, rests with its second end on a vertical dividing wall 50 passing through the centre O of the distribution element 3. In this first condition, denoted by the numeral 100 in the drawings, the dividing wall 50 and the guide surface 53 of the deflector 43 prevent the passage of the mixture through the opening 33.

[0053] The shape of the guide surface 53 may be different from that of a half dome, provided that this surface, in the condition where it rests on the dividing wall 50, always prevents the passage of the mixture in the first operating condition 100: for example, the guide surface 53 might be formed by two panels joined along a common edge to form a cusp; in such a case, the dividing wall 50 would have a triangular shape.

[0054] Thanks to the joint 43a, the guide surface 53 of the deflector element 43 is able to rotate about the joint itself by effect of the pressure exerted by the mixture M on the guide surface. When the pressure reaches a pre-determined threshold level PS, the second end of the guide surface 53 is displaced from the dividing wall 50 and moves away from the output surface Su. The angle of rotation of the guide surface 52 and, accordingly, the extent of displacement of the second end are variable and, generally speaking, depend on the pressure of the mixture: consequently, the second direction D2 in which the guide surface 52 will direct the mixture output from the opening 33 is also variable. For this reason, the deflector element 43 is hereinafter called "movable deflector element" or, more simply, "movable deflector". It is evident that the variation in the orientation of the guide surface 53 results in a variation in the cross-section size of the distribution device through which the mixture passes.

[0055] The movable deflector element 43 is made preferably of aluminised steel; in the example of Figures 1A-1D and 2A-2B, the deflector weighs approximately 6.1 grams. The material used in the embodiments of Figures 1A-1D and 2A-2(D) is purely exemplary: for the purposes of the invention, materials other than aluminised steel can be used. The value of the weight force acting on the deflector defines the pressure threshold value Ps above which the movable deflector 43 moves away from the dividing wall 50 and allows the passage of the mixture in a variable direction D2 dependent on the pressure of the mixture: it is therefore evident that the weight of the deflector (6.1 grams) used in the embodiments is purely exemplary and may be varied as a function of the pressure threshold value required. It is also possible to control the threshold value Ps by constraining the movable deflector to the output surface Su by means of a spring or a magnetic field; for constructional simplicity and to reduce costs, however, it is preferable to adjust this threshold only by acting on the weight of the movable deflector.

[0056] In the second operating condition, illustrated in Figure 1C and denoted by the numeral 200, the pressure exerted by the mixture output from the opening 33 is greater than the weight force acting on the movable deflector 43: the action of the pressure causes the guide surface 53 to rotate about the joint 43a, thereby lifting its second end. In the example of Figure 1C, the pressure of the mixture is considerably higher than the weight force acting on the movable deflector element 43 and so the latter is in a substantially vertical position - that is to say, in the direction of the axis of symmetry (and of propagation of the mixture) A. In the operating condition 200 illustrated in Figure 1C, the mixture flows out of the opening 33 substantially undisturbed and proceeds in axial direction; in this condition, the movable deflector 43 confines the flow of the mixture in the axial direction and prevents flow in the radial direction: thus, in the operating condition 200, the deflection direction D3 forms a substantially null inclination angle with the axis A (in equiv-

alent manner, the deflection angle formed by the movable deflector 43 with the output surface Su is substantially equal to 90 degrees). In the operating condition 200 illustrated in Figure 1C, the flow of mixture in the distributor 1 is at its maximum, because it is not obstructed by the guide surface 53 of the movable deflector 43.

[0057] It is evident that the output surface Su of the distribution element 3 and the joint 43a connected to the output surface constrain and limit the rotational movement of the movable deflector 43 to remain within a finite angular interval: the position illustrated in Figure 1C is the position of maximum rotation of the deflector.

[0058] On the other hand, in the first operating condition, illustrated in Figure 1A and denoted by the numeral 100, the movable deflector element 43 is, as also mentioned previously, resting on the upper edge of the dividing wall 50 and prevents the passage of the mixture. In the operating condition 100, the movable deflector element 43 deflects the mixture in a direction substantially orthogonal to the direction of the axis A and parallel to the output surface Su (inclination angle equal to 90 degrees and deflection angle equal to 0 degrees), thus preventing the passage of the mixture. In the operating condition 100, the flow of mixture is at its minimum.

[0059] Figure 9 illustrates the opening angle (in degrees) of the movable deflector element 43 as a function of the flow of the mixture (measured in m³/h) when the weight is 6.1 grams (thin-line curve) and when the deflector is made heavier (weight equal to 8.1 grams; bold-line curve); the opening angle corresponds to the angle of deflection defined above. As shown in the graph, the movable element 43 of the distributor 1 illustrated in Figures 1A-1D is substantially closed (that is, it has an opening angle near zero) for values of mixture flow less than 10 m³/h: in the case of the deflector weighing 6.1 g, the angle is 4 degrees for a flow of approximately 5 m³/h; whilst in the case of the heavier deflector, the opening angle is reduced to 2 degrees. The region around 5 m³/h corresponds to the first operating condition 100 discussed above. The value of mixture flow below which the movable deflector element 43 remains closed depends on the weight of the deflector and the material it is made of and is thus not limited to the abovementioned value of 10 m³/h.

[0060] Figure 9 shows that for values of mixture flow of 80 m³/h, the opening angle (that is, the angle of deflection) reaches the value of 40 degrees for the movable deflector weighing 8.1 g and the value of 46 degrees for the movable deflector weighing 6.1 g.

[0061] Figure 9 also shows that the opening angle varies in the flow range illustrated and, generally speaking, increases as a function of the flow: in other words, the movable deflector 43 may adopt in sequence a series of positions where it is increasingly more open (that is, where the opening angle increases). The movable deflector 43 thus has a guide surface 53 that is variably and continuously orientable relative to the direction of the axis A or, equivalently, relative to the output surface Su, as a

function of the mixture flow and, for each orientation, the guide surface 53 directs the mixture M in a variable direction D2. Each opening angle is associated with a different second direction D2 in which the mixture M is deflected.

[0062] Figures 1A-1D and 2A-2B illustrate the embodiment with a fixed deflector element 42, a movable deflector element 43 and respective openings 32 and 33. The distributor device according to this invention can, however, be provided with a larger number of fixed deflector elements: more specifically, the distribution element 3 may comprise one or more second fixed distribution elements, whose function is to regulate the fluid dynamic distribution of the mixture M output from the distributor.

[0063] In the embodiment of Figures 3A-3D and 4A-4B, an example of a second fixed deflector element, labelled 41, is illustrated. The second deflector element 41 has a generally tapered shape, with a first, narrow end connected to the output surface Su at the centre O of the distribution element 3 and a second, wide end proximate to the periphery of the distributor. The second end is located at a non-null height above the second surface Su.

[0064] As clearly shown in Figures 3A and 3C, the second fixed deflector 41 progressively increases in width and in height in the radial direction, that is to say, in the direction from the centre O towards the periphery of the distributor, above the respective opening 31. The second fixed deflector 41 has a guide surface 51 which is oriented in such a way as to permanently direct the mixture M output from the opening below it 31 in a third direction D3 which forms with the axis of symmetry A a fixed, non-null third angle β_3 , different from the first angle β_1 of the first fixed deflector 42: in the embodiment illustrated in Figures 3A-3D, 4A and 4B, the inclination angle β_3 of the second fixed deflector 41 is 61 degrees (corresponding to an angle of 29 degrees with the surface Su), whilst the inclination angle β_1 of the fixed deflector 42 is 37.5 degrees (corresponding to an angle of 52.5 degrees with the surface Su); it is understood that these values are purely illustrative and can be varied. The direction D3 also forms an azimuth angle ϕ_3 with the axis B orthogonal to the axis of symmetry (and of propagation of the mixture) A.

[0065] The second deflector 41 separates and directs a part of the flow of mixture M to a peripheral region different from that to which the first fixed deflector 42 directs the mixture output from the opening 32: this allows controlling and regulating the fluid dynamic distribution of the mixture output from the distributor without interfering with the formation of a flow of mixture intended for generating an ionisation signal. The further embodiment of the distributor, illustrated in Figures 3A-3D and 4A-4B is able to regulate the level of the ionisation signal and the fluid dynamic distribution of the mixture independently of each other.

[0066] The number of second fixed deflectors is not limited to one, as in the embodiment illustrated in Figures

3A-3D and 4A-4B: it is possible, for example, to use a number of second deflectors greater than or equal to two, especially if the spatial distribution of the mixture inside the burner needs to be controlled more precisely and gradually. In such a case, the guide surface 53 of the movable deflector element 43 and the opening 33 below it occupy a more limited region of the distribution element 3 to allow more second fixed deflectors to be fitted. If there are more second fixed deflectors like the fixed deflector 41 illustrated, they are oriented according to a common inclination angle relative to the axis of symmetry A and have identically shaped guide surfaces; the common inclination angle β_3 of such second fixed deflectors is always different from the inclination angle of the first fixed deflector element 42. The common inclination angle may be, for example, 61 degrees, as in the embodiment illustrated in Figures 3A-3D, 4A and 4B.

[0067] The fluid dynamic distribution obtainable with the second deflector elements can be controlled by acting on the common inclination angle β_3 , on the common height of the second end of the guide surfaces and/or on the shape of these surfaces; the three parameters (angle β_3 , height and shape of the surface 51) are adjustable individually and independently of each other. The common inclination angle may be, for example, 61 degrees, as in the case of the single deflector discussed above. The surface may, for example, be flat and in the shape of a circular sector, as in the case of the deflector 41 in Figures 3A-3D and 4A-4B; alternatively, the surface of the first deflectors 41 may be concave, with concavity facing the output surface Su below.

[0068] It is, however, preferable for the guide surface 51 of the second fixed deflectors 41 to be less directive than the guide surface 52 of the first fixed deflector 42, so that the output flow from the latter is separate and spatially distinct from the output flow from the second fixed deflectors 41. For example, the guide surface 51 of the second fixed deflector 41 is preferably flat, whilst the first fixed deflector 42 has a preferably concave shape. The concavity of the guide surface 52 of the first fixed deflector 42 faces down, that is, towards the opening below, so as to create a channel capable of spatially concentrating and directing the mixture flowing under the surface.

[0069] In the embodiment of Figures 3A-3D and 4A-4B, the first deflector element 42 is characterized by a concave guide surface 52 having the shape of a cusp - that is, an upturned V shape - consisting of two inclined panels joined along a common edge in such a way as to form a guide or channel. In the embodiment of Figures 1A-1D and 2A-2B, on the other hand, the first deflector element 42 has a guide surface 52 that is shaped like a tunnel of 23.45 mm height (measured from the output surface Su) and 7.5 mm inside width. These values are purely exemplary and may be varied without departing from the invention.

[0070] Generally speaking, the choice of the shape of the guide surface 52 of the first fixed deflector 42 and the

height of the second end of that surface (measured from the output surface S_u) allow controlling the intensity of the detectable ionisation signal: in particular, these parameters allow ensuring that the ionisation signal remains above a minimum level in the range of thermal flows required of the burner. The minimum level that the ionisation signal must reach generally depends on the sensitivity of the components making up the electronic control circuit which regulates the operation of the burner. By way of example, the minimum level required by some electronic components commonly available on the market is at least 10 μ A.

[0071] Figures 2A-2B and 4A-4B illustrate two burners equipped with a distributor according to the two embodiments of the invention discussed above and provided with an ionisation sensor 6. The sensor shown in the drawings is an electrode 6 of elongate shape, placed at a position opposite and proximate to the point of the burner wall to which the fixed deflector element 42 directs the mixture.

[0072] The control circuit receives as input the ionisation signal (typically in the form of a current) detected by the sensor and generates an output control signal. This signal is sent to an actuator (a valve, for example) which controls the supply of fuel and/or oxidant (typically gas and air); the actuator regulates the quantity of fuel and/or oxidant based on the control signal received.

[0073] Figure 5 illustrates the advantages obtainable with this invention in terms of intensity of the ionisation signal in the region of low thermal flows (between 2 kW and 6 kW, approximately). The graph shows the trend of the ionisation current I_0 as a function of the thermal flow Q (in kW) for a burner provided with a conventional distributor according to patent EP 2 037 175 B1 (dashed line), for a burner provided with a distributor according to the first embodiment of Figure 1A (bold-line curve) and for a burner provided with a distributor according to the embodiment of Figure 3A (thin-line curve).

[0074] Figure 5, as mentioned above, shows the ionisation signal for low thermal flows (between 2 kW and 6 kW); Figure 6 shows the trend of the signal over the full operating range, between 1.5 kW and 24 kW, for the burner according to the invention (solid-line curve) and between 2.2 kW and 23 kW for a conventional burner (dashed line). Looking more closely at Figure 5, it is first of all evident that an ionisation signal I_0 of given intensity is obtainable for a low thermal flow and thus, under equal ionisation signal conditions, it is possible to modulate the thermal power down to lower values (1.7 kW and 2.6 kW, respectively) compared to those obtainable with a conventional distributor (2.9 kW). The same conclusion can be drawn from an examination of the trend of the ionisation signal over the full range of thermal flows, illustrated in Figure 6. It is also evident from Figure 5 that at least the burner provided with a distributor according to the first embodiment of Figure 1A (bold-line curve) is able to provide an ionisation signal even for thermal flows under 2 kW, unlike the burner provided with a conventional dis-

tributor, where the ionisation signal is already very weak with thermal flows under 3 kW.

[0075] Figure 7 illustrates the advantages obtainable with this invention in terms of thermal flow. The graph shows the thermal power Q (in kW) as a function of the rpm of the air fan, obtainable with a burner provided with a distributor according to the second embodiment of Figure 3A (solid-line curve) and with a burner according to the aforementioned patent EP 2 037 175 B1 (dashed-line curve). Figure 7 shows that under equal conditions of fan operating regime (that is, the fan rpm being equal) at high thermal flows, a burner provided with a distributor according to the invention (solid-line curve) allows obtaining a higher thermal power than the prior art (represented by the burner according to patent EP 2 037 175 B1), thanks to the fact that the movable deflector element is able to reduce the load losses.

[0076] Lastly, Figure 8 illustrates the advantages obtainable with this invention in terms of modulation ratio.

The graph shows the thermal power Q (expressed in kW) as a function of the rpm of the fan for a burner provided with a distributor according to the embodiment of Figure 1A (solid-line curve) and for a burner according to the prior art (EP 2 037 175 B1; dashed-line curve). The burner according to the invention allows modulating the thermal power over a significantly wider range than a burner provided with a conventional distributor, thus making it possible to obtain decidedly higher modulation ratios: as may be appreciated from Figure 8, for rpm between 1000 and 5200, the burner according to the invention is capable of modulating the power between 1.5 kW and 24 kW, that is, with a modulation ratio of 1:16; in the same operating range, the conventional burner guarantees a modulation of between 3 kW and 23 kW, that is, a ratio of 1:8.

[0077] With reference to Figures 5, 7 and 8, it is evident that the invention allows obtaining significant improvements over the prior art in terms of sensitivity to the ionisation signal, in terms of thermal flow obtainable under equal conditions of fan operating regime and in terms of modulation ratios.

Claims

1. A variable cross-section distributor device (1) for inputting a mixture (M) of fuel and oxidant into a premix burner (2), wherein the distributor device (1) comprises a distribution element (3) having an axis (A) of propagation of the mixture (M) and is provided with a first surface (S_i) for inputting the mixture (M) into the distribution element (3) and with a second surface (S_u) for outputting the mixture (M) from the distribution element (3), wherein the first and the second surface (S_i , S_u) are located opposite each other along the axis (A) of propagation such that said axis (A) is normal to both surfaces (S_i , S_u) at the respective points where

said axis (A) of propagation crosses said surfaces (Si, Su),

wherein the distribution element (3) comprises a plurality of openings (31, 32, 33) putting the first surface (Si) into communication with the second surface (Su) so as to allow the passage of the mixture (M) through the distribution element (3), the openings (31, 32, 33) being mutually separated and distributed angularly about the axis (A) of propagation in such a way that the position of each opening on the second surface (Su) is defined uniquely by a respective azimuth angle (φ_1 , φ_2 , φ_3), measured relative to a second axis (B) perpendicular to the axis (A) of propagation of the mixture (M),

the distribution element (3) further comprising deflector elements (41, 42, 43) distributed on the second surface (Su), each of said deflector elements being located proximate to a respective opening (31, 32, 33) and provided with a guide surface (51, 52, 53) positioned above the respective opening (31, 32, 33) and configured so as to be able to direct the mixture (M) output from the second surface (Su) in at least one deflection direction (D1, D2, D3), wherein the at least one deflection direction (D1, D2, D3) forms the same azimuth angle (φ_1 , φ_2 , φ_3) with the above-mentioned second axis (B) as the respective opening (31, 32, 33), and wherein the deflection direction (D1, D2, D3) furthermore forms a deflection angle (β_1 , β_2 , β_3) with the axis (A) of propagation, the distributor device being **characterised in that** the deflector elements (41, 42, 43) comprise:

a first fixed deflector element (42) the guide surface (52) of which is oriented in such a way as to direct the mixture in a first fixed direction (D1) forming a fixed, non-null first angle (β_1) with the axis (A) of propagation;

a movable deflector element (43) the guide surface (53) of which is oriented in such a way as to direct the mixture in at least one second direction (D2) which is variable and different from the first direction (D1) and wherein said guide surface (53) is provided with means for varying the second direction (D2), said means being configured to allow a relative displacement of the guide surface (53) away from or towards the second surface (Su), the relative displacement being a function of the pressure (P) exerted on the guide surface (53) of the movable deflector element (43) by the mixture (M) output from the respective opening (33).

2. The distributor device (1) according to claim 1, wherein the first and the second surface (Si, Su) have a centrally symmetrical geometrical shape about the axis (A) of propagation.

3. The distributor device (1) according to any of the

preceding claims, wherein the movable deflector element (43) is configured in such a way that its guide surface (53), for a first value (P1) of the pressure (P) of the mixture (M) output from the respective opening (33) being smaller than a predetermined threshold value (PS), takes on a first position (100) in which the movable deflector element (43) closes the respective opening (33) proximate to which it is located, so as to prevent the output of the mixture (M), and in which distributor device (1) the movable deflector element (43) is further configured in such a way that its guide surface (53), for at least one second value (P2) of the pressure (P) of the mixture (M) output from the respective opening (33) being equal to or greater than the predetermined threshold value (PS), takes on at least one second position (200) in which the second end of the guide surface (53) is spaced from the above-mentioned opening (33) under the effect of the pressure (P2), so as to allow the output of the mixture (M) to the at least one second direction (D2).

4. The distributor device (1) according to any of the preceding claims, wherein the means for varying the second direction (D2) configured to allow a relative displacement of the guide surface (53) of the mobile deflector element (43) comprise a joint (60), and wherein the guide surface (53) has a first end connected to the second surface (Su) of the distribution element (3) by means of the joint (60) and a second free end opposite the first end, the joint (60) being configured in such a way as to allow a rotation of the movable deflector element (43) about the joint (60) under the effect of the pressure (P) exerted on the guide surface (53) of the movable deflector element (43) by the mixture (M) output from the respective opening (33), such that the second end can move away from the second surface (Su) and the guide surface (53) can be oriented so as to direct the mixture in the at least one second direction (D2), said second direction (D2) forming a second variable angle (β_2) with the axis (A) of propagation, the second variable angle (β_2) being variable as a function of the pressure (P).

5. The distributor device (1) according to claim 4, wherein the movable deflector element (43) is configured in such a way that its guide surface (53), for each of a plurality of second pressure values (P2, P3, ... Pn) of the mixture (M) output from the respective opening (33) that are progressively greater than the threshold value (PS) and not greater than a maximum pressure value (PM), takes on a plurality of respective second positions (2001, 2002, ... 200n) in which the second end of the movable deflector element is progressively spaced from the above-mentioned opening (33) under the effect of the pressure (P2, P3, ... Pn), so as to allow the output of the

- mixture (M) in a plurality of respective second directions (D31, D32, ... D3n) that are mutually different, each of the second directions (D31, D32, ... D3n) respectively forming a second angle (β_{31} , β_{32} , ... β_{3M}) with the axis (A) of propagation, the maximum pressure value (PM) being equal to the pressure (P) for which the respective second direction of deflection (D2) is parallel to the axis (A) of propagation.
6. The distributor device (1) according to claim 3 or claim 5, wherein the movable deflector element (43) has a mass (m) and the threshold value (PS) is equal to the weight force acting on the mass (m).
 7. The distributor (1) according to claim 6, wherein the guide surface (53) of the movable deflector element (43) is dome-shaped, the distributor (1) comprising a dividing wall (50) located on the second surface (Su) of the distribution element (3) at a position between the first fixed deflector element (42) and the movable deflector element (43) such that, for values of the pressure (P) of the mixture (M) smaller than the threshold value (PS) and under the effect of the weight force, the second end of the guide surface (52) is in contact with the dividing wall (50) thereby preventing the output of the mixture (M) from the opening (33) proximate to the movable deflector element (43).
 8. The distributor device (1) according to any of the preceding claims, wherein the guide surface (52) of the first fixed deflector element (42) is elongate in shape between a first end, connected to the second surface (Su) at the central point (O) of the distribution element (3), and a second end, positioned at a non-null height with respect to the second surface (Su), the height of the guide surface (52) increasing progressively from the first end to the second end.
 9. The distributor device (1) according to claim 8, wherein the width of the guide surface (52) of the first fixed deflector element (42) remains constant between the first end and the second end.
 10. The distributor device (1) according to claim 8, wherein the width of the guide surface (52) increases progressively from the first end to the second end.
 11. The distributor device (1) according to claim 10, wherein the guide surface (52) of the first fixed deflector element (42) is a flat surface.
 12. The distributor device (1) according to claim 9 or claim 10, wherein the guide surface (52) of the first fixed deflector element (42) is a concave surface the concavity of which is directed towards the second surface (Su) of the distribution element (3).
 13. The distributor (1) according to claim 12, wherein the concave surface consists of two panels that are mutually joined so as to form a cusp.
 14. The distributor device (1) according to claim 12, wherein the concave surface (52) consists of two parallel walls positioned on the second surface (Su) and a vault positioned on said walls in such a way as to form a channel with the walls, wherein the channel is closed at the first end and open at the second end.
 15. The distributor device (1) according to any of the preceding claims, wherein the movable deflector element (43) and the respective opening (33) extend on a half of the second surface (Su).
 16. The distributor device (1) according to any of the preceding claims, wherein the deflector elements (41, 42, 43) comprise at least one second fixed deflector element (41) the guide surface (51) of which is oriented in such a way as to direct the mixture in a third direction of deflection (D3) forming a fixed, non-null third angle (β_3) with the axis (A) of propagation.
 17. The distributor device (1) according to claim 16, wherein the third angle (β_3) is different from the first angle (β_1).
 18. The distributor device (1) according to claim 17, wherein the third angle (β_3) is smaller than the first angle (β_1).
 19. The distributor device (1) according to claim 16 or claim 18, wherein the guide surface (51) of the at least one second fixed deflector element (41) is a flat surface.
 20. The distributor device (1) according to any of the preceding claims, wherein the guide surface of the first fixed deflector element (42) and/or of the second fixed deflector element (41) have a plurality of holes.
 21. The distributor device (1) according to any of the preceding claims, wherein the distribution element (3) comprises a flange (4) for fixing the distributor device (1) to the burner (2), the flange (4) being located at the periphery of the distribution element (3) and being preferably formed as a single piece with the distribution element (3).
 22. A premix burner (2) comprising a distributor device (1) according to any of the preceding claims and an electrode (6) for detecting an ionisation signal (Io) produced by the combustion of the mixture (M) in the burner (2), the electrode (6) having a first end (69) located opposite the first fixed deflector element

(42).

- 23.** The premix burner (2) according to claim 20, comprising an electronic control circuit having at least one input arranged to receive the ionisation signal (Io) detected by the electrode (6) and at least one output, the electronic control circuit being further configured to generate a control signal as a function of the detected ionisation signal at the at least one output, the burner (2) further comprising an actuator configured to receive the control signal and to adjust the amount of fuel and/or oxidant to be input into the burner (2) as a function of the received control signal.

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FIG.1A

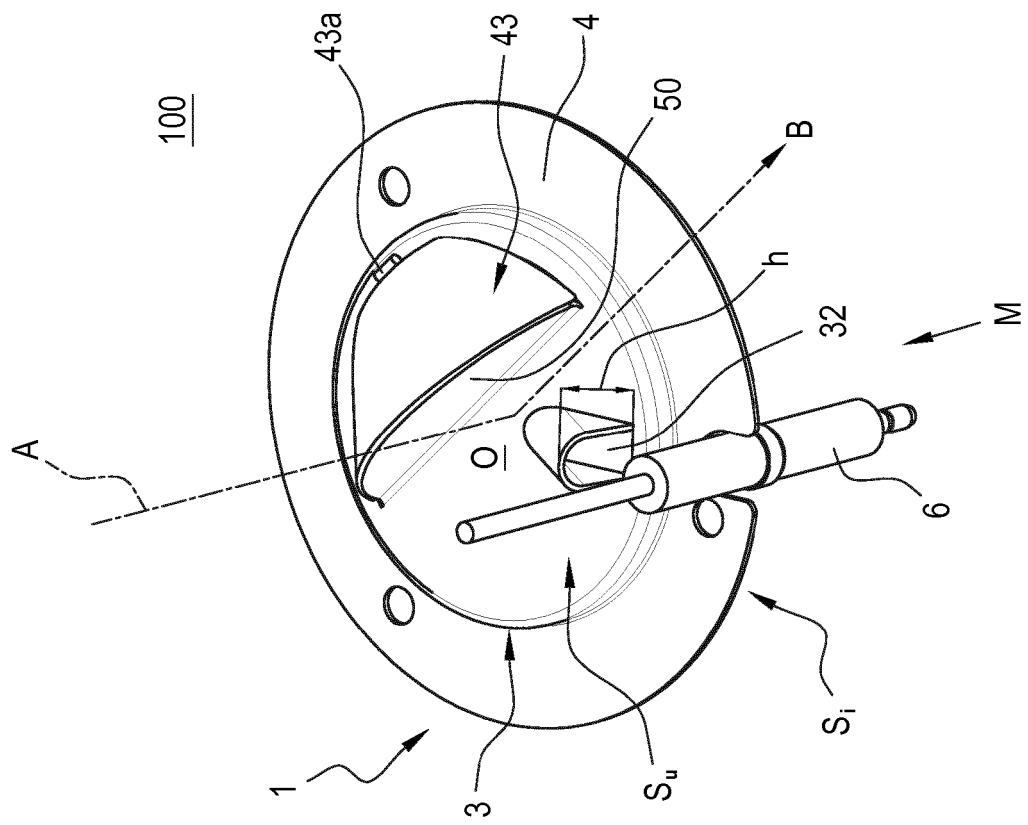


FIG.1B

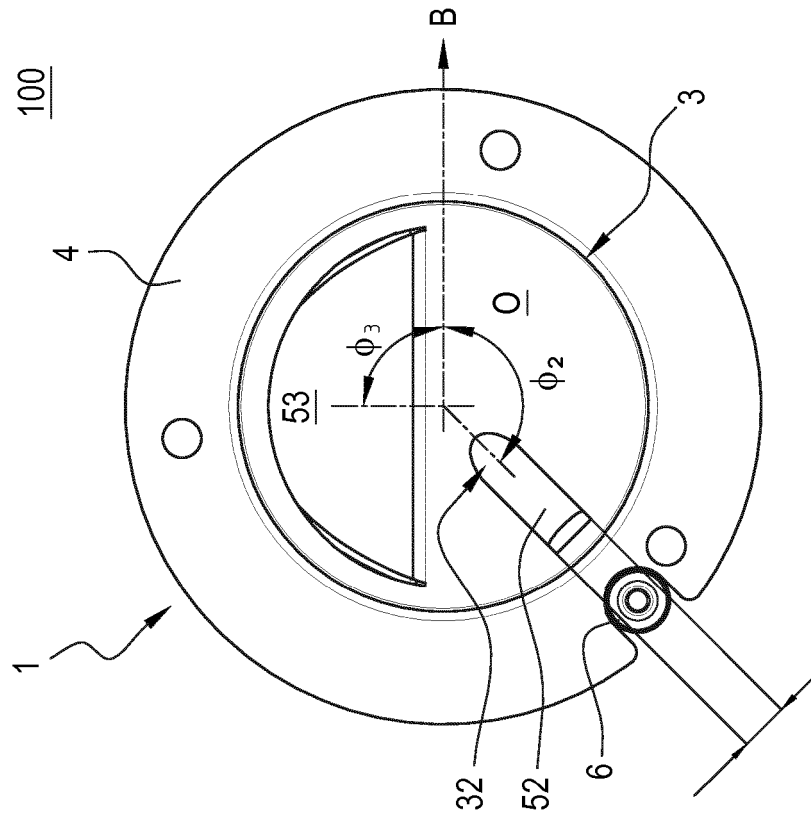


FIG.1D

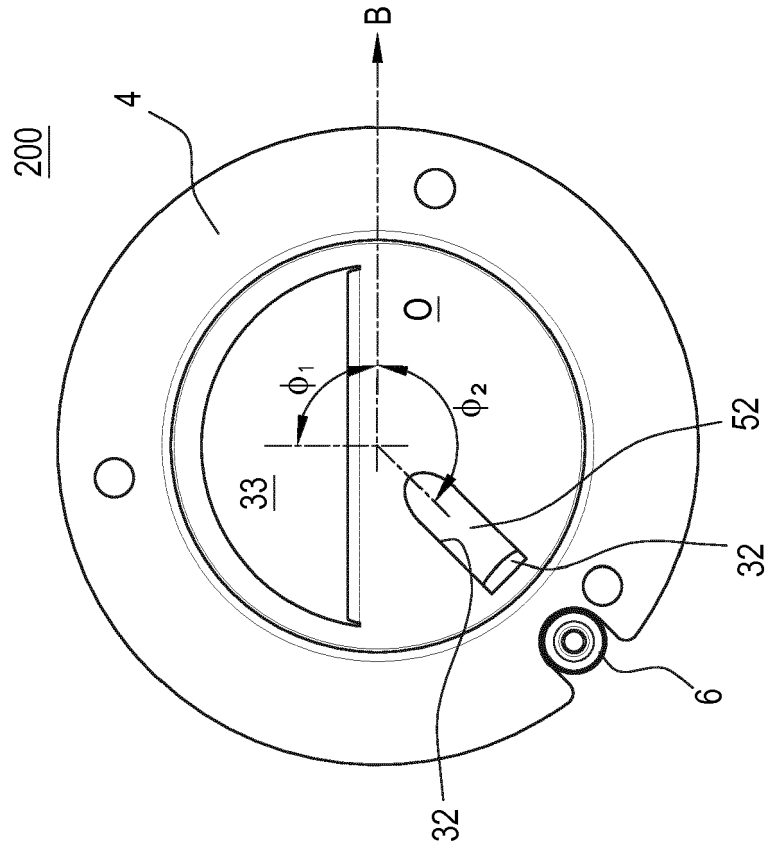


FIG.1C

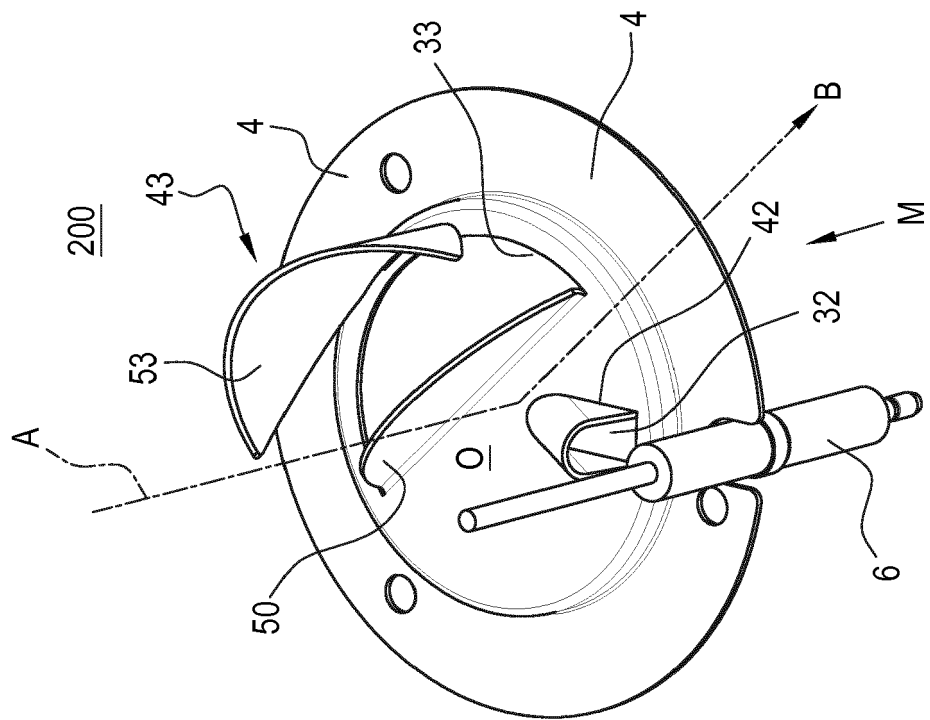


FIG. 3A

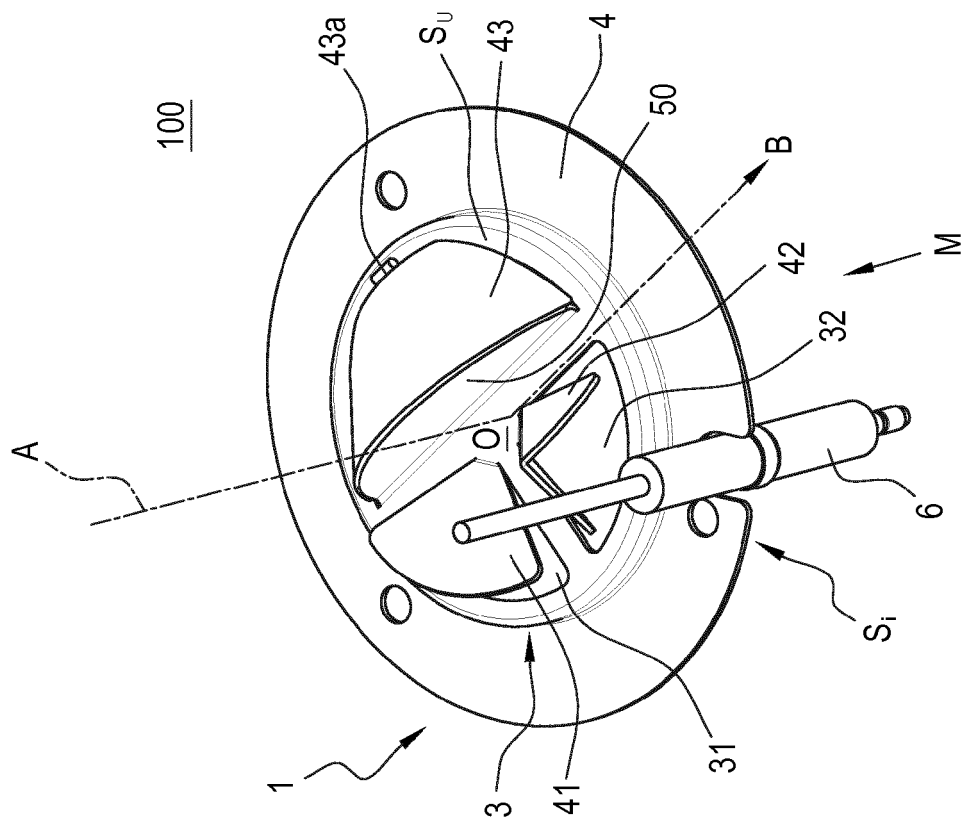


FIG. 3B

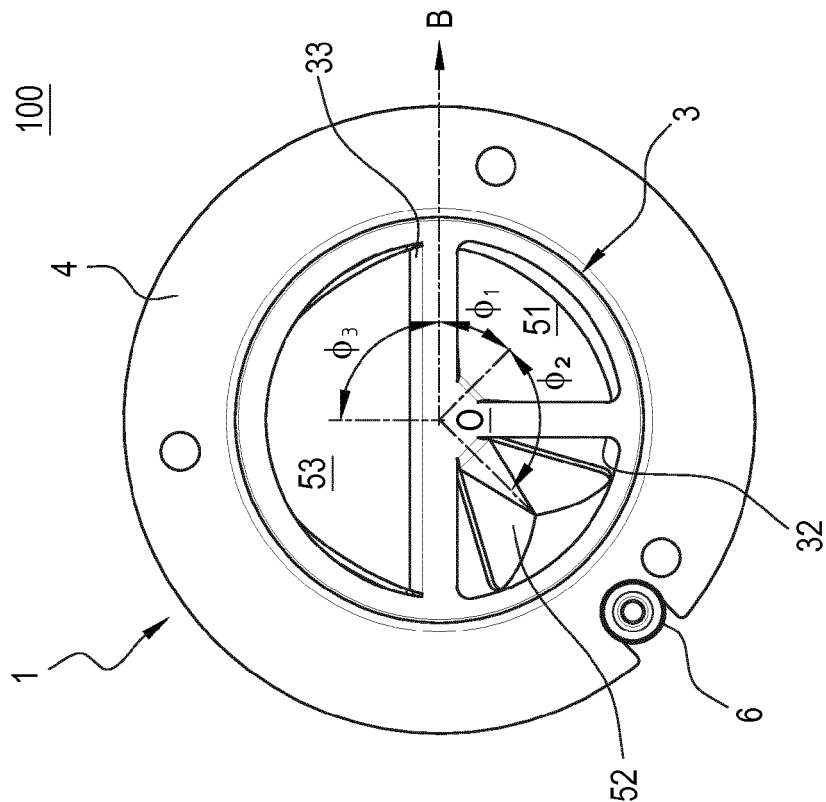


FIG. 3D

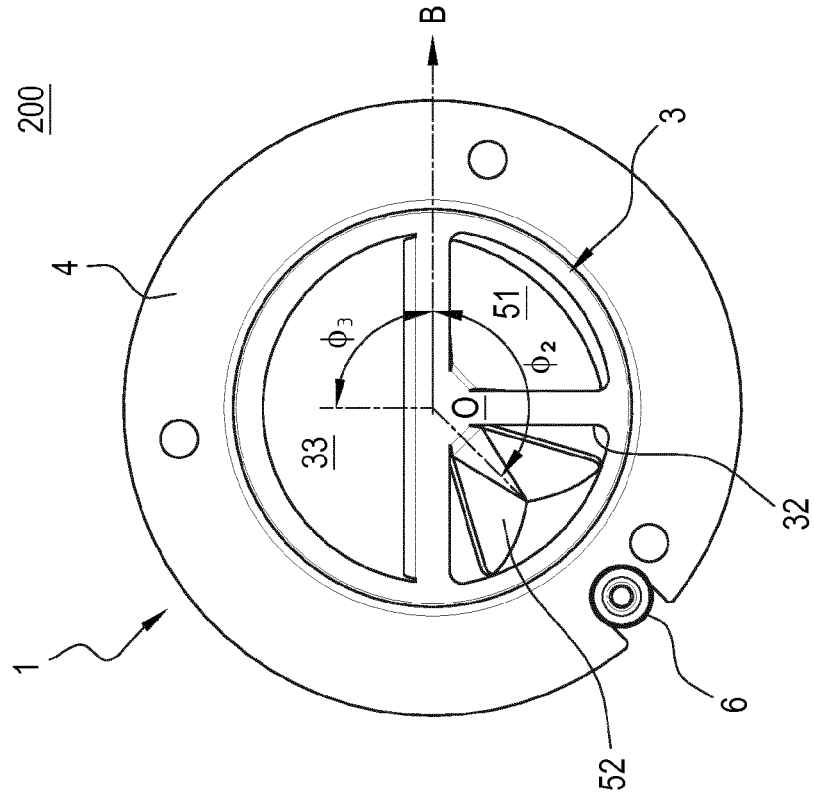


FIG. 3C

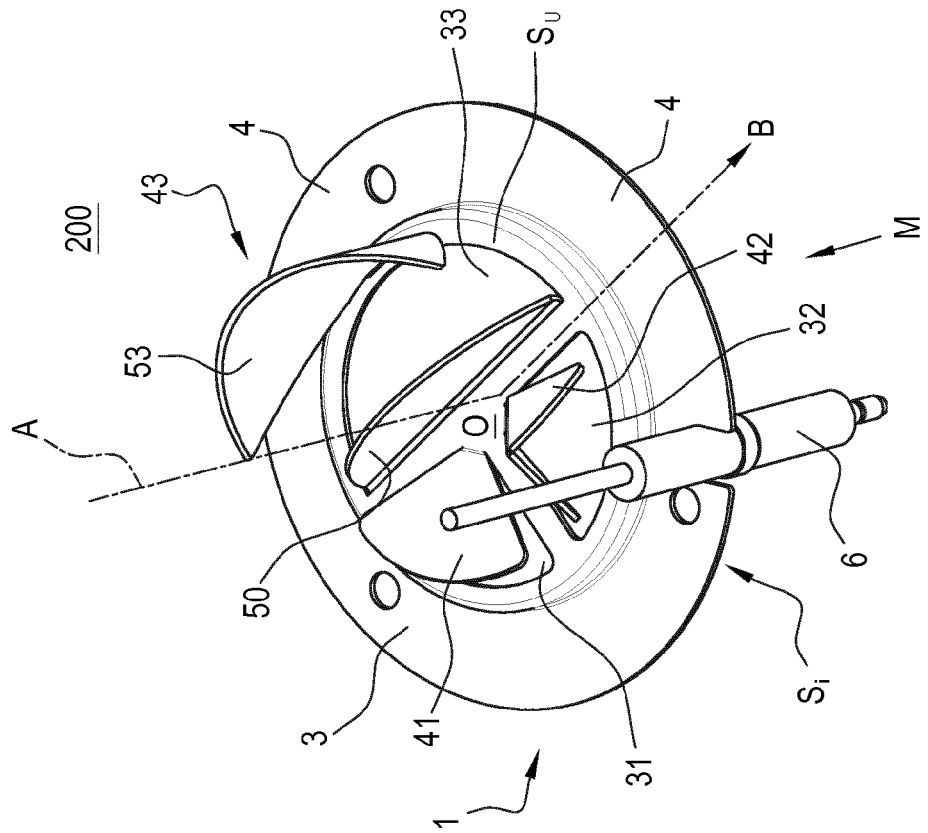


FIG. 4B

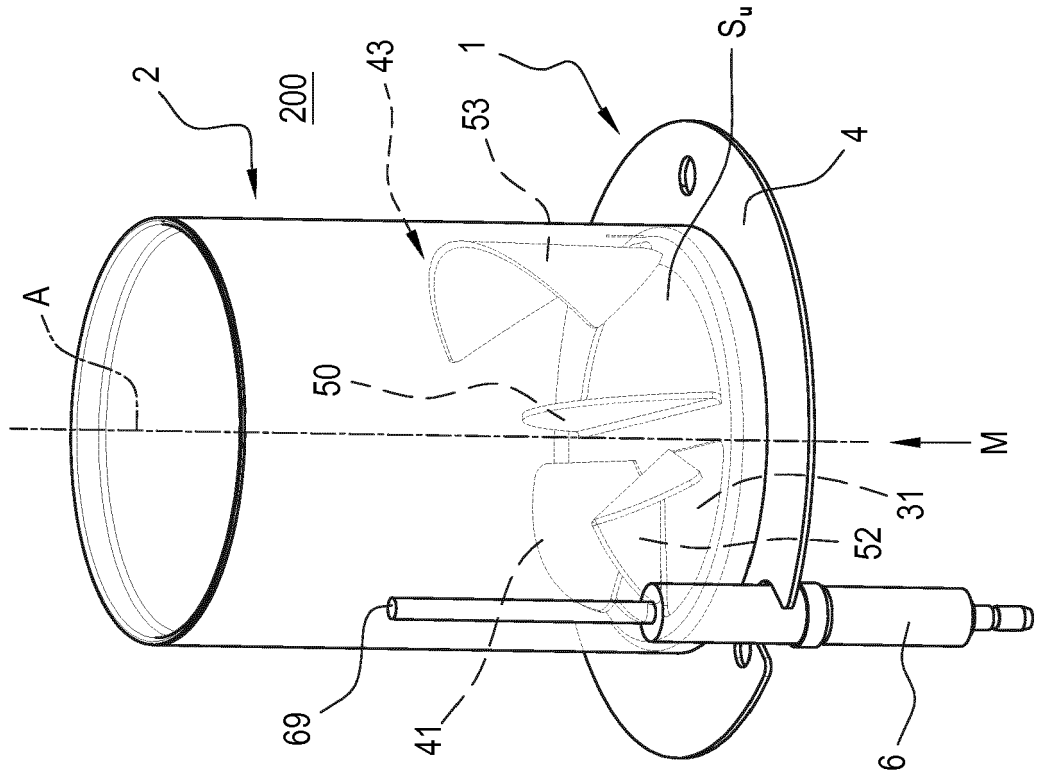


FIG. 4A

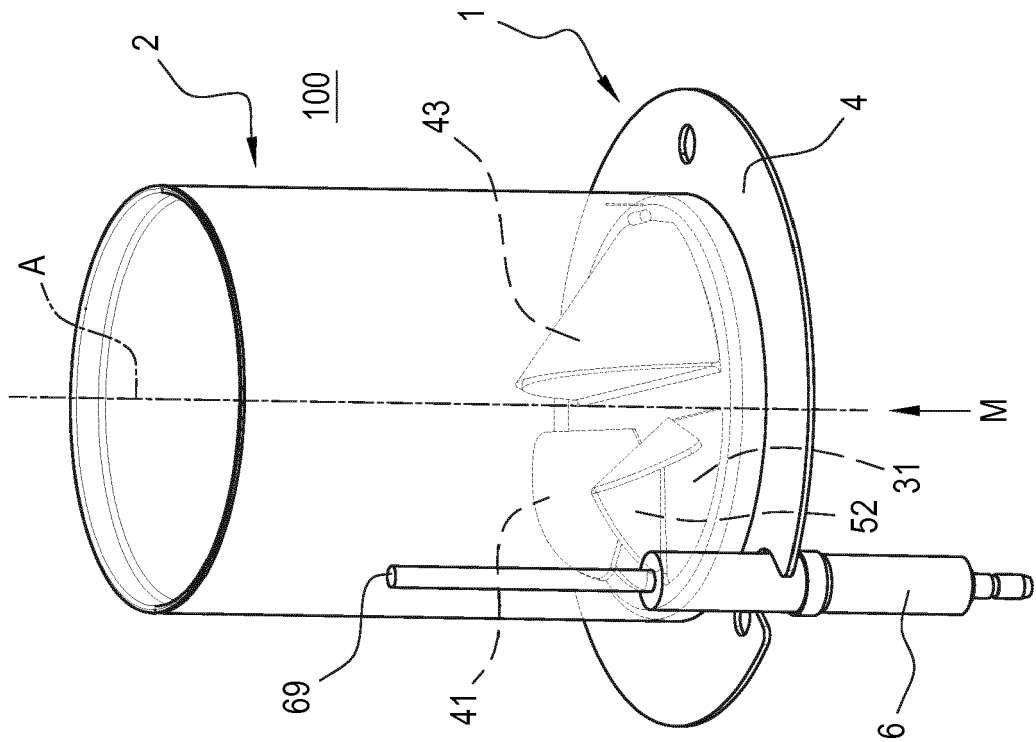


FIG. 5

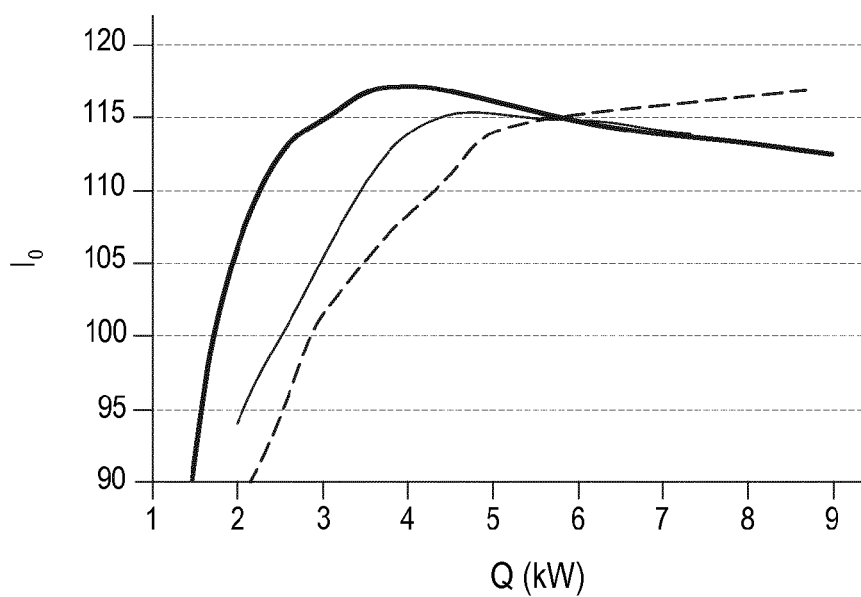


FIG. 6

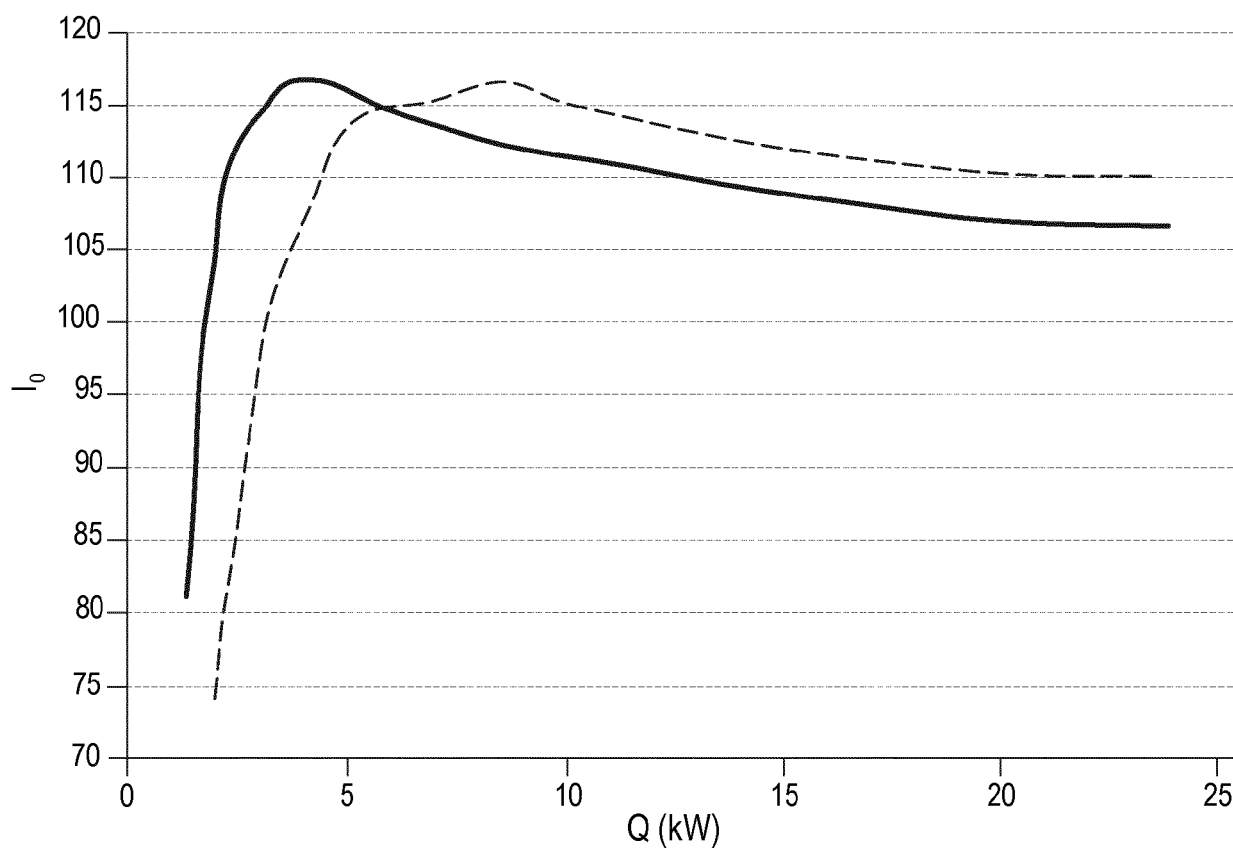


FIG. 7

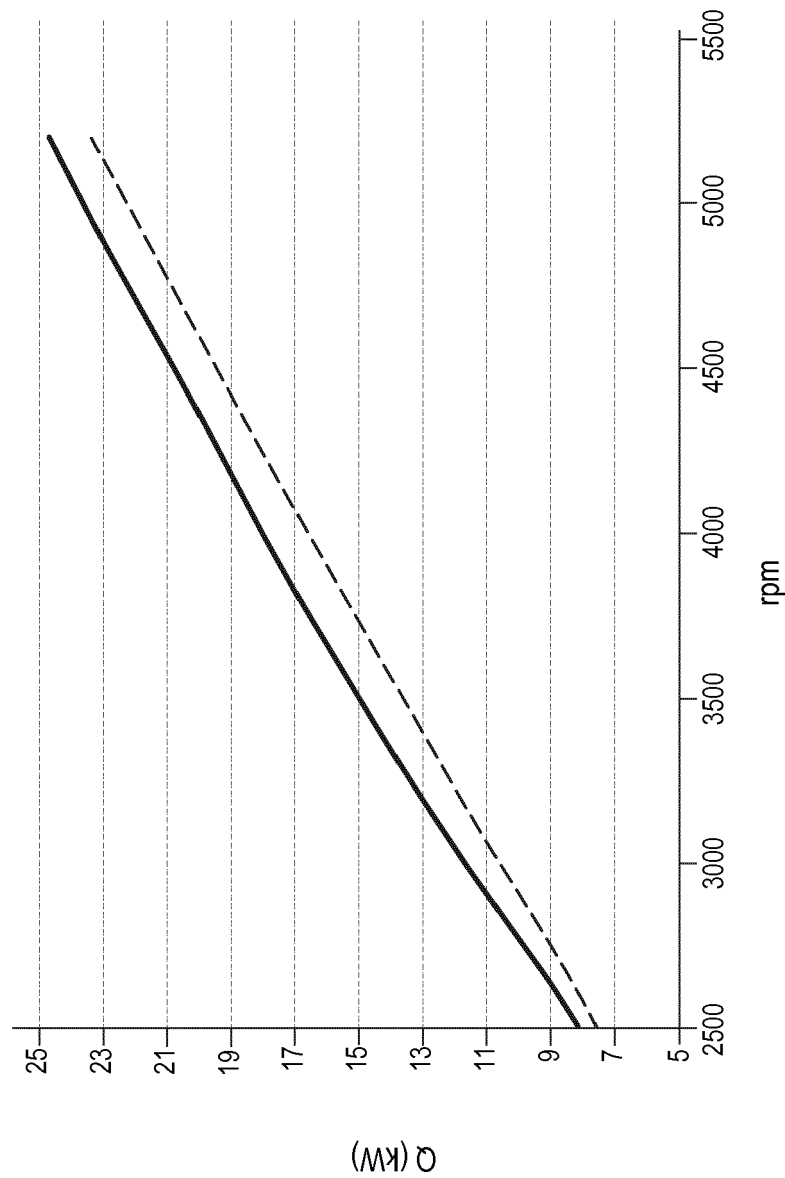


FIG. 8

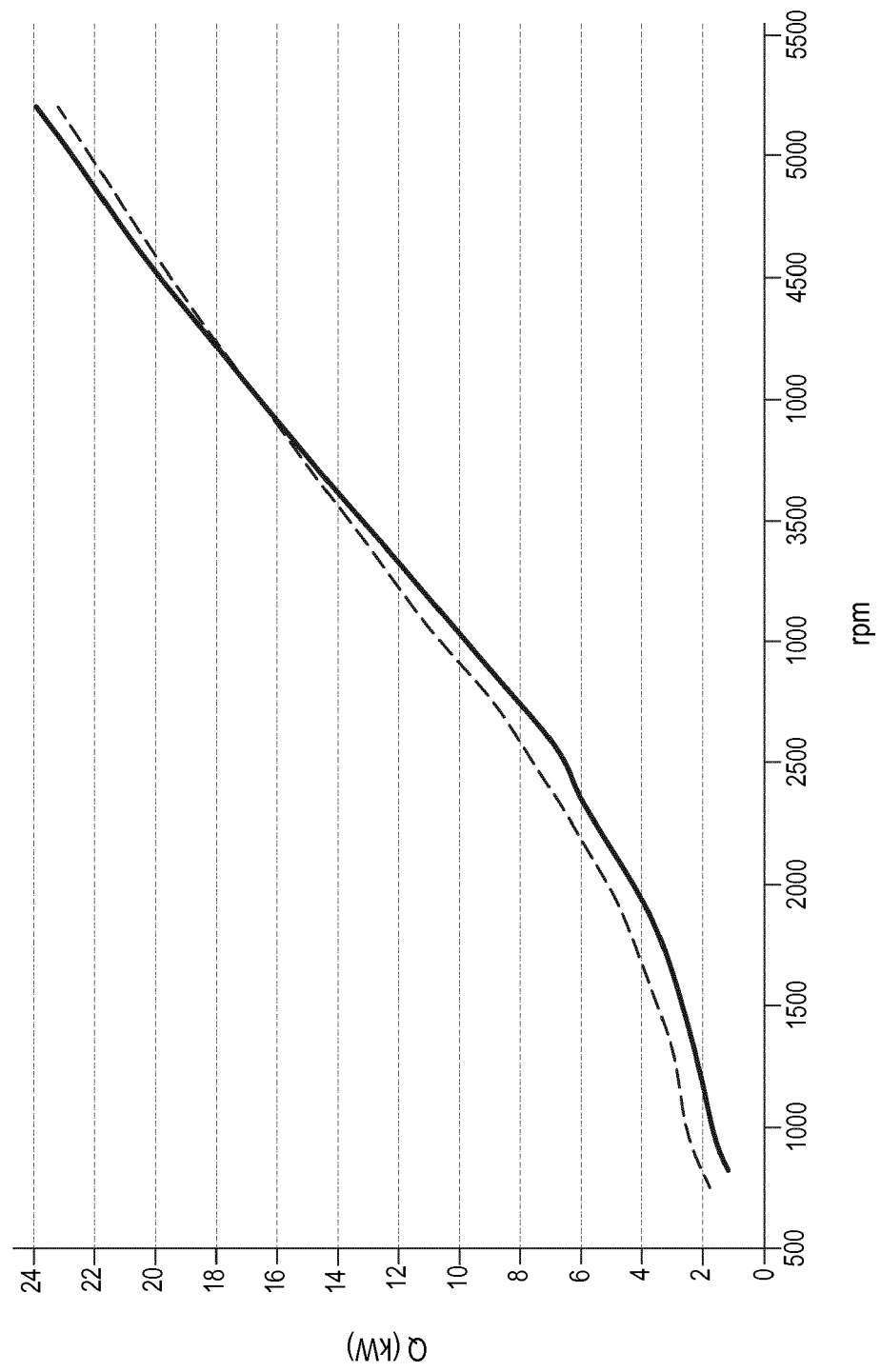
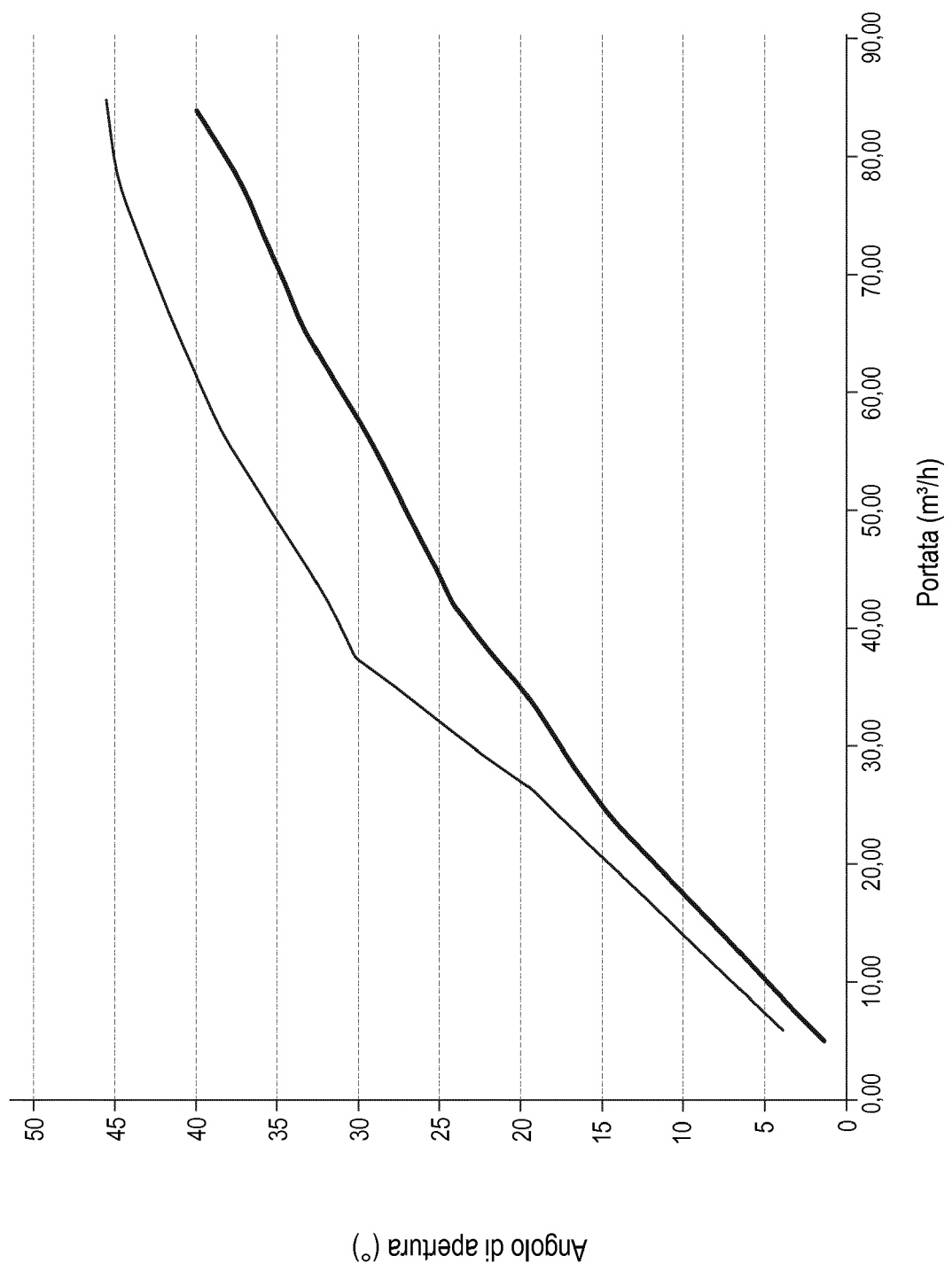


FIG. 9





EUROPEAN SEARCH REPORT

Application Number
EP 19 19 8841

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 January 2020	Examiner Hauck, Gunther
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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14-01-2020

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