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(54) **HYDRAULIC TURBINE, PRESSURE CONTROL DEVICE WITH ENERGY RECOVERY, WATER DISTRIBUTION SYSTEM, DELIVERY TUBE, FITTING, VOLUTE**

(57) A pressure control device (1) comprises a hydraulic turbine (10) and a generator (12) operationally connected to the hydraulic turbine (10) to recover and store energy from the thermal jump operated by the hydraulic turbine (10). The hydraulic turbine (10) comprises a volute (4) suitable for receiving water in the axial direction and transmitting it to the impeller (102) of the turbine in the radial direction.

A water distribution system (9) comprises a pressure control device (1) according to the invention.

Also forming the subject matter of the invention per se are a fitting (2’), a delivery tube (2") and a volute (4) .

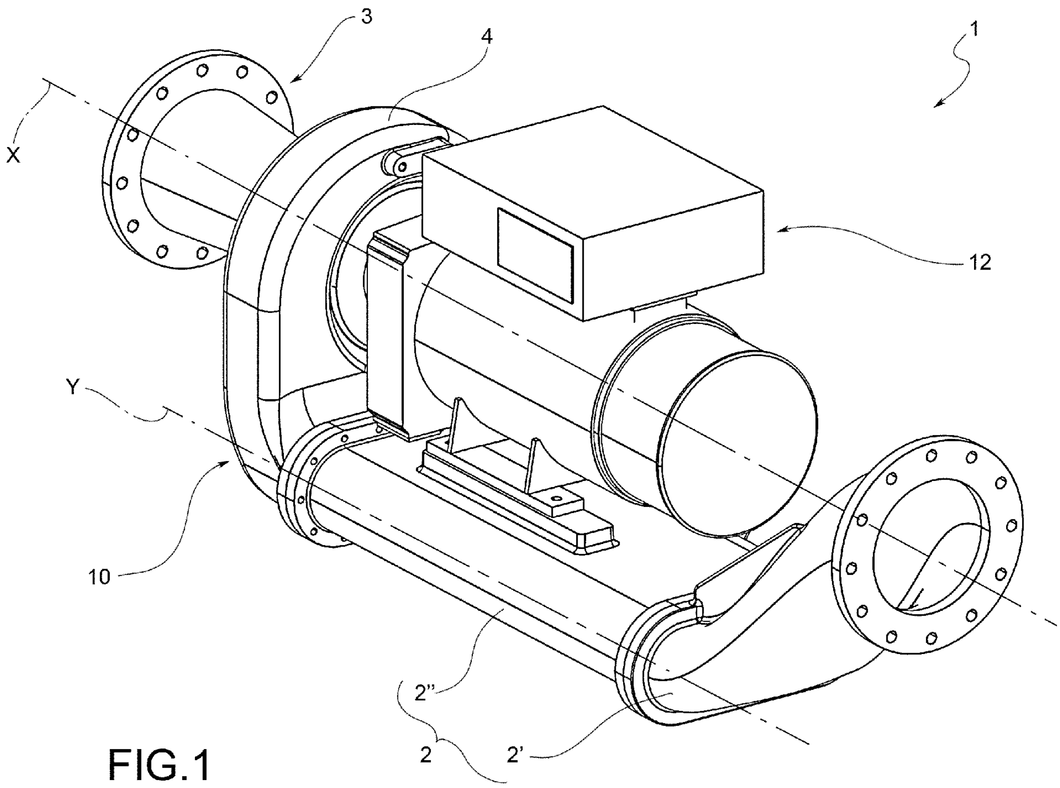


FIG.1



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## Description

### Field of application

**[0001]** The present invention relates to a hydraulic turbine for a pressure control device, and a pressure control device suitable for installation in-line in a water transport or distribution network, for pressure and/or flow control and for clean power generation.

**[0002]** In the hydroelectric sector, and particularly in the water distribution sector and in water treatment plants, it is necessary to provide for the use of pressure control devices that allow the pressure and flow rate exiting a main duct to be regulated to serve secondary ducts or utilities.

**[0003]** This, for example, is required in aqueducts, wherein it is essential to obtain a pressure and flow rate at the outlet of the main supply that meets the needs of the end user, i.e., to serve each private, residential, and industrial water system.

**[0004]** Known systems provide for the use of control valves placed along the water mains, which are adapted to control or alter the pressure or flow of fluid within a duct.

**[0005]** Disadvantageously, in applications wherein it is necessary to drastically reduce the pressure inside the duct (i.e., in the case of large pressure jumps and small flow rates, or vice versa, in the case of large flow rates and limited pressure jumps), the dissipation of a certain amount of energy in the form of heat and vibration is unavoidable.

**[0006]** Also, disadvantageously, such systems are particularly bulky and difficult to access for maintenance.

**[0007]** According to a further disadvantage, a massive change in pressure in such systems may cause fluid cavitation or water hammer. Such effects are unpleasant and result in wear and damage to the mechanical parts of the entire fluid circuit.

### Solution of the invention

**[0008]** Therefore, there appears to be a significant need to provide a pressure control device capable of overcoming the drawbacks typical of the state of the art.

**[0009]** In particular, the object of the present invention is to provide a pressure control device suitable for recovering the energy otherwise dissipated due to pressure jump and making it available for further applications.

**[0010]** A further object of the present invention is to provide a compact, space-saving hydraulic turbine.

**[0011]** At the same time, a further object of the present invention is to construct a pressure control device that is adaptable to various applications and insertable into existing water distribution and conveyance systems.

**[0012]** A further object of the present invention is also to construct a water distribution system that allows high reliability and ensures the operation of the system even under conditions of blockage of the pressure control device.

**[0013]** Such requirement is met by a hydraulic turbine, a pressure control device, and a water distribution system according to the attached independent claims. The claims dependent thereon describe preferred or advantageous embodiments of the invention, comprising further advantageous features.

### Description of the drawings

**[0014]** The features and advantages of the hydraulic turbine, of the pressure control device and of the distribution system will become apparent from the description below of a number of preferred embodiment examples, given by way of non-limiting example, with reference to the attached figures, wherein:

- Fig. 1 is a perspective view of a pressure control device according to an embodiment of the present invention;
- Fig. 2 is a side view of a pressure control device according to an embodiment of the present invention;
- Fig. 3 is a longitudinal sectional view of a pressure control device according to an embodiment of the present invention;
- Fig. 4 is a perspective detail view of a hydraulic turbine of a pressure control device according to an embodiment of the present invention;
- Fig. 5 is a perspective view of an inlet duct and a volute of a pressure control device according to an embodiment of the present invention;
- Fig. 6 is a side view of an inlet duct and a volute of a pressure control device according to an embodiment of the present invention;
- Fig. 7 shows some significant views (7A, 7B, 7C, 7D, 7E) of a fitting of an inlet duct for a pressure control device according to an embodiment of the present invention;
- Fig. 8 shows some significant views (8A, 8B, 8C, 8D) of a delivery tube of an inlet duct for a pressure control device according to an embodiment of the present invention;
- Fig. 9 shows some significant views (9A, 9B, 9C, 9D) of a volute of a hydraulic turbine for a pressure control device according to an embodiment of the present invention;
- Fig. 10a shows a water distribution system comprising a pressure control device according to an embodiment of the present invention;
- Fig. 10b shows a water distribution system comprising a pressure control device according to a further embodiment of the present invention.

### Detailed description

**[0015]** With reference to the aforesaid figures, reference number 1 has been used to indicate collectively the pressure control device with energy recovery. In the remainder of the present discussion reference is made succinctly to a pressure control device or simply a device, in the interest of descriptive clarity.

**[0016]** According to the invention, the pressure control device 1 comprises a hydraulic turbine 10, preferably a Francis-type hydraulic turbine 10.

**[0017]** The hydraulic turbine 10 comprises a distributor 101 and an impeller 102, having a rotation axis X, and a volute 4.

**[0018]** The term "volute" is known in the industry to refer to the casing that houses the distributor 101 and the impeller 102. It is evident that the internal volume identified by the volute 4 is not entirely occupied by the impeller and distributor, but comprises a passage cavity for the treated fluid, suitable for allowing the flow of an incoming fluid through the distributor 101 and into the impeller 102.

**[0019]** Furthermore, the pressure control device 1 comprises a generator 12 operationally connected with the hydraulic turbine 10 and suitable for extracting (and storing) a portion of the energy produced by the pressure reduction operated on the water.

**[0020]** It is evident that a subject matter of the present invention is also a hydraulic turbine 10 per se, even when not associated with a generator 12 in a pressure control device 1.

**[0021]** In one embodiment, the hydraulic turbine 10 comprises a water inlet duct 2 upstream of the volute 4 and a water outlet duct 3 downstream of the volute 4.

**[0022]** The references "upstream" and "downstream" in this discussion are taken to refer to the flow of water from the inlet duct 2 to the outlet of the turbine 10.

**[0023]** That is, the volute 4 is arranged between the water inlet duct 2 and the water outlet duct 3.

**[0024]** Such volute 4 is shaped to direct the inlet water flow from the water inlet duct 2 to the distributor 101 so that such distributor 101 directs the water to enter the impeller 102 of the hydraulic turbine 10 radially with respect to the rotation axis X.

**[0025]** That is, the distributor 101 is shaped to vary the direction of water flow entering the volute 4 to direct it radially toward the impeller 102.

**[0026]** The volute 4 comprises an internal wall 40 that determines an internal volume of the volute. In particular, the volute 4 houses the distributor 101 and the impeller 102 in such internal volume.

**[0027]** According to one embodiment, the volute 4 comprises an impeller seat 400 suitable for accommodating the impeller 102 in such a way that the rotation of the impeller 102 in the volute 4 about said rotation axis X is allowed.

**[0028]** Preferably, the impeller seat 400 is a through cavity obtained in the volute 4.

**[0029]** As known, Francis type turbines commonly include a volute with an inlet duct with an annular geometry and a circular cross section. In other words, the water inlet duct develops like a ring around the axis of rotation of the impeller.

**[0030]** These volutes comprise a receiving mouth positioned in a tangential direction with respect to the axis of rotation of the impeller. In other words, in common Francis turbines the receiving mouth is equipped with a tangential section with respect to the axis of rotation of the impeller which allows the entry of water into the volute directly in a radial/tangential direction with respect to the axis of rotation of the impeller.

**[0031]** Differently from what occurs for common Francis type turbines, according to the invention, the volute 4 comprises a receiving mouth 410 suitable for receiving incoming water along an injection axis Y upstream of the distributor 101. Said injection axis Y is substantially parallel to the rotation axis X of the impeller 102.

**[0032]** In other words, the receiving mouth 410 is suitable for receiving directly the water flow in a direction parallel with respect to the rotation axis X of the impeller 102 and to the exit direction.

**[0033]** That is, according to the invention, the turbine 10 is shaped so that the water enters the volute through the receiving mouth 410 along a direction parallel to the rotation axis X (i.e., along the axial direction), is diverted by the volute 4 and the distributor 101 to enter tangentially toward the impeller 102, and exits along the axial direction.

**[0034]** In other words, the receiving mouth 410 identifies an axial injection direction Y with respect to the rotation axis X.

**[0035]** Preferably, there are no elements interposed between the inlet duct 2 and the receiving mouth 410.

**[0036]** In other words, the volute 4 is shaped so that the water flow is axial directly upstream of the distributor 101 and is radial downstream of the distributor 101 and upstream of the impeller 102.

**[0037]** The expression "directly upstream" or "directly downstream" in this discussion refers to direct connections, occurring without any section interposed.

**[0038]** That is, just before encountering the distributor, the water flow is axial, and is gradually transformed into radial properly thanks to the action of the distributor blades.

**[0039]** Preferably, the volute 4 comprises an elbow manifold 45 directly downstream of the receiving mouth 410 and upstream of the distributor 101, suitable for diverting at least part of the water flow by varying its direction from the injection direction Y axial with respect to the rotation axis X, to a radial/tangential direction with respect to the rotation axis X.

**[0040]** In other words, the manifold 45 has a geometry suitable for changing the flow direction from axial with respect to the direction of rotation of the impeller 102 to radial/tangential with respect to the direction of rotation of the impeller 102.

**[0041]** That is, the elbow manifold 45 cooperates with the distributor 101 to cause the diversion of the incoming water flow axially to reach the impeller 102 of the turbine 10 tangentially/radially.

**[0042]** In other words, contrary to that which is commonly known about Francis turbines - in which the volute terminates in a receiving mouth tangential (having tangential inlet) with respect to the rotation axis of the impeller - in the present invention, the volute 4 is specially shaped so that the turbine inlet (i.e., the water inlet zone directly upstream of the distributor) is situated in the same direction as the outlet, i.e., the axial direction.

**[0043]** In an embodiment, the volute 4 is a single piece, i.e. the body of the volute in which the receiving mouth 410 and the elbow manifold 45 are made are made in one piece and are solidal with each other.

**[0044]** It is evident to the person skilled in the art that "axial direction" means the direction containing the rotation axis X of the impeller 102 and that "radial direction" with respect to the rotation axis X means any direction contained in a transverse plane and comprising a point on the rotation axis X.

**[0045]** In an advantageous embodiment, the volute 4 has an asymmetrical frontal section - a frontal section is defined as a section taken in a plane orthogonal to the rotation axis X - and the impeller seat 400 is obtained off-center from said volute 4.

**[0046]** In other words, the volute 4 develops eccentrically about the impeller seat 400.

**[0047]** This shape makes the volute 4 and the distributor 101 suitable for diverting the incoming water through the receiving mouth 410 along an essentially spiral fluid path to enter radially towards the impeller 102.

**[0048]** In one embodiment, the distributor 101 comprises stator blades 51, 52, preferably protruding from the inner wall 40 of the volute. That is, the stator blades 51, 52 are part of the volute 4, preferably made in one piece with the volute 4.

**[0049]** In an advantageous embodiment, the stator blades 51, 52 develop into a first series 51 and a second series 52 of stator blades.

**[0050]** Said first series 51 runs directly about the impeller seat 400 - and thus the impeller 102 - in an at least partially concentric manner, i.e., the first series 51 of stator blades surrounds the impeller 102 at least partially.

**[0051]** The second series 52 runs more externally with respect to the first series 51 in the radial direction, i.e., they are further from the rotation axis X of the impeller with respect to the first series 51. Preferably, the stator blades of the second series 52 are larger in size with respect to the stator blades of the first series 51.

**[0052]** The stator blades 51, 52 are suitable for diverting the incoming water flow along the injection direction Y through the receiving mouth 410 to allow the radial inlet thereof toward the impeller 102.

**[0053]** In one embodiment, the turbine 10 further comprises movable blades 55 arranged circumferentially about the impeller 102 and suitable for providing additional directionality to the flow towards the impeller 102.

**[0054]** Such movable blades 55 are arranged between the first series 51 of stator blades and the impeller 102.

**[0055]** The water inlet duct 2 extends between an entry end 20 and a connection end 21. In particular, at such inlet end 20 and connection end 21, the water inlet duct 2 is delimited respectively by an inlet mouth 200 and a respective injection mouth 210.

**[0056]** The water inlet duct 2 is therefore suitable for being penetrated by water entering from the inlet mouth 200 and toward the injection mouth 210.

**[0057]** The water inlet duct 2 is suitable for being connected to a reservoir, a water basin, a water supply device, or a tubing by connection at said inlet end 20.

**[0058]** The water inlet duct 2 may be directly connected to the volute 4 by connection between the injection mouth 210 and the receiving mouth 410.

**[0059]** That is, the volute 4 comprises a respective connection end 41 at which it is connected to the connection end 21 of the water inlet duct 2.

**[0060]** In one embodiment, the pressure control device 1 is suitable for being applied to a water distribution system 9. In particular, the water inlet duct 2 is suitable for being connected to an inlet tubing 91 at the inlet end 20.

**[0061]** The inlet tubing 91 is preferably fed from a reservoir 90, a water basin, a supply device, or an auxiliary tubing.

**[0062]** The water outlet duct 3 is suitable for discharging water leaving the impeller 102 axially with respect to the rotation axis X, i.e., along a discharge direction parallel to the rotation axis X.

**[0063]** In one embodiment, the water outlet duct 3 extends between a first end 32 and a second end 33. The first end 32 is suitable for being connected to a discharge end 42 of the volute 4, downstream of the impeller 102. The second end 33 is suitable for being connected to a discharge tubing 92 of a water distribution system 9.

**[0064]** Preferably, the water outlet duct 3 is tapered toward the first end 32. That is, the output section A3 of the second end 33 is larger than the input section A2 of the first end 32.

**[0065]** In one embodiment, the water outlet duct 3 defines the volume of a truncated cone having the minor base at the first end 32 and the major base at the second end 33.

**[0066]** Preferably, the water outlet duct 3 is axisymmetric with respect to the rotation axis X of the impeller 102.

**[0067]** In one embodiment, the water outlet duct 3 is directly keyed onto the volute 4.

**[0068]** Preferably, the mechanical connections between the water inlet duct 2, the volute 4, and the water outlet duct 3 are made by standard, removable fixing means, e.g., flanges and bolts, or fixed means, by welding.

**[0069]** In an advantageous embodiment, the inlet duct 2 comprises a fitting 2’ and a delivery tube 2". Preferably, the inlet duct 2 is composed exclusively of such said fitting 2’ and said delivery tube 2".

**[0070]** In one embodiment, the delivery tube 2" extends predominantly along the injection axis Y. The delivery tube 2" is directly connected to the receiving mouth 410 of the volute 4.

**[0071]** Preferably, the delivery tube 2'' has a substantially linear development along the injection axis Y and has the cross-section of an oval.

**[0072]** The delivery tube 2" comprises a side wall 25 having a substantially flat upper portion 251 and lower portion 252, preferably parallel to each other, preferably joined by curvilinear portions 253, 254.

**[0073]** In one embodiment, the delivery tube 2" comprises ribs 250 protruding internally, i.e., toward the inner volume of the delivery tube 2", from the side wall 25.

**[0074]** Preferably, the ribs 250 extend predominantly parallel to the injection axis Y.

**[0075]** Preferably, the ribs 250 extend the entire length of the delivery tube 2" along the injection axis Y.

**[0076]** Preferably, there are two ribs 250.

**[0077]** Even more preferably, the ribs 250 extend from the upper portion 251 or the lower portion 252 of the side wall 25.

**[0078]** In a preferred embodiment, the ribs extend internally to the delivery tube 2" between the upper portion 251 and the lower portion 252.

**[0079]** In an advantageous embodiment, when the generator 12 is connected to the impeller 102 and the delivery tube 2'' is connected to the volute 4, the generator 12 is placed above the delivery tube 2".

**[0080]** In an advantageous embodiment, when the delivery tube 2'' is connected to the volute 4, the flattened upper portion 251 is suitable for supporting the generator 12.

**[0081]** In an advantageous embodiment, the generator 12 is directly keyed onto the delivery tube 2" at the upper portion 251.

**[0082]** In other words, in one embodiment the pressure control device 1 comprises the generator 12 keyed directly above the inlet duct 2, preferably above the delivery tube 2".

**[0083]** Advantageously, in such an embodiment, the overall dimensions of the device are reduced and the device is suitable for in-line installation in a water distribution system.

**[0084]** In an advantageous embodiment, the pressure control device 1 has predominant development parallel to the rotation axis of the impeller X.

**[0085]** In one embodiment, the delivery tube 2" comprises one or more support elements 80 suitable for supporting the weight of the generator 12.

**[0086]** Preferably, such support elements 80 are located on the side wall 25, even more preferably on the upper portion 251.

**[0087]** In one embodiment, such support elements 80 are protuberances obtained in one piece on the upper portion 251 and/or on one or more of the curvilinear portions 253, 254 of the side wall 25.

**[0088]** In one embodiment, such protuberances 80 extend parallel to the injection axis Y.

**[0089]** In one embodiment, such protuberances 80 are spaced in an unbalanced manner with respect to said injection axis Y, i.e., they are not symmetrical with respect to the delivery tube 2".

**[0090]** Preferably, such protuberances 80 are equidistant from the rotation axis X of the impeller.

**[0091]** Advantageously, in such embodiment the delivery tube 2'' is suitable for stably maintaining the generator 12 that is connected to the impeller 102.

**[0092]** Preferably, the generator 12 is attachable in a stable manner to said protuberances 80 by attachment means (not shown).

**[0093]** The fitting 2' is directly connectable upstream of the delivery tube 2" and is suitable for connection downstream of a reservoir, a water basin, a water supply device, or a tubing.

**[0094]** That is, preferably the inlet mouth 200 is obtained in such fitting 2'.

**[0095]** In other words, the fitting 2' allows the incoming water to flow from the inlet mouth 200 towards the delivery tube 2" to reach the volute 4.

**[0096]** In one embodiment, the fitting 2' comprises a connection opening 201 at the end opposite from the inlet mouth 200 along the direction of the water flow S, said connection opening 201 being connectable directly upstream of the delivery tube 2".

**[0097]** Preferably, the delivery tube 2'' comprises a delivery opening 202, opposite the injection mouth 210 and directly connectable to said connection opening 201.

**[0098]** Preferably, the connection opening 201 has the same cross-section as the delivery tube 2" (and thus the delivery opening 202).

**[0099]** In one embodiment, the fitting 2' comprises a curvilinear wall 27 that connects the inlet mouth 200 and connection opening 201 together.

**[0100]** In one embodiment, the water inlet 200 defines and develops about an inlet axis Z.

**[0101]** In a preferred embodiment, the input axis Z is substantially parallel to the rotation axis X and to the injection axis Y.

**[0102]** In the present discussion, the formula "substantially parallel" denotes two axes parallel or incident to each other with an angle of incidence contained within a limited range, preferably less than 90 degrees, even more preferably less than 50 degrees, even more preferably less than 10 degrees.

**[0103]** Preferably, the input axis Z is parallel to the rotation axis X and the injection axis Y.

**[0104]** Even more preferably, in the pressure control device 1 the input axis Z coincides with the rotation axis X.

**[0105]** In a preferred embodiment, when the fitting 2' and the delivery tube 2" are connected to each other a height difference H1 results between the injection axis Y and the inlet axis Z.

**[0106]** That is, in the fitting 2' the water inlet mouth 200 and the connection opening 201 are offset from each other in height. This configuration is fundamental for providing an elevation jump to the water flow entering the turbine 10.

**[0107]** In one embodiment, the inlet mouth 200 has a circular cross-section, centered in the inlet axis Z.

**[0108]** In one embodiment, the connection opening 201 has an oval cross-section, preferably the same size as the cross-section of the delivery tube 2" (and the delivery opening 202).

**[0109]** In one embodiment, the fitting 2' comprises stiffening ridges 270, preferably two, that protrude from the curvilinear wall 27.

**[0110]** Further, in one embodiment, the fitting 2' comprises one or more internal ribs 275 protruding from the curvilinear wall 27 inward, i.e., into the internal volume of the fitting 2' delimited by the curvilinear wall 27.

**[0111]** Preferably, the fitting 2' comprises only one internal rib 275.

**[0112]** In a particularly advantageous embodiment, the pressure control device 1 comprises the turbine 10, the generator 12, the delivery tube 2" connected upstream of the volute 4, and the fitting 2' connected upstream of the delivery tube 2" in such a way that the inlet axis Z is parallel to the rotation axis X of the impeller and to the injection axis Y. The generator 12 is connected to the impeller 102 and is located above the delivery tube 2", preferably directly keyed onto the delivery tube 2".

**[0113]** In one embodiment, the inlet duct 2 is one piece, that is, the delivery tube 2" and the fitting 2' are made in one piece and are integral to each other.

**[0114]** A subject matter of the present invention is a water distribution system 9 comprising a pressure control device 1 according to the present invention.

**[0115]** In one embodiment, the water distribution system 9 comprises a bypass mechanism that is operable, e.g., in case of failure, malfunction, rupture, or overload of the pressure control device 1, to ensure pressure regulation and the operation of the plant.

**[0116]** In one embodiment, the bypass mechanism comprises a bypass duct and a control valve, preferably a spindle valve or a pressure reducing valve, configured to keep the access to the bypass duct closed under working conditions and to open the access to the bypass duct under emergency conditions. Preferably the control valve is operated electrically or through counterweight.

**[0117]** In one embodiment, the inlet duct 2, the outlet duct 3, and the turbine 10 are made of materials suitable for contact with potable water, such as stainless steel, or are painted with a coating suitable for potable water applications.

**[0118]** In one embodiment, the impeller is made of AISI316L stainless steel.

**[0119]** In one embodiment, the outlet duct 3, the inlet duct 2, and the volute 4 are made of ductile iron and coated with epoxy protection through the FBE (Fusion Bonded Epoxy) process according to EN14901-1.

**[0120]** Preferably, the fitting 2', the delivery tube 2'', the volute 4, and the discharge tube 3 are obtainable by casting.

**[0121]** Innovatively, the present invention solves the typical drawbacks of pressure control devices of the prior art.

**[0122]** Advantageously, the present invention enables the conversion of excess hydraulic energy into clean electricity.

**[0123]** Advantageously, the hydraulic turbine according to the present invention is usable as an in-line pressure regulator in water distribution systems.

**[0124]** Advantageously, the Applicant has verified that the hydraulic turbine according to the present invention provides high overall yield in the optimal operating range thereof and reduces pressure drop between the inlet and outlet.

**[0125]** Advantageously, the inlet duct according to the present invention allows a generator to be housed while keeping the footprint of the pressure control device contained and at the same time supplying incoming water in the direction axial to the hydraulic turbine.

**[0126]** At the same time, the present invention enables good performance at the distribution level to be obtained and makes existing systems more efficient.

**[0127]** Furthermore, advantageously, the pressure control device is space-saving and easy to implement and maintain.

**[0128]** According to a further advantage, the pressure control device is versatile and scalable and may be adapted to any need.

**[0129]** According to a further advantage, the water distribution system is safe and reliable and ensures service even if the pressure control device fails or malfunctions.

**[0130]** According to an even further advantage, the water distribution system is efficient.

**[0131]** It is evident that, to the embodiments of the aforesaid pressure control device, the aforesaid turbine, and the distribution system, a person skilled in the art, in order to meet specific needs, could make variations or substitutions of elements with functionally equivalent ones.

**[0132]** These variants are also contained within the scope of protection as defined by the following claims.

**[0133]** Moreover, each variant described as belonging to a possible embodiment may be implemented independently of the other variants described.

## Claims

1. A hydraulic turbine (10) comprising a distributor (101), an impeller (102) having a rotation axis (X) and a volute (4) which houses said distributor (101) and impeller (102),

    wherein the volute (4) comprises a receiving mouth (410) directly upstream of the distributor (101), said receiving mouth (410) extending about an injection axis (Y) substantially parallel to the rotation axis (X),

    wherein the volute (4) is suitable for receiving incoming water along said injection axis (Y) and is shaped to direct the incoming water flow through said receiving mouth (410) tangentially towards the impeller (102), said hydraulic turbine (10) being suitable for discharging such a water flow parallel to the rotation axis (X).

**2.** Hydraulic turbine (10) according to claim 1, wherein the volute (4) comprises an elbow manifold (45) directly downstream of the receiving mouth (410) and upstream of the distributor (101), said elbow manifold (45) being suitable for diverting at least partially the water flow from the injection direction (Y) to tangentially enter towards the impeller (102).

**3.** Hydraulic turbine (10) according to claim 1 or 2, wherein the volute (4) comprises an inner wall (40) and the distributor (101) comprises stator blades (51, 52) projecting from said inner wall (40).

**4.** Hydraulic turbine (10) according to any one of the preceding claims, comprising an impeller seat (400) obtained in the volute (4) and suitable for accommodating the impeller (102) in a rotatable manner about the rotation axis (X) and wherein the distributor (101) comprises a first series (51) of stator blades which at least partially surrounds said impeller seat (400).

**5.** Hydraulic turbine (10) according to the preceding claim, wherein the distributor (101) comprises a second series (52) of stator blades which extend more externally than the first series (51) and which are larger in size as compared the first series (51) of stator blades.

**6.** A pressure control device (1) comprising a hydraulic turbine (10) according to any one of the preceding claims and a generator (12) connected to the impeller (102).

**7.** Pressure control device (1) according to claim 6, comprising an inlet duct (2) connected upstream of the volute (4) and suitable for providing incoming water to the receiving mouth (410) along the injection axis (Y).

**8.** Pressure control device (1) according to claim 7, wherein the inlet duct (2) comprises a delivery tube (2'') directly connected to the receiving mouth (410), wherein said delivery tube (2") has a substantially linear development along the injection axis (Y) and has the cross-section of an oval.

**9.** Pressure control device (1) according to claim 8, wherein the delivery tube (2'') comprises a side wall (25) having an upper portion (251) and a lower portion (252) which are substantially flat and parallel to each other.

**10.** Pressure control device (1) according to any one of claims 7 to 9, wherein the generator (12) is directly keyed onto the inlet duct (2).

**11.** Pressure control device (1) according to claims 8 and 10, wherein the generator (12) is directly keyed onto the delivery tube (2").

**12.** Pressure control device (1) according to any one of claims 8 to 11, wherein the inlet duct (2) comprises a fitting (2') connectable upstream of the delivery tube (2'') and extending with a curvilinear wall (27) between a water inlet mouth (200) suitable for receiving incoming water along an inlet axis (Z) and a connection opening (201) suitable for being connected to an injection opening (202) of the delivery tube (2"), wherein the inlet axis (Z) is parallel to the injection axis (Y) and the rotation axis (X).

**13.** Pressure control device (1) according to claim 12, wherein the inlet axis (Z) is coincident with the rotation axis (X).

**14.** Pressure control device (1) according to claim 12 or 13, wherein there is a height difference (H1) between the injection axis (Y) and the inlet axis (Z).

**15.** A water distribution system (9) comprising a pressure control device (1) according to any one of claims 6 to 14.

**16.** Water distribution system (9) according to claim 15, comprising a bypass mechanism which is operable instead of the pressure control device (1), for example in the case of a breakdown or malfunction.

**17.** A delivery tube (2'') for a pressure control device (1), having a substantially linear extension along an injection axis (Y) and having the cross-section of an oval, comprising a side wall (25) and being suitable for supporting a generator (12) resting on said side wall (25) .

**18.** A fitting (2') for a pressure control device (1), connectable upstream of a delivery tube (2'') according to claim 17 and extending with a curvilinear wall (27) between a water inlet mouth (200) suitable for receiving incoming water along an inlet axis (Z) and a connection opening (201), wherein the inlex axis (Z) is parallel to the injection axis (Y) and the connection opening extends about an injection axis (Y), and wherein there is a height difference (H1) between the injection axis (Y) and the inlet axis (Z).

**19.** A volute (4) for a hydraulic turbine (10) according to any one of the claims from 6 to 14, comprising an elbow manifold (45).

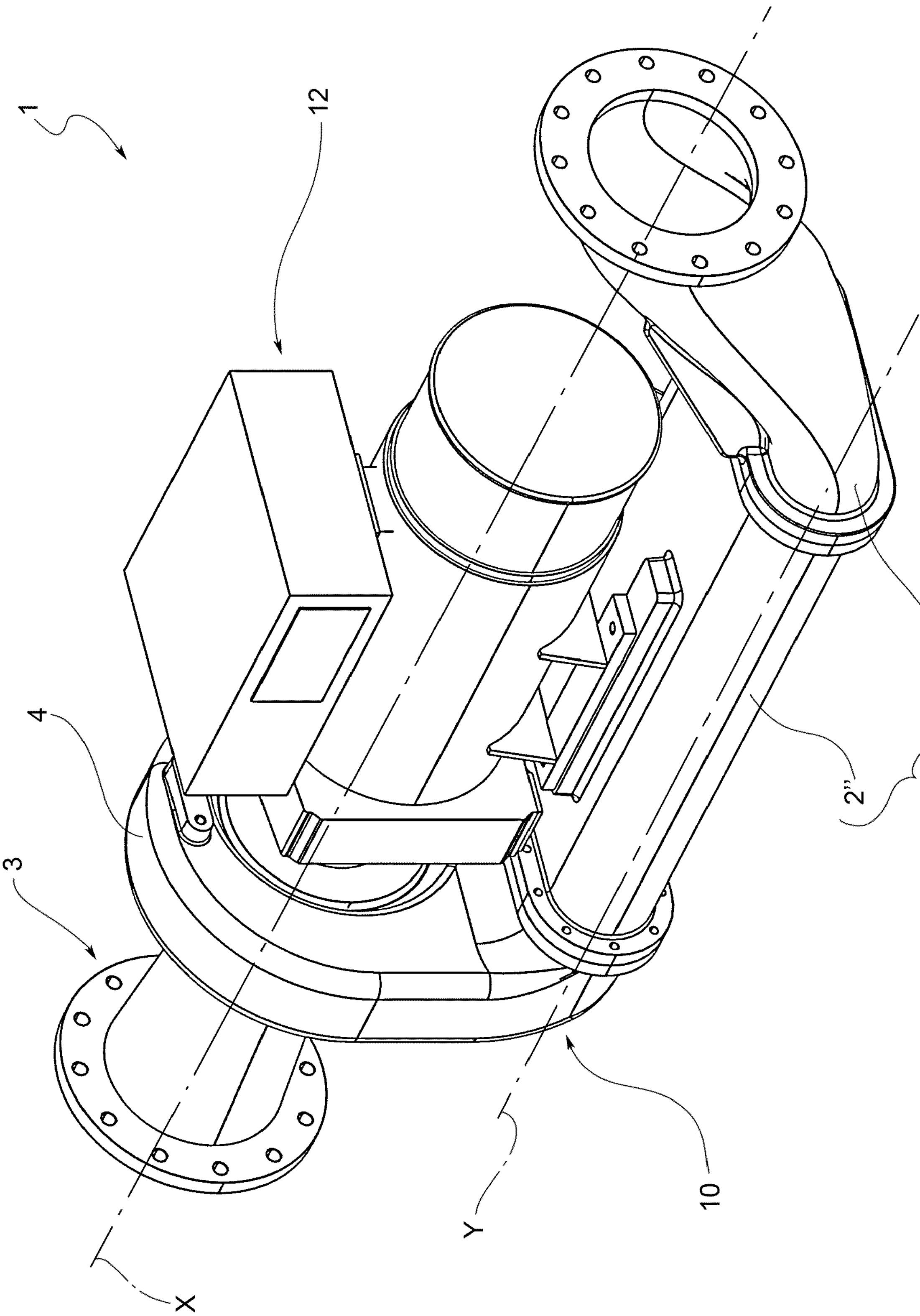


FIG.1

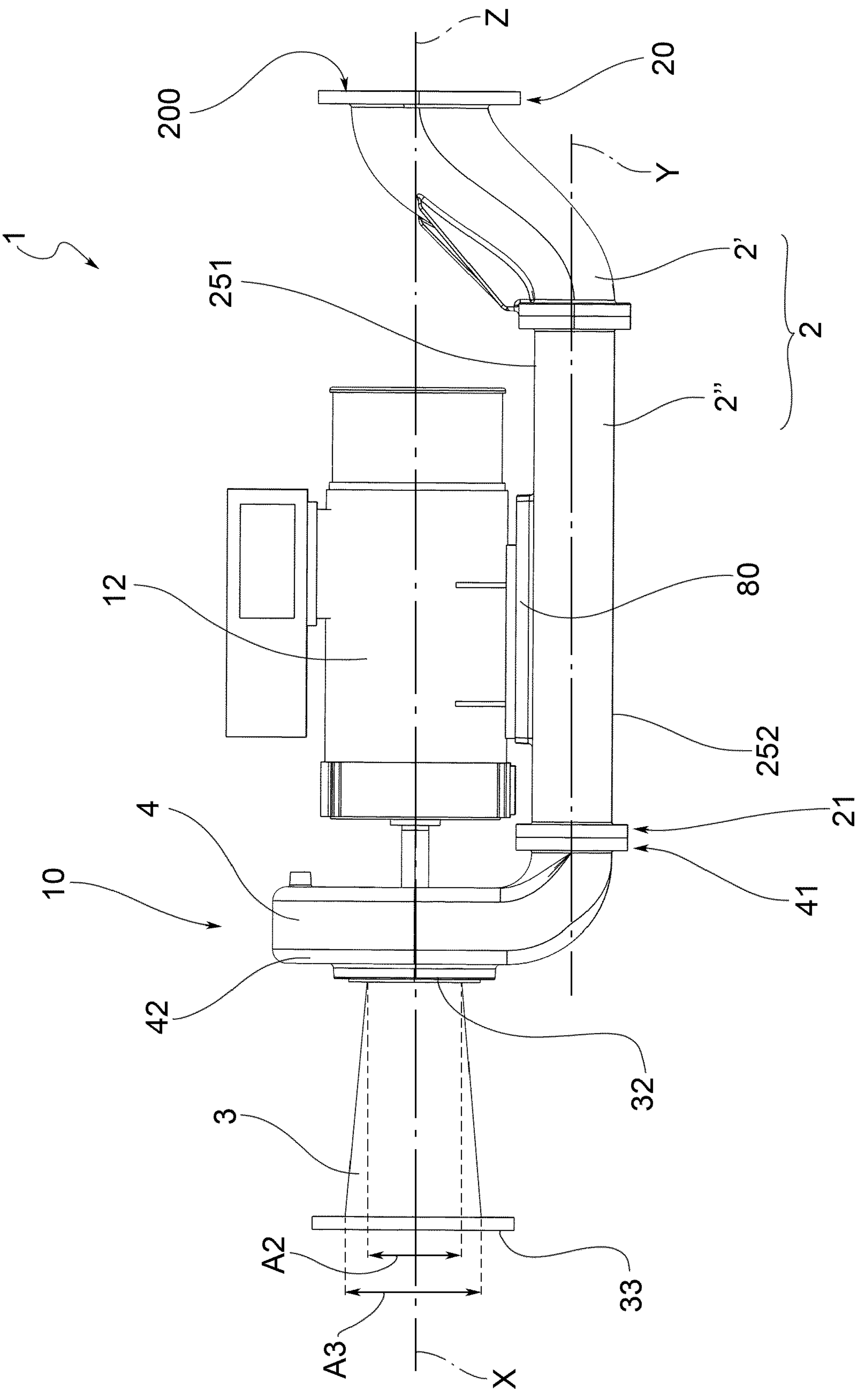


FIG.2

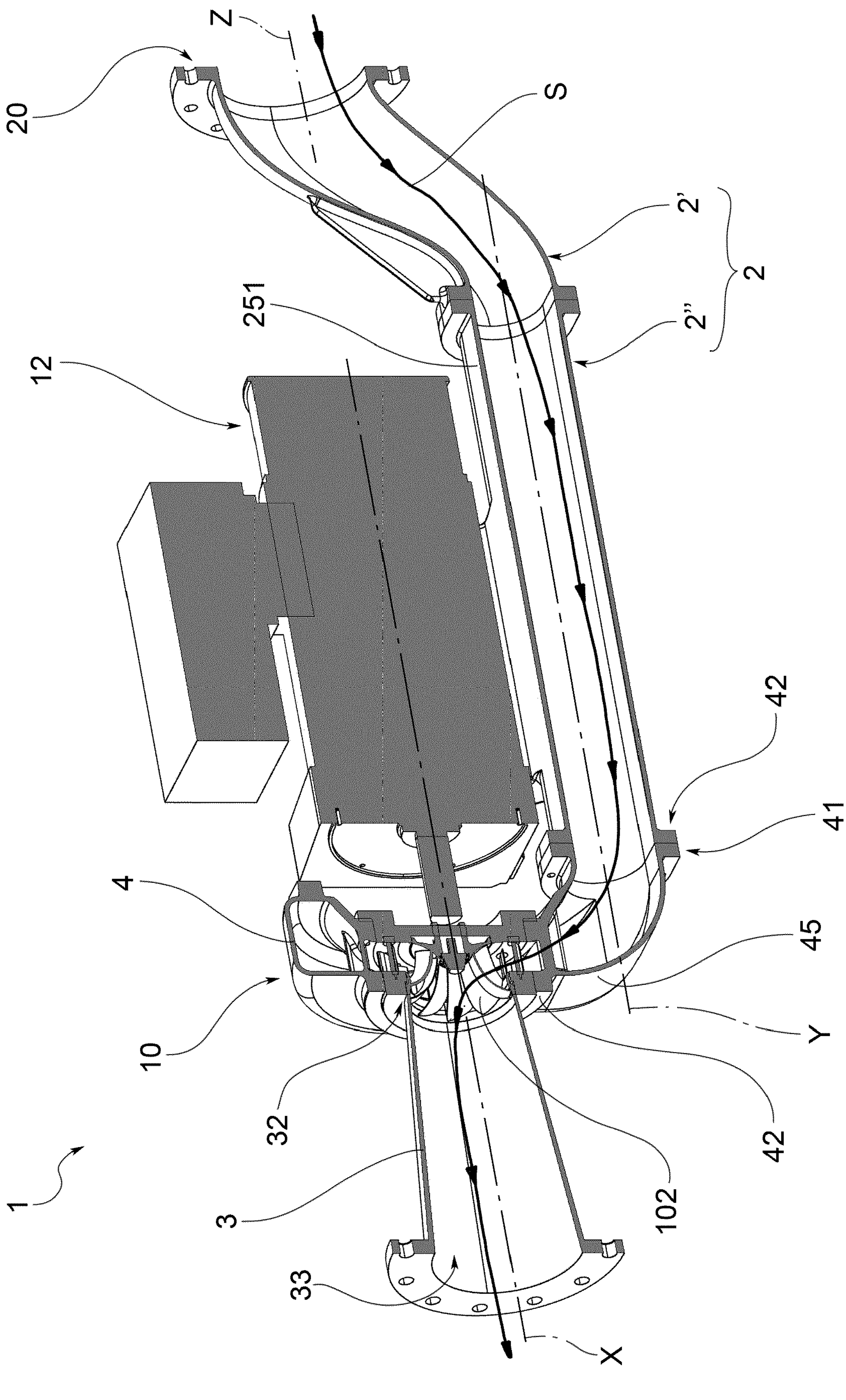


FIG.3

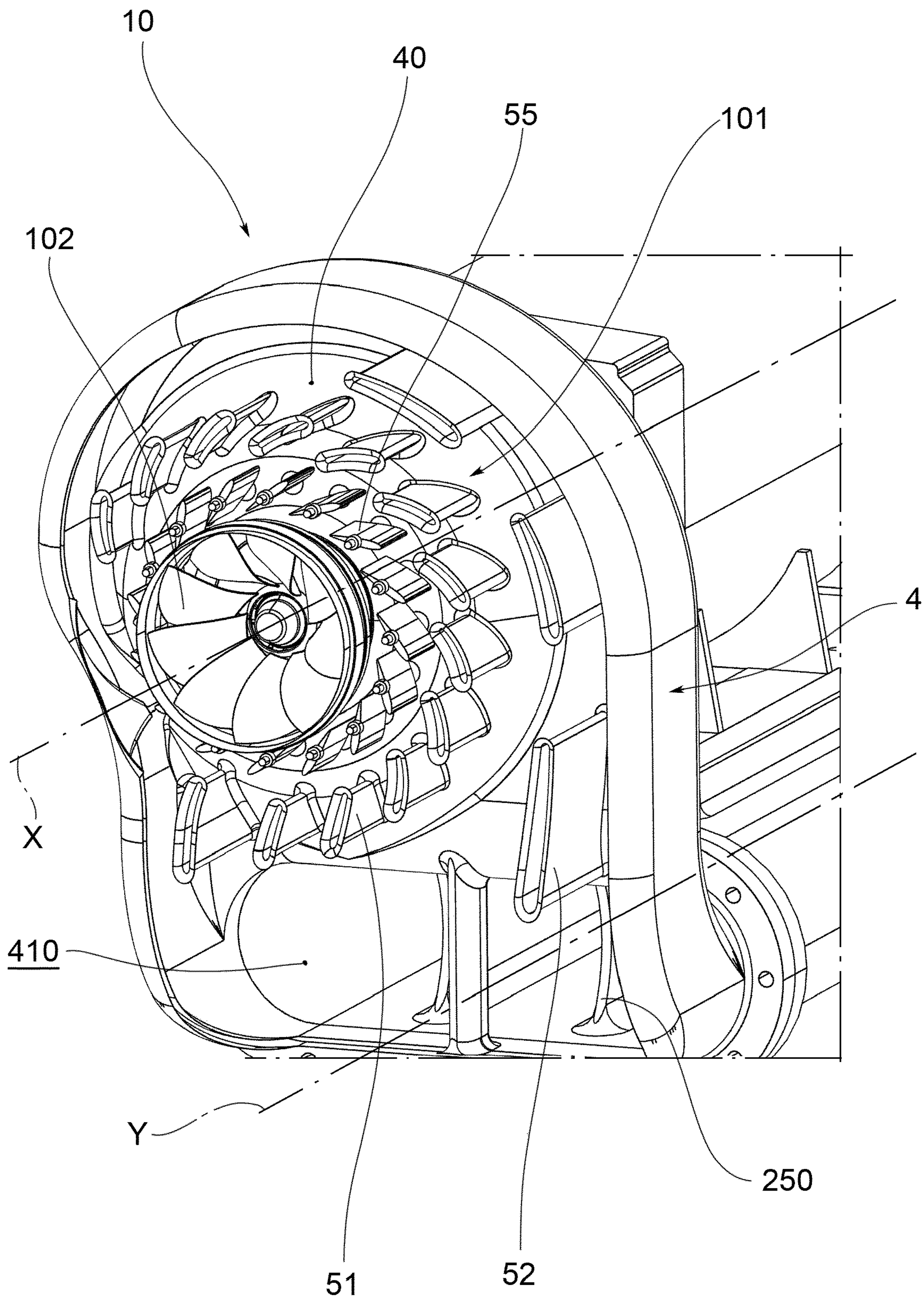


FIG.4

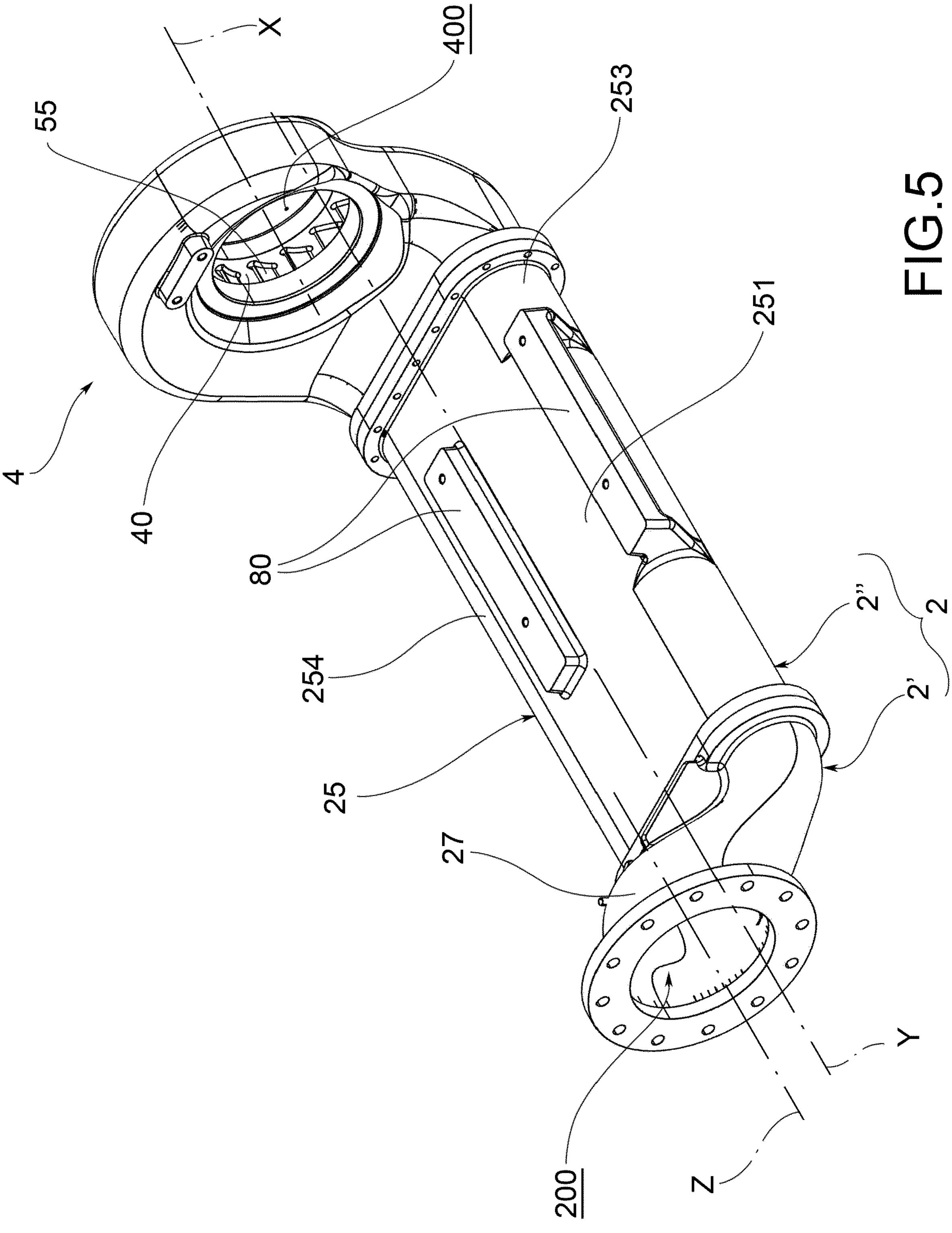


FIG.5

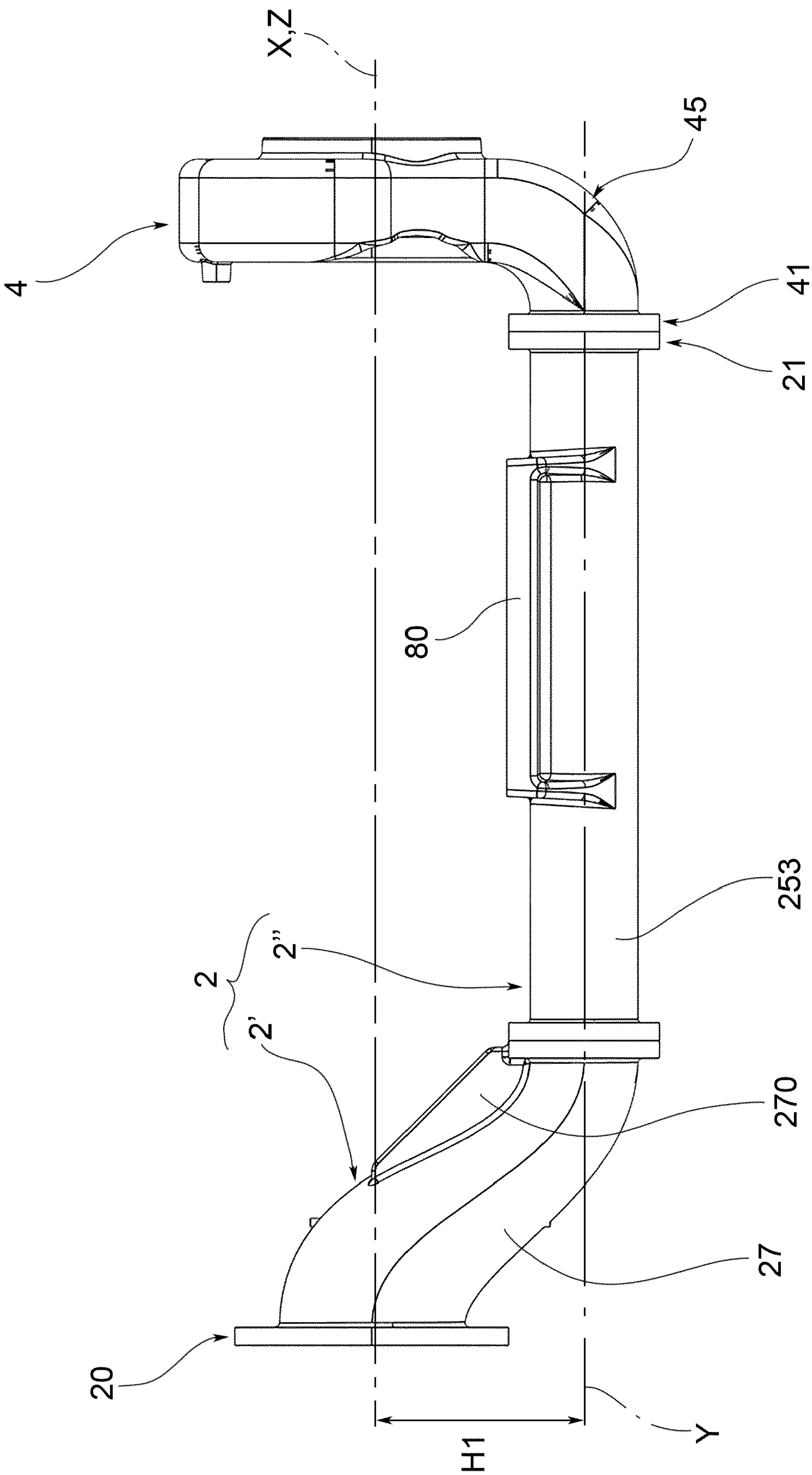


FIG.6

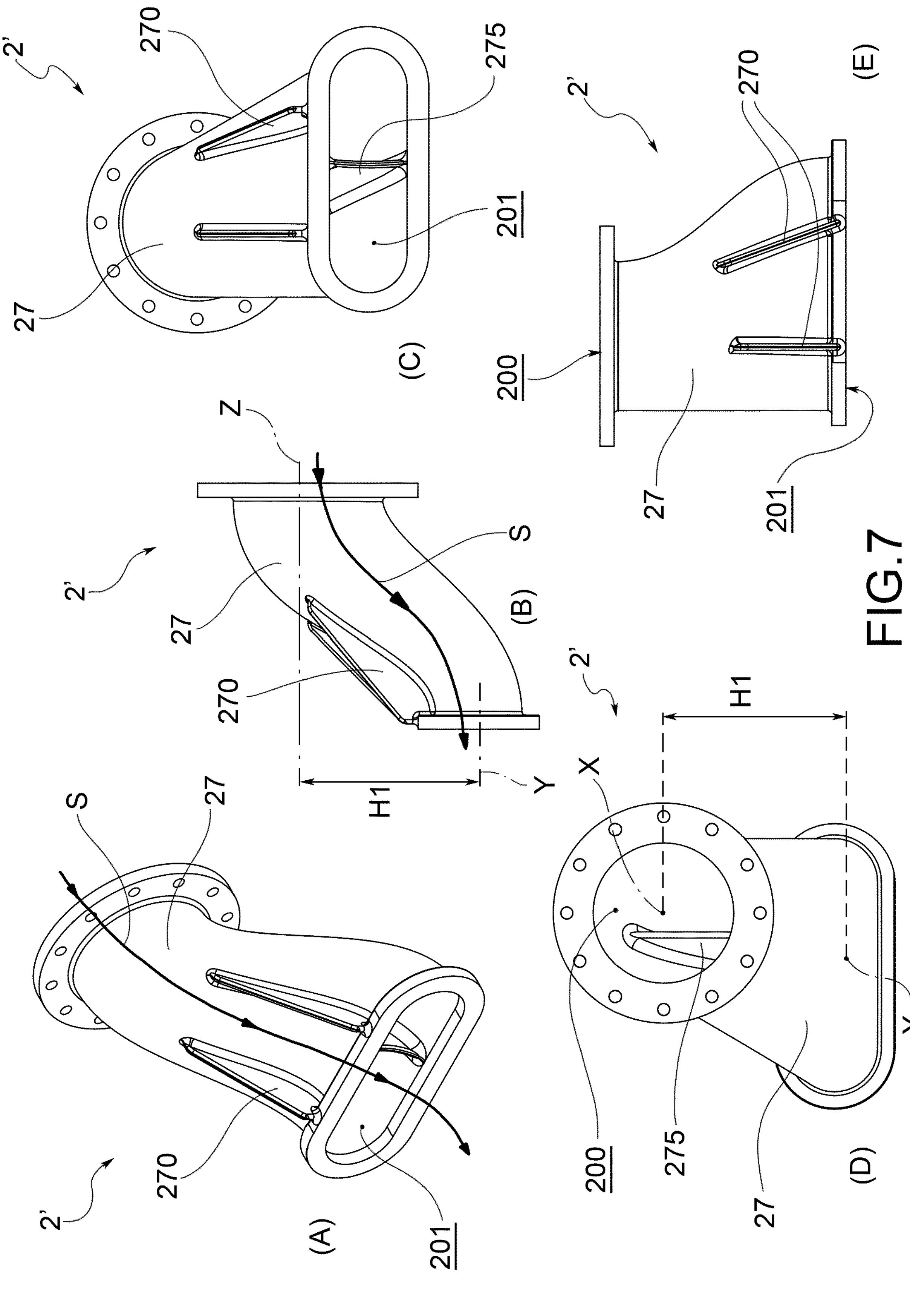


FIG.7

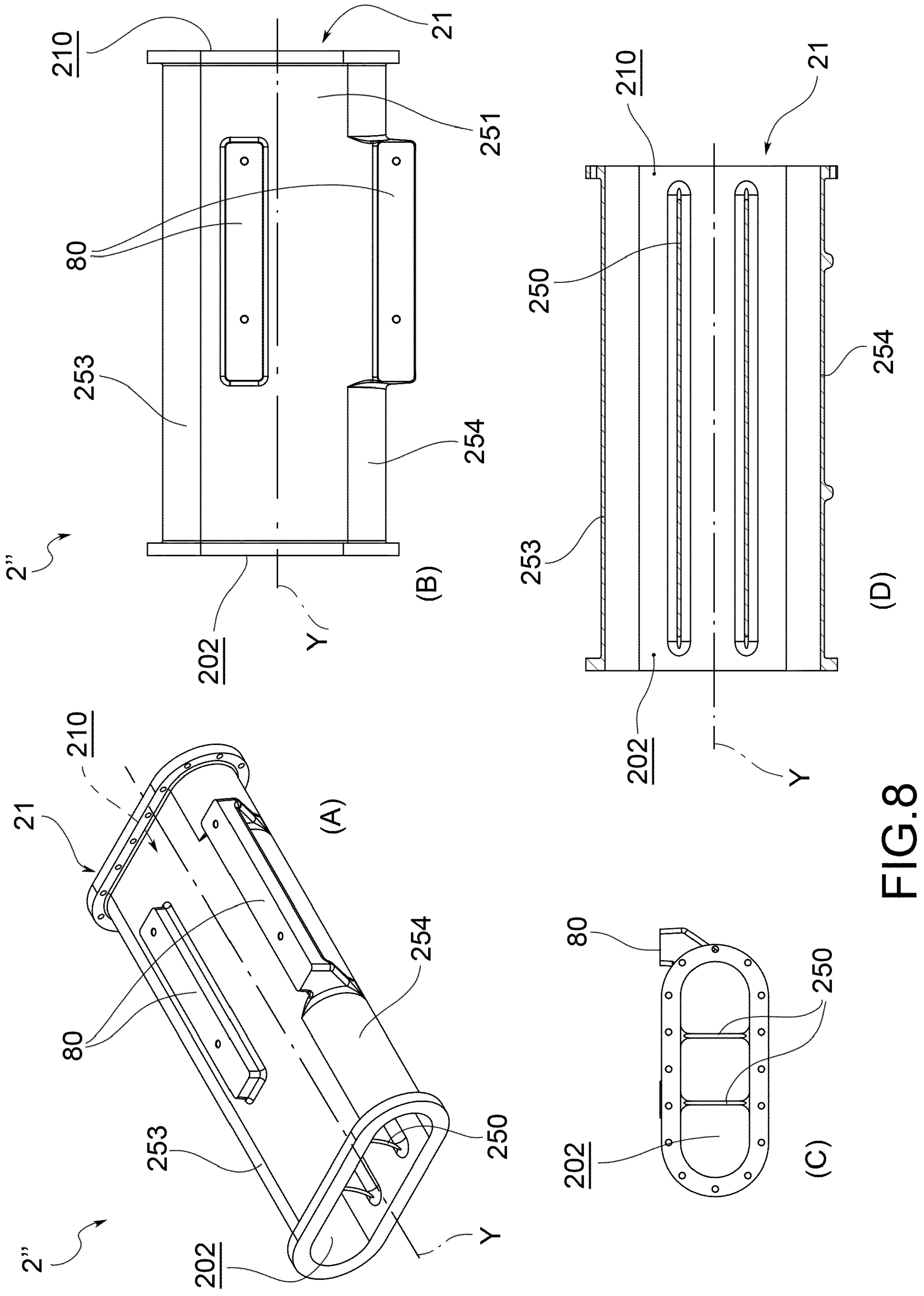


FIG.8

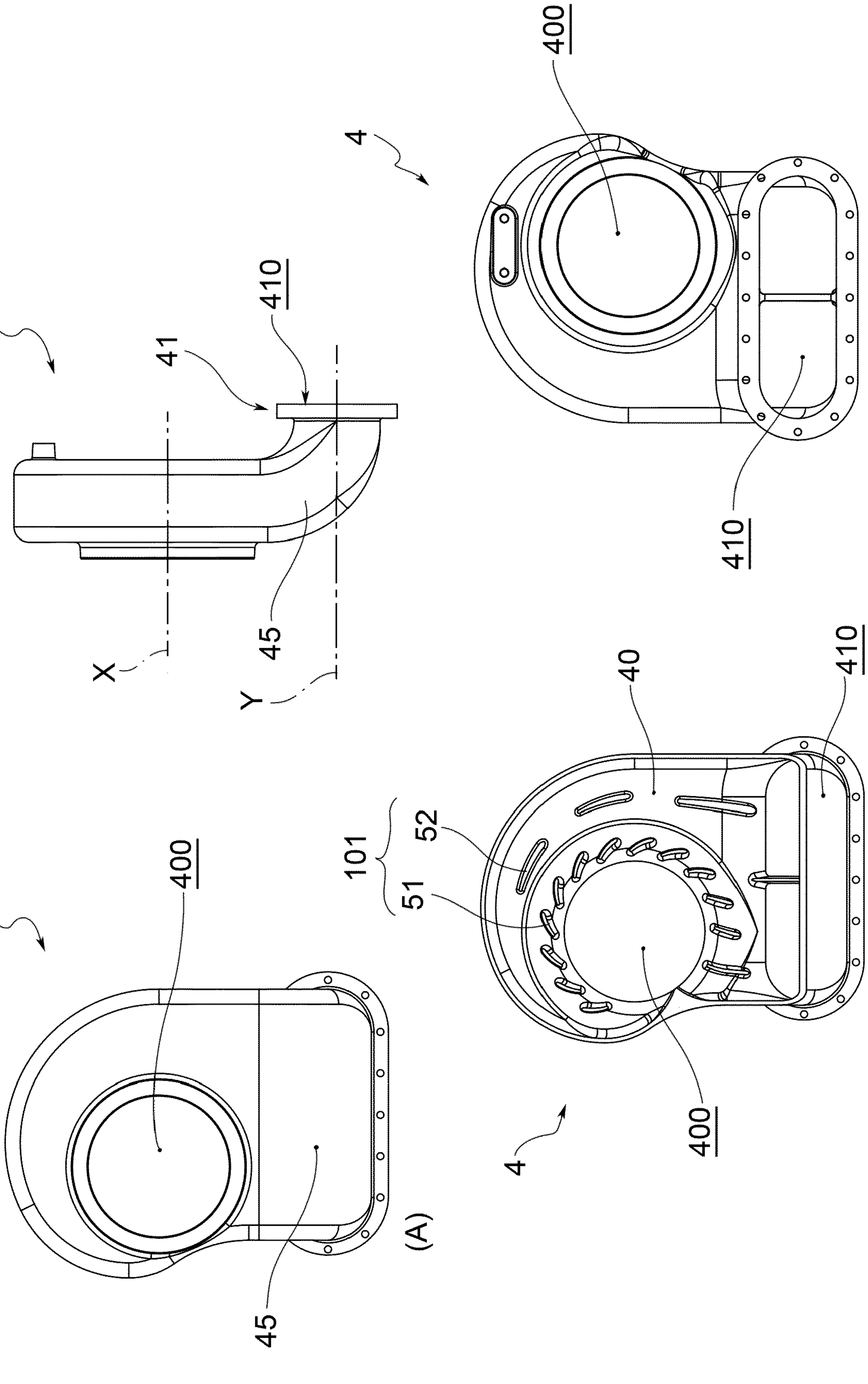


FIG.9

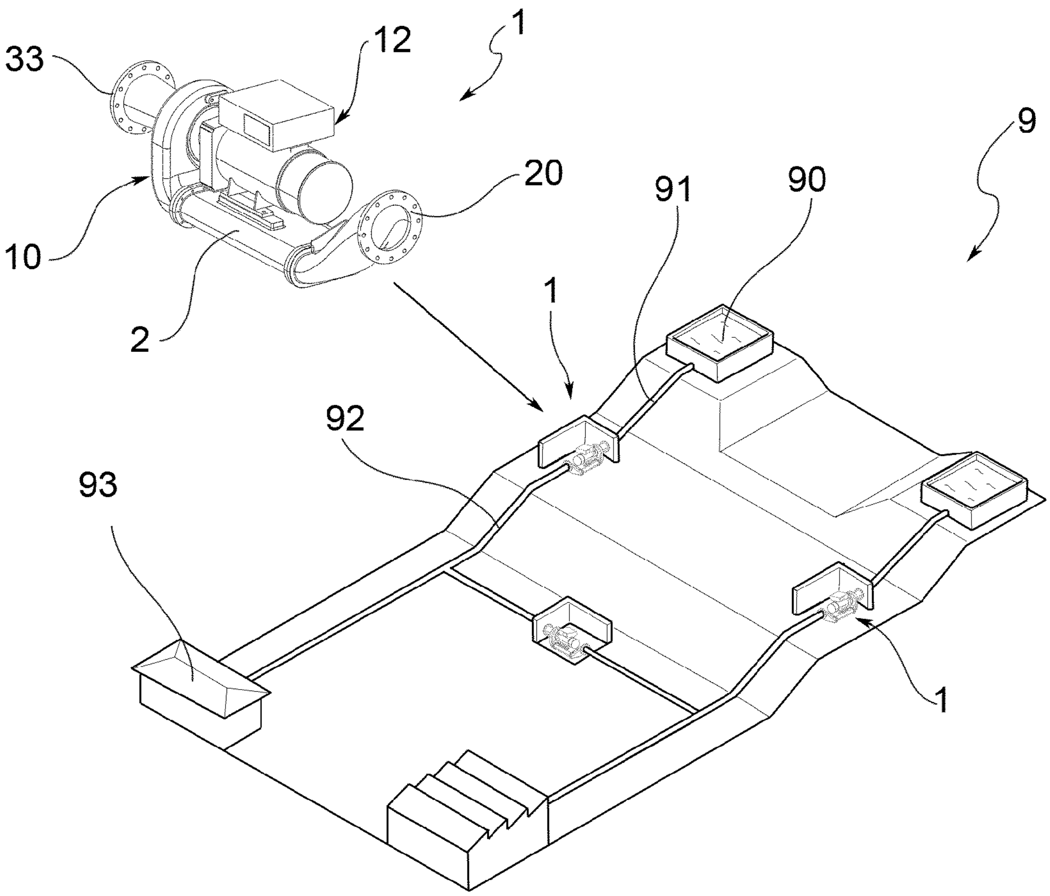


FIG.10a

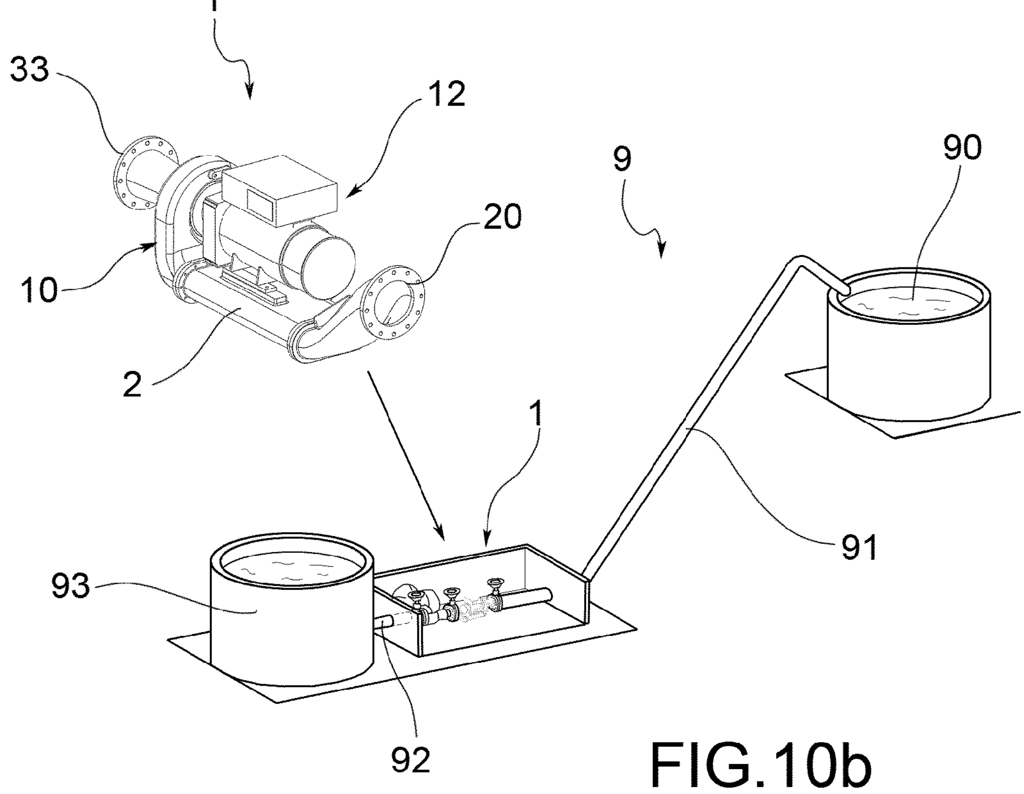


FIG.10b

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Application Number
EP 24 16 6703

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F03B

The present search report has been drawn up for all claims

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| Place of search | Date of completion of the search | Examiner |
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| Munich | 22 August 2024 | Lux, Ralph |

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