

(19)



(11)

EP 4 826 292 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
F23D 14/22 ^(2006.01) **F23D 14/58** ^(2006.01)
F23D 14/78 ^(2006.01) **F23L 7/00** ^(2006.01)

(21) Application number: **26160759.2**

(52) Cooperative Patent Classification (CPC):
F23D 14/22; F23D 14/58; F23D 14/78; F23L 7/007;
F23D 2214/00

(22) Date of filing: **25.02.2026**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH LA MA MD TN

(72) Inventors:
• **VECCHIET, Fabio**
I-33017 Tarcento, UDINE (IT)
• **GREGUOLDO, Jacopo**
I-33017 Tarcento, UDINE (IT)
• **DAPIT, Gabriele**
I-33017 Tarcento, UDINE (IT)
• **LAVIOSA, Cesare**
I-33017 Tarcento, UDINE (IT)

(30) Priority: **17.04.2025 IT 202500008700**

(74) Representative: **Zanettin, Gianluigi et al**
Jacobacci & Partners S.p.A.
Piazza Mario Saggin, 2
35131 Padova (IT)

(71) Applicant: **SMS group S.p.A.**
33017 Tarcento (UD) (IT)

(54) **INJECTOR-BURNER FOR FURNACE, IN PARTICULAR FOR THE PRODUCTION OF STEEL OR METALS**

(57) The present invention relates to an injector-burner (1) for furnaces, for example electric arc furnaces, having an axial-symmetric extension with respect to a longitudinal axis (X) and defining in sequence from said axis (X) outwards: a central nozzle (3); a first annular chamber (10); a second annular chamber (20); and a third annular chamber (30), wherein said three annular chambers are concentric to said central nozzle. Said injector-burner (1) comprises a main injector body (40) on which are formed: - a head (2); - said central nozzle (3) which extends axially in a position opposite to the head (2). The injector-burner (1) comprises an assembly of four concentric tubular bodies (50, 51, 52, 53) which are sealingly connected by welding on said main injector body (40) in positions that are axially and radially offset from one another to define, two by two, said three annular chambers (10, 20, 30). The main injector body (40) is made of a first material, while said tubular bodies (50, 51, 52, 53) are made of a second material. On said main injector body (40), three annular shoulders (41, 42, 43) are obtained concentrically around said central nozzle (3). Each of said annular shoulders (41, 42, 43) has a lowered annular seat (410, 420, 430), which is arranged on the outer edge of said shoulder and acts as a centering and welding seat for the head of the respective tubular body. Each lowered annular seat (410, 420, 430) is defined by two surfaces incident with each other, wherein: - a first surface (4) is transverse to the long-

itudinal axis (X) and is connected by a welding bead (90) to the thickness of the wall of the tubular body at the head; - a second surface (5) is parallel to the longitudinal axis (X) and at least partially faces the inner wall of the tubular body at the head. On said lowered annular seat there is a fill (91) which consists of a material compatible in welding with said first material and said second material and occupies a recess (93) obtained on said main injector body at the lowered annular seat, said fill (91) defining at least the first surface (4) of said lowered annular seat and extending radially inwards beyond said second surface (5). [Fig. 8]

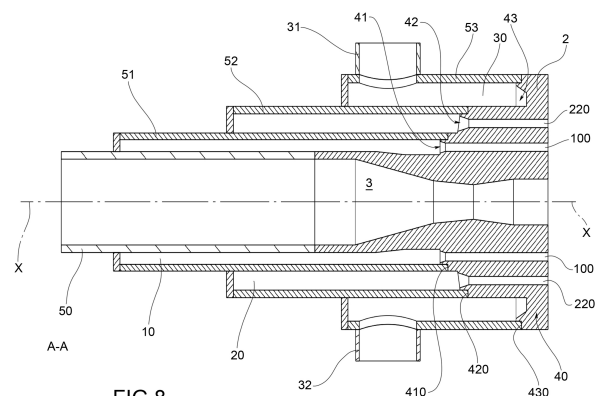


FIG. 8

Description

Field of application

[0001] The subject of the present invention is an injector-burner for furnaces, in particular for the production of steel or metals, for example electric arc furnaces.

Prior art

[0002] In the field of furnaces, for example electric arc furnaces, for use in the steel and metal industry, it is known to make openings on the side walls of the furnace chamber, through which devices such as burners, injectors, and lances can be inserted.

[0003] In particular, it is known to use auxiliary burners that allow additional energy to be added to the energy supplied by the electric arc in order to facilitate and accelerate the melting of the metal.

[0004] It is also known to use injectors capable of introducing gas or granular material into the furnace chamber and into the bath of molten metal and slag generated therein. They may be fixed to the wall or movable within the furnace by means of suitable manipulators (in this case they are sometimes referred to as lances). The injectors are often used to generate a supersonic gas flow or a high-speed jet of granular material. Injectors and lances, in addition to functioning as gas injectors or burners, allow additives to be introduced into the bath of molten metal, which are used during the metallurgical process, such as carbon, lime or other granular material. Auxiliary burners, injectors and lances will hereinafter be referred to as "injectors".

[0005] These injectors, in order to achieve maximum effectiveness, must be positioned inside the furnace as close as possible to the melting bath. In this configuration, the injectors are intended to operate at the working temperature of the furnace, which may reach 1500°C - 1700°C, and are also exposed to possible splashes of liquid steel and slag. For these reasons, these injectors are internally provided with forced water cooling circuits.

[0006] The operating conditions of these injectors are therefore very severe and cause them to wear out very quickly. Significant levels of wear or, at the limit, the breakage of the injector due to thermo-mechanical stress can cause a leakage of water from the internal cooling circuit into the furnace, resulting in a deterioration of the operating conditions.

[0007] Moreover, any water infiltration into the molten bath and below the layer of refractory material can cause the formation of steam, which results in a rapid increase in volume and pressure with the effect of a real explosion.

[0008] In addition, the wear of the injector or the formation of cracks in its parts entails the risk of leaks occurring within the circuits of the fuel and/or the com-

bustion agent that are delivered into the furnace by the injector. In this case, the gaseous fuel (for example, methane) and the combustion agent (in particular, oxygen) would no longer be mixed in the area designated for combustion inside the furnace, but would mix upstream of the injector (or inside it), once again causing a serious risk of explosion.

[0009] From the above, it is therefore clear how important the following factors are:

- high cooling efficiency suitable to reduce the thermo-mechanical stresses in the injector and thus reduce wear and the risk of crack formation or breakage;
- a construction configuration that ensures high sealing between the internal ducts of the different fluids handled (gaseous fuel, combustion agent and water);
- ease of construction, in order to contain production costs and therefore the costs related to the replacement of worn injectors.

[0010] To all this is added the need to reduce as much as possible the weight and dimensions of the injectors in order to increase their manoeuvrability and thus facilitate the operations related to the transport, removal and installation of worn and new injectors in the furnace area.

[0011] The search for weight and size reduction must not, however, be pursued at the expense of the functionality and the containment of the production costs of the injector.

[0012] Typically, an injector comprises a head T having an axial-symmetric development, composed of several components, generally made of copper or steel and welded together. The head of the injector presents, from the axis outward, the following sequence of ducts/chambers:

- a central duct C for the primary combustion agent which supplies a central nozzle U of the injector;
- an annular chamber C1 for the gaseous fuel (for example, methane) which supplies a first circular series of nozzles D1 via respective ducts;
- an annular chamber C2 for the secondary combustion agent which supplies a second D2 and possibly also a third circular series of nozzles D3 via respective ducts;
- an annular chamber C3 for water cooling.

[0013] This sequence of chambers/ducts may be implemented with various construction configurations.

[0014] According to a construction type known as "concentric tubes", of which an example is illustrated in figures 1 to 4, the injector is defined by four or more concentric tubular bodies which define, two by two, the annular chambers, including the cooling chamber. These tubular bodies are fitted at a first end onto the

head of the injector where the nozzles are formed, while at a second end they are connected to respective supply ducts.

[0015] Generally, the annular chambers are separated from one another by sealing joints, in many cases made by welding. In the event of even a partial failure of the joints, dangerous fluidic short circuits may occur between fuel and combustion agent, with the risk of forming explosive mixtures. This problem is particularly significant in injectors of the "concentric tubes" type.

[0016] For these reasons, the known construction types of injectors require particularly laborious methods of implementation, especially of the sealing joints. All this, combined with the intrinsic construction complexity of the injectors (consisting of a multiplicity of parts assembled together), negatively affects production costs.

[0017] Compared to other types of injectors, the "concentric tubes" type - although afflicted by the aforementioned problems - represents the technically simplest and most economical construction solution to implement.

[0018] In the field of injectors for furnaces, in particular electric arc furnaces, the need is therefore still strongly felt to have injectors of the concentric tubes type with increased manoeuvrability, at the same time having construction features such as to maintain their functionality, without however increasing the complexity of implementation, and possibly even reducing it.

[0019] Other important factors to be considered in the implementation of injectors are related to:

- the need to ensure efficient cooling of the head exposed to greater thermo-mechanical stresses, with a view to reducing wear and the risk of breakage;
- the need to ensure fluid dynamics favourable to combustion at the outlet of the injector.

[0020] In the field of injectors for furnaces, in particular electric arc furnaces, the need to have injectors of the concentric tubes type with increased manoeuvrability should preferably be associated with the need to continue to offer adequate cooling of the head, as well as to achieve fluid dynamic performance favourable to combustion.

Presentation of the invention

[0021] Therefore, the main object of the present invention is to eliminate, in whole or in part, the drawbacks of the known prior art mentioned above, by providing an injector-burner for furnaces, in particular for the production of steel or metals, for example electric arc furnaces, which can be constructed so as to be more manageable and more economical, while at the same time having construction features such as to maintain its functionality, without however increasing the complexity of implementation, and possibly even

reducing it.

[0022] A secondary object of the present invention is to provide an injector-burner for furnaces, in particular for the production of steel or metals, for example electric arc furnaces, which, while being capable of being constructed so as to be more manageable and more economical, continues to allow efficient cooling of the head.

[0023] Another secondary object of the present invention is to provide an injector-burner for furnaces, in particular for the production of steel, for example electric arc furnaces, which, while being capable of being constructed so as to be more manageable and more economical, continues to offer fluid dynamic performance favourable to combustion.

Brief description of the drawings

[0024] The technical features of the invention, according to the aforementioned objects, are clearly identifiable from the content of the claims set out below, and the advantages thereof will become more evident in the detailed description that follows, made with reference to the accompanying drawings, which represent one or more purely exemplary and non-limiting embodiments thereof, in which:

- Figure 1 shows a front perspective view of a traditional type injector-burner;
- Figure 2 shows a front orthogonal view of the injector-burner of figure 1;
- Figure 3 shows a sectional view of the injector-burner of figure 2 taken along the section plane A-A indicated therein;
- Figure 4 shows a sectional view of the injector-burner of figure 2 taken along the section plane B-B indicated therein;
- Figure 5 shows a front perspective view of an injector-burner according to a preferred embodiment of the invention;
- Figure 6 shows a front orthogonal view of the injector-burner of figure 5;
- Figure 7 shows a rear orthogonal view of the injector-burner of figure 5;
- Figure 8 shows a sectional view of the injector-burner of figure 6 taken along the section plane A-A indicated therein;
- Figure 9 shows a sectional view of the injector-burner of figure 5 taken along the section plane B-B indicated therein;
- Figure 10 shows an exploded view of the injector-burner of figure 5;
- Figure 11 shows a perspective view of a detail of the injector-burner of figure 10 relating to a main injector body;
- Figure 12 shows a detailed view of a detail of figure 8 relating to a welding joint area; and
- Figure 13 shows a detailed view of a particular of

figure 8 relating to a welding joint area between the central nozzle and tubular body.

[0025] The figures constitute purely schematic representations of the object, without necessarily respecting the proportions between the various parts.

Detailed description

[0026] The injector-burner for furnaces, in particular for the production of steel or metals according to the invention, is generally denoted by 1 in the attached figures.

[0027] In particular, the furnace is an electric arc furnace, but in general it may be an industrial furnace.

[0028] Here and in the following description and claims, reference will be made to the injector 1 in its condition of use. In this sense, any references to a lower or upper position, front or rear, or to a horizontal or vertical orientation, are to be understood accordingly.

[0029] According to a general embodiment of the invention, the injector-burner 1 has an axial-symmetric extension with respect to a longitudinal axis X.

[0030] As shown in particular in figures 8 and 9, the injector-burner 1 defines in sequence from said longitudinal axis X outwards:

- a central nozzle 3, which is arranged along said longitudinal axis X and is intended to be fluidically supplied with a flow of primary combustion agent through a first supply duct 50;
- a first annular chamber 10, which is intended to be fluidically supplied with a flow of gaseous fuel or with a flow of secondary combustion agent through at least a second supply duct 11;
- a second annular chamber 20, which is intended to be fluidically supplied through a third supply duct 21 with a flow of secondary combustion agent, in the case where said first annular chamber 10 is supplied with a flow of gaseous fuel, or with a flow of gaseous fuel, in the case where said first annular chamber 10 is supplied with a flow of secondary combustion agent; and
- a third annular chamber 30, which is intended to be fluidically connected to the delivery 31 and return 32 of a circulation circuit of a cooling fluid.

[0031] The gaseous fuel may be of any type suitable for the purpose, for example methane.

[0032] The primary combustion agent and the secondary combustion agent may be air, oxygen-enriched air, or pure oxygen, depending on the operating conditions of the injector-burner 1.

[0033] The cooling fluid may be of any type suitable for the purpose, preferably water.

[0034] As shown in particular in figures 8 and 9, the injector-burner 1 comprises a main injector body 40 on which are formed:

- a head 2, which is arranged at a first axial end 1' of said injector-burner 1 and is intended to face the inside of a furnace, for example an electric arc furnace (not shown in the figures);
- the central nozzle 3 which extends axially in a position opposite to the head 2;

[0035] The head 2 is coaxially traversed by said central nozzle 3 and is provided with several circular series of nozzles 100, 210, 220 that connect the first annular chamber 10 and the second annular chamber 20 with the outside of the injector-burner 1.

[0036] Preferably, the main injector body 40 is made in a single piece. In particular, the main injector body 40 may be obtained from solid material from a single piece. Alternatively, the main injector body 40 may be produced by printing or additive manufacturing.

[0037] The injector-burner 1 comprises an assembly of four concentric tubular bodies 50, 51, 52, 53 which are sealingly connected by welding on said main injector body 40 in positions that are axially and radially offset from one another to define, two by two, said three annular chambers 10, 20, 30.

[0038] Of said four concentric tubular bodies 50, 51, 52, 53, the innermost tubular body 50 (which acts as the first supply duct) is connected to the central nozzle 3, while the other three tubular bodies 51, 52, 53 are coaxially external to said central nozzle 3.

[0039] Said three annular chambers 10, 20 and 30 are therefore concentric to said central nozzle 3, configuring the injector-burner 1 as an injector-burner of the concentric tubes type.

[0040] Said main injector body 40 is made of a first material, while said tubular bodies 50, 51, 52, 53 are made of a second material.

[0041] Preferably, the first material with which said main injector body 40 is made is copper or copper alloy, while the second material with which said tubular bodies 50, 51, 52, 53 are made is steel. The tubular bodies may be made of the same type of steel or of different types of steel, for example some in stainless steel and others in carbon steel.

[0042] According to a first essential aspect of the invention, on said main injector body 40 there are obtained concentrically around said central nozzle 3 three annular shoulders 41, 42, 43 which:

- are offset from one another radially and axially,
- are all obtained in a position axially opposite said head 2.

[0043] A first annular shoulder 41 defines the bottom of the first annular chamber 10 and is axially the farthest from the head 2.

[0044] A second annular shoulder 42 defines the bottom of the second annular chamber 20 and is axially in an intermediate position between the first and third shoulder.

[0045] A third annular shoulder 43 defines the bottom of the third annular chamber 30 and is axially the closest to the head 2.

[0046] Starting from the longitudinal axis X outward in the radial direction, there is in sequence the first annular shoulder 41, the second annular shoulder 42, and the third annular shoulder 43.

[0047] According to a further aspect of the invention, each of said annular shoulders 41, 42, 43 has a lowered annular seat 410, 420, 430, which is arranged on the outer edge of said shoulder and acts as a centering and welding seat for the head of the respective tubular body.

[0048] Each lowered annular seat 410, 420, 430 is sized to completely house the thickness of the wall of the respective tubular body 51, 52, 53 at the head portion of the latter.

[0049] As illustrated in figure 12, each lowered annular seat 410, 420, 430 is defined by two surfaces incident with each other, wherein:

- a first surface 4 is transverse to the longitudinal axis X and is connected by a welding bead 90 to the thickness of the wall of the tubular body at the head;
- a second surface 5 is parallel to the longitudinal axis X and at least partially faces the inner wall of the tubular body at the head.

[0050] As illustrated in figure 12, between the head of each tubular body and the respective lowered annular seat there is a fill 91 which:

- consists of a material compatible in welding with said first material and said second material, and
- occupies a recess 93 obtained on said main injector body at the lowered annular seat.

[0051] Said fill 91 defines at least the first surface 4 of said lowered annular seat and extends radially inwards beyond said second surface 5.

[0052] The welding bead 90 is arranged between said head and said fill 91.

[0053] Preferably, the surface 6 of said head and the surface 7 of said fill 91 facing said bead 90 are chamfered.

[0054] The expression "a material compatible in welding with said first material and said second material" means a material that can be welded with both the first and the second material.

[0055] Thanks to the invention, and in particular due to the presence of a lowered annular seat 410, 420, 430 for each shoulder 41, 42 and 43, the following advantages are achieved.

[0056] A first advantage relates to the ease of assembly of each tubular body 51, 52 and 53 on the main injector body 40. Each lowered annular seat 410, 420 and 430 defines, in fact, a centering seat for the re-

spective tubular body intended to be associated with the shoulder in which said annular seat is obtained. On the one hand, this facilitates the assembly of the injector-burner 1 since the axial alignment of the tubular bodies 51, 52, 53 is guided; on the other hand, it simplifies the welding operations as no specific operative measures are required to maintain the alignment of the tubular bodies during welding.

[0057] A second advantage is related to the fact that, again thanks to the presence of said lowered annular seats 410, 420 and 430, it is possible to define in the joining area between the head of the tubular body and said main injector body 40 a weld 900 (consisting of the welding bead 90 and the fill 91) having a resistant section that extends beyond the wall thickness of the tubular body.

[0058] In fact, as illustrated in figure 12, the fill 91 on which the welding bead 90 adheres has an extension not limited by the thickness of the wall of the tubular body, but may extend inside the main injector body beneath the respective shoulder, radially beyond the second surface without affecting the shoulder itself.

[0059] Given the same wall thickness of the tubular body, this results in a greater resistant section of the weld joint.

[0060] Operationally, as is known, the welding operations of the tubular bodies on the main injector body 40 require the preheating of the tubular bodies themselves. This causes their inevitable expansion. At the end of welding, cooling causes shrinkage of the tubular body, resulting in stress generation on the weld joint. The shorter the tubular body, the smaller the length over which the shrinkage is distributed and therefore the higher the thermo-mechanical stresses and deformations on the joint during the shrinkage phenomena that occur after welding.

[0061] Given the same length of the tubular body, having a greater resistant section in the weld joint means reducing the risk of tearing of the welded joints.

[0062] Thanks to the invention, there is a greater resistant section at the welding joints. This margin can be exploited to compensate for greater shrinkage due to a reduction in the length of the tubular body.

[0063] The reduction in the length of the tubular bodies thus translates into a reduction in the overall length of the injector-burner 1, which for this reason proves to be more manageable.

[0064] Thanks to the invention, the injector-burner 1 for furnaces, for example electric arc furnaces, is more manageable, while maintaining construction features that ensure its functionality. All this is achieved without increasing the complexity of implementation, and indeed reducing it thanks to greater ease of construction.

[0065] Preferably, from a production point of view, on each annular seat a machining operation is performed which removes said first material and produces a recess 93 that extends radially inwards beyond said second surface, onto which recess 93 a fill 91 of a material

compatible in welding with said first material and said second material is then deposited, which is subsequently machined to create a chamfered surface 7, and onto which the welding is then carried out, forming a welding bead 90 arranged between said head, which is in turn previously chamfered 6, and the chamfered surface 7 of said fill 91. In figure 12, the original lines of the surface of the head 6' and of the fill 7' before chamfering are shown in dashed lines.

[0066] Preferably, as already mentioned, the welding bead 90 extends between two chamfered surfaces 6 and 7, one obtained on the head of the tubular body and the other on the fill 91.

[0067] Preferably, as illustrated in figure 12, said fill 91 defines a stop step 92 for said head, which is not involved in the welding bead 90.

[0068] Preferably, as illustrated in figure 12, said fill 91 extends to at least a part of said second surface 5.

[0069] In particular, the welding may be performed, for example, using TIG or MAG technique.

[0070] Preferably, as illustrated in figure 13, the head portion of the central nozzle 3 where the respective tubular body 50 (first supply duct) is joined includes a lowered annular seat 400 which is arranged on the outer edge of said head portion and acts as a centering and welding seat for the head of the respective tubular body, a weld being present between said head and said annular seat.

[0071] Advantageously, the same features provided for the joining of the other tubular bodies may also be applied to the central tubular body 50 and the central nozzle 3.

[0072] Depending on the array to which they belong, said nozzles 100, 210, 220 are open on said first annular chamber 10 or on said second annular chamber 20 respectively on said first annular shoulder 41 or on said second annular shoulder 42.

[0073] The ideal solution for the inlet of said holes from the respective annular chambers should provide for the presence of radiused chambers CR on the bottom of the annular chambers themselves, as these ensure internal uniformity of flow. However, the presence of the lowered annular seats makes the adoption of such a solution impossible.

[0074] Preferably, as illustrated in the attached figures, to mitigate the fluid dynamic limitations related to imperfect inlet conditions of the holes and to still achieve good inlet conditions and uniform filling of the holes, said first annular shoulder 41 and said second annular shoulder 42 are defined by a flat surface:

- having an inclination such as to be orthogonal to the axis of each of said nozzles, if said nozzles have a single angle with respect to the longitudinal axis X, or
- having an inclination defined as an intermediate value between the angles orthogonal to the axis of each of said nozzles, if said nozzles have different

angles with respect to the longitudinal axis X.

[0075] In addition, on said first annular shoulder 41 and/or on said second annular shoulder 42, an inlet 44 is obtained for each nozzle.

[0076] Preferably, said inlet 44 is defined by a conical flaring of the surface defining the shoulder with an axis coincident with the axis of the nozzle.

[0077] As already highlighted previously, the first annular chamber 10 is intended to be fluidically supplied with a flow of gaseous fuel or with a flow of secondary combustion agent, while the second annular chamber 20 is intended to be fluidically supplied with a flow of secondary combustion agent, in the case where said first annular chamber 10 is supplied with a flow of gaseous fuel, or with a flow of gaseous fuel, in the case where said first annular chamber 10 is supplied with a flow of secondary combustion agent.

[0078] According to a preferred embodiment of the invention, the first annular chamber 10 is intended to be fluidically supplied with a flow of gaseous fuel, while the second annular chamber 20 is intended to be fluidically supplied with a flow of secondary combustion agent.

[0079] As is known, once the power deliverable by the injector-burner is fixed, the outlet cross-section of the gases (including oxygen) is automatically determined.

[0080] Moreover, as is known, to ignite the flame it is necessary to leave between said holes a sufficient distance to allow the recall of hot gases from the furnace, which are the ignition source.

[0081] Traditionally, to reconcile the above two requirements, large holes are made and distributed in a single array. In order to provide sufficient space between the holes for the recall of hot gases, the diameter of the injector-burner head is increased. This is detrimental to the manageability of the injector-burner, which becomes more cumbersome.

[0082] Traditionally, a possible alternative solution involves making fewer holes but of large size. In this case, if one does not intend to increase the diameter of the head, either the recall of hot gases from the outside is allowed without, however, reaching the required power, or the recall of hot gases is sacrificed in order to reach the required power. To ensure sufficient space between the holes to allow the recall of hot gases, it is indeed necessary to reduce the number of holes at the expense of the flow cross-section; conversely, to guarantee an adequate flow cross-section to achieve the required power, the holes must be brought closer together, preventing the recall of hot gases from the outside.

[0083] Advantageously, the present invention proposes to address this issue differently from traditional solutions.

[0084] Advantageously, as illustrated in particular in figure 6, the head 2 is provided with:

- the central nozzle 3,
- a circular series of first nozzles 100 that connect the first annular chamber 10 at said first annular cavity 41 with the outside of the injector-burner 1;
- two concentric circular series of second nozzles 210 and 220, which connect the second annular chamber 20 at said second annular cavity 42 with the outside of the injector-burner 1.

[0085] The central nozzle 3 is aligned on said axis X and said circular series of first nozzles 100 is intermediate between said two concentric circular series of second nozzles 210; 220.

[0086] As will be clarified below, the choice to arrange the second nozzles in two concentric circular arrays, for a given power deliverable by the injector-burner, allows reducing the radial dimensions of the head 2 of the injector-burner while simultaneously allowing the recall of hot gases. In this way, the injector-burner 1, while ensuring full functionality, being radially smaller, proves to be even more manageable.

[0087] More specifically, an arrangement that provides for organizing the second holes in a double circular array makes available an adequate cross-section for the required power and enough space between the various holes to allow the recall of hot gases from the furnace.

[0088] This arrangement of the holes also has a further advantage. The fuel (e.g., methane) is encapsulated in a double layer of combustion agent (e.g., oxygen), ensuring complete combustion (due to the impossibility for the fuel to move radially without intersecting the combustion agent) and, particularly in the case of injector function, ensuring that the fuel burns with the combustion agent of the innermost layer without consuming the combustion agent (oxygen) supplied by the central nozzle of the injector.

[0089] Advantageously, the reduction of the radial dimensions of the head of the injector-burner 1 (for equal power delivered) allows reducing the surface of the head exposed inside the furnace. Therefore, under equal thermal conditions inside the furnace, the thermal load received by the head is reduced, making cooling easier.

[0090] Therefore, given the power to be delivered, thanks to the arrangement of the second holes in a double circular array, excessive crowding of the outermost array of second holes is avoided, not only ensuring good ignition by suction of gases from the furnace but also obtaining a "dual-stage" flame with confinement of the fuel.

[0091] Finally, the reduction of the radial dimensions of the head not only makes the injector-burner more manageable but also allows reducing the thermal load to be dissipated, thus lowering the cooling requirements.

[0092] Advantageously, the first nozzles 100 are angularly equally distributed.

[0093] Preferably, the circular series of first nozzles 100 is concentric to said central nozzle 3.

[0094] Advantageously, said first nozzles 100 may have axes with a non-zero circumferential component with respect to the longitudinal axis X. In other words, the first nozzles 100 may be configured to impart a swirl to the flow passing through them.

[0095] Advantageously, the second nozzles 210, 220 are angularly equally distributed.

[0096] Preferably, the two concentric circular series of second nozzles 210 and 220 are concentric to the central nozzle 3.

[0097] Advantageously, the second nozzles 210 of the innermost circular series may have axes with a non-zero circumferential component with respect to the longitudinal axis X. In other words, the second nozzles 210 of the innermost circular series may be configured to impart a swirl to the flow passing through them.

[0098] Advantageously, the second nozzles 220 of the outermost circular series may have axes with a non-zero circumferential component with respect to the longitudinal axis X. In other words, the second nozzles 220 of the outermost circular series may be configured to impart a swirl to the flow passing through them.

[0099] According to the preferred embodiment illustrated in the attached figures, the second nozzles 220 of the outermost circular series are in a number from 2 to 80, preferably from 6 to 48.

[0100] The first nozzles 100 (preferably intended to deliver gaseous fuel) and the second nozzles 210 of the innermost circular series (preferably intended to deliver secondary combustion agent) allow the creation of a first flame core that is stable and well enveloped, consistent with the axial flow of primary combustion agent delivered by the central nozzle 3. The second nozzles 220 of the outermost circular series (also preferably intended to deliver secondary combustion agent) - in addition to supplying the oxygen to complete the combustion - allow the creation of a stable envelope of secondary combustion agent around the above-described central flame core. In this way, it is ensured that the gaseous fuel cannot exit in any way towards the outside of the flame (at least not unmixed with oxygen), thereby avoiding the formation of dangerous pockets in the material being melted inside the furnace.

[0101] Preferably, all or part of said first nozzles 100 and said second nozzles 210 and 220 have a constant cross-section in the direction of their respective axes, for example circular, slot-shaped, or elliptical.

[0102] All or part of said first nozzles 100 and said second nozzles 210 and 220 may have a variable cross-section in the direction of their respective axes, for example convergent-divergent.

[0103] Advantageously, the central nozzle 3 has a variable cross-section in the axial direction, preferably convergent-divergent. Even more preferably, the nozzle 3 defines a De Laval nozzle, suitable for generating a supersonic flow of primary combustion agent at the

outlet of the injector-burner 1, sized to produce, at the design supply pressure, a jet free from shock waves and other dissipative phenomena.

[0104] The invention makes it possible to obtain numerous advantages, partly already described.

[0105] The injector-burner for furnaces, for example electric arc furnaces, according to the invention can be constructed so as to be more manageable and more economical, while at the same time having construction features such as to maintain its functionality, without however increasing the complexity of implementation, and possibly even reducing it.

[0106] In particular, the injector-burner for furnaces, for example electric arc furnaces, according to the invention can be constructed so as to reduce its longitudinal development without increasing the risk of tearing at the joining zones between tubular bodies and the main injector body.

[0107] The injector-burner for furnaces, for example electric arc furnaces, according to the invention can be constructed so as to be more manageable and more economical, while still allowing efficient cooling of the head.

[0108] In particular, the injector-burner for furnaces, for example electric arc furnaces, according to the invention can be constructed so as to reduce the radial development of the head without loss of deliverable power, and at the same time improving cooling of the head.

[0109] The injector-burner for furnaces, for example electric arc furnaces, according to the invention can be constructed so as to be more manageable and more economical, while continuing to offer fluid dynamic performance favourable to combustion.

[0110] The invention thus conceived therefore achieves the intended objects.

[0111] Obviously, it may assume, in its practical implementation, also forms and configurations different from those illustrated above without thereby departing from the present scope of protection.

[0112] Furthermore, all details may be replaced by technically equivalent elements, and the dimensions, shapes, and materials used may be of any kind, depending on requirements.

Claims

1. Injector-burner (1) for furnaces, for example electric arc furnaces, having an axial-symmetric extension with respect to a longitudinal axis (X) and defining sequentially from said axis (X) outwards:

- a central nozzle (3) which is arranged along said longitudinal axis (X) and is intended to be fluidically supplied with a flow of primary combustion agent through a first supply duct (50);
- a first annular chamber (10), which is in-

tended to be fluidically supplied with either a flow of gaseous fuel or with a flow of secondary combustion agent through at least a second supply duct (11);

- a second annular chamber (20), which is intended to be fluidically supplied by at least a third supply duct (21) with a flow of secondary combustion agent, in the case where said first annular chamber (10) is fed with a flow of gaseous fuel, or with a flow of gaseous fuel, in the case where said first annular chamber (10) is fed with a flow of secondary combustion agent; and

- a third annular chamber (30), which is intended to be fluidically connected to the delivery (31) and return (32) of a cooling fluid circulation circuit,

wherein said three annular chambers are concentric to said central nozzle,

wherein said injector-burner (1) comprises a main injector body (40) on which are obtained:

- a head (2), which is arranged at a first axial end of said injector-burner (1) and is intended to face the inside of a furnace, said head (2) being coaxially crossed by said central nozzle (3) and being provided with several circular series of nozzles (100; 210, 220) which connect the first annular chamber (10) and the second annular chamber (20) with the outside of the injector-burner (1),
- said central nozzle (3) extending axially in a position opposite to the head (2);

wherein said injector-burner (1) comprises an assembly of four concentric tubular bodies (50, 51, 52, 53) which are sealingly connected by welding on said main injector body (40) in positions which are axially and radially offset from each other to define two by two said three annular chambers (10, 20, 30),

wherein said main injector body (40) is made of a first material, while said tubular bodies (50, 51, 52, 53) are made of a second material, **characterised in that** on said main injector body (40) three annular shoulders (41, 42, 43) are obtained concentrically around said central nozzle (3), the shoulders being radially and axially offset from each other, all obtained in a position axially opposite said head (2), wherein:

- a first annular shoulder (41) defines the bottom of the first annular chamber (10) and is axially the farthest from the head (2);
- a second annular shoulder (42) defines

the bottom of the second annular chamber (20) and is axially in an intermediate position between the first and the third shoulder; and

- a third annular shoulder (43) defines the bottom of the third annular chamber (30) and is axially closest to the head (2),

and **in that** each of said annular shoulders (41, 42, 43) has a lowered annular seat (410, 420, 430), which is arranged on the outer edge of said shoulder and acts as a centering and welding seat for the head of the respective tubular body, wherein each lowered annular seat (410, 420, 430) is sized to completely house the thickness of the wall of the respective tubular body (51, 52, 53) at the head portion of the latter wherein each lowered annular seat (410, 420, 430) is defined by two surfaces incident with each other, wherein:

- a first surface (4) is transverse to the longitudinal axis (X) and is connected by a welding bead (90) to the thickness of the wall of the tubular body at the head;

- a second surface (5) is parallel to the longitudinal axis (X) and at least partially faces the inner wall of the tubular body at the head

and **in that** on said lowered annular seat there is a fill (91) consisting of a material compatible in welding with said first material and said second material and occupies a recess (93) obtained on said main injector body at the lowered annular seat, said fill (91) defining at least the first surface (4) of said lowered annular seat and extending radially inwards beyond said second surface (5), wherein the welding bead (90) is arranged between said head and said fill (91), preferably the surface (6) of said head and the surface (7) of said fill (91) facing said bead (90) being chamfered.

2. Injector-burner (1) according to claim 1, wherein said fill (91) defines a stop step (92) for said head.
3. Injector-burner (1) according to any one of the preceding claims, wherein said fill (91) extends to at least a part of said second surface (5).
4. Injector-burner (1) according to any one of the preceding claims, wherein the first material with which said main injector body (40) is made is copper or copper alloy.
5. Injector-burner (1) according to any of the preced-

ing claims, wherein said main injector body (40) is made in a single piece.

6. Injector-burner (1) according to any one of the preceding claims, wherein the second material from which said tubular bodies (50, 51, 52, 53) are made is steel.
7. Injector-burner (1) according to any one of the preceding claims, wherein depending on the array to which they belong, said nozzles (100; 210, 220) are open on said first annular chamber (10) or on said second annular chamber (20) respectively on said first annular shoulder (41) and on said second annular shoulder (42).
8. Injector-burner (1) according to claim 7, wherein said first annular shoulder (41) and said second annular shoulder (42) are defined by a flat surface:
 - having an inclination such as to be orthogonal to the axis of each of said nozzles, if said nozzles have a single angle with respect to the longitudinal axis (X), or
 - having an inclination defined as an intermediate value between the angles orthogonal to the axis of each of said nozzles, if said nozzles have different angles with respect to the longitudinal axis (X),
9. Injector-burner (1) according to claim 7 or 8, wherein on said first annular shoulder (41) and/or on said second annular shoulder (42) a mouth (44) is obtained for each nozzle, preferably said mouth (44) being defined by a conical flaring of the surface defining the axis shoulder coincident with the axis of the nozzle.
10. Injector-burner (1) according to any one of the preceding claims, wherein:
 - said first annular chamber (10) is intended to be fluidically supplied with a flow of gaseous fuel; and
 - said second annular chamber (20) is intended to be fluidically supplied with a flow of secondary combustion agent.
11. Injector-burner (1) according to claim 10, wherein said head (2) is provided with:
 - said central nozzle (3),
 - a circular series of first nozzles (100) connecting the first annular chamber (10) at said first annular shoulder (41) with the outside of the injector-burner (1);
 - two concentric circular series of second nozzles (210; 220), which connect the second an-

nular chamber (20) at said second annular shoulder (42) with the outside of the injector-burner (1).

wherein said central nozzle (3) is aligned on said axis (X) and said circular series of first nozzles (100) is intermediate between said two concentric circular series of second nozzles (210; 220). 5

12. Injector-burner (1) according to claim 11, wherein said first nozzles (100) are angularly equally distributed, preferably said circular series of first nozzles (100) being concentric to said central nozzle (3). 10

13. Injector-burner (1) according to claim 12, wherein said first nozzles (100) have axes with non-zero circumferential components with respect to the longitudinal axis (X). 15

14. Injector-burner (1) according to any one of claims 11, 12 or 13, wherein said second nozzles (210, 220) are angularly equally distributed and wherein said two concentric circular series of second nozzles (210; 220) are concentric to said central nozzle (3). 20 25

15. Injector-burner (1) according to any one of claims 11 to 14, wherein the second nozzles (210) of the innermost circular series have axes with non-zero circumferential component with respect to the longitudinal axis (X). 30

16. Injector-burner (1) according to any one of claims 11 to 15, wherein the second nozzles (220) of the outermost circular series have axes with non-zero circumferential component with respect to the longitudinal axis (X). 35

17. Injector-burner (1) according to any one of claims 11 to 16, wherein all or a portion of said first nozzles (100) and said second nozzles (210; 220) have a constant cross-section in the direction of their respective axes, for example in the form of a circle, slot or ellipse. 40 45

18. Injector-burner (1) according to any one of claims 11 to 16, wherein all or a portion of said first nozzles (100) and said second nozzles (210; 220) have a variable cross-section in the direction of their respective axes, for example convergent-divergent. 50

19. Injector-burner (1) according to any of the preceding claims, wherein said central nozzle (3) has a variable cross-section in the axial direction, preferably convergent-divergent. 55

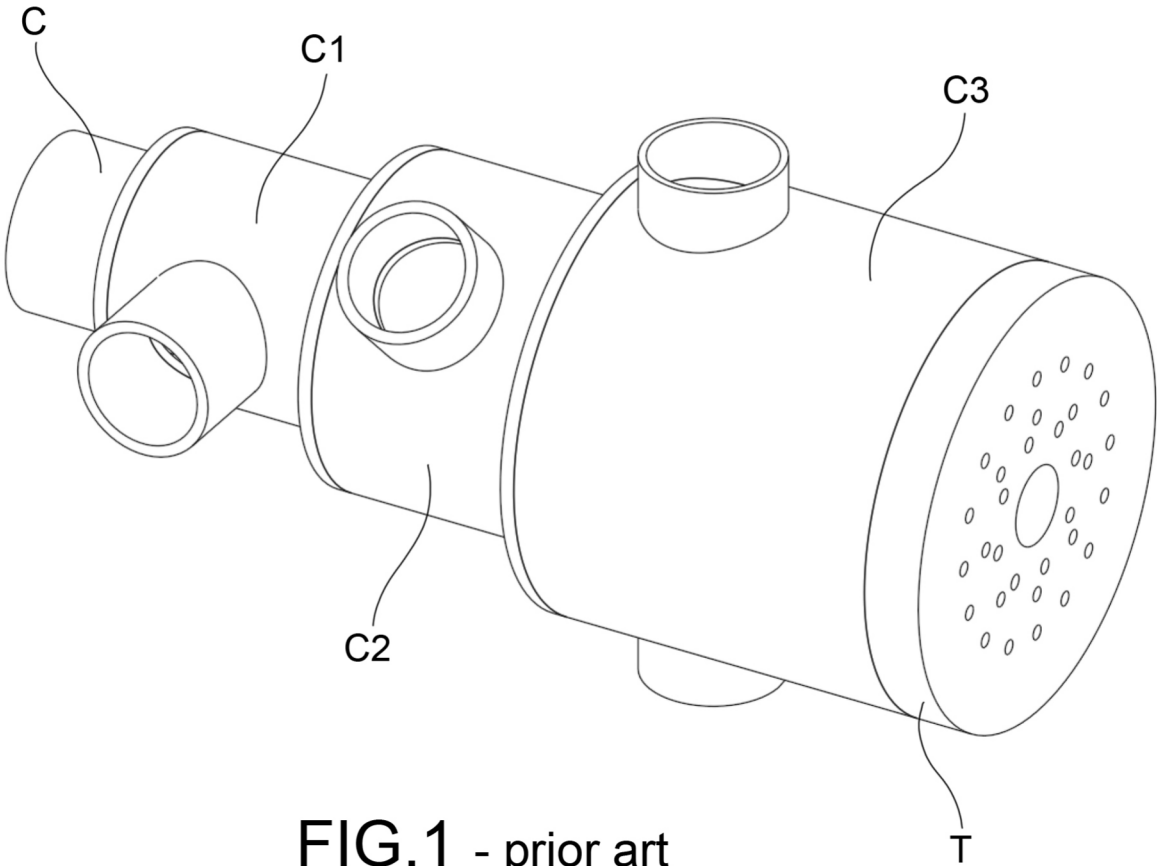


FIG.1 - prior art

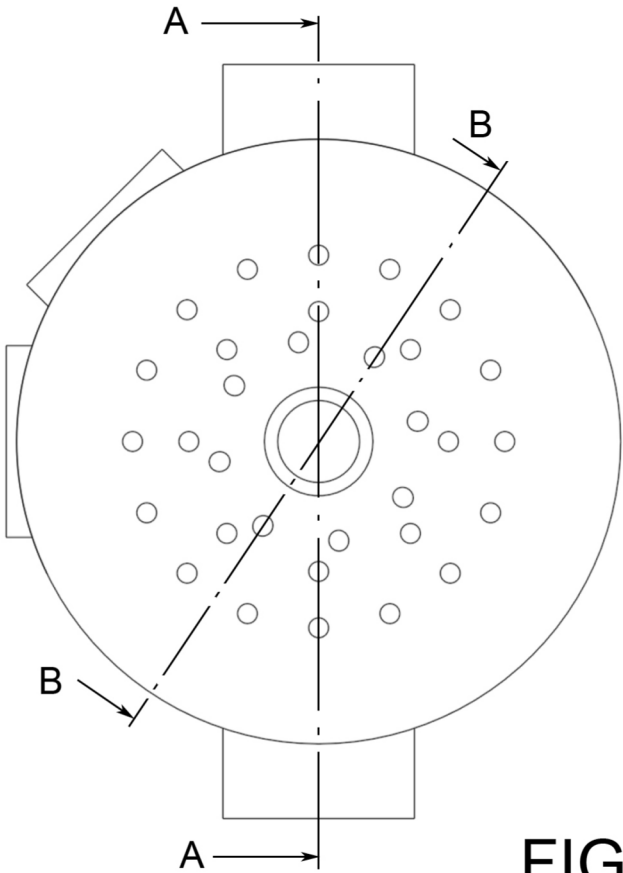


FIG.2 - prior art

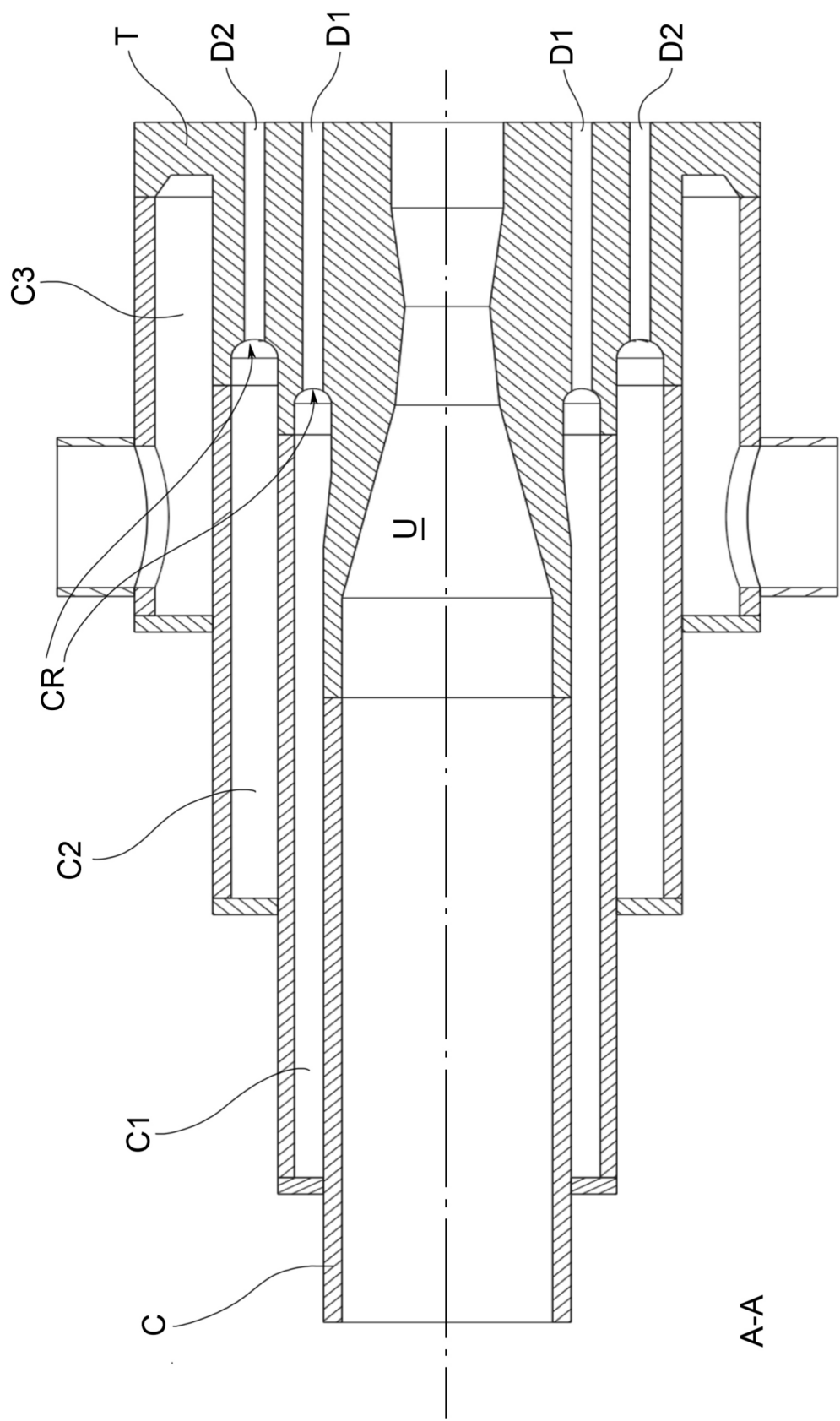


FIG.3 - prior art

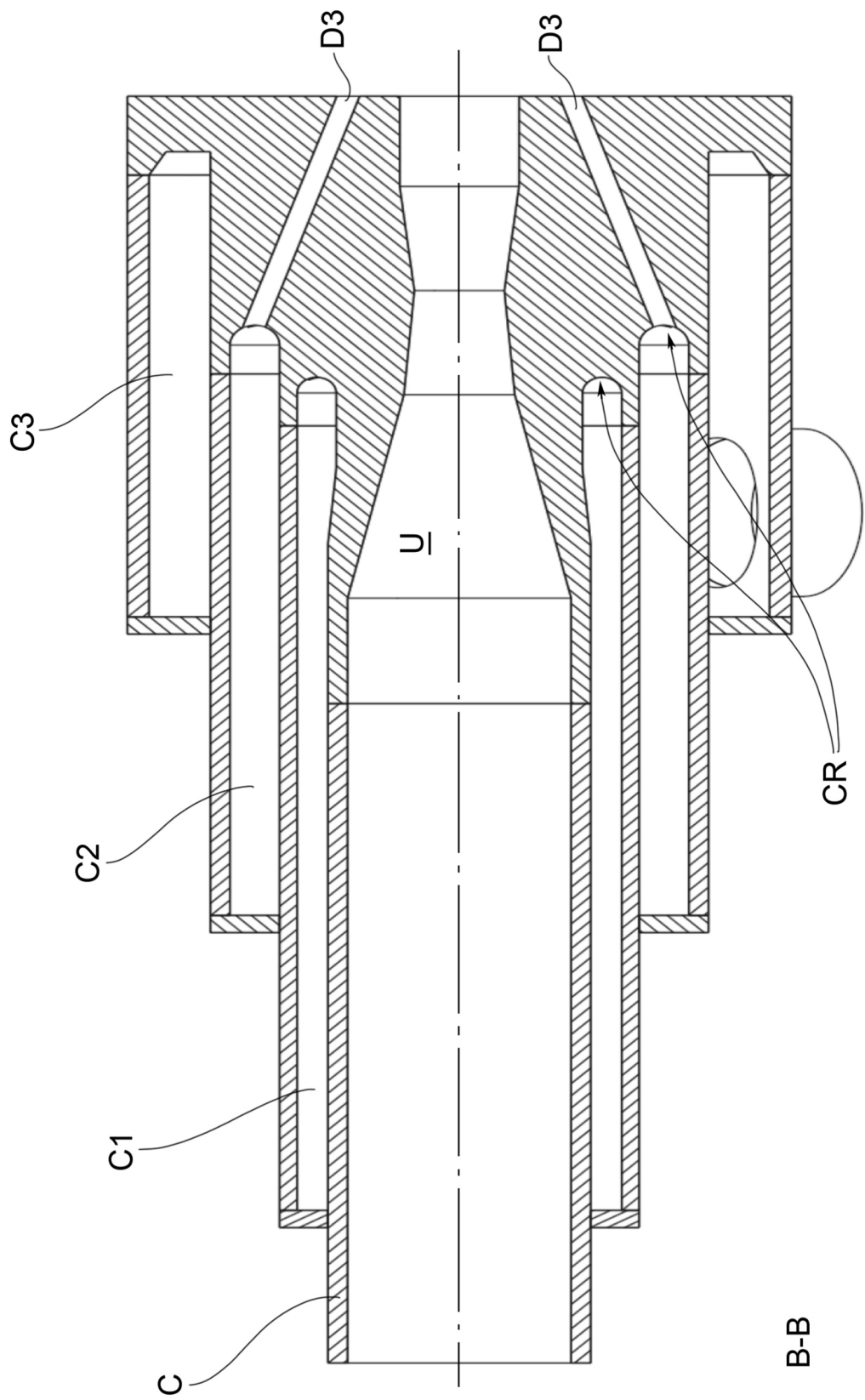


FIG.4 - prior art

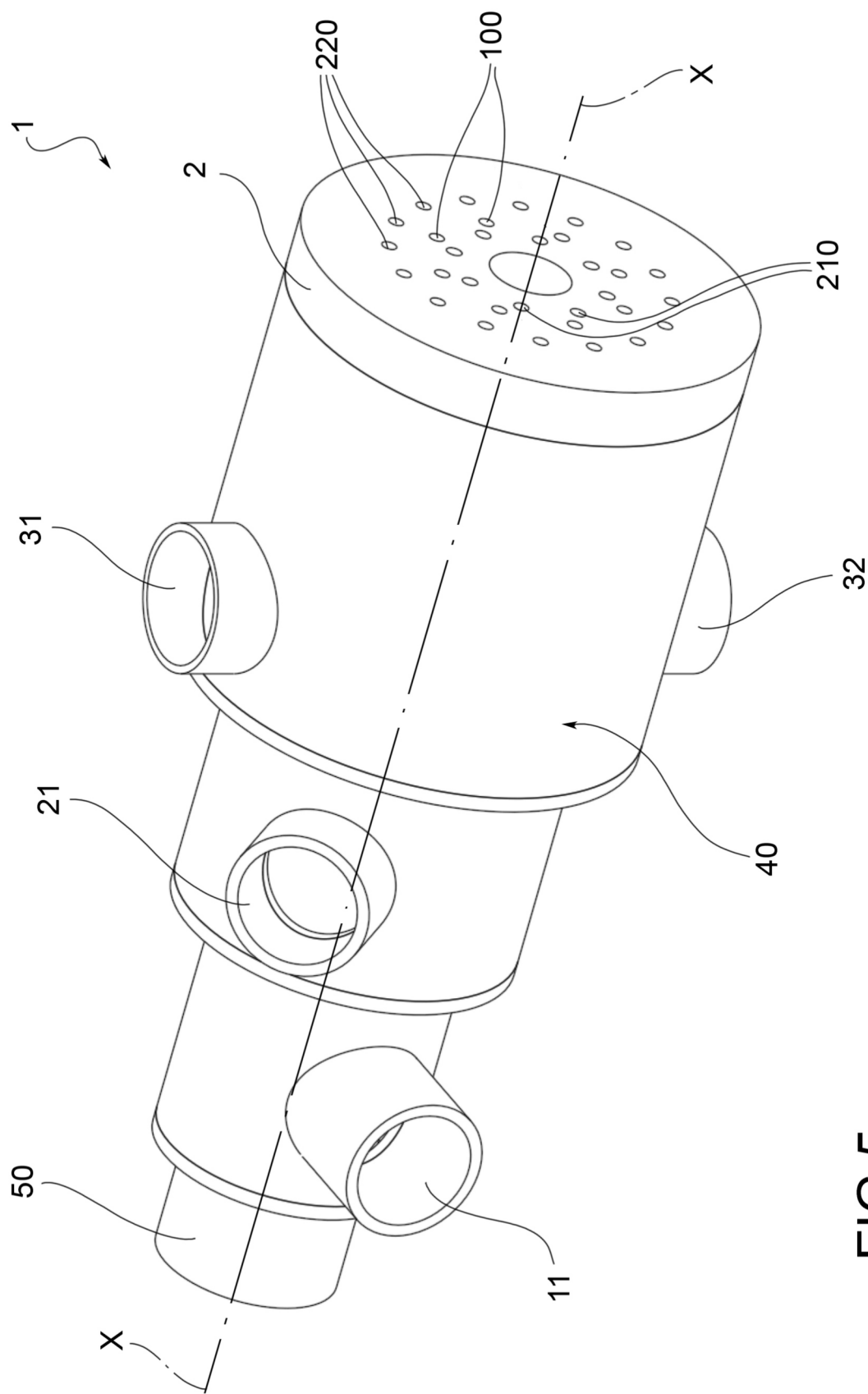
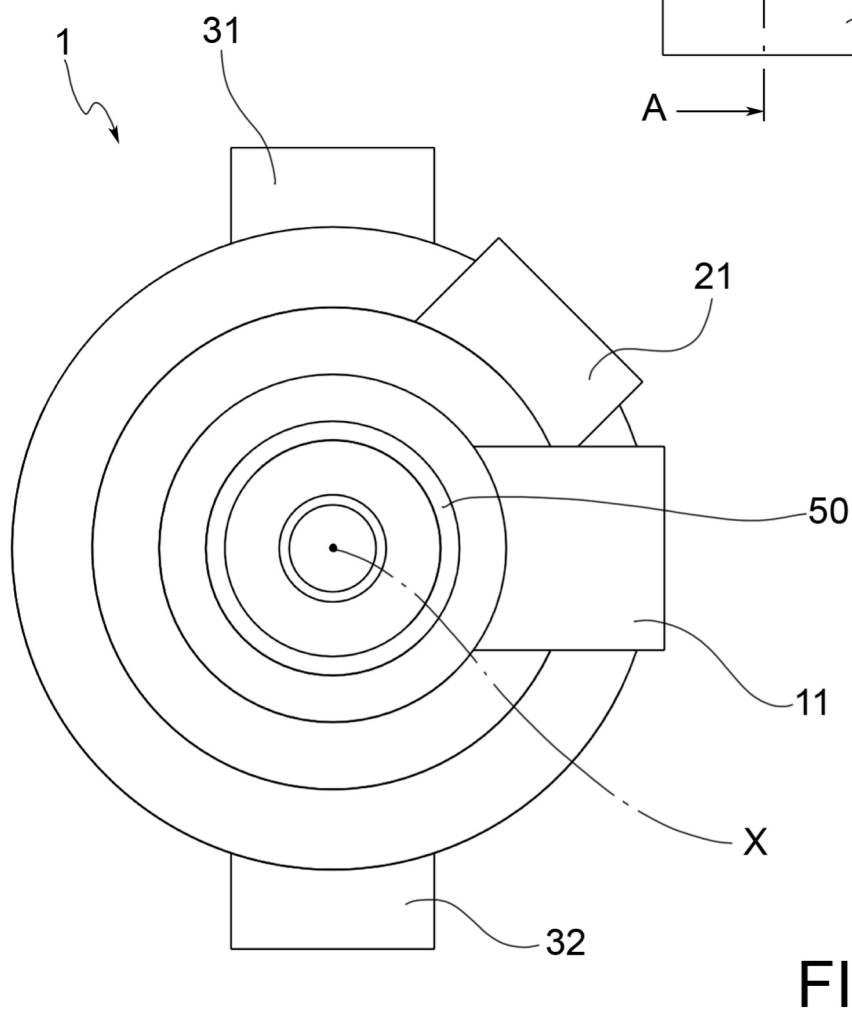
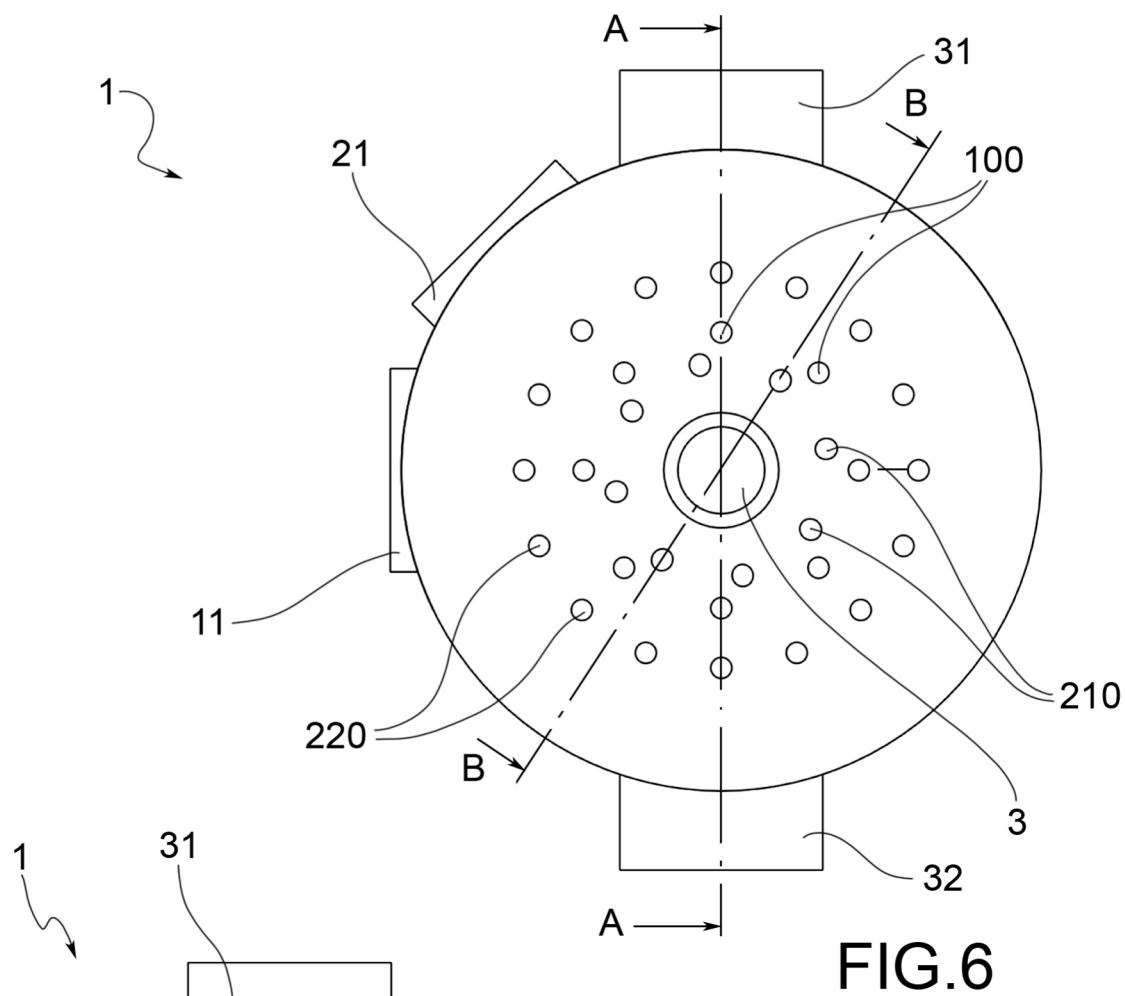


FIG.5



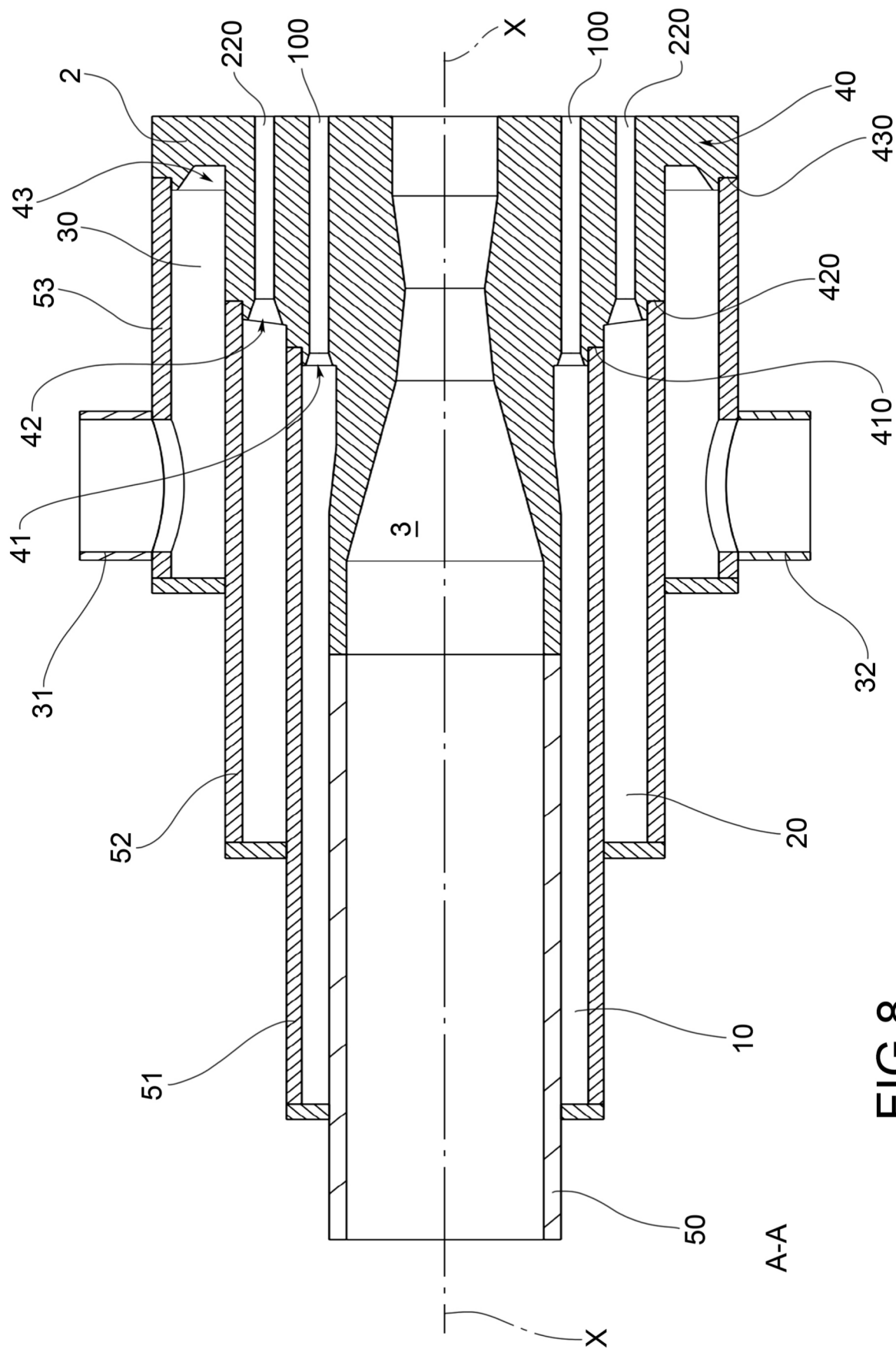


FIG.8

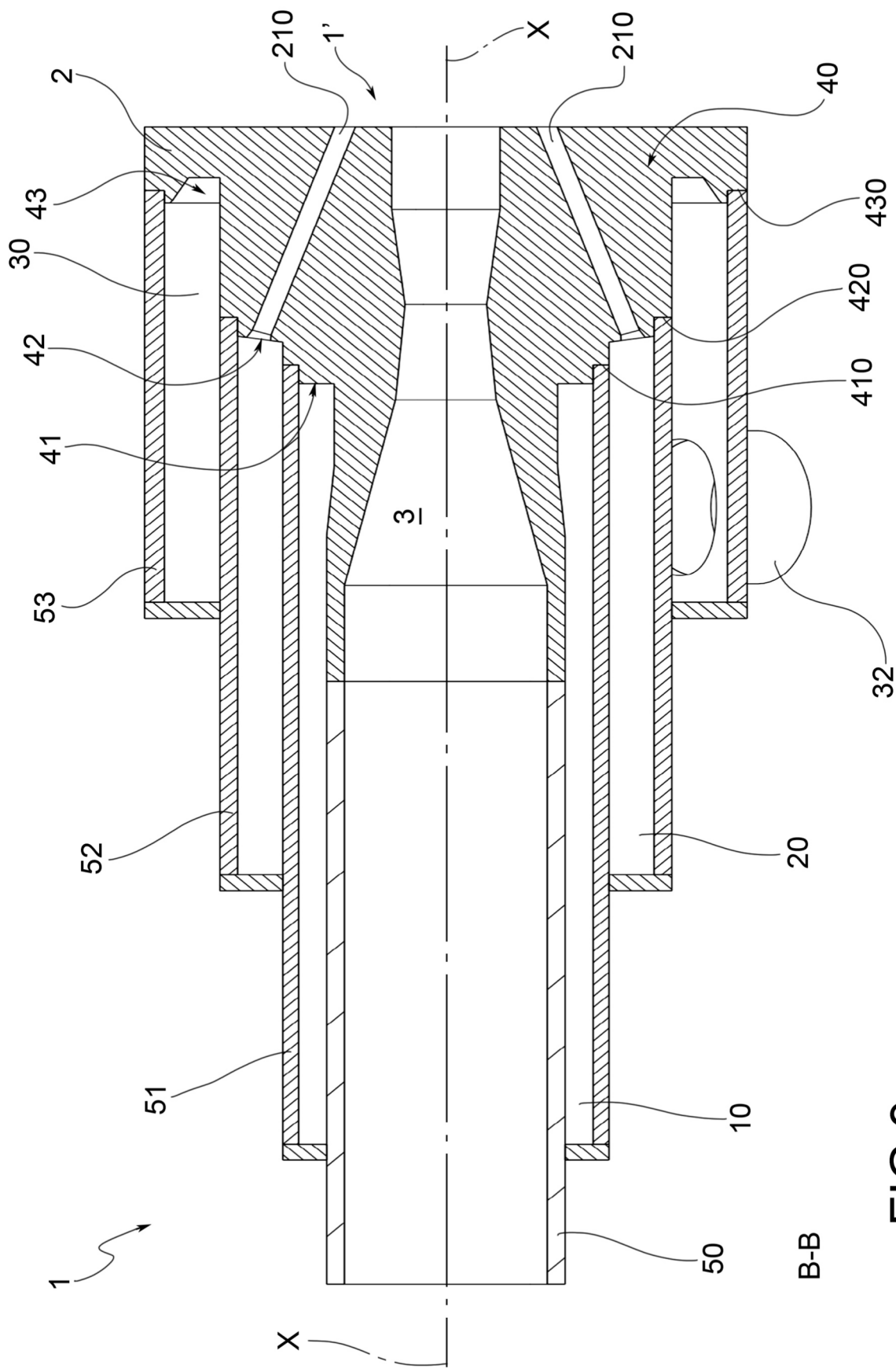


FIG.9

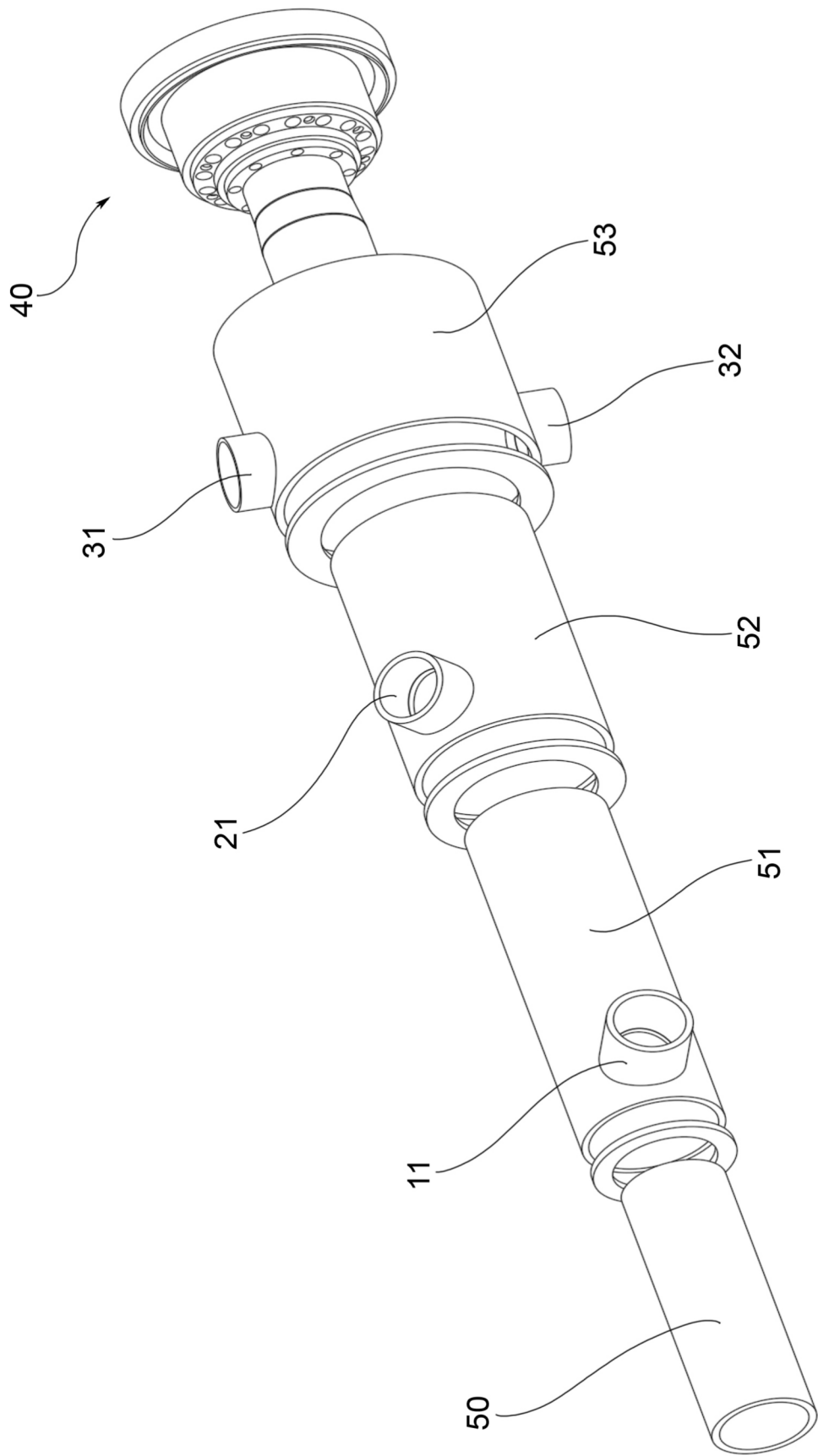


FIG.10

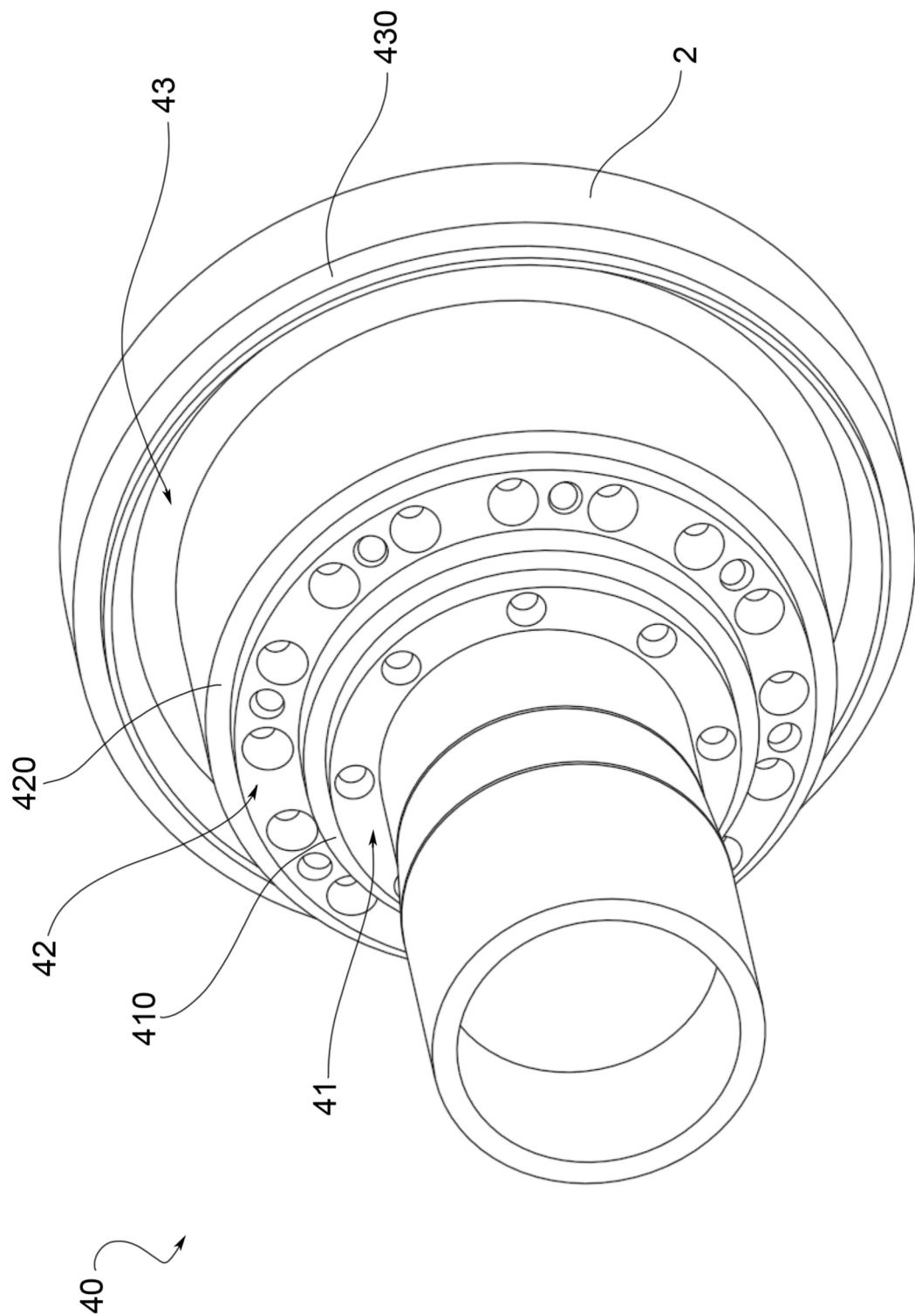


FIG.11

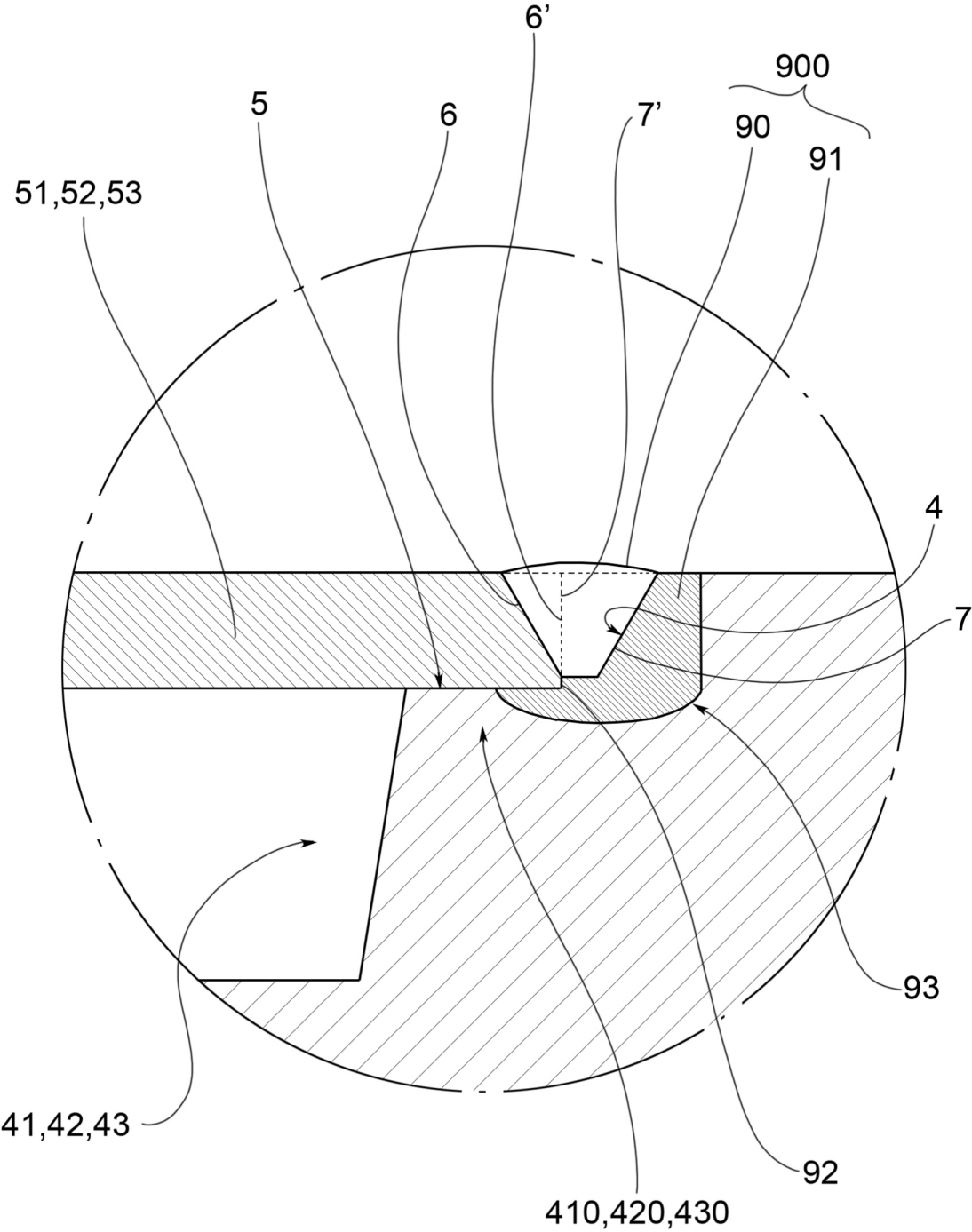


FIG.12

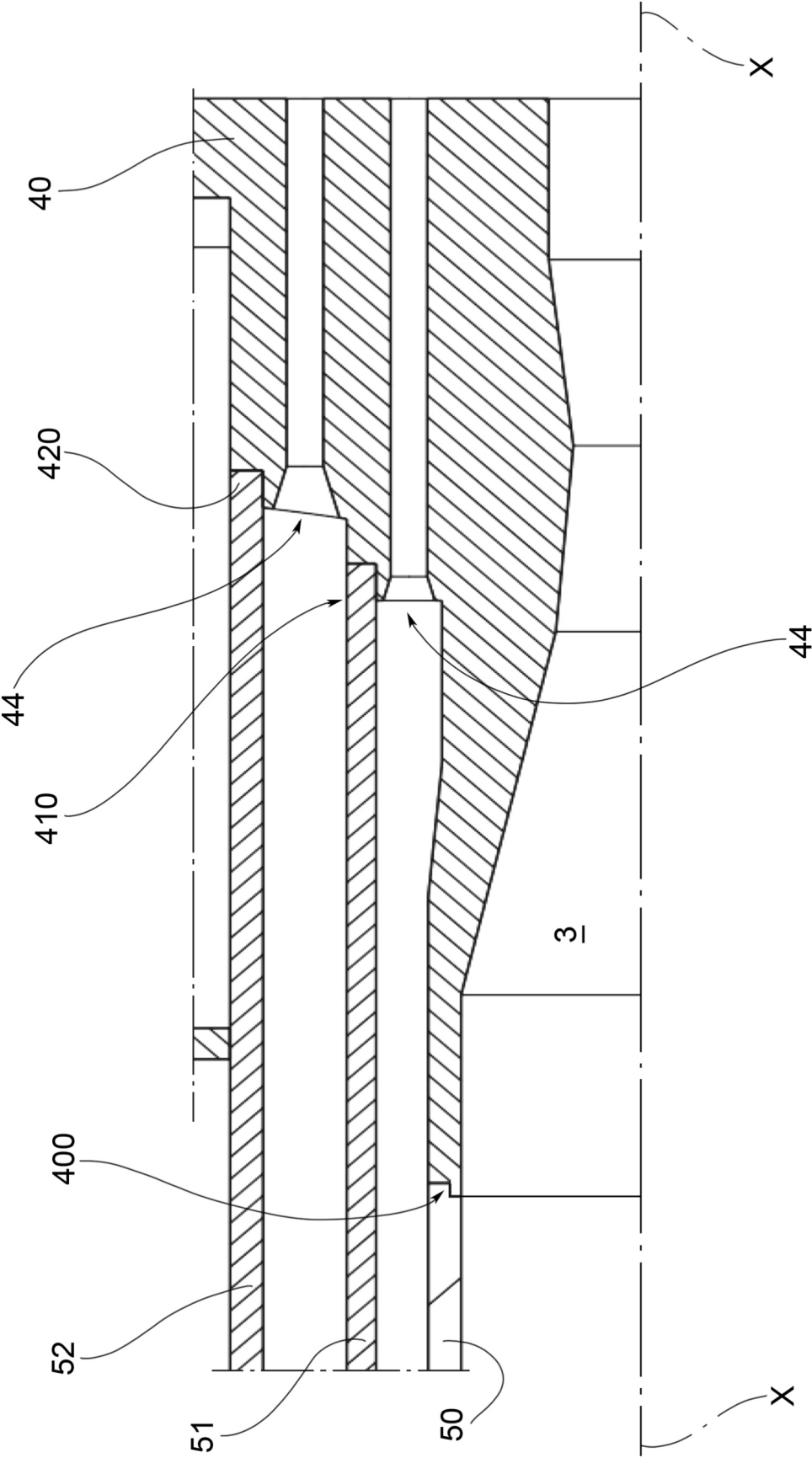


FIG.13



EUROPEAN SEARCH REPORT

Application Number

EP 26 16 0759

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2004/007776 A2 (DANIELI OFF MECC [IT]; VECCHIET FABIO [IT] ET AL.) 22 January 2004 (2004-01-22) * page 8, line 4 - page 9, line 13; figures 1,2 *	1-19	INV. F23D14/22 F23D14/58 F23D14/78 F23L7/00
A	DE 10 2014 222452 A1 (SAAR-METALLWERKE GMBH [DE]) 4 May 2016 (2016-05-04) * paragraph [0042] - paragraph [0044]; figures 1-9 *	1-19	
A	US 2003/196576 A1 (WHITTAKER GARY SCOTT [US] ET AL) 23 October 2003 (2003-10-23) * paragraph [0032] - paragraph [0035]; figures 1,3 *	1-19	
A	WO 2022/269551 A1 (SMS GROUP S P A [IT]) 29 December 2022 (2022-12-29) * the whole document *	1-19	
			TECHNICAL FIELDS SEARCHED (IPC)
			F23D F23L
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		9 July 2026	Theis, Gilbert
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	

EPO FORM 1503 03.82 (P24C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 26 16 0759

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-07-2026

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004007776 A2	22-01-2004	AT E326552 T1	15-06-2006
		AU 2003250018 A1	02-02-2004
		DE 60305321 T2	26-04-2007
		EP 1521852 A2	13-04-2005
		ES 2265586 T3	16-02-2007
		IT MI20021526 A1	12-01-2004
		US 2006038326 A1	23-02-2006
		WO 2004007776 A2	22-01-2004

DE 102014222452 A1	04-05-2016	DE 102014222452 A1	04-05-2016
		WO 2016071273 A1	12-05-2016

US 2003196576 A1	23-10-2003	AU 2003223622 A1	03-11-2003
		CN 1662633 A	31-08-2005
		EP 1495094 A1	12-01-2005
		JP 2005523371 A	04-08-2005
		US 2003196576 A1	23-10-2003
		WO 03089549 A1	30-10-2003
		ZA 200408332 B	21-10-2005

WO 2022269551 A1	29-12-2022	EP 4359716 A1	01-05-2024
		WO 2022269551 A1	29-12-2022
