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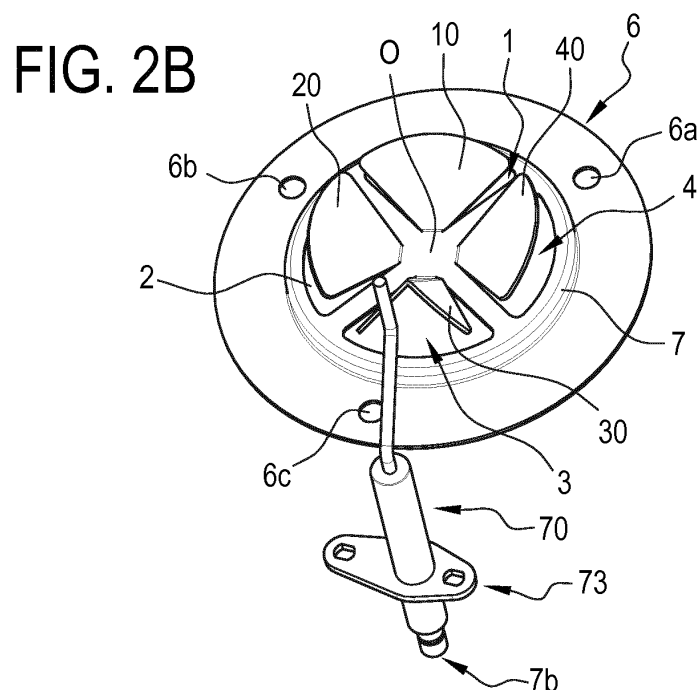
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(54) **DISTRIBUTOR DEVICE FOR A PREMIXING BURNER AND BURNER COMPRISING SUCH DISTRIBUTOR**

(57) A distributor (100) for a premix burner (200) comprises a distribution element (5) having a centrally symmetrical shape and provided with openings (1-4) distributed about a central axis of symmetry (A). The distribution element (5) comprises deflector elements (10-40) located proximate to each opening (1-4) and oriented in such a way as to direct an air and gas mixture (M) in a

respective deflection direction (D_1 - D_4) which forms a non-null angle with the axis (A). At least one deflector element (30) is oriented in such a way that the mixture (M) output from the opening (3) it is proximate to is directed in a direction (D_3) which forms with the axis (A) an angle which is different from the angle formed with the axis (A) by the remaining deflector elements.



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 length of perforated sheet metal rolled to form a cylindrical body provided with an inlet mouth at one end; the burner also comprises a sheet metal base, welded at the opposite end of the cylindrical body to close it, and a disc-shaped distributor integrated in the flange used to attach the burner to the boiler and located at the inlet mouth of the cylindrical body. The distributor is also provided with openings for inputting a mixture of gas (fuel) and air (oxidant), whose combustion produces a flame on the external surface of the cylindrical body.

[0003] Hereinafter in this description, distributors integrated in the fixing flange, like the distributor of patent EP 2 037 175 B1, will be called "external distributors"; also, the term "burner" will be used to refer to the device whose lateral outside surface coincides with that of the above mentioned cylindrical sheet metal body on which the flame is formed, whilst the region on the outside of this surface, where the ignition electrode is located, will be called "combustion cell".

[0004] 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.

[0005] The configuration described in patent EP 2 037 175 B1 improves the thermo-acoustic behaviour and the thermal insulation of the burner. Patent EP 2 037 175 B1 does not deal with the problem of detecting the ionisation signal.

[0006] As is known, the formation of the flame produced by combustion of a gas 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.

[0007] 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.

[0008] European patent application EP 1 036 984 A1, filed by G. Kromschröder 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 operation of a gas delivery valve in order to keep the value of the air-gas

ratio at a predetermined optimum level.

[0009] In application EP 1 036 984 A1, the sensor comprises an electrode located proximate to an "internal distributor" in the sense defined above. On its lateral surface, the distributor is provided with holes through which the mixture flows out and is distributed; furthermore, the electrode is located in a zone of the lateral surface of the distributor with a higher density of holes compared to the rest of the surface.

[0010] 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 working in regimes of low generated thermal power: in effect, it is known that the ionisation signal decreases considerably in this operating state, reaching values that are too low to be used to control the operation of the burner through a control circuit.

[0011] It may be inferred from the above that the solution described in application EP 1 036 984 A1 uses a distributor that is not capable of directing the flow of mixture towards a well-delimited region or in a preferred direction. When the burner described in application EP 1 036 984 A1 works at low thermal power 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.

[0012] 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.

[0013] Unlike application EP 1 036 984 A1, 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.

[0014] 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 caused by repeatedly switching the heating system on and off. It is therefore essential to be able to regulate the level of the ionisation signal inde-

pendently of the control of other parameters such as, for example, the fluid dynamic distribution of the mixture inside the burner.

[0015] 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.

[0016] 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 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. That way, the pressure in the region with the ionisation electrode is higher than in the rest of the cavity in any operating state, thus ensuring a higher ionisation signal over the full operating range of the burner.

[0017] The burner described in application EP 2 177 830 A1 has a certain number of drawbacks, however.

[0018] 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.

[0019] Secondly, the burner needs an internal distributor to distribute the mixture effectively and is thus subject to microcracking and thermoacoustic instability.

[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 increasing the intensity of the ionisation signal of the flame produced during combustion and, at the same time, capable of allowing the signal to be optimised easily, reliably and economically independently of the fluid dynamic distribution of the mixture inside the burner, without necessitating mixture distribution elements located inside the burner.

[0022] 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.

[0023] 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.

[0024] 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, preferably at least equal to 1:10.

[0025] These aims are fully achieved by the distributor and the burner of this invention as characterized in the appended claims.

[0026] The distributor device according to this invention comprises a distribution element provided with a first surface for inputting the mixture into the distribution element and with a second surface, located opposite the first surface, for outputting the mixture from the distribution element. The first and the second surface have a centrally symmetrical geometrical shape about an axis that is perpendicular to both surfaces and passes through the centre of the distribution element.

[0027] The distribution element comprises a set of openings distributed about the axis and configured to allow the mixture to flow through the first surface out to the second surface.

[0028] The distribution element also comprises a set of deflector elements distributed on the second surface; each deflector element is located proximate to one of the openings and is provided with a guide surface positioned above the opening and oriented in such a way as to be able to direct the mixture flowing out of the opening from the second surface in a respective deflection direction forming with the axis an angle of deflection that is different from zero.

[0029] The deflector elements comprise a set of first deflector elements whose guide surfaces are oriented in such a way that the respective deflection directions form the same first angle of deflection with the axis.

[0030] The deflector elements of the distributor according to the invention also comprise at least one second deflector element whose guide surface is oriented in such a way as to direct the mixture in a direction which forms with the axis a second angle of deflection that is different from the first angle.

[0031] The distributor device according to the invention is thus characterized in that the guide surface of at least one deflector element is inclined at a different angle than the surfaces of the other deflectors.

[0032] That way, a part of the mixture flowing through the distributor device can be separated from the mixture output from the remaining openings and conveyed to a well-delimited region of the space, distinct from the region in which the mixture output from the remaining openings is distributed.

[0033] Using the distributor according to the invention in combination with a sensor for detecting the ionisation of the flame produced by the combustion of the mixture in that well-delimited, distinct region makes it possible to obtain an ionisation signal of high intensity under any working conditions.

[0034] In other words, at least one deflector element of the distributor according to this invention is geometrically configured to be more directive than the other de-

flector elements. This technical effect is obtained by choosing, for that deflector element, an angle of inclination - measured relative to the axis of symmetry of the distributor - different from the angle of inclination of the other deflector elements. The technical effect can be further enhanced by controlling the height and/or shape of the deflector.

[0035] Thus, the deflector configured to be more directive is capable of directing a larger quantity of mixture towards a well-delimited region inside the burner in proximity to the periphery of the distribution element, hence close to the wall of the burner where the flame is formed: consequently, the flame formed during combustion of the mixture in that well-delimited region is more intense than the flame formed in the rest of the burner and produces a particularly intense ionisation signal.

[0036] Thanks to the fact that at least one deflector element is more directive than the other deflector elements and can thus convey a higher, spatially concentrated flow of mixture in any operating state of the burner, the distribution element and the burner of this invention overcome the drawbacks of the devices known from documents EP 1 036 984 A1 and EP 2 177 830 A1, in which the ionisation signal when working in regimes of low thermal flow decreases significantly with the decreasing intensity of the flame.

[0037] In the distributor according to the invention, it is therefore possible to dimension the more directive deflector in such a way as to ensure that the ionisation signal is of a sufficiently high level under any working conditions, even when the intensity of the flame is low.

[0038] Used in combination with a feedback control circuit, this feature allows regulating and keeping constant the value of the λ ratio between the amount of air and gas in the mixture over the full range of thermal flows required of the burner; at the same time, it is possible to reach high modulation ratios at least equal to 1:10.

[0039] Moreover, the distributor and burner of this invention allow maintaining the advantageous features of the device known from patent EP 2 177 830 A1: that is to say, the significant reduction of mechanical stress and thermoacoustic instability by eliminating the conventional internal distributor and at the same time ensuring that the ionisation signal is controlled independently of the control of mixture distribution inside the burner. The device of this invention thus also overcomes the drawbacks of the premix burner described in document EP 2 177 830 A1.

[0040] The distributor device of this invention is preferably used in a premix burner without an internal distributor: in other words, the distributor device according to this invention is the only constructional component of the burner configured to input and distribute the mixture in the burner. The advantages offered by the invention in terms of ionisation signal quality obtainable in regimes of low thermal flows can, however, also be usefully applied to a burner equipped with an internal distributor: thanks to the use of the more directive deflector element

in combination with deflector elements provided with guide surfaces, the distributor according to this invention guarantees a better quality ionisation signal even in a burner with an internal distributor.

[0041] Furthermore, it is evident that the greater directivity of the distributor of this invention can also be obtained by configuring two or more deflector elements in such way as to be more directive than the other deflectors: in particular, when there are more than four openings and deflectors associated therewith, it is possible to configure at least two adjacent deflector elements in such a way that they direct, in combination, a flow of mixture at a well-delimited peripheral region in order to generate a more intense ionisation signal in that region. The use of a directive element allows defining more precisely the extent of the region where the ionisation signal is more intense; moreover, such a configuration allows creating a local gradient of the ionisation signal in that region.

[0042] In an embodiment, the deflector element that is inclined differently from the others has a tapered guide surface whose large end is located at a height - measured from the output surface of the distribution element - that is different, and preferably greater than, the height reached by the remaining deflector elements. The directive effect is thus obtained by directing a part of the mixture towards a peripheral region located above the output surface of the distributor, at a position higher than the region to which the rest of the flow is directed.

[0043] In another embodiment, the greater directive effect of the predetermined deflector element is obtained by giving the guide surface a concave shape with concavity facing down, that is say, facing the openings below. Preferably, the guide surface of the more directive deflector element has the shape of a cusp, that is to say, of an upturned "V": in this case, the directive effect is enhanced by the side panels of the cusp which, between them, form a channel in which the mixture is effectively confined and guided towards a well-delimited peripheral region.

[0044] The features of the two embodiments just described can be advantageously combined to increase the directive effect and the spatial confinement of the flow of mixture.

[0045] These and other features of the invention will become more apparent from the following detailed description of a preferred, non-limiting example embodiment of it, with reference to the accompanying drawings, in which:

- Figure 1 shows a plan view of a first embodiment of a distributor element;
- Figure 2A shows the distributor element of Figure 1 in a side view;
- Figure 2B shows the distributor element of Figure 1 in a perspective view;
- Figure 3A shows a side view of a second embodiment of a distributor element;
- Figure 3B shows the distributor element of Figure

- 3A in a perspective view;
- Figure 4 shows a burner comprising a distributor element according to the invention;
- Figure 5 is a block diagram of a control circuit of a burner according to the invention;
- Figure 6 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 invention and for a burner provided with a distributor according to patent EP 2 177 830 A1;
- Figure 7 is a graph showing the trend of the ionisation signal as a function of the thermal flow for two burners provided with distributors according to the invention where the more directive deflectors differ from each other in height;
- Figure 8 is a graph showing the trend of the ionisation signal as a function of the thermal flow for three burners provided with distributors according to the invention where the more directive deflectors differ from each other in height;
- Figure 9 is a graph showing the trend of the ionisation current measured over a wide range of thermal flows for a burner provided with a distributor according to the invention.

[0046] Figure 1 shows a plan view of a distributor device 100 according to a first embodiment of this invention. As illustrated in Figure 4, the distributor device 100 is preferably used in a burner of the premix type, labelled 200 in Figure 4, to input a mixture of fuel and oxidant (typically gas and air) into the burner 200.

[0047] The distributor device 100 comprises a distribution element 5 which, in the embodiment illustrated in Figures 1, 2A, 2B and 4, is circular in shape and substantially flat. The distribution element 5 is provided, at its periphery, with a fixing flange 6 which allows the distributor device 100 to be fixed to the door of a boiler. In the example of Figure 1, the flange 6 is 1 mm thick and the overall thickness of the disc is 7.5 mm; the diameter of the disc, excluding the flange, is approximately 70 mm.

[0048] More generally speaking, the distribution element 5 has a centrally symmetrical geometrical shape about an axis of symmetry A passing through the centre O of the element 5 and it may have other geometrical shapes: by way of example, the distributor element 5 may have a polygonal shape, such as a hexagonal or octagonal shape, instead of a circular shape.

[0049] The distribution element 5 has a first surface or input surface Si, for receiving the mixture of fuel and oxidant, preferably gas and air, labelled M in the drawings, and a second surface or output surface Su to allow the mixture M to be output and then input into the burner.

[0050] Figure 1 shows the distribution element 5 in a plan view from the side of the input surface Si, whilst Figure 2 shows the same element 5 in a perspective view from the side of the output surface Su.

[0051] The distributor 100 is also provided with a plurality of openings, labelled 1, 2, 3 and 4 in Figure 1, and

arranged symmetrically about the axis of symmetry A passing through the centre O: in the example illustrated, these openings are approximately in the shape of a circular sector and are mutually separated by arms, labelled b1, b2, b3 and b4, arranged in the shape of a cross around the centre O. The arms b1, b2, b3 and b4 meet at the central point O of the distribution element 5; they are also connected to each other at the periphery of the element, at the step 7 between the flange 6 and the distribution element 5.

[0052] The openings 1, 2, 3 and 4 allow the mixture of air and gas to flow through the distribution element 5 from the input surface Si to the output surface Su in order to allow the mixture M to be input into the burner (see Figure 4). In the example of Figure 1, the four openings 1, 2, 3 and 4 are formed from a flat sheet metal disc, about 105 mm in diameter, using a mechanical progressive die: in a first processing step, the die forms the flange by stamping the metal sheet; the metal sheet is then advanced and, in a subsequent step, is partly cut away by the die at the openings so as to form four tabs; the die then bends the four tabs, which are joined at the centre O and separated by the four sheet metal arms b1, b2, b3 and b4, and also perforates the sheet metal to form the fixing holes 6a-6c; during the subsequent operations, the distribution element moves.

[0053] The tabs are then lifted and, if necessary, shaped to form a plurality of deflector elements 10, 20, 30 and 40 disposed on the output surface Su, in proximity to a respective opening, around the axis of symmetry A of the distributor itself. This axis, in the complete burner illustrated in Figure 4, is also the longitudinal axis of the burner.

[0054] The deflector elements 10, 20, 30 and 40 have a generally tapered shape, as shown in Figure 2B, and are fixed, at their narrow ends, to the output surface SU at the centre O of the distribution element 5. As may be clearly seen in Figure 2B, the deflectors 10, 20, 30 and 40 extend and rise progressively in width and in height in a radial direction: that is, in the direction from the centre O towards the periphery of the distributor, above the respective openings 1, 2, 3 and 4.

[0055] Each of the deflector elements 10, 20, 30 and 40 has a surface facing towards the respective opening 1, 2, 3, 4 below it. These surfaces, labelled S10, S20, S30 and S40 have a first end fixed to the output surface Su at the centre O of the distribution element 5 and a second end located at the periphery of the element 5 at a certain height above the output surface Su.

[0056] In the embodiment illustrated in Figure 2A, the second end of the guide surface S30 of the deflector element 30 extends to a greater height than the ends of the guide surfaces of the remaining deflectors 10, 20 and 40: in the example of Figure 2A, the deflector element 30 reaches to a height of 19.6 mm from the plane defined by the output surface Su, whilst the remaining deflectors 10, 20 and 40 rise to a height of 12.5 mm.

[0057] Each of the deflectors 10, 20, 30, 40 is inclined

relative to the axis of symmetry A of the distribution element 5 at an angle, referred to as inclination angle, labelled β_{10} , β_{20} , β_{30} and β_{40} , respectively. The complementary angle of the inclination angle, is called angle of deflection and measures the inclination of each deflector relative to the output surface Su of the distribution element 5.

[0058] In the embodiment illustrated in Figures 1, 2A and 2B, the deflectors labelled 10, 20 and 40 are inclined at the same angle of deflection β_F , equal to 30 degrees, whilst the deflector labelled 30 is inclined at an angle β_D of 55 degrees. The deflector elements 10, 20 and 40 having the same angle of deflection β_F in common are hereinafter called first deflector elements, whilst the deflector element 30 that is inclined at an angle β_{30} equal to β_D (where β_D is different from β_F) is hereinafter called second deflector element.

[0059] The inclination angle β_{10} , β_{20} , β_{30} , β_{40} or, equivalently, the angle of deflection of each deflector element defines a direction, called deflection direction: in the embodiment illustrated in Figures 1, 2A and 2B, the four deflector elements 10, 20, 30 and 40 are associated with four respective deflection directions, labelled D1, D2, D3 and D4.

[0060] Each of the surfaces S10, S20, S30 and S40 is able guide and direct the flow of mixture leaving the respective opening below towards the periphery of the distributor itself: in other words, the lower surface S10, S20, S30 and S40 of each deflector element 10, 20, 30 and 40 acts as a guide that can change the direction of the flow of mixture M from the axial direction A to a radial direction, coinciding with one of the above mentioned deflection directions D1, D2, D3 and D4. That way, the distributor device 100 is able to direct and distribute the mixture fed into the burner through the openings 1, 2, 3 and 4 towards the periphery of the distributor device.

[0061] Generally speaking, the inclination angle, the height and the shape of the guide surfaces allow regulating the distribution of the mixture M inside the burner 200.

[0062] The distributor device according to this invention is characterized in that the inclination of at least one deflector element relative to the axis of symmetry A or, equivalently, relative to the output surface Su, is different from the inclination of the remaining deflectors: in the example of Figures 1, 2A and 2B, the first deflector elements 10, 20 and 40 are inclined at the same first angle β_F equal to 30 degrees, whilst the second deflector element 30 is inclined at a second angle β_D of 55 degrees, as stated above.

[0063] Thanks to its different inclination angle and by means of its guide surface S30, the second deflector element 30 is able to direct and guide the mixture, flowing out of the opening 3 below it, in a precise direction D3 which differs from the remaining directions D1, D2 and D4 in its angle of deflection. As explained below, this feature allows directing a part of the mixture, in any working conditions of the burner, towards a sensor that detects

an ionisation current, so as to ensure that the sensor detects this current at all times and uses it to regulate the operation of the device in which the burner is installed, under any working conditions. At the same time, the first deflectors 10, 20 and 40 can be used to control the fluid dynamic distribution of the mixture M inside the burner.

[0064] The distributor device 100 according to the invention is thus capable of regulating the fluid dynamic distribution of the mixture in a premix burner and, at the same time, ensures that the intensity of the ionisation signal used to control the operation of the burner is sufficiently high under any working conditions.

[0065] Figure 2B also shows that the deflector element 30, in the embodiment illustrated, has the shape of a cusp - that is, an upturned V - characterized by two inclined panels joined to form a channel capable of directing the mixture flowing out of the opening below towards the periphery of the distributor. In the plan view of Figure 1, the two panels are labelled S30a and S30b and are connected to each other by a third surface, having the shape of a triangular sector, labelled S30c and located between the panels S30a and S30b with the base of the triangle proximate to the central point O of the distribution element 5 and the top directed towards the periphery - that is, towards the region of the flange 6.

[0066] The third surface S30c is optional: the cusp may be made by joining the two panels S30a and S30b along a common side in such a way as to form a channel - defined by the opposite faces of the panels - in which the mixture can be confined and directed towards the periphery of the distributor. The third surface S30c, thanks to its progressively narrower shape in the radial direction, is advantageous because it allows enhancing the guiding effect of the cusp.

[0067] The combination of the cusp shape and height of the second deflector element 30, different from the first deflector elements 10, 20 and 40, allows directing towards the wall of the burner 200, a flow of mixture that is more concentrated and intense than the mixture flowing from each of the first deflector elements. Consequently, the flame produced on the wall of the burner by the combustion of this local flow is accompanied by a stronger ionisation signal under any working conditions of the burner, compared to that associated with the flow deflected by the remaining deflectors. It is important to stress that this technical effect, although it has practical significance for the burner 200, is obtained through the distributor device 100 only and does not therefore depend on the presence of the burner or of the sensor.

[0068] The inclination angle β_{30} or, equivalently, the angle of deflection of the second deflector 30, is the fundamental geometrical parameter for obtaining the effects of the invention: by fixing the angle β_{30} at a value β_D different from a value β_F which the angles β_{10} , β_{20} and β_{40} are fixed at, it is possible to direct a part of the flow of the mixture to a region of the space distinct from the region where the mixture M from the first deflectors 10, 20 and 40 is distributed.

[0069] The height at which the second end of the guide surface of the second deflector 30 is located and the shape of the guide surface S30 allow regulating the relative intensity of the flame produced by that deflector element compared to the flame produced at the first deflectors 10, 20 and 40. In practice, these parameters (height and/or shape) allow ensuring that the ionisation signal associated with the flame produced by the flow deflected by the predetermined deflector element is always greater than or equal to a predetermined minimum level. This minimum level depends, generally speaking, on the sensitivity of the electronic components used in a control circuit to regulate the operation of the burner and, in particular, to control an actuator (for example, a valve) which in turn regulates the supply of fuel to the mixture. By way of example, the minimum level required by some electronic components commonly available on the market is at least 15 μ A.

[0070] It is important to stress, however, that the height of the second end of the guide surface S30 and the shape of the surface are parameters independent of, and supplementary to, the inclination angle: in other words, the effects of the invention can also be achieved using deflector elements all of the same shape and located at the same height from the output surface, provided always that at least one second deflector element is inclined differently from the first deflectors. In such a configuration, the constraint that all the deflectors have the same height and at least one of the deflectors has a different inclination implies that the differently inclined one (that is, the second deflector element) has a radial extension (that is, from the centre O to the periphery of the distributor) that is different from that of the remaining deflector elements (first deflector elements).

[0071] In the same way, the effects of the invention can also be achieved by a distributor whose deflector elements are all the same shape and only one element - the second deflector element - has an inclination β_D that is different from the angle β_F of the remaining deflectors and, in addition, rises to a height greater than the remaining deflectors. This configuration, corresponding to a second embodiment of the invention, is illustrated in Figures 3A and 3B: all four deflector elements 10, 20, 30 and 40 are the same shape and have flat guide surfaces S10, S20, S30 and S40, each in the shape of a circular sector; the three deflectors 10, 20 and 40 (first deflector elements) are inclined at the same angle β_F (that is, the condition $\beta_{10} = \beta_{20} = \beta_{40} = \beta_F$ is true) and the second end of each of their guide surfaces S10, S20 and S40 is located at the common height HF; the deflector element 30 (second deflector element), on the other hand, is inclined at an angle β_D ($\beta_{30} = \beta_D$) different from the angle β_F and has a guide surface S30 whose second end is located at a height HD of 19.6 mm, different from the common height HF, which is 12.5 mm. In the second embodiment illustrated in Figures 3A and 3B, the inclination angle of the deflector element 30 is 35 degrees (the complementary angle of the inclination angle β_D ,

which is 55 degrees); the inclination angle common to the three deflectors 10, 20 and 40 is 60 degrees. These values of the angles β_D and β_F can also be advantageously used in the first embodiment, illustrated in Figures 1, 2A and 2B.

[0072] Generally speaking, it is preferable for the second deflector element to also have a guide surface whose shape is chosen to enhance the guiding effect, compared to the remaining deflectors, so as to increase the local intensity of the flame: generally speaking, the shape of the guide surface is chosen to create a channel and is thus preferably concave, as illustrated in Figure 2B. The concavity of the surface 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.

[0073] If a sensor capable of detecting an ionisation signal - for example, an elongate electrode - is placed at a position opposite and proximate to the point of the burner wall to which the second deflector element directs the mixture, as illustrated in Figure 4, it becomes possible to reliably detect the aforesaid ionisation signal under any working conditions of the burner. As may be observed in Figure 4, the end 70a of the electrode 70 is located beside the wall 80 of the burner 200 in the region opposite the deflector element 30; this element, as can be appreciated from Figure 2A, is configured in such a way as to direct the mixture M output from the opening 3 in the preferential direction D3. The height at which the end 70a of the electrode 70, measured from the top of the deflector 30 (that is, from the second end of its surface S30) is chosen to maximise the amplitude of the detected signal, associated with the flow of mixture deflected in the direction D3 deflected by the deflector 30: in the example of Figure 2A, this height is 29 mm. Generally speaking, the position of the detecting end 70a relative to the top of the deflector element 30 varies as a function of the shape of the guide surface and can be determined by a person skilled in the art through simple calibration tests.

[0074] The electrode 70 acts as a sort of antenna and intercepts the flow of ions generated by the combustion of the mixture deflected by the deflector element 30; this flow induces an electric current of the order of several dozen μ A in the conductive material the electrode 70 is made of. Since the electrode is fixed, in proximity to the fixing flange 6, on the outside of the perforated metal sheet on whose surface 80 the flame is formed, it cannot normally extend in rectilinear manner from the flange 6 to the detection region and therefore has a first, inclined stretch 72, followed by a rectilinear stretch 71 which constitutes the ionisation sensor proper. The length of the rectilinear stretch 71 is chosen to ensure that the ionisation signal is sufficiently intense and, at the same time, that the electrode is mechanically robust; generally speaking, the intensity of the signal increases with the length of the rectilinear stretch 71 because the region along which the ions are intercepted is larger, thus increasing the ionisation current (proportional to the

number of ions intercepted); conversely, mechanical robustness limits the length of the stretch 71. In the example of Figure 2A, the rectilinear stretch 71 is 15 mm long.

[0075] If the minimum level above which to keep the ionisation signal is suitably chosen, the operation of the burner can be regulated using a control circuit, illustrated in Figure 5.

[0076] In such a circuit, the ionisation signal generated by the flame during combustion of the mixture M on the surface of the burner 200 is sent by the electrode 70 to the input of an electronic circuit 300 which, as a function of the value of that input signal (for example, compared to a threshold value), generates an output signal used to drive the valve 500 which regulates the inflow of gas. The circuit 300 can generate a further output signal used to regulate the operation of the fan 400 and thus to control the air-gas ratio of the mixture flowing into the inlet of the distributor device 100. In terms of electrical behaviour, the flame acts as a diode which conducts the ionisation current in one direction only: for this reason, a voltage must be applied by the generator 300a across the electrode 70 and the burner 200 so that the ionisation current can flow towards the element 300b.

[0077] Depending on the intensity of the ionisation signal detected, the degree to which the gas flow regulator valve 500 is opened can be changed (or kept constant) so as to guarantee that the value of the λ ratio between the quantity of air and that of gas input to the burner remains constant. Since it is possible to keep the intensity of the ionisation signal above a minimum level (for example, 15 μm) even when the burner is working in regimes of low thermal flow, the distributor device of this invention, if the inclination and/or the height and/or the guide surface are suitably configured, can ensure that the electronic circuit 300 always receives a signal whose intensity is sufficient to allow the burner to be controlled in any operating state.

[0078] More generally speaking, the control signal generated by the electronic circuit 300 is supplied as input to a premixing device which, as a function of that control signal, determines the optimum ratio between the quantity of air and the quantity of gas of the mixture to be input into the burner. This optimum ratio can be stored in an electronic memory in the form, for example, of a lookup table, in which a set of values of the control signal are associated with corresponding values of the air-gas ratio, determined beforehand in a step of calibrating the ionisation sensor. By continuously checking the λ ratio, it is possible to modulate the thermal power delivered by the burner over a very wide range without having to switch the burner on and off continually; that way, a burner equipped with a distributor according to the invention and provided with a control circuit is capable of obtaining modulation ratios of at least 1:10.

[0079] By way of example, Figure 9 shows the ionisation current measured over the range of thermal flows from 2.5 to 25 kW for a burner provided with a distributor according to the invention and a control circuit of the type

illustrated in Figure 5. Figure 9 shows how the burner in question is capable, thanks to the distributor and the control circuit, of keeping the ionisation current practically constant over a range of ten kW, thus guaranteeing a modulation ratio of at least 1:10. The same graph also shows that the ionisation current remains above a threshold value, labelled ITH, which, in the case illustrated, is 15 μA .

[0080] Figure 6 shows the trend of the ionisation signal (in hundredths of a microampere) as a function of the thermal flow (in kilowatts) in a conventional burner provided with a distributor of the type illustrated in Figure 5 of patent EP 2 037 175 B1, with deflector elements all characterized by the same inclination, shape and height, and in a burner provided with a distributor according to this invention. The graph shows, in particular, the ionisation signal obtained by the two distributors for low thermal flows of the burner, in the range between 3.1 and 4 kW, in which the ionisation signal is typically weak.

[0081] The conventional distributor has ten deflectors, formed in a circular region of the metal sheet 60 mm in diameter and inclined at an angle of 37.5 degrees to the output surface of the distributor; each deflector reaches to a height of 7.3 mm from the output surface. The burner of this invention, on the other hand, has the geometry and dimensions discussed above with reference to Figures 3A and 3B, that is to say, a second deflector inclined at an angle of 55 degrees and whose top reaches to a height of 19.6 mm, combined with three first deflectors inclined at an angle of 30 degrees and whose tops reach to a height of 12.5 mm; the four deflectors are formed in the central region, 60 mm in diameter, of a sheet metal disc. The curve for the burner according to the invention (the curve with the squares) has, for any value of thermal flow in the region between 3.1 and 4 kW, a value of the ionisation signal that is always higher than that of the curve for the conventional burner (the curve with the lozenges): in particular, for low thermal flow values - for example, around 3.1 kW - the ionisation signal obtained with the distributor according to the invention is approximately 11 μA , whilst the signal obtained with the distributor of the type described in EP 2 037 175 B1 is around 9 μA , with a relative increase of 22.2%. It is therefore evident that the distributor according to the invention allows obtaining a stronger ionisation signal compared to that obtainable with a conventional distributor, even for low thermal flows.

[0082] Figure 7 shows the trend of the ionisation signal as a function of the thermal power of two burners according to the invention where the predetermined deflector element of one differs in height from that of the other, all other conditions being equal. The two burners each have four deflectors, formed in a circular region 60 mm in diameter; the three first deflectors reach to a height of 12.5 mm from the output surface. The burner provided with a predetermined deflector reaching to a height of 20 mm from the output surface of the distributor produces an ionisation signal (represented by the thin curve) whose

value is higher than that obtained with the distributor whose predetermined deflector reaches to a height of 16.1 mm (thick curve). Figure 7, too, illustrates the trend of the ionisation signal around the region of low thermal flows (between 2.5 and 4 kW) and shows how the choice of the height of the second end of the guide surface of the second deflector allows controlling the level (that is, the intensity) of the ionisation signal.

[0083] Figure 8 shows the curves of the ionisation signal obtainable with three distributors according to the invention, characterized by three different heights of the second deflector element; the range of thermal flows considered (2.5 - 5 kW) is wider than that of Figures 6 and 7. The thick curve relates to a distributor whose second deflector element - that is, the more directive element - reaches to a height HD of 17.2 mm and has an angle of deflection of 45°; the dashed curve relates to a distributor whose second deflector element reaches to a height HD of 12.2 mm (with an angle of deflection of 30°); the thin curve, on the other hand, represents the ionisation signal obtainable with a distributor whose second deflector element reaches to a height HD of 22.7 mm (with an angle of deflection of 68°). The results of Figure 8 show that there is an optimum value for the height of the second deflector element (in this case HD=17.2 mm) which, all other geometrical conditions being equal, allows maximising the ionisation signal obtainable on a predetermined range of thermal flows.

[0084] As mentioned above, the first deflectors 10, 20 and 40 of the distributor according to the invention are inclined at the same angle βF , have guide surfaces that are the same shape and reach to the same height HF. The geometric parameters common to the first deflector elements allow regulating the distribution of the mixture inside the burner according to the principles set out in patent EP 2 037 175 B1: for example, by adjusting the common height of the first deflectors, it is possible to direct the flow towards the bottom of the burner or towards the closing base located on the side opposite that where the distributor according to the invention is located; it is also possible to create a fluid dynamic distribution with a spiralling pattern (swirl). Although the shape of the first deflectors may be different, in principle, (for example, downward facing concave) from that shown in Figure 3, it is nevertheless preferable for the guide surfaces of the first deflectors to have a less directive shape than the guide surface of the second deflector so as to ensure that the flow produced by the second deflector will be more directive.

[0085] It is also possible to form a plurality of holes, preferably circular, on the guide surfaces of the first deflectors, such as to allow a controlled flow of a part of the mixture through each guide surface towards the axial region of the burner, in addition to the directive flow produced by these guide surfaces in the radial direction. In the case of circular holes, the minimum diameter is at least 1.5 mm; the number of holes and their distribution vary as a function of the desired size of the axial flow and

can be easily determined by a person skilled in the art both by experimental tests and by simulations.

[0086] A distribution of holes may advantageously also be used on the guide surface of the second deflector element in order to produce on the surface thereof a flow that is directed towards the axis of the burner so as to compensate for the asymmetry of the distribution in the region above the second deflector on account of its directive effect predominantly in the radial direction and towards a region distinct from the region towards which the flow of the remaining deflectors is directed.

[0087] The distributor element 5 according to the invention is provided, at its periphery, with a flange 6 formed as a single piece with the distributor to allow the latter to be fixed to the burner door.

[0088] The distributor element of this invention can be manufactured using a machine tool provided with a progressive mechanical die: a metal sheet is moved by rollers through successive stations in which it is partly cut by a die in such a way as to form a set of tabs or "petals"; before moving the metal sheet to the next station, the machine models and finishes the partly cut portion in such a way as to give the "petal" a desired height and shape (for example, the shape of a cusp).

[0089] In the example embodiments illustrated in the drawings, the distributor device 100 comprises four openings and four deflector elements; in other embodiments not illustrated, the number of deflectors may be equal to two or three. The number of deflectors may also be greater than four in order to control the spatial distribution of the mixture inside the burner in a more precise and gradual manner. The minimum number of openings and deflector elements is equal to two; it is, however, preferable to use at least four openings and four deflector in order to be able to control the distribution of the mixture inside the burner in a sufficiently precise manner and, at the same time, to obtain a more intense flame in a precisely delimited region in order to generate a particularly intense ionisation signal thanks to this "concentrated" flame.

[0090] It is also possible to use more than one second deflector element inclined differently from the first deflector elements which share the same inclination angle βF : for example, it is possible to use two second deflector elements inclined at the same angle βD (different from the common angle βF) and placed side by side in order to obtain a more spatially extended region in which to measure the ionisation.

Claims

1. A distributor device (100) for inputting a mixture (M) of fuel and oxidant into a premix burner (200), wherein the distributor (100) comprises a distribution element (5) provided with a first surface (S_i) for inputting the mixture (M) into the distribution element (5) and with a second surface (S_o) opposite the first surface (S_i) for outputting the mixture (M) from the

- distribution element (5), wherein the first and the second surface (S_i , S_u) have a centrally symmetrical geometrical shape about an axis (A) that is perpendicular to both surfaces (S_i , S_u) and passes through a central point (O) of the distribution element (5), wherein the distribution element (5) comprises openings (1, 2, 3, 4) distributed about the axis (A) and configured to allow the passage and the output of the mixture (M) from the first surface (S_i) out to the second surface (S_u), the distribution element (5) further comprising deflector elements (10, 20, 30, 40) distributed on the second surface (S_u), each of the deflector elements being located proximate to a respective opening (1, 2, 3, 4) and provided with a guide surface (S_{10} , S_{20} , S_{30} , S_{40}) positioned above said respective opening (1, 2, 3, 4) and oriented in such a way as to be able to direct the mixture (M) output from the respective opening (1, 2, 3, 4) from the second surface (S_u) in a respective deflection direction (D_1 , D_2 , D_3 , D_4) forming a non-null angle of deflection (β_D , β_F) with the axis (A), the deflector elements (10, 20, 30, 40) comprising first deflector elements (10, 20, 40) the guide surfaces (S_{10} , S_{20} , S_{40}) of which are oriented such that the respective deflection directions (D_1 , D_2 , D_4) form an identical, non-null first angle of deflection (β_F) with the axis (A), the distributor device (100) being **characterised in that** the deflector elements (10, 20, 30, 40) comprise at least one second deflector element (30) whose guide surface (S_{30}) is oriented in such a way as to direct the mixture in a direction (D_3) forming a non-null second angle of deflection (β_D) with the axis (A), the second angle of deflection (β_D) being different from the first angle (β_F).
2. The distributor device (100) according to claim 1, wherein the guide surface (S_{10} , S_{20} , S_{30} , S_{40}) of each of the deflector elements (10, 20, 30, 40) has a tapered shape having a first end connected to the second surface (S_u) at the central point (O) of the distribution element (5) and a second end wider than the first end and positioned at a non-null relative to the second surface (S_u), each guide surface extending progressively in height and width above the opening proximate to it from the first end to the second end.
 3. The distributor device (100) according to claim 2, wherein the second end of the guide surface (S_{10} , S_{20} , S_{40}) of each of the first deflectors (10, 20, 40) is positioned at the same first height (H_F) and the second end of the guide surface (S_{30}) of the at least one second deflector element (30) is positioned at a second height (H_D) different from the first height (H_F).
 4. The distributor device (100) according to claim 3, wherein the second height (H_D) is greater than the first height (H_F).
 5. The distributor device according to any of the preceding claims, wherein the number of openings (1, 2, 3, 4) and the number of deflector elements (10, 20, 30, 40) is equal to four.
 6. The distributor device according to any of claims 2 to 4, the number of openings and the number of deflector elements is equal to two or three.
 7. The distributor device (100) according to any of the preceding claims, wherein the guide surface (S_{10} , S_{20} , S_{40}) of each of the first deflectors (10, 20, 40) has a shape of a plane sector.
 8. The distributor device (100) according to any of claims 2 to 6, wherein the guide surface (S_{30}) of the at least one second deflector (30) is a concave surface which has a concavity facing towards the second surface (S_u) of the distribution element (5).
 9. The distributor device (100) according to claim 8, wherein the guide surface (S_{30}) of the at least one second deflector (30) is formed by at least two flat panels (S_{30a} , S_{30b}) joined in such a way as to form a cusp at the second end of the guide surface (S_{30}).
 10. The distributor device (100) according to claim 9, wherein the guide surface (S_{30}) of the at least one second deflector (30) comprises a joining surface (S_{30c}) having a shape of a triangular sector and positioned between the at least two flat panels (S_{30a} , S_{30b}) in such a way as to form a channel located between the first and the second end of the guide surface (S_{30}), the channel having a width progressively increasing from the first end to the second end.
 11. The distributor device according to any of the preceding claims, wherein each of the deflector elements (10, 20, 30, 40) has a distribution of holes on the guide surface.
 12. The distributor device (100) according to any of the preceding claims, wherein the distribution element (5) comprises a flange (6) for fixing the distributor (100) to the burner (200), the flange (6) being located on the periphery of the distribution element (5) and being preferably formed as a single piece with the distribution element (5).
 13. A premix burner (200) comprising a distributor device (100) according to any of the preceding claims and a sensor (70) for detecting an ionisation signal produced by the combustion of the mixture (M) in the burner (200), the sensor (70) being located opposite the at least one second deflector element (30) in such

a way as to be able to detect the ionisation signal produced by the combustion of the mixture (M) directed out of the guide surface (S_{30}) of the at least one second deflection element (30) in the direction (D_3) forming the second angle of deflection (β_D) with the axis (A). 5

14. The premix burner (200) according to claim 13, wherein the sensor (70) for detecting an ionisation signal consists of an electrode (70a, 71, 72, 73, 70b) of elongate shape having a first end (70a) located proximate to the at least one second deflection element (30). 10
15. The premix burner (200) according to claim 14, comprising a cylindrical body having a lateral flame surface (80) provided with holes, preferably circular and/or elongate in shape, a first closed end and a second open end, the distributor (100) being fixed to the second end of the cylindrical body of the burner (100), the electrode (70) being located in a position opposite the cylindrical body along the lateral flame surface (80). 15 20
16. The premix burner (200) according to any of claims 13 to 15, comprising an electronic control circuit (300) having at least one input arranged to receive the ionisation signal detected by the sensor (70) and at least one output, the electronic control circuit (300) being further configured to generate, on the at least one output, a control signal as a function of the detected ionisation signal, the burner (200) further comprising an actuator (500) configured to receive the control signal and to adjust the amount of fuel to be fed into the burner (200) as a function of the received control signal. 25 30 35

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FIG. 1

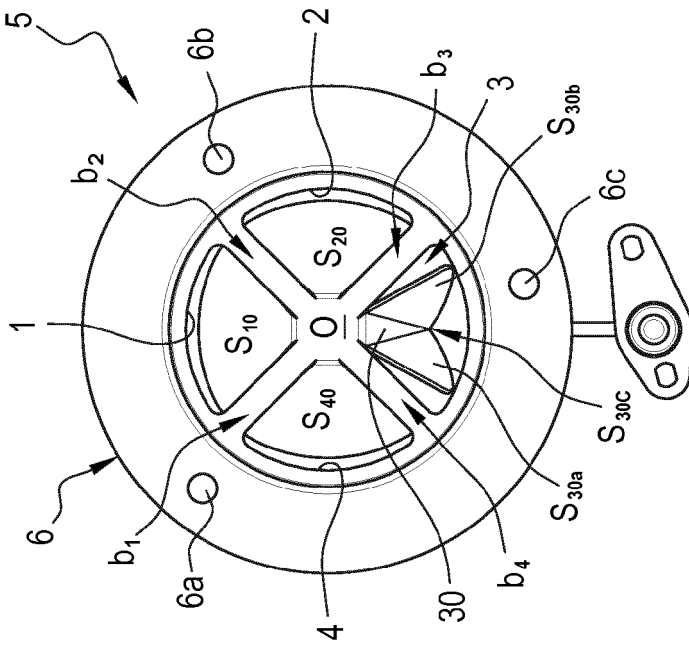


FIG. 2B

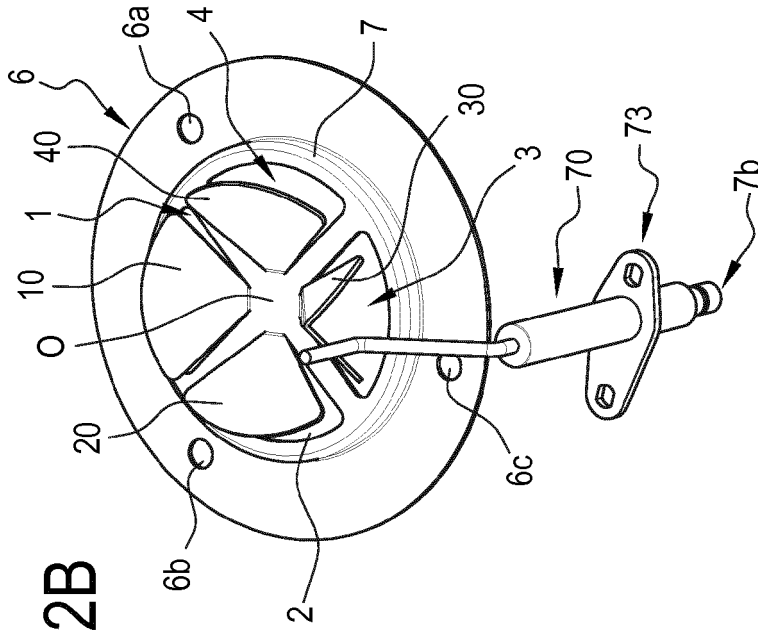


FIG. 2A

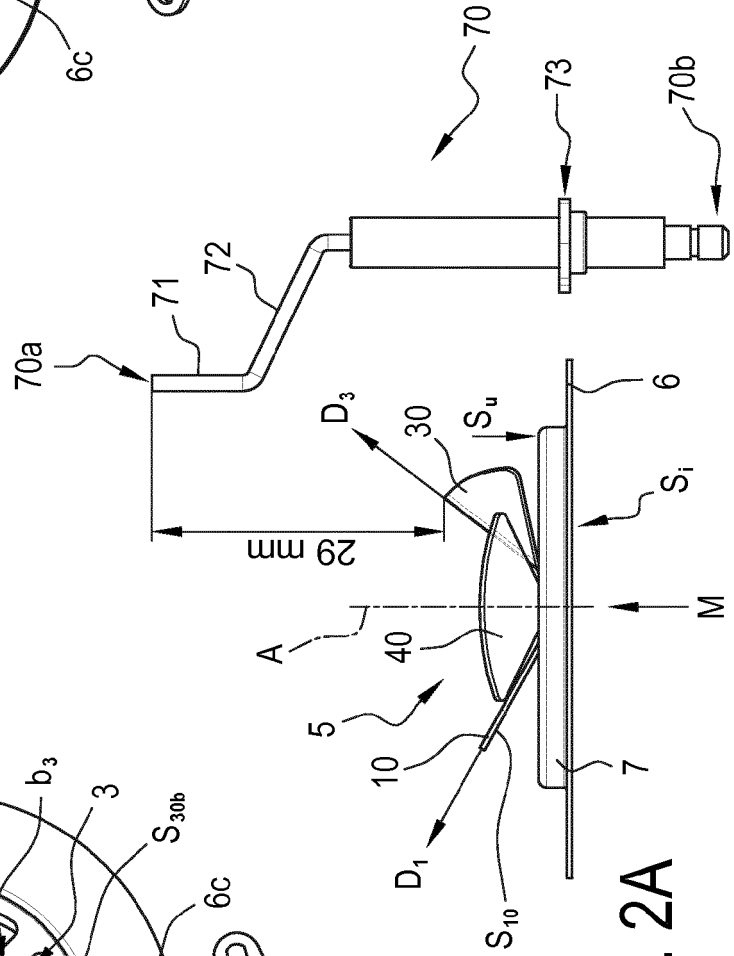


FIG. 3A

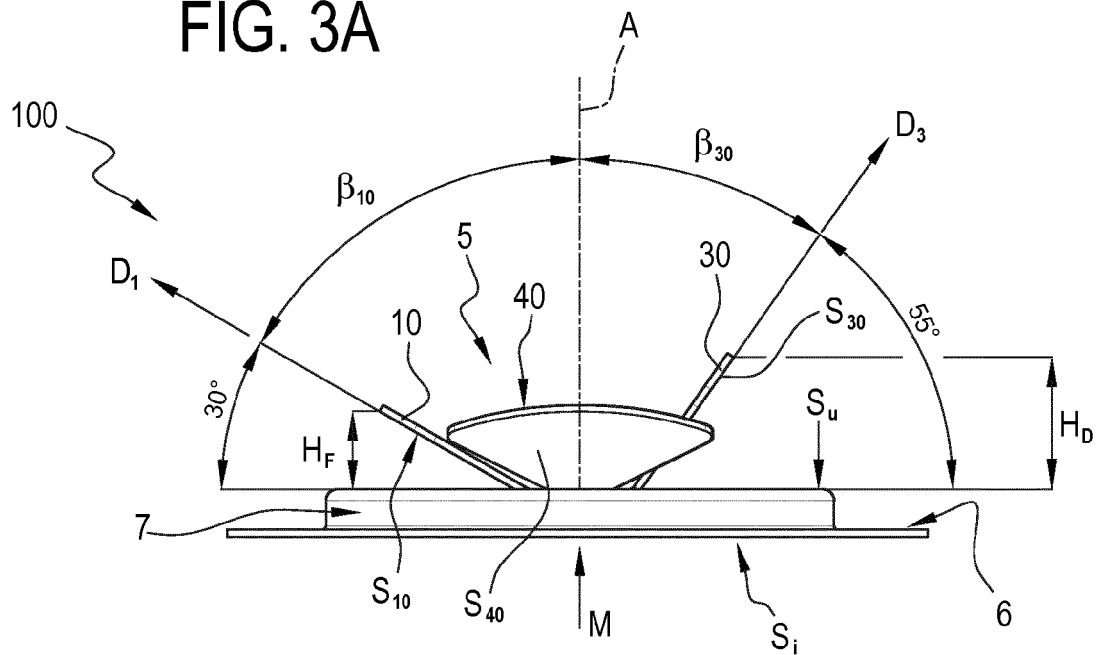


FIG. 3B

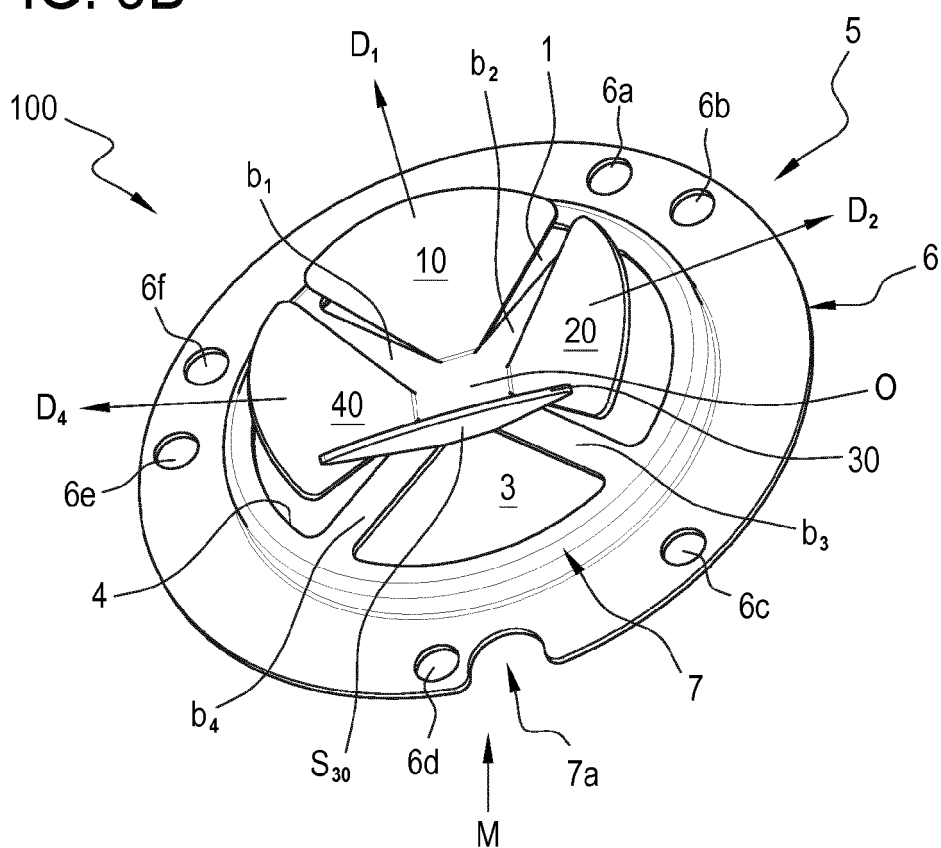


FIG. 4

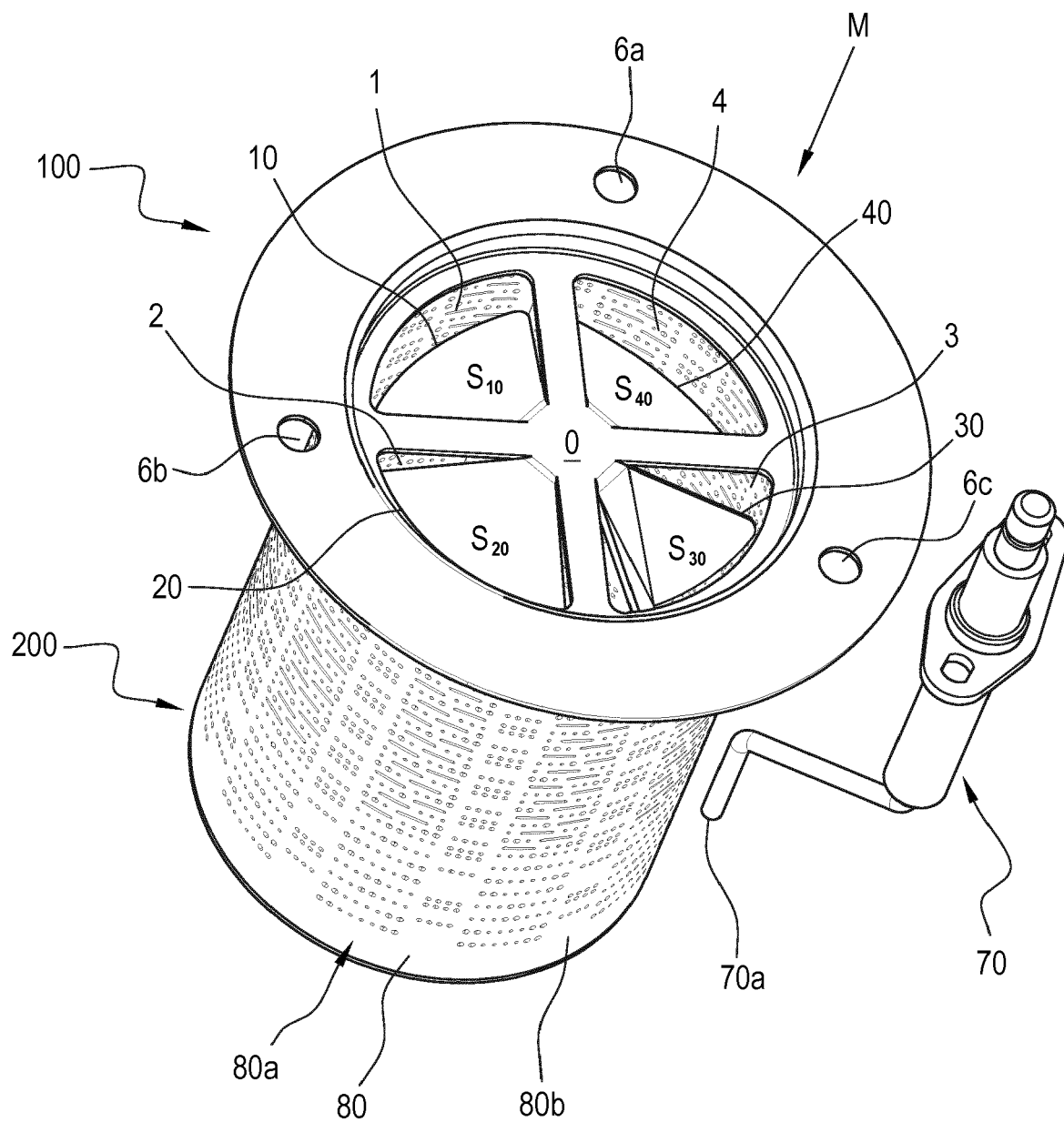


FIG. 5

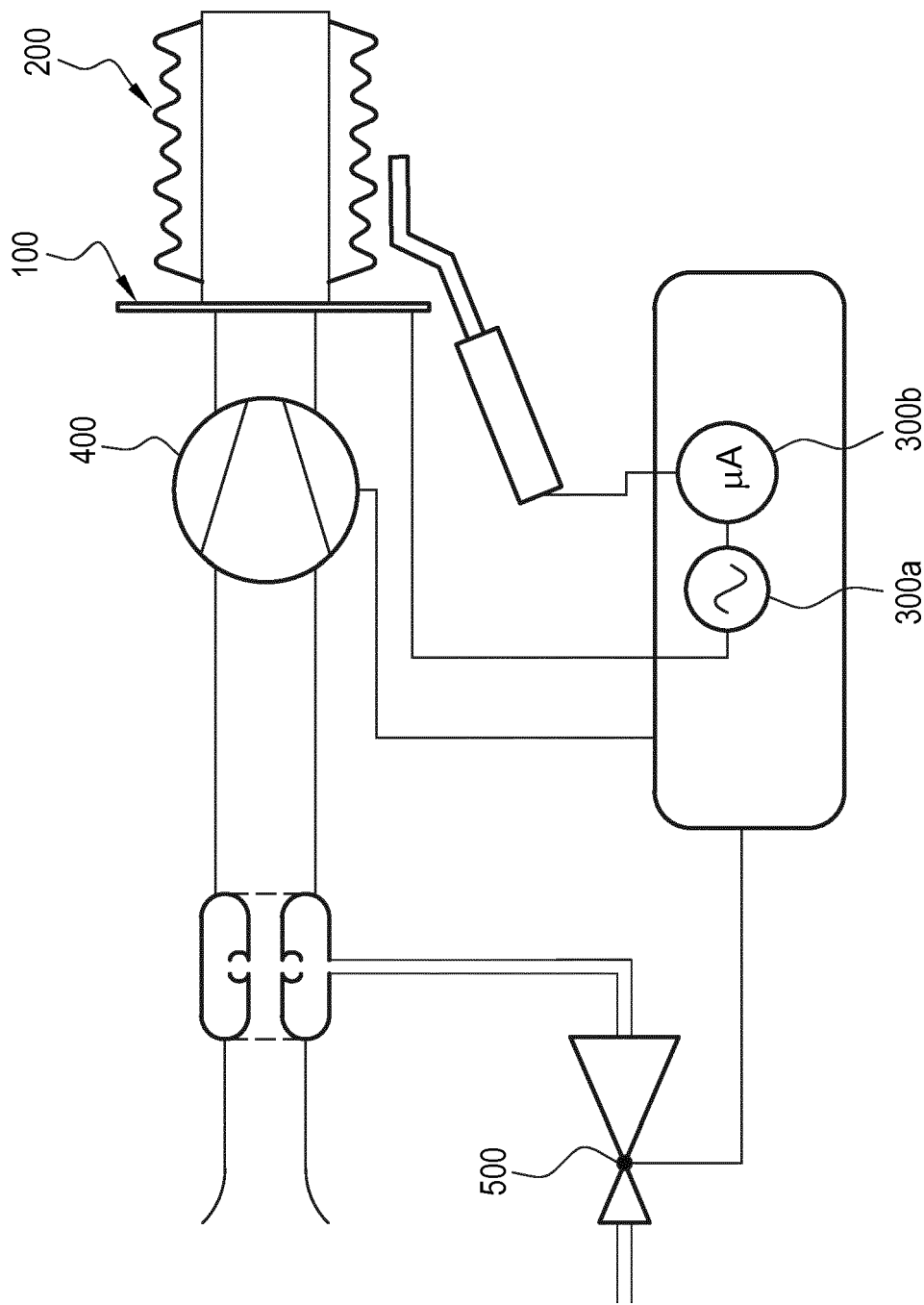


FIG. 6

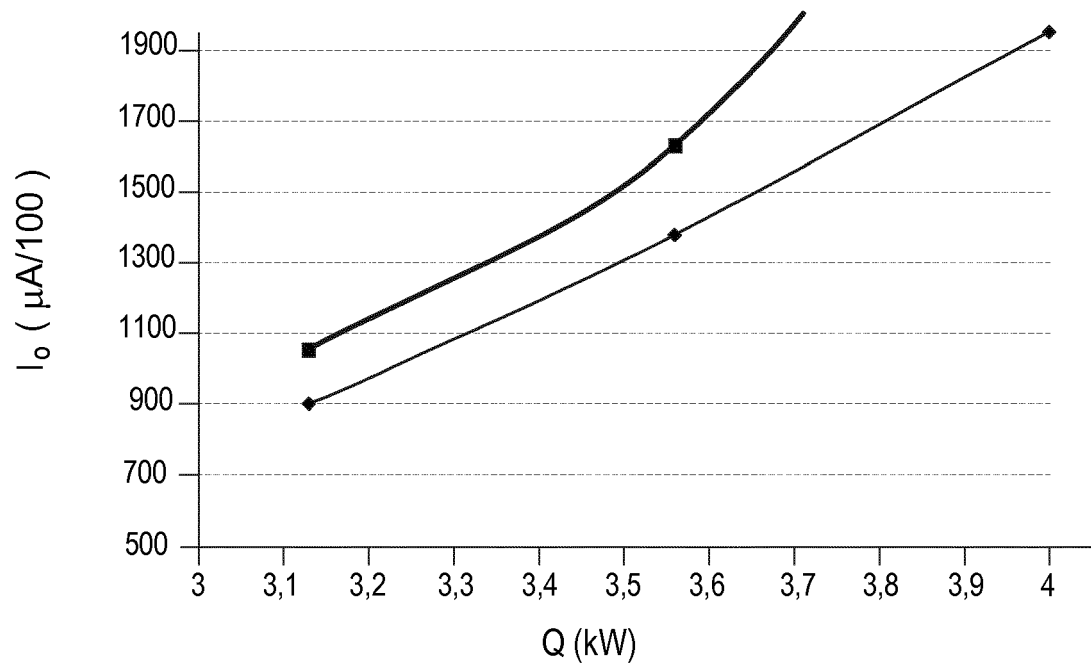


FIG. 7

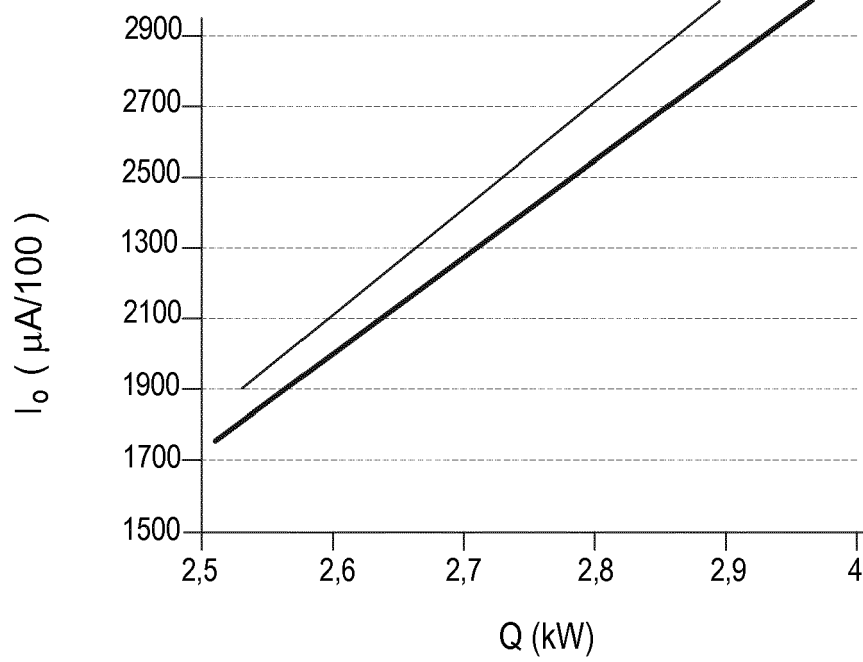


FIG. 8

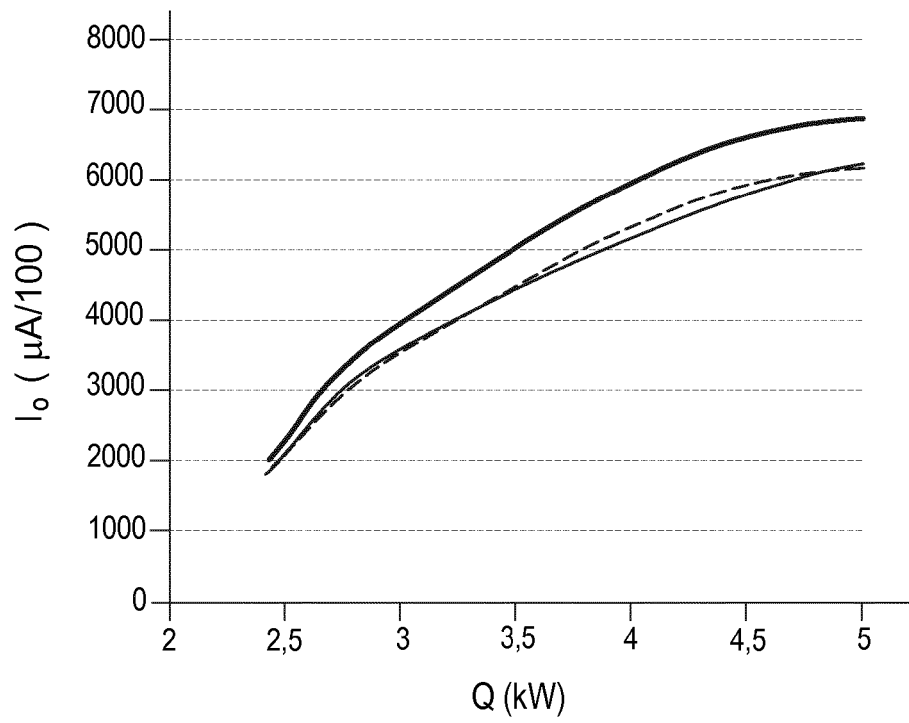
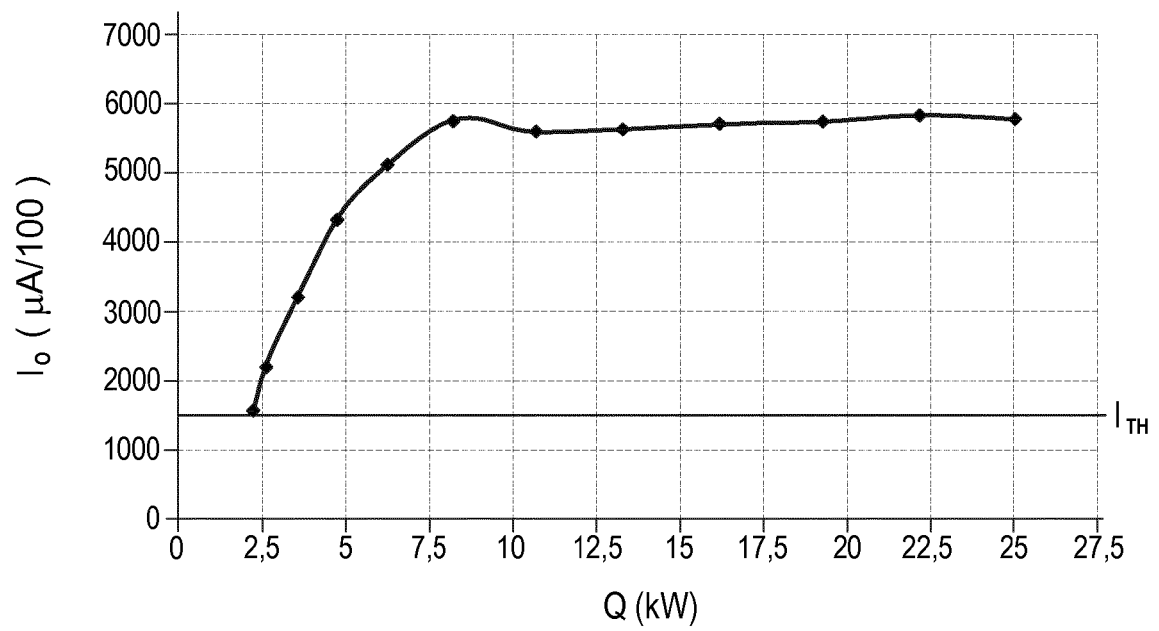


FIG. 9





EUROPEAN SEARCH REPORT

Application Number
EP 19 19 8838

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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 13 January 2020	Examiner Hauck, Gunther
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