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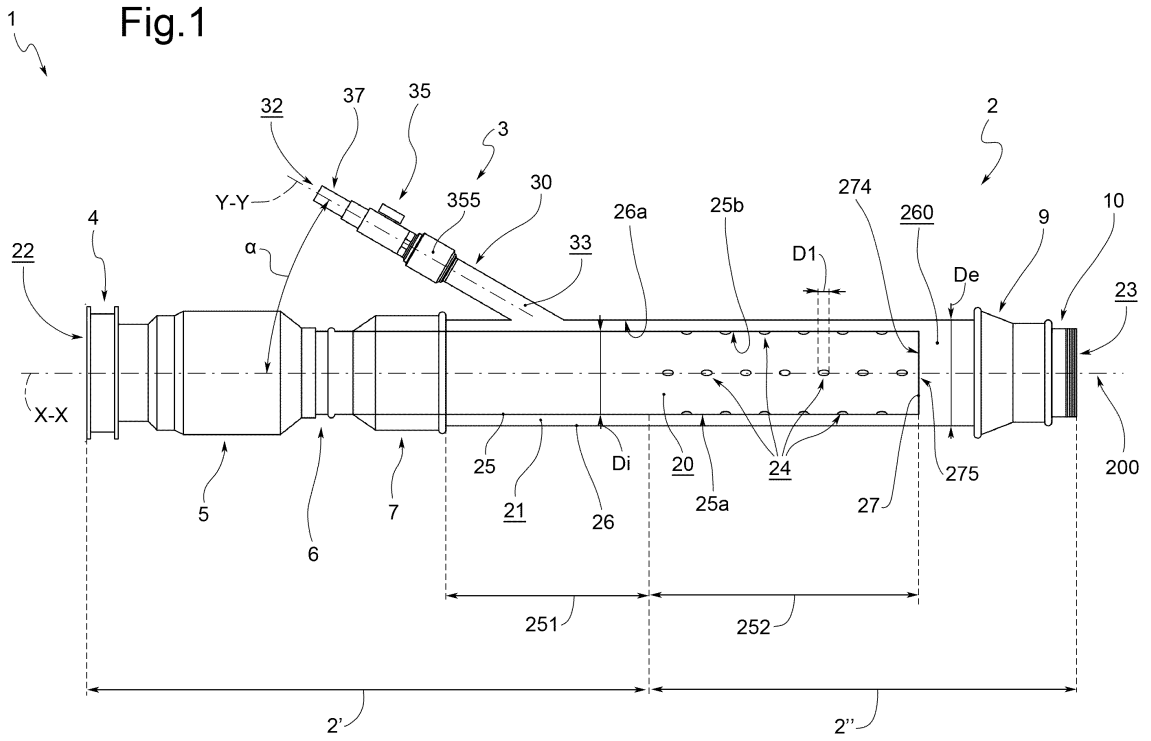
(54) **FIRE-FOAM GENERATOR, FIXED FIRE-FIGHTING SYSTEM AND FIRE-FIGHTING VEHICLE**

(57) A fire-foam generator (1) comprising a mixing device (2) and an air injection device (3).

The mixing device (2) extends along a main axis (X-X) and comprises an inner chamber (20) and an outer chamber (21) extending along and around the inner chamber (20), an inlet mouth (22) for the inlet of a foaming solution into the inner chamber (20) and an outlet mouth (23) for the outlet of the fire-fighting foam from the outer chamber (21).

The mixing device (2) comprises a plurality of radial openings (24) for the passage of the foaming solution from the inner chamber (20) to the outer chamber (21). The air injection device (3) comprises an injection channel (30) to introduce compressed air directly into the outer chamber (21).

Fig.1



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Description

[0001] The object of the invention is a fire-foam generator for fire-fighting applications. The invention also concerns a fixed fire-fighting system and a fire-fighting vehicle, each comprising the fire-foam generator.

[0002] In particular, in the present discussion the term fire-fighting vehicle refers to a generic vehicle suitable for performing fire-fighting operations, for example a fire truck, a fire truck with tank, a fire engine tanker or fire-fighting module.

[0003] The present invention is generally situated in the field of fire-fighting systems, that is, the set of apparatuses and devices suitable for preventing the risk and reducing the damage associated with a fire.

[0004] The invention is directed both to active fire-fighting systems, which require the action of a user for its operation, and to passive fire-fighting systems, the operation of which is controlled by a system of sensors that detect the state of an indoor or outdoor environment.

[0005] The invention is directed both to fixed fire-fighting systems, for example fixed fire-fighting systems for indoor or outdoor environments of a building, and to mobile fire-fighting systems, such as fire trucks or fire trucks with tank.

[0006] The present invention is situated in the field of mixing systems known as CAFS, acronym for Compressed Air Foam System, which inject and mix pressurized air inside a foaming solution, also known as foam liquid, to obtain at the outlet a fire-fighting foam, commonly known as formed foam. Typically, the foaming solution contains a foaming agent, for example of the multi-expansion type, appropriately diluted in water.

[0007] The operating principle of such mixing systems provides, at the inlet, the foaming solution and the compressed air in variable proportions, depending on the flow rate and the type of fire; in this way, such mixing systems allow to determine the type of foam to be dispensed.

[0008] A designated operator carries out an initial evaluation of the type of fire and determines the type of foam required to extinguish the fire. For example, for each liter of foaming solution, by injecting about 30 liters of compressed air, an adhesive (and dry) foam is obtained, capable of covering the burning surfaces by isolating them. Conversely, for example by injecting about 10 liters of compressed air, a fluid (and/or light) foam is obtained, capable of sliding between the debris.

[0009] In view of such requirements, countless solutions of fire-foam generators specifically designed to meet the specific application needs are known in the sector.

[0010] A typical problem of such known fire-foam generators in the sector relates to their complexity of design and manufacture.

[0011] Said structurally complex fire-foam generators have a greater likelihood of faults or defects.

[0012] Said particularly complex fire-foam generators, furthermore, must undergo more careful maintenance.

[0013] As complexity increases, the fire-foam generators prove to be unintuitive to use and, therefore, require specific training.

[0014] The known fire-foam generators are typically controlled by advanced electronic control units, frequently subject to hardware and software malfunctions.

[0015] There are known in the sector fire-foam generators that present the aforementioned problems.

[0016] Generators of fire-fighting foam are known, for example, comprising expansion chamber devices, for example of the vane type or of the valve type, electronically controlled and operated by one or more motors and corresponding gear reducers. Such systems are notoriously very complex and bulky and must be subjected to high levels of maintenance, therefore they are extremely costly.

[0017] Further embodiments of fire-foam generators are described in documents DE4204906A1 and US2051841A. Such solutions do not generate fire-fighting foam satisfactorily in terms of local pressures, allowable flow rates, head losses and reduction of turbulence, especially during the mixing phase between air and foaming solution.

[0018] An object of the present invention is to present a fire-foam generator, a fixed fire-fighting system and a fire-fighting vehicle that meet the needs of the sector and overcome the problems mentioned with reference to the known art solutions.

[0019] One of the objects of the present invention is to present a structurally simple fire-foam generator.

[0020] Another object of the present invention is to present a particularly reliable fire-foam generator.

[0021] A further object of the present invention is to present an extremely versatile fire-foam generator.

[0022] A still further object of the present invention is to present a fire-foam generator with a simple and intuitive operation.

[0023] These and other objects are achieved by means of the fire-foam generator according to claim 1, the fixed fire-fighting system according to claim 14 and the fire-fighting vehicle according to claim 15. The claims dependent thereon seek protection for additional features that provide further advantageous technical effects.

[0024] The features and advantages of the invention are clarified by the description given below of its preferred embodiments, provided by way of non-limiting example, with reference to the accompanying figures, in which:

- Figures 1 and 1a show the fire-foam generator in accordance with the present invention, respectively in a first and a second embodiment;
- Figure 2 shows a fixed fire-fighting system in accordance with the present invention, in one embodiment;
- Figure 2a shows a sectional view of the fixed fire-fighting system along the sectional plane A-A of figure 2;
- Figure 3 shows a fire-foam generator according to

one embodiment of the present invention, comprising a foaming solution flow rate adjustment device;

- Figure 4 shows a fire-foam generator according to one embodiment of the present invention, comprising an auxiliary chamber, in which the pre-mixing of water and foaming agent to obtain foaming solution occurs.

[0025] With reference to the attached figures, number 1 denotes a fire-foam generator as a whole according to the present invention. Number 100 as denotes a fixed fire-fighting system a whole.

[0026] In the course of the discussion, "axial direction" and "axially" mean a direction substantially parallel to an axis, "radial" and "radially" mean a direction substantially orthogonal to an axis, and "circumferential", "circumferentially" mean a direction tangent to a circumference having its center on an axis.

[0027] According to the present invention, the fire-foam generator 1 comprises a mixing device 2 and an air injection device 3. The air injection device 3 introduces compressed air into the foaming solution present in a chamber of the mixing device 2. The foaming solution and the compressed air physically and/or chemically interact, generating fire foam.

[0028] According to the present invention, the mixing device 2 extends along a main axis X-X.

[0029] In one embodiment, the main axis X-X is rectilinear.

[0030] In one embodiment, the main axis X-X is curvilinear or is straight in sections.

[0031] According to the present invention, the mixing device 2 comprises an inner chamber 20 which extends predominantly along the main axis X-X, and an outer chamber 21 which extends at least partially along and around the inner chamber 20.

[0032] In particular, the outer chamber 21 also extends predominantly along the main axis X-X.

[0033] In one embodiment, the outer chamber 21 is coaxial with the inner chamber 20.

[0034] In one embodiment, the outer chamber 21 extends, at least partially or completely, circumferentially around the inner chamber 20.

[0035] Preferably, the outer chamber 21 peripherally surrounds the inner chamber 20.

[0036] In one embodiment, the inner chamber 20 has a circular cross-section on a plane transverse to the main axis X-X.

[0037] In one embodiment, the outer chamber 21 has an annular cross-section on a plane transverse to the main axis X-X.

[0038] According to the present invention, the mixing device 2 comprises an inlet mouth 22 to receive, for example in an axial direction, the foaming solution into the inner chamber 20.

[0039] In other words, through the inlet mouth 22, the foaming solution enters the inner chamber 20. Preferably, the inlet mouth 22 is open and facing into the inner chamber 20.

[0040] According to the present invention, the mixing device 2 comprises an outlet mouth 23 for the exit, for example in an axial direction, of the fire-fighting foam from the outer chamber 21.

[0041] In other words, through the outlet mouth 23, the fire-fighting foam exits the outer chamber 21. Preferably, the outlet mouth 23 is open and facing into the outer chamber 21.

[0042] In one embodiment, the inlet mouth 22 and the outlet mouth 23 are axially opposed.

[0043] In one embodiment, the mixing device 2 extends axially between an initial region 2' comprising the inlet mouth 22, and a bottom region 2" comprising the outlet mouth 23. Preferably, the initial region 2' and the bottom region 2" are adjacent and joined axially.

[0044] In one embodiment, the mixing device 2 comprises an outer side wall 26 which extends with respect to the main axis X-X.

[0045] Preferably, the outer side wall 26 is made of stainless steel.

[0046] In one embodiment, the outer side wall 26 is engaged with a diffuser device 7, which will be described later.

[0047] In one embodiment, the mixing device 2 comprises an inner side wall 25 at least partially surrounded by the outer side wall 26.

[0048] Preferably, the inner side wall 25 is made of stainless steel.

[0049] Preferably, the inner side wall 25 is spaced in the radial direction from the outer side wall 26.

[0050] Preferably, the inner side wall 25 is coaxial with the outer side wall 26.

[0051] Preferably, the inner side wall 25 is directly facing the outer side wall 26.

[0052] Preferably, the outer side wall 26 comprises a first surface 26a radially facing the outer chamber 21.

[0053] Preferably, the inner side wall 25 comprises a second surface 25a radially facing the outer chamber 21.

[0054] Preferably, the outer chamber 21 is defined in the radial direction between the outer side wall 26, in particular the first surface 26a, and the inner side wall 25, in particular the second surface 25a.

[0055] Preferably, the inner side wall 25 comprises a third surface 25b radially facing into the inner chamber 20.

[0056] Preferably, the inner chamber 20 is defined radially inside the inner side wall 25, in particular by the third surface 25b.

[0057] In one embodiment, the outer side wall 26 has a circular or polygonal cross-section, for example square, rectangular, hexagonal or octagonal.

[0058] In one embodiment, the outer side wall 26 has a circular cross-section and an outer diameter De.

[0059] Preferably, the outer diameter De is between 30 and 70 millimeters, for example it is approximately 45 millimeters.

[0060] In one embodiment, the outer side wall 26 has a

circular or polygonal cross-section, for example square, rectangular, hexagonal or octagonal.

[0061] In one embodiment, the inner side wall 25 has a circular cross-section and an inner diameter Di.

[0062] In one embodiment, the ratio between the inner diameter Di of the inner side wall 25 and the outer diameter De of the outer side wall 26 is between 0.60 and 0.90.

[0063] In one embodiment, the entire volume of the inner chamber 20 and/or of the outer chamber 21 is filled with at least one moving fluid, that is respectively the foaming solution, the compressed air, the foam and mixtures thereof.

[0064] Preferably, the mixing of foaming solution and compressed air is achieved solely through the turbulent motion of the fluids, that is, by means of high-pressure interaction between the two fluids.

[0065] Preferably, the mixing device 2 is devoid of additional mixing elements, deflectors, turbulators or agitators in the inner chamber 20 and/or in the outer chamber 21.

[0066] Specifically, the mixing device 2 is devoid of additional moving elements housed in the inner chamber 20 and/or in the outer chamber 21.

[0067] According to the present invention, the mixing device 2 comprises a plurality of radial openings 24 for the passage of the foaming solution from the inner chamber 20 to the outer chamber 21.

[0068] In other words, the radial openings 24 fluidically connect the inner chamber 20 with the outer chamber 21.

[0069] Preferably, the foaming solution passes radially through the radial openings 24 in an inward-outward direction.

[0070] The outer chamber 21 thus functions as a mixing chamber, within which the foaming solution and compressed air interact.

[0071] In one embodiment, the radial openings 24 are positioned on the inner side wall 25, for example opened on the second surface 25a.

[0072] In one embodiment, the radial openings 24 are homogeneously distributed on at least a portion of the inner side wall 25, for example a bottom portion 252 of the inner side wall 25, which will be discussed later.

[0073] In one embodiment, the radial openings 24 are positioned in axial rows 29.

[0074] Preferably, the axial rows 29 are parallel to each other.

[0075] Preferably, the axial rows 29 are angularly equidistant.

[0076] In one embodiment, the radial openings 24 of each row 29 are axially equidistant.

[0077] In one embodiment, the axially consecutive radial openings 24 are angularly offset.

[0078] Preferably, the radial openings 24 of a first row 29 are angularly offset with respect to the radial openings 24 of a second row 29 angularly adjacent to the first row 29. Preferably, the radial openings 24 of two adjacent rows 29 are angularly offset by an angle between 20 and 45 degrees, for example about 30 degrees.

[0079] In one embodiment, the radial openings 24 are circular holes having a first diameter D1 between 2 and 8 millimeters.

[0080] In one embodiment, the radial openings 24 are circular holes having a first diameter D1.

[0081] In one embodiment, the radial openings 24 are openings having decreasing area in the axial direction and moving away from the inlet mouth 22.

[0082] In one embodiment, the radial openings 24 comprise first radial openings 24 proximal to the inlet mouth 22, and second radial openings 24 distal from the inlet mouth 22. The first radial openings 24 have a first diameter D1 greater than the first diameter D1 of the second radial openings 24.

[0083] In one embodiment, the inner side wall 25 extends axially between an initial portion 251 proximal to the inlet mouth 22, for example distal from a bottom wall 27 which will be discussed later, and a bottom portion 252 distal from the inlet mouth 22, for example engaged with the bottom wall 27.

[0084] Preferably, the initial portion 251 is upstream and the bottom portion 252 is downstream, along the fluid path of the foaming solution in the inner chamber 20.

[0085] Preferably, the initial portion 251 and the bottom portion 252 are adjacent and joined axially.

[0086] In one embodiment, the initial portion 251 and the bottom portion 252 have substantially the same axial size.

[0087] Preferably, the initial portion 251 of the inner side wall 25 is included in the initial region 2' of the mixing device 2, for example it is engaged with a diffuser device 7, which will be discussed later.

[0088] Preferably, the bottom portion 252 of the inner side wall 25 is included in the bottom region 2" of the mixing device 2, for example it is engaged with a second reducer fitting 9, which will be discussed later.

[0089] In one embodiment, the radial openings 24 are positioned exclusively in the bottom portion 252.

[0090] In one embodiment, the initial portion 251 of the inner side wall 25 is devoid of radial openings 24. For example, the second surface 25a of the inner side wall 25 in the initial portion 251 is continuous both in the axial direction and in the circumferential direction.

[0091] Preferably, in one embodiment, the radial openings 24 are not positioned exclusively in the bottom portion 252.

[0092] In one embodiment, the mixing device 2 comprises a bottom wall 27 which axially closes the inner side wall 25, extending incidentally with respect to the main axis X-X.

[0093] In one embodiment, the bottom wall 27 is included in the bottom region 2".

[0094] In one embodiment, the bottom wall 27 extends transversely with respect to the main axis X-X.

[0095] Preferably, the bottom wall 27 has a circular shape on a plane transverse to the main axis X-X.

[0096] In one embodiment, the bottom wall 27 extends

incidentally to the main axis X-X.

[0097] Preferably, the bottom wall 27 comprises an inner bottom surface 274 which defines a convex region in the inner chamber 20. For example, the inner bottom surface 274 has the shape of a cone or truncated cone or ogival or tapered or blended shape.

[0098] Preferably, the bottom wall 27 comprises an inner bottom surface 274 which defines a flat region in the inner chamber 20.

[0099] In one embodiment, the bottom wall 27 comprises an outer bottom surface 275 at least partially axially oriented, for example directly facing, the outlet mouth 23.

[0100] In one embodiment, the inner side wall 25 and the bottom wall 27 separate the inner chamber 20 from the outer chamber 21.

[0101] In one embodiment, the mixing device 2 comprises a plurality of axial openings 270 for the passage of foaming solution from the inner chamber 20 to the outer chamber 21.

[0102] In one embodiment, the foaming solution passes through the axial openings 270 in an axial direction with respect to the main axis X-X. Preferably, the foaming solution that passes through the axial openings 270 meets the foaming solution previously discharged from the radial openings 24 and at least partially mixed with the compressed air radially around the inner side wall 25.

[0103] In one embodiment, the axial openings 270 are positioned in the bottom wall 27, for example opened on the outer bottom surface 275.

[0104] In one embodiment, the axial openings 270 are homogeneously distributed on at least a portion of the bottom wall 27.

[0105] In one embodiment, the axial openings 270 are positioned on imaginary concentric circumferences, for example equidistant in the radial direction, and having their center on the main axis X-X.

[0106] In one embodiment, the axial openings 270 are angularly equidistant.

[0107] Preferably, the axial openings 270 are positioned on imaginary circumferences.

[0108] Preferably, the radially consecutive axial openings 270 are angularly offset.

[0109] In one embodiment, the axial openings 270 are circular holes having a second diameter D2 between 2 and 5 millimeters, for example constant.

[0110] In one embodiment, the second diameter D2 of the axial openings 270 is smaller than the first diameter D1 of the radial openings 24.

[0111] In one embodiment, the second diameter D2 of the axial openings 270 is smaller than or equal to the smallest first diameter D1 of the radial openings 24.

[0112] In one embodiment, the mixing device 2 comprises a swivel fitting 4, for example a UNI45F fitting, preferably positioned in the initial region 2'. Preferably, the swivel fitting is fluidically connectable to a first fluid circuit 110 of the fire-fighting vehicle to receive foaming solution, which will be discussed later. In other words, said swivel fitting 4 is connectable to the outlet of a foam liquid mixer.

[0113] Preferably, the swivel fitting 4 comprises the inlet mouth 22.

[0114] In one embodiment, the mixing device 2 comprises a one-way valve 5, for example positioned in the initial region 2'.

[0115] In one embodiment, the valve is a PN25 valve engaged with the swivel fitting 4. Preferably, said valve is of the one-way type, and has sealing suitable for the operating pressures in the circuit.

[0116] In one embodiment, the valve is a PN40 valve fluidically connectable to a first fluid circuit 110 of the fixed fire-fighting system 100 to receive foaming solution, which will be discussed later, for example through a first reducer fitting 8. Preferably, said valve is of the one-way type, and has sealing suitable for the operating pressures in the circuit.

[0117] In one embodiment, the one-way valve comprises the inlet mouth 22.

[0118] In one embodiment, the first reducer fitting 8 comprises the inlet mouth 22.

[0119] In one embodiment, the mixing device 2 comprises a Niplo fitting 6, also known as nipples fitting, for example positioned in the initial region 2'.

[0120] In one embodiment, the mixing device 2 comprises a diffuser device 7, preferably positioned in the initial region 2' of the mixing device 2.

[0121] In one embodiment, the diffuser device 7 is engaged with the inner side wall 25, for example with the initial portion 251, preferably also with the outer side wall 26.

[0122] In one embodiment, the mixing device 2 comprises a second reducer fitting 9, preferably engaged with the bottom portion 252, for example in the bottom region 2" of the mixing device 2.

[0123] Preferably, the second reducer fitting 9 comprises the outlet mouth 23.

[0124] In one embodiment, the second reducer fitting 9 is connectable to a third fluid circuit 130 for the circulation of fire-fighting foam toward dispensing devices of the fixed fire-fighting system, fixed to a wall or ceiling of a building, also known as adjustments or dispensers.

[0125] In one embodiment, the mixing device 2 comprises a connection fitting 10, for example a UNI45M fitting, preferably engaged with the second reducer fitting 9, for example included in the bottom region 2".

[0126] Preferably, the connection fitting 10 comprises the outlet mouth 23.

[0127] Preferably, the connection fitting 10 is fluidically connectable to a dispensing lance 200, which will be discussed later.

[0128] In one embodiment, the mixing device 2 comprises a safety device fluidically connected to the outer chamber 21, comprising an automatic overpressure valve configured to discharge from the outer chamber 21 fluids at pressures higher than a predefined maximum

design pressure.

[0129] As stated initially, the fire-foam generator 1 according to the present invention comprises an air injection device 3 for introducing compressed air into the outer chamber 21 of the mixing device 2.

[0130] In one embodiment, the air injection device 3 is engaged with the mixing device 2.

[0131] In one embodiment, the air injection device 3 is housed in the initial region 2' of the mixing device 2.

[0132] In one embodiment, the air injection device 3 comprises an injection channel 30 which extends between an air inlet mouth 32 for receiving compressed air, and an air introduction mouth 33 for introducing compressed air into the outer chamber 21.

[0133] In one embodiment, the air injection device 3 comprises a single injection channel 30.

[0134] Preferably, the injection channel 30 protrudes from the outer side wall 26.

[0135] Preferably, the air introduction mouth 33 passes through the outer side wall 26.

[0136] In one embodiment, the air injection device 3 introduces compressed air directly onto the initial portion 251.

[0137] In one embodiment, the air introduction mouth 33 is radially directly facing the initial portion 251 of the inner side wall 25, for example the second surface 25a.

[0138] Preferably, the air introduction mouth 33 is axially positioned at the initial portion 251.

[0139] Preferably, the injection channel 30 introduces compressed air in a radial direction from outside to inside.

[0140] In other words, in the outer chamber 21, the compressed air flows counter to the foaming solution.

[0141] In one embodiment, the injection channel 30 introduces compressed air into the outer chamber 21 along an introduction axis Y-Y inclined with respect to the main axis X-X.

[0142] Preferably, the introduction axis Y-Y and the main axis X-X form an introduction angle α between 10 and 90 degrees, for example about 30 degrees.

[0143] In one embodiment, the air injection device 3 comprises at least one adjustment group 35, for example a plurality of adjustment groups 35, fluidically connected between the air inlet mouth 32 and the air introduction mouth 33 to adjust the amount of compressed air flowing toward the outer chamber 21.

[0144] In one embodiment, each adjustment group 35 comprises at least one compressed air hole having a diameter between 2 and 8 millimeters.

[0145] In one embodiment, the at least one adjustment group 35 is supported by the injection channel 30.

[0146] In one embodiment, the at least one adjustment group 35 is of the mechanical type.

[0147] In one embodiment, the at least one adjustment group 35 is manually controllable by a user.

[0148] In one embodiment, each adjustment group 35 is controllable independently of the other adjustment groups 35.

[0149] In one embodiment, the air injection device 3 comprises a plurality of adjustment groups 35, preferably at least two, for example three, adjustment groups 35, fed and operating in parallel.

[0150] In one embodiment, the at least one adjustment group 35 comprises a tap, for example a ball valve, configurable in a closed configuration, in which it prevents the flow of compressed air toward the outer chamber 21, and an open configuration.

[0151] Preferably, the amount of compressed air flowing toward the outer chamber 21 is proportional to the number of taps configured in the open configuration.

[0152] In one embodiment, the air injection device 3 comprises three adjustment groups 35, each of which comprises a tap, for example a ball valve. By configuring one tap in the open configuration and the other two taps in the closed configuration, the amount of compressed air reaching the outer chamber 21 is one third of the predefined amount of compressed air supplied as input to the air injection device 3.

[0153] In one embodiment, the air injection device 3 comprises a single adjustment group 35 configurable in a plurality of working configurations, in which each working configuration corresponds to the passage of a predefined amount of compressed air toward the outer chamber 21, for example through the compressed air hole.

[0154] In one embodiment, the single adjustment group 35 comprises an adjustment element positionable continuously or discretely in a plurality of positions, for example rotatable in a plurality of angular positions, each of which corresponds to a working configuration.

[0155] In one embodiment, the air injection device 3 comprises an air fitting 37, for example a quick coupling, connectable to a second fluid circuit 120 included in the fixed fire-fighting system 100 or in the fire-fighting vehicle, to receive compressed air.

[0156] In one embodiment, the air injection device 3 comprises a one-way valve 355.

[0157] In one embodiment, the air injection device 3 comprises a first control solenoid valve 38 operatively connected to the at least one adjustment group 35 and operatively connectable to an electronic control unit to control the operation of the adjustment group 35.

[0158] In one embodiment, the electronic control unit is included in the fire-foam generator 1.

[0159] In one embodiment, the electronic control unit is included in the fixed fire-fighting system 100.

[0160] In one embodiment, the electronic control unit is included in the fire-fighting vehicle.

[0161] In one embodiment, the electronic control unit comprises a PLC.

[0162] In one embodiment, the electronic control unit is configured to adjust the pressure of the compressed air at the inlet of the air inlet mouth 32 as a function of the pressure of the foaming solution at the inlet mouth 22.

[0163] In one embodiment, the air injection device 3 comprises a pressure adjustment group configured to vary the pressure of the compressed air at the inlet of the air inlet mouth 32.

[0164] Preferably, the pressure adjustment group is a variable pressure reducer, for example comprising a pressure gauge.

[0165] In one embodiment, the air injection device 3 comprises a first sensor configured to detect a first value determined as a function of the pressure of the foaming solution at the inlet mouth 22.

[0166] Preferably, the pressure of the foaming solution at the inlet is equal to or greater than 2 bar, for example greater than 5 bar.

[0167] In one embodiment, the fire-foam generator 1 comprises a second sensor configured to detect a second value determined as a function of the pressure of the compressed air at the inlet of the air inlet mouth 32.

[0168] Preferably, the pressure of the compressed air at the inlet is equal to or greater than 5 bar.

[0169] In one embodiment, the electronic control unit is operatively connected with the first sensor, the second sensor and the pressure adjustment device, and is configured to receive and process the first value and the second value, and to consequently control the operation of the pressure adjustment group.

[0170] The subject of the present invention is also a fixed fire-fighting system 100 comprising a fire-foam generator 1 having the features described above, a first fluid circuit 110 for the circulation of foaming solution fluidically connected to the inlet mouth 22, and a second fluid circuit 120 for the circulation of compressed air, fluidically connected to the air injection device 3, for example the air inlet mouth 32.

[0171] In one embodiment, the first fluid circuit 110 is connectable to an external fire-fighting water network to receive water.

[0172] Preferably, the fixed fire-fighting system 100 comprises, fluidically upstream of the first fluid circuit 110, a pump group, and a tank of foaming solution or a mixing device of water and foaming agent, controlled by the pump group.

[0173] Preferably, in the first fluid circuit 110 flows a water flow rate of foaming solution or water of about 200 liters per minute.

[0174] In one embodiment, the fire-foam generator 1 is fluidically connected between a system inlet mouth 115 and a system outlet mouth 135 included in the fixed fire-fighting system 100.

[0175] In one embodiment, downstream of the system inlet mouth 115, the first fluid circuit 110 comprises an intermediate fitting 118 and a by-pass channel 140 which connect the system inlet mouth 115 and the system outlet mouth 135, preventing the passage of water into the fire-foam generator 1.

[0176] Preferably, the first fluid circuit 110 comprises a second control solenoid valve 119, for example a sensorized tap, to allow or prevent the fluid path in the by-pass channel 140.

[0177] In one embodiment, the fixed fire-fighting system 100 comprises a third solenoid valve to adjust the flow of compressed air in the second fluid circuit 120, and a flow switch device to detect the flow rate of foaming solution at the inlet of the first fluid circuit 110, operatively connected with the third solenoid valve. The electronic control unit is configured to control the operation of the third solenoid valve based on the detection of the flow switch device, for example to prevent the flow of compressed air when the fire-foam generator is inactive.

[0178] In other words, preferably, the fixed fire-fighting system 100, shown by way of example in figure 2, is connectable to fixed pipes or hose reels.

[0179] The object of the present invention is also a fire-fighting vehicle, for example a tank fire-fighting vehicle, comprising a fire-foam generator 1 having the characteristics described above, a first fluid circuit 110 for the circulation of foaming solution, fluidically connected to the inlet mouth 22, and a second fluid circuit 120 for the circulation of compressed air, fluidically connected to the air injection device 3, for example to the air inlet mouth 32.

[0180] Preferably, the fire-fighting vehicle comprises on board a pump and a tank of foaming solution.

[0181] Preferably, the fire-fighting vehicle comprises on board the vehicle a compressed air tank, for example a group of compressed air cylinders, or a compressed air compressor, for example driven by an electric motor unit on board the vehicle connected to the vehicle engine or the vehicle braking system or the vehicle auxiliary systems. Preferably, said compressor is connected to, and operated by, the vehicle motor unit.

[0182] In one embodiment, the fire-fighting vehicle comprises a dispensing lance 200 having a main dimension and configured to receive and dispense the fire-fighting foam.

[0183] Preferably, in a resting condition, the dispensing lance 200 is folded or wound upon itself. In particular, according to one embodiment, the dispensing lance 200 is connected to a tube called hose reel which is wound on a drum or reel.

[0184] Preferably, the dispensing lance 200 is of the smooth bore type or triple action type or of the shrapnel type for hose reels and semi-rigid tubes.

[0185] In one embodiment, the fire-foam generator 1 comprises a hollow outer box-like body, in which the mixing device 2 and the air injection device 3 are at least partially housed, forming overall an integrated unit.

[0186] Preferably, the outer box-like body is made of stainless steel.

[0187] In one embodiment, the integrated unit is anchorable to a support structure, for example a support frame of a fire-fighting vehicle, preferably in a removable manner, for example by means of threaded screws or by means of snap-fit coupling means.

[0188] In one embodiment, fluidically upstream of the inlet mouth 22, the fire-foam generator comprises an internal auxiliary chamber 70, into which flows foaming solution in transit toward the inner chamber 20. Preferably, the internal auxiliary chamber 70 is directly fluidically upstream of the inner chamber 20. Preferably, the inlet mouth 22 fluidically connects the internal auxiliary

chamber 70 with the inner chamber 20.

[0189] In one embodiment, the fire-foam generator comprises an auxiliary wall 77, for example tubular, which defines inside it the internal auxiliary chamber 70, preferably made in two or more parts. Preferably, the auxiliary wall 77 has a circular or polygonal cross-section, for example square, rectangular, hexagonal or octagonal.

[0190] In one embodiment, the fire-foam generator comprises upstream a check valve 99 to adjust the fluid inlet into the internal auxiliary chamber 70, for example connected to the auxiliary wall 77 or to a venturi tube which will be discussed later.

[0191] In one embodiment, the fluid entering the internal auxiliary chamber 70 is pre-mixed foaming solution.

[0192] In one embodiment, the fire-foam generator comprises a flow rate adjustment device 80 to adjust the flow rate of foaming solution flowing toward the inner chamber 20, preferably arranged in the internal auxiliary chamber 70, for example near or at the inlet mouth 22.

[0193] In one embodiment, the flow rate adjustment device 80 comprises a first body, for example in the form of a disc, provided with at least one first foaming solution passage opening. In particular, said at least one first foaming solution passage opening is directly facing the inlet mouth 22. In addition, the flow rate adjustment device 80 comprises a second body, for example in the form of a disc, provided with at least one second foaming solution passage opening. The second body is rotatable with respect to, preferably also engaged with, the first body, to vary the position of said at least one second foaming solution passage opening with respect to said at least one first foaming solution passage opening, thus varying the flow rate of foaming solution in transit through both said first and second foaming solution passage openings and entering the inner chamber 20.

[0194] In one embodiment, at least one of the first foaming solution passage opening and second foaming solution passage opening extends predominantly in a radial direction with respect to an auxiliary axis K-K of the internal auxiliary chamber 70, and/or has an increasing passage section in the radial direction and toward the outside with respect to an auxiliary axis K-K of the internal auxiliary chamber 70. For example, at least one of said first and second foaming solution passage openings has a trapezoidal or rectangular or oval or elliptical shape or substantially a sector of a circle or substantially a circular arc shape.

[0195] In one embodiment, the fire-foam generator comprises a venturi tube fluidically connected directly upstream of the inlet mouth 22. In one embodiment, the venturi tube defines inside it the internal auxiliary chamber 70. In one embodiment, the check valve 99 adjusts the fluid inlet into the venturi tube.

[0196] In one embodiment, the venturi tube is axially divided into two parts sealed together, comprising a first tube wall 40 and a second tube wall 41 at least partially overlapping and spaced from the first tube wall 40 in the radial direction with respect to an auxiliary axis K-K of the internal auxiliary chamber 70. Between said first tube wall 40 and second tube wall 41 an external auxiliary chamber 71 having an at least partially annular shape around the internal auxiliary chamber 70 is defined. In addition, a plurality of angularly spaced auxiliary holes 45, for example aligned on one or more imaginary circumferences, extend radially through the first tube wall 40 and fluidically connect the external auxiliary chamber 71 with the internal auxiliary chamber 70.

[0197] Preferably, each auxiliary hole 45 is a through-hole made in the first tube wall 40 in an inclined manner, for example having an auxiliary hole axis incident, non-orthogonal, to the auxiliary axis K-K of the internal auxiliary chamber 70, so that the foaming agent is immersed into the internal auxiliary chamber 70 in the same direction as the flow of water already present in the internal auxiliary chamber 70.

[0198] Preferably, the auxiliary holes 45 are made axially at, or near and upstream of, a minimum passage section 76 of the internal auxiliary chamber 70 defined by the venturi tube.

[0199] In one embodiment, the venturi tube comprises an auxiliary bottom wall 73 engaged with the first tube wall 40 and provided with axial auxiliary openings 74 passing axially, preferably having a cross-section smaller than the auxiliary holes.

[0200] In one embodiment, the fluid entering the internal auxiliary chamber 70, for example defined by the venturi tube, is water, and the fire-foam generator further comprises a foaming agent injector 90, for example a tap, to introduce foaming agent into the internal auxiliary chamber 70 to be mixed with water, forming foaming solution in the internal auxiliary chamber 70 directly upstream of the inlet mouth 22.

[0201] In one embodiment, the foaming agent injector 90 is configured to introduce foaming agent axially at, or upstream and near, a minimum passage section 76 of the internal auxiliary chamber 70 defined by the venturi tube. In one embodiment, the foaming agent injector 90 is configured to introduce foaming agent into the external auxiliary chamber 71 substantially axially corresponding to at least one auxiliary hole 45. In other words, in this embodiment, the internal auxiliary chamber 70 is a water and foaming agent mixing chamber or a foaming solution obtaining chamber.

[0202] The foaming solution thus obtained in the internal auxiliary chamber 70 passes through the axial auxiliary openings 74 of the auxiliary bottom wall 73, continuing along the venturi tube, in particular accelerating, toward the inlet mouth 22.

[0203] Innovatively, the fire-foam generator, the fixed fire-fighting system and the fire-fighting vehicle meet the needs of the sector and overcome the typical problems of the known art.

[0204] Advantageously, the fire-foam generator is structurally simple.

[0205] Advantageously, the fire-foam generator is markedly versatile, as it can be used to generate different

types of fire-fighting foam, depending on the characteristics of the fire.

[0206] Advantageously, to handle greater water flow rates and generate higher foam flow rates, it is sufficient to increase the volumes of the inner and outer chambers, while maintaining the general structure of the fire-foam generator unchanged.

[0207] Advantageously, the fire-foam generator allows precise adjustment of the amount of pressurized air injected into the foaming solution.

[0208] Advantageously, the fire-foam generator can be operated manually, in an intuitive manner, even by users without advanced training.

[0209] Advantageously, to obtain a denser or less dense foam, it is sufficient to adjust the at least one adjustment group, keeping the other operating parameters constant.

[0210] Advantageously, to obtain a more adhesive foam, it is sufficient to open a greater number of taps of the air injection device. Advantageously, to obtain a more adhesive foam, it is sufficient to reduce the water flow by means of the foaming solution flow rate adjustment device.

[0211] Advantageously, the fire-foam generator can be installed in fixed fire-fighting systems.

[0212] Advantageously, the fire-foam generator can be installed on board fire-fighting vehicles.

[0213] Advantageously, the fire-foam generator is extremely reliable.

[0214] Advantageously, the fire-foam generator reduces or eliminates the need for advanced electronic control units to control its operation.

[0215] Advantageously, the fire-foam generator is predominantly mechanical and avoids the need for dedicated actuators, as it only requires pump groups and motor units already present on board the vehicle. Advantageously, the fire-foam generator avoids the need for additional internal combustion engine groups specifically provided.

[0216] Advantageously, the fire-foam generator is configured to minimize weight and dimensions.

[0217] Advantageously, the fire-foam generator optimizes the flows of foaming liquid and compressed air inside the outer chamber.

[0218] Advantageously, the flow of compressed air is initially deflected by a continuous surface and continues both axially and radially, reaching the entire volume of the outer chamber and achieving an homogeneously mixing.

[0219] Advantageously, the direction of introduction of compressed air optimizes the formation of fire-fighting foam while at the same time minimizing overall dimensions.

[0220] Advantageously, the fire-foam generator ensures high convenience during installation, adjustment and use operations.

[0221] Advantageously, the fire-foam generator is easily transportable.

[0222] Advantageously, the fire-foam generator can be operated with constant flow rates of water and/or foaming agent and/or foaming solution, depending on the characteristics of the system or vehicle or other associated system.

[0223] Advantageously, the fire-foam generator can be easily dismounted from a fire-fighting vehicle in case of failure or malfunction, for example with a flat tire.

[0224] Advantageously, the fire-foam generator is equipped with check valves to prevent backflows of air or liquids into circuits not suitable for receiving fire-fighting foam.

[0225] Advantageously, the fire-foam generator in an inactive condition avoids the problem of high-pressure piping.

[0226] Advantageously, the fire-foam generator can be used to pressurize the pipes, for hydraulic tightness testing of pipes and fittings, for indoor simulations, for training with rigid piping while limiting water waste.

[0227] Advantageously, the fire-foam generator can be operated with flow rates between 50 and 400 liters per minute, by appropriately scaling the dimensions and proportions of the apparatus, and variable inlet pressures between 2 and 40 bar, up to 200 bar using suitable materials and thicknesses. For example, with foaming solution input at 200 liters per minute and 6 bar, compressed air at 6 bar and an external diameter of the outer side wall of 11 millimeters, dry-type fire-fighting foam (high amounts of compressed air per liter of foaming solution) will have a flow rate between 350 and 400 liters per minute at a pressure of 6 bar.

[0228] Advantageously, the fire-foam generator can be installed and used at the outlet line of a variable flow mixer, keeping constant the mixing proportions and the pressure ratio, adjusting the output flow rate via front nozzles for smooth bore or dual-effect lances or via a ring nut for DMR lances.

[0229] Advantageously, the fire-foam generator can be installed in hose reel systems comprising high-pressure fluid lines.

[0230] It is clear that a person skilled in the art, in order to meet contingent needs, may make changes to the invention described above, all within the scope of protection as defined by the following claims.

Claims

1. A fire-foam generator (1) comprising:

i) a mixing device (2) extending along a main axis (X-X) comprising an inlet mouth (22), an outlet mouth (23) and comprising:

- an inner chamber (20) extending mainly axially, fluidically connected to the inlet mouth (22), through which a foaming solution enters;
- an outer chamber (21) extending at least

partially along and around the inner chamber (20), fluidically connected to the outlet mouth (23), through which fire foam exits; and

- a plurality of radial openings (24) connecting the inner chamber (20) with the outer chamber (21), for the passage of the foaming solution;

ii) an air injection device (3) fluidically connected with the mixing device (2) to introduce compressed air into the outer chamber (21).

2. Fire-foam generator (1) according to claim 1, wherein the air injection device (3) comprises at least one adjustment group (35) configured to adjust the amount of compressed air flowing towards the outer chamber (21).

3. Fire-foam generator (1) according to any one of the preceding claims, wherein the radial openings (24) are positioned on axial angularity spaced rows (29), preferably wherein the radial openings (24) of a first row (29) are angularly offset, for example by about 30 degrees, with respect to the radial openings (24) of a second row (29) angularly adjacent to the first row (29).

4. Fire-foam generator (1) according to any one of the preceding claims, wherein the mixing device (2) comprises:

- an outer side wall (26) extending with respect to the main axis (X-X),
- an inner side wall (25) spaced in a radial direction, coaxial and directly facing the outer side wall (26), and
- a bottom wall (27) closing axially the inner side wall (25) and extending in an incident manner with respect to the main axis (X-X);

wherein the inner side wall (25) and the bottom wall (27) separate the inner chamber (20) from the outer chamber (21).

5. Fire-foam generator (1) according to claim 4, wherein the inner side wall (25) extends axially between an initial portion (251) and a bottom portion (252) connected to the bottom wall (27), wherein the air injection device (3) introduces compressed air directly onto the initial portion (251).

6. Fire-foam generator (1) according to claim 5, wherein the radial openings (24) are exclusively in the initial portion (251).

7. Fire-foam generator (1) according to any one of claims 4 to 6, wherein the bottom wall (27) extends transversely with respect to the main axis (X-X) and comprises an outer bottom surface (275) axially directly facing the outlet mouth (23), wherein the mixing device (2) comprises a plurality of axial openings (270) in the bottom wall (27) for the passage of foaming solution from the inner chamber (20) to the outer chamber (21).

8. Fire-foam generator (1) according to claim 7, wherein the radial openings (24) and the axial openings (270) are circular holes having respectively a first diameter (D1) and a second diameter (D2), wherein the second diameter (D2) is smaller than the first diameter (D1).

9. Fire-foam generator (1) according to any one of the preceding claims, wherein the outer side wall (26) and the inner side wall (25) have circular cross-section and respectively an outer diameter (De) and an inner diameter (Di), wherein the ratio between the inner diameter (Di) and the outer diameter (De) is between 0.60 and 0.90.

10. Fire-foam generator (1) according to any one of the preceding claims, comprising a hollow outer box-shaped body, in which the mixing device (2) and the air injection device (3) are at least partially housed, forming an integrated unit as a whole.

11. Fire-foam generator (1) according to any one of the preceding claims, comprising an inner auxiliary chamber (70) directly upstream of the inner chamber (20), and a flow adjustment device (80) to adjust the flow rate of foaming solution flowing from the inner auxiliary chamber (70) to the inner chamber (20), arranged in the inner auxiliary chamber (70).

12. Fire-foam generator (1) according to claim 11, comprising a Venturi tube divided into a first tube wall (40) and a second tube wall (41) at least partially overlapped, which internally define the inner auxiliary chamber (70) and define radially at least partially between them an outer auxiliary chamber (71) at least partially annular around the inner auxiliary chamber (70), wherein the fire-foam generator (1) comprises a foaming agent injector (90) to introduce foaming agent into the inner auxiliary chamber (70).

13. Fire-foam generator (1) according to claim 12, wherein the first tube wall (40) comprises a plurality of auxiliary holes (45) connecting the outer auxiliary chamber (71) with the inner auxiliary chamber (70), wherein the foaming agent injector (90) is configured to introduce foaming agent substantially axially at least at one auxiliary hole (45).

14. Fixed fire-fighting system (100) comprising:

- a fire-foam generator (1) according to any one of the preceding claims;
- a first fluidically circuit (110) for the circulation of foaming solution, fluidically connected to the inlet mouth (22);
- a second fluidically circuit (120) for the circulation of compressed air, fluidically connected to the air injection device (3); and
- at least one dispensing device fixed to a wall or ceiling of a building and fluidically connected with the outlet mouth (23) to dispense fire-fighting foam.

15. Fire-fighting vehicle comprising:

- a fire-foam generator (1) according to any one of claims 1 to 13, mounted on board the vehicle, preferably removably;
- a first tank containing a foaming solution, a pump and a first fluidic circuit (110) fluidically connected upstream with the first tank and with the pump, and downstream with the inlet mouth (22);
- a second tank containing compressed an air or an air compressor and a second fluidic circuit (120) fluidically connected upstream with the second tank or with the compressed air compressor, and downstream with the air injection device (3); and
- a dispensing lance (200) having a main extension dimension and fluidically connected to the outlet mouth (23) to dispense fire-fighting foam.

Fig.1

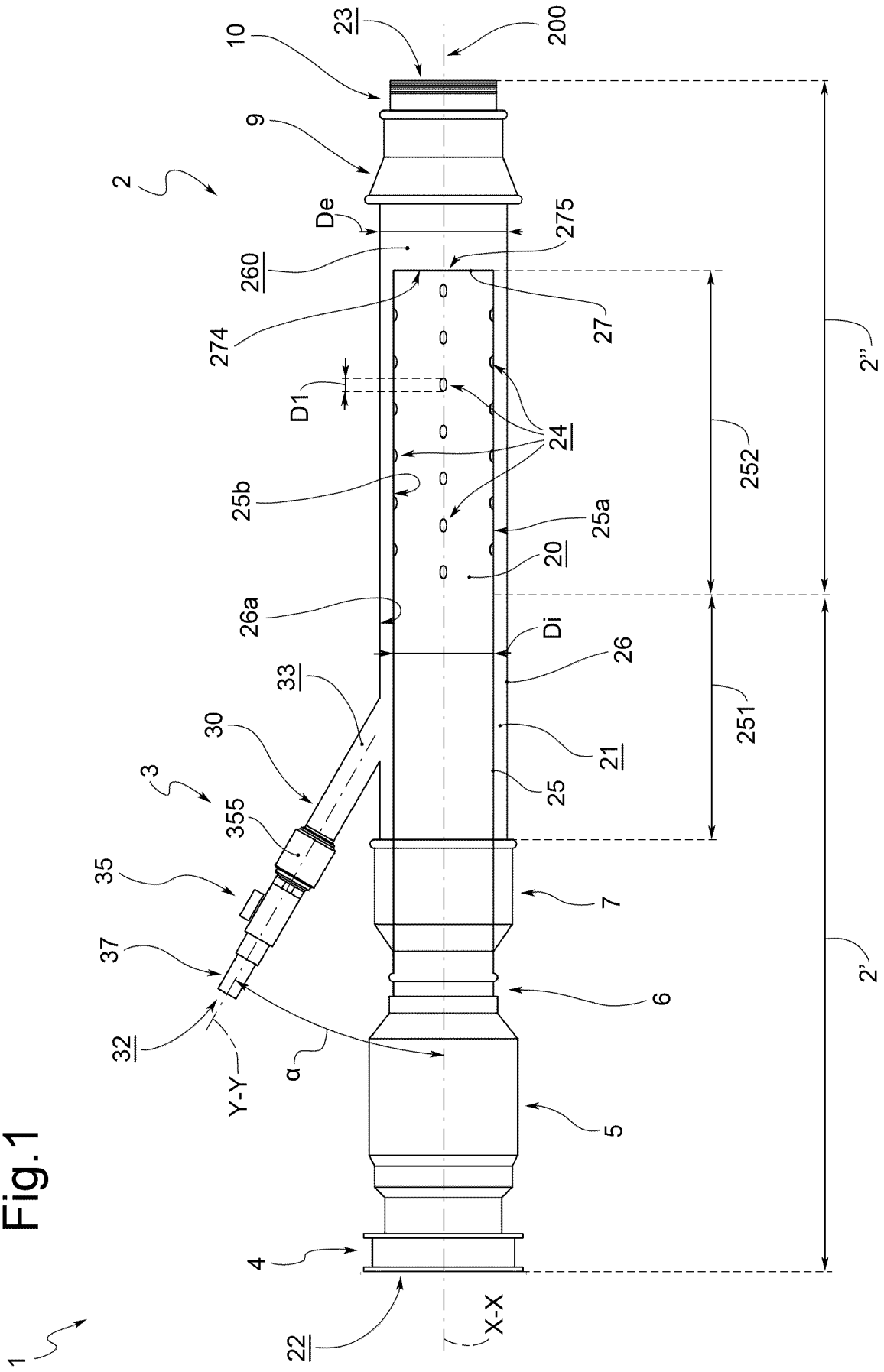
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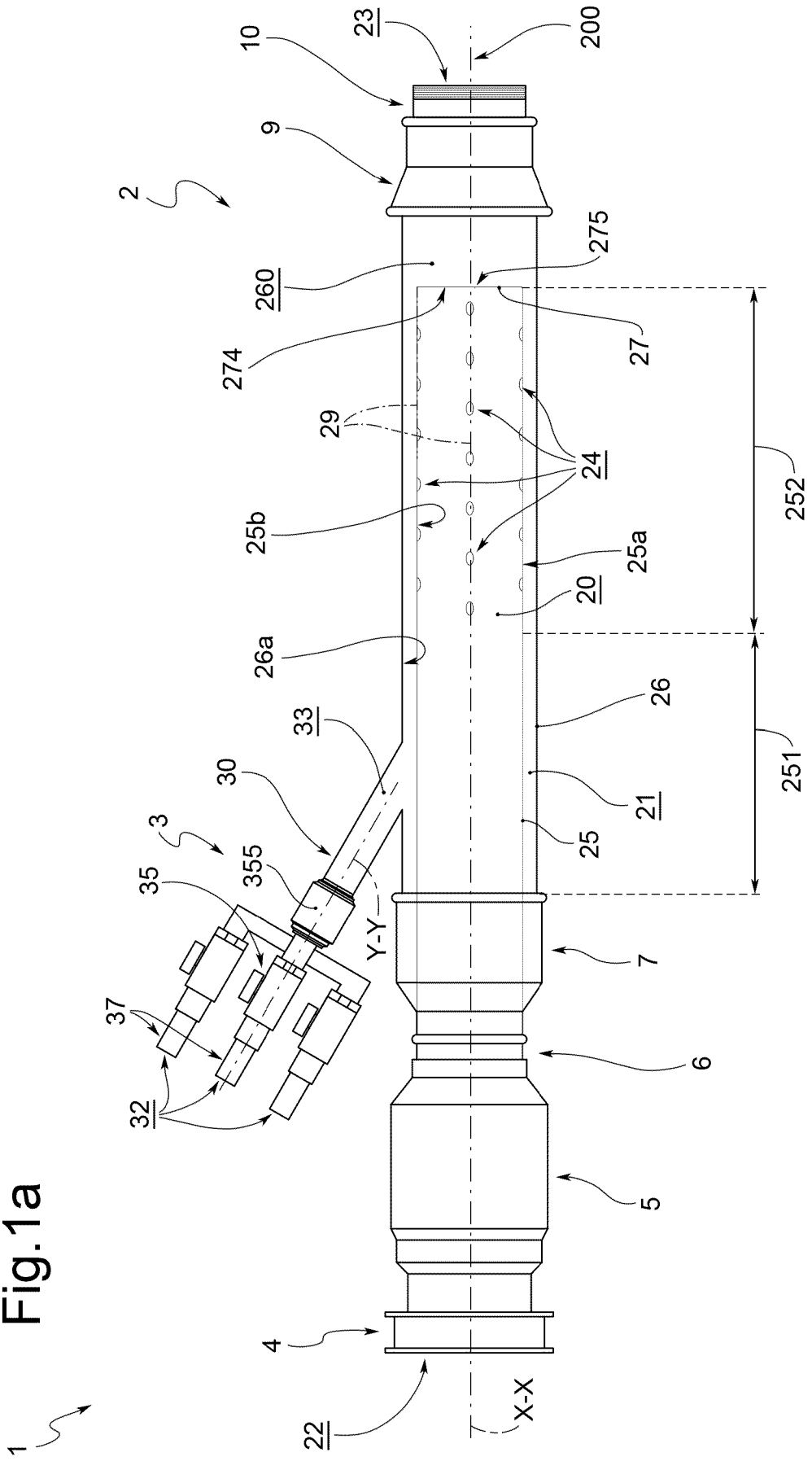
Fig.1a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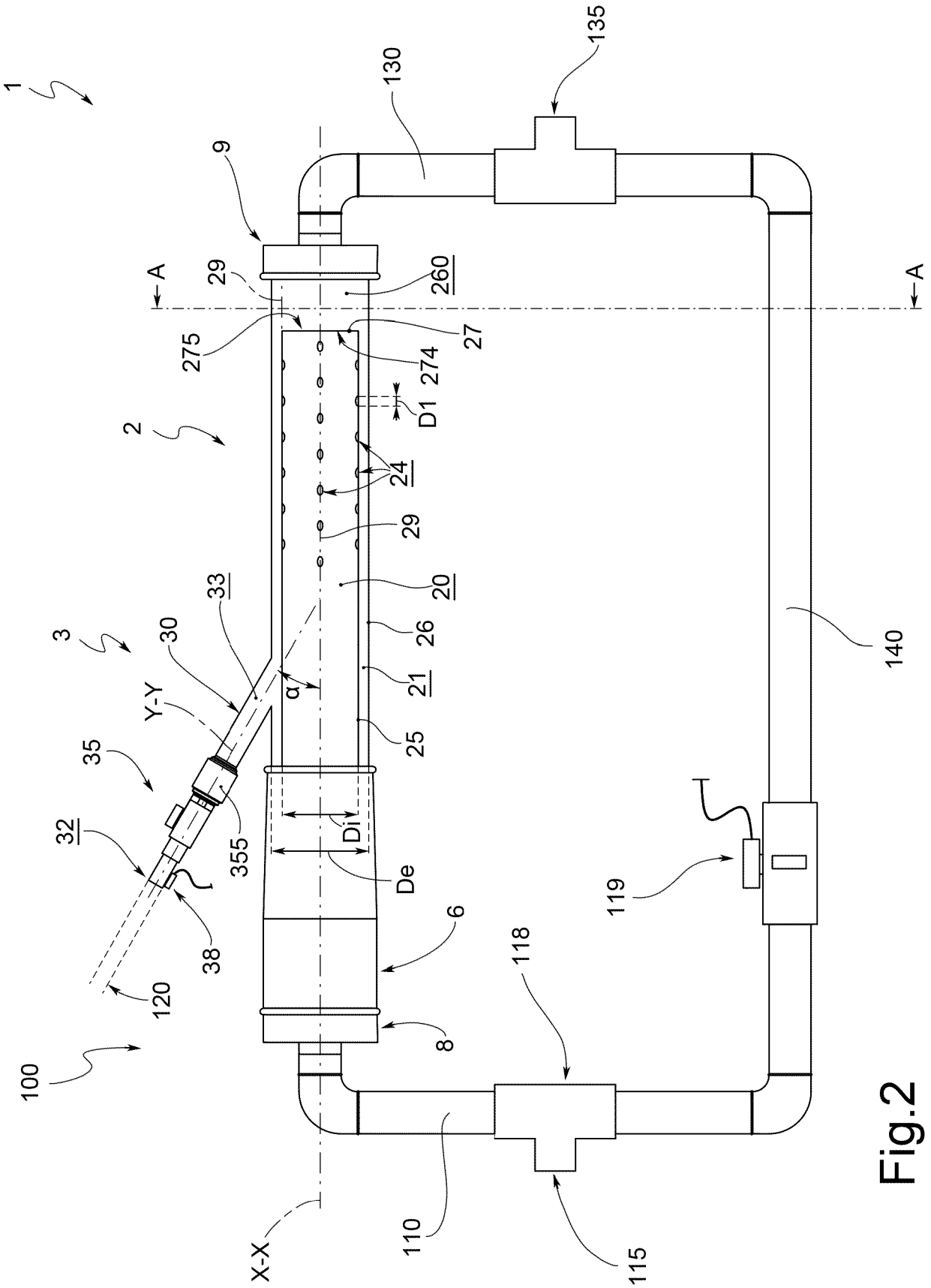
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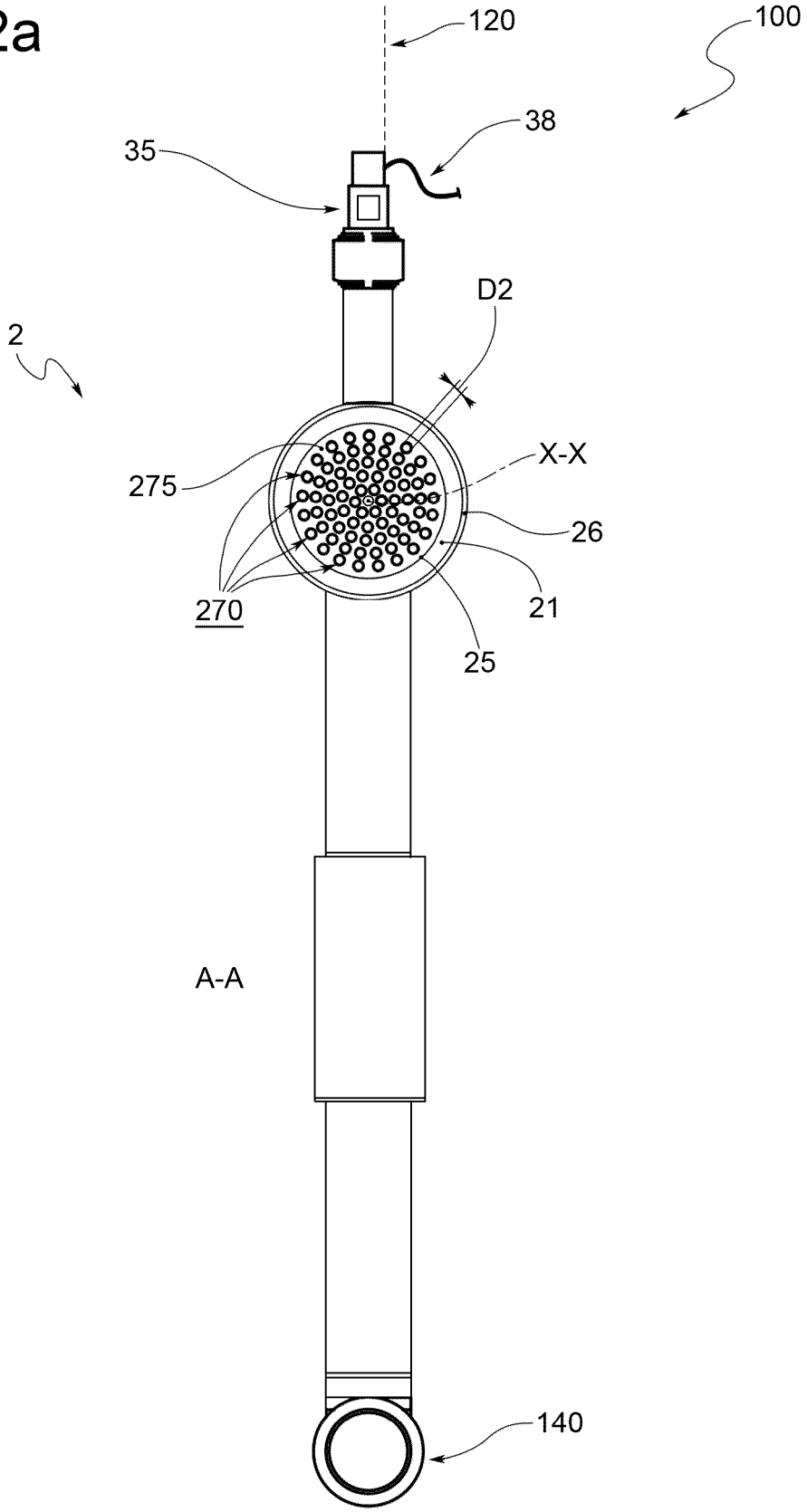
119
118
115

Fig.2

Fig.2a



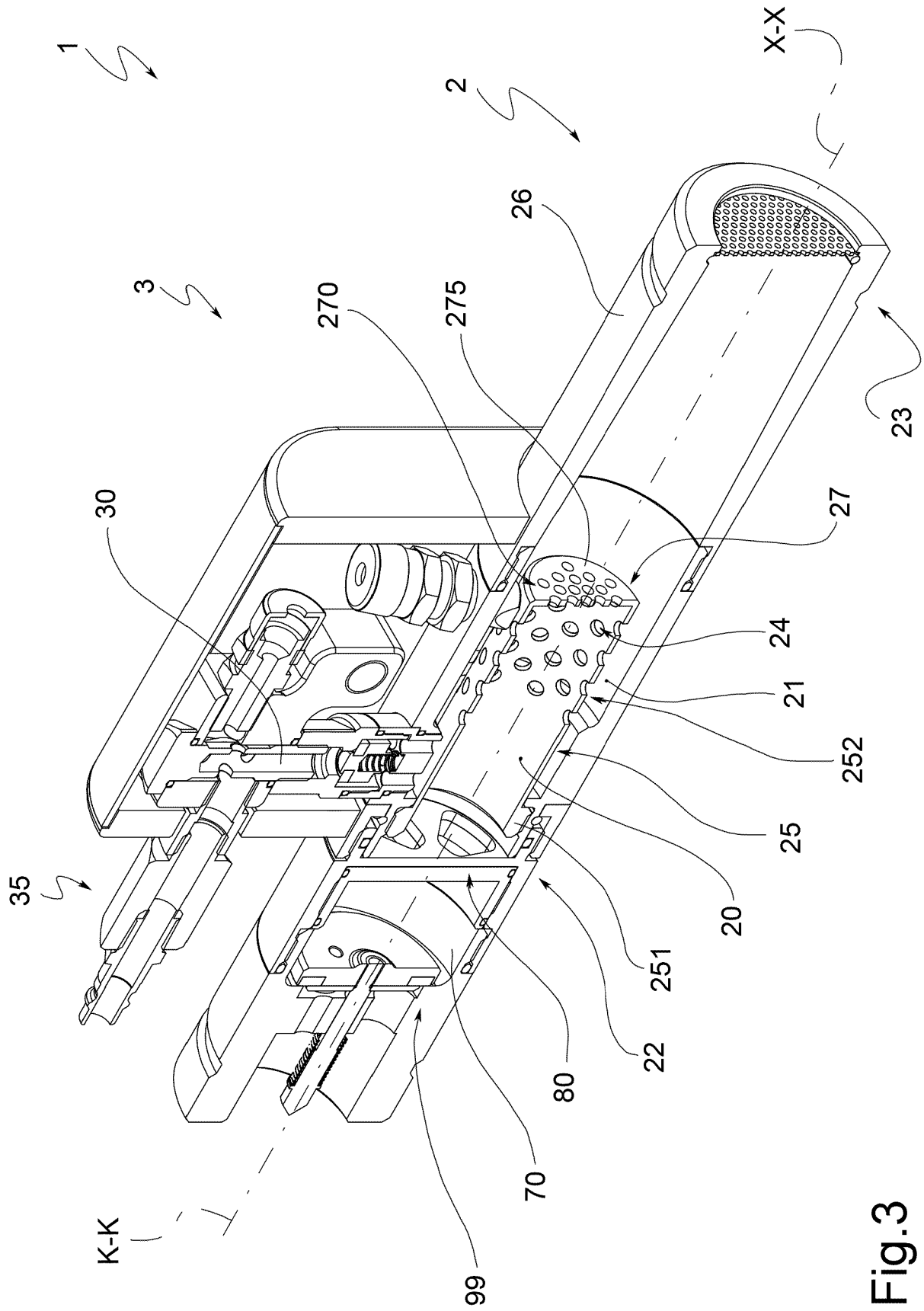
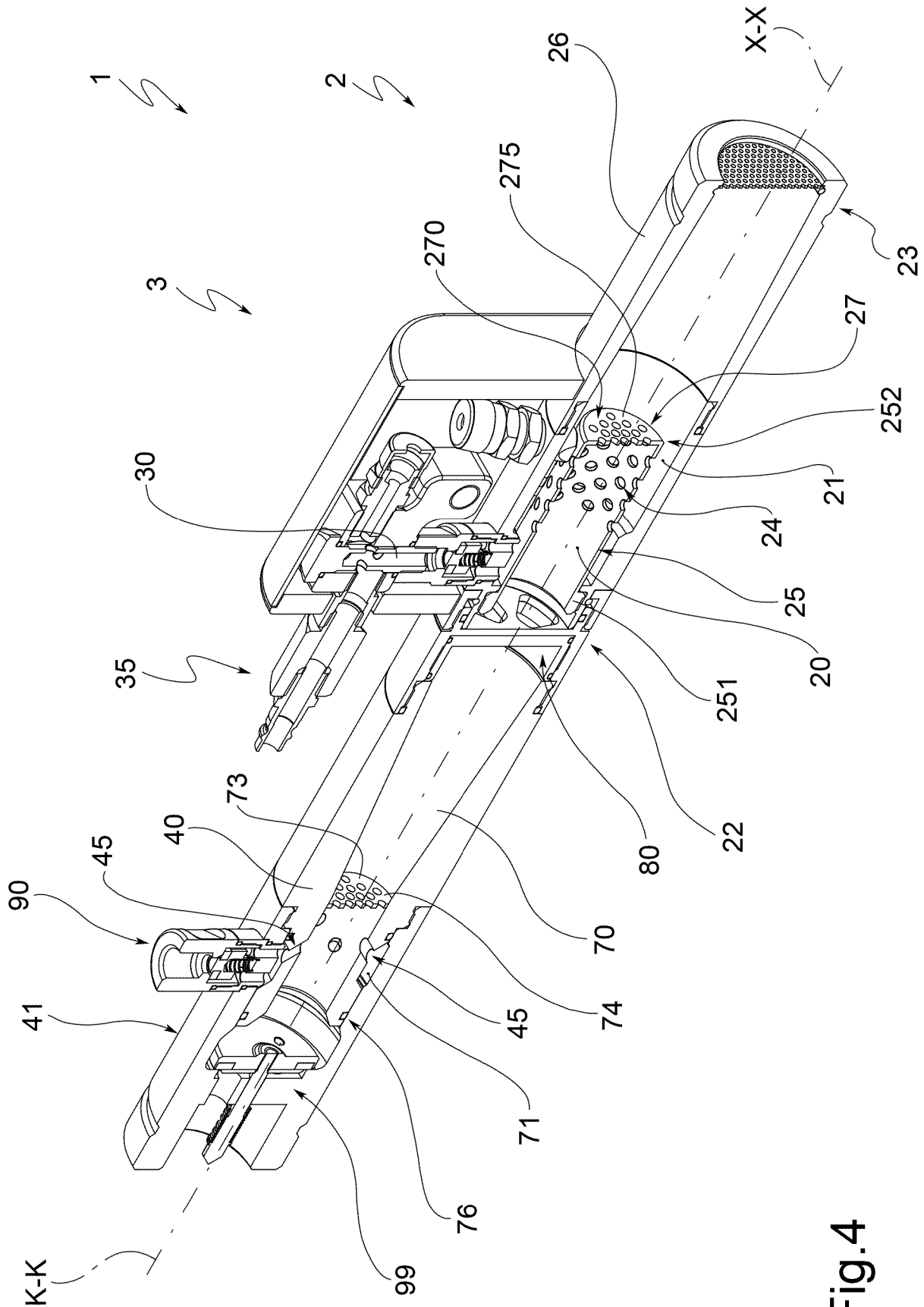


Fig.3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71
76
K-K
99

Fig.4

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EUROPEAN SEARCH REPORT

Application Number
EP 25 18 7594

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 42 04 906 A1 (LIPPMANN ECKART [DE]; LIPPMANN OLAF [DE]) 19 August 1993 (1993-08-19) * column 1, line 61 - column 2, line 11 * * column 2, lines 24-52 * * column 3, lines 26-49 * * column 3, lines 50-68 * * column 4, lines 1-18 * * column 5, lines 4-50 * * column 5, line 62 - column 6, line 11 * * figure 1 *	1-15	INV. B01F23/235 B01F25/31 B01F25/314 A62C31/12
X	US 2 051 841 A (WILLIAM GILBERT VICTOR GEORGE) 25 August 1936 (1936-08-25) * page 1, column 1, line 18 - page 1, column 2, line 9 * * figure 1 *	1	
X	US 5 900 191 A (GRAY PAUL T [US] ET AL) 4 May 1999 (1999-05-04) * column 5, lines 16-28 * * column 5, lines 56-64 * * figure 3 *	1	TECHNICAL FIELDS SEARCHED (IPC) B01F A62C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14 November 2025	Posten, Katharina

CATEGORY OF CITED DOCUMENTS

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D : document cited in the application
L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 25 18 7594

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14-11-2025

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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