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(54) A SNOW MAKING DEVICE AND A SYSTEM AND METHOD FOR PRODUCING ARTIFICIAL SNOW

(57) A snow making device comprising: a main channel (102) which is arranged to receive and to guide water, and which has a first portion (104), a second portion (106) downstream of the first portion (104), and a third portion (208) downstream of the second portion (106), wherein the second portion (106) presents a constriction (112) with a reduced cross-section compared to the first portion (104) and the third portion (208) for creating a reduced water pressure at the constriction (112); at least one diversion channel (122) which has an inlet (120) connected to the main channel (102) at the constriction (112) of the second portion (106) and is arranged to divert part of the water from the main channel (102) as a diverted water flow of reduced pressure; and at least one ice nucleator nozzle (150) which is arranged to create ice nuclei from said diverted water flow and compressed air.

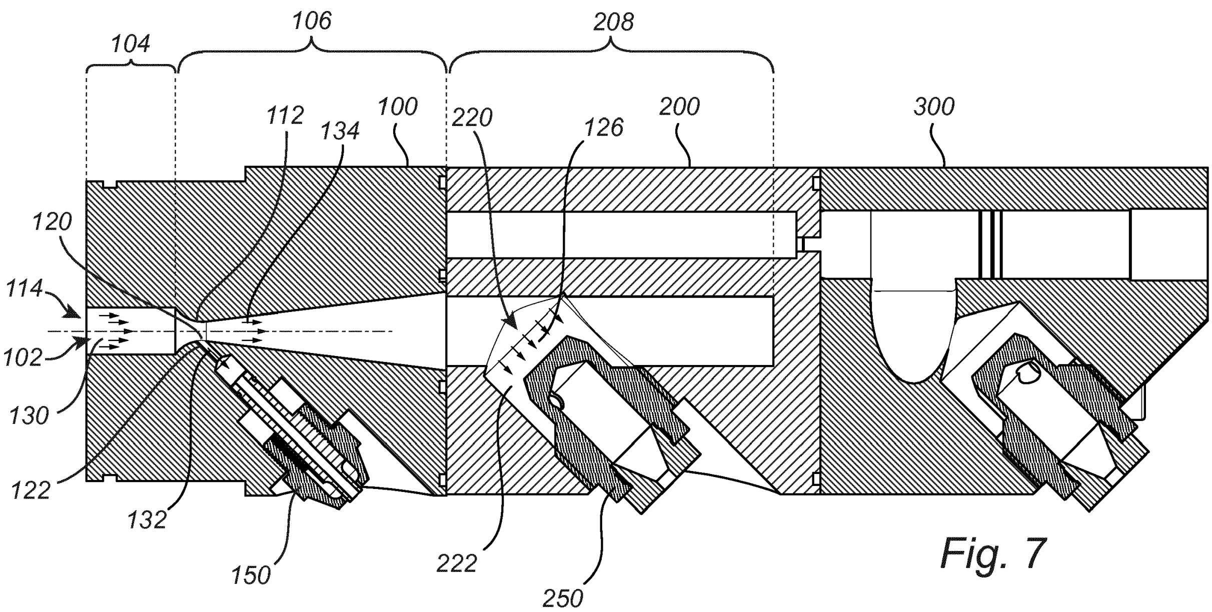

Fig. 7

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Description

Technical field

[0001] The present invention relates to a snow making device, a method for producing artificial snow, and a system for producing artificial snow. The present invention especially relates to a snow lance head and a snow lance incorporating such head.

Background

[0002] The production of artificial snow is well known. Snow guns and snow lances are used to make snow for several different purposes, in particular for winter sport venues. A snow lance comprises a relatively long vertical or somewhat inclined main tube which delivers water and compressed air to a snow lance head, which is arranged at the upper end of the main tube and may be situated several meters above the ground. The snow lance head comprises at least one ice nucleator nozzle and at least one water nozzle. The ice nucleator nozzle mixes water with compressed air and forcibly expels the mixture into the freezing atmosphere. The compressed air may then expand and cool, thereby creating an ice nuclei jet. Simultaneously, the water nozzle is spraying water droplets into the path of the ice nuclei jet so that the ice nuclei may act as seeds for the crystallization of the water droplets, whereupon snow flakes are formed.

[0003] There are several issues whith prior art snow lances:

- Manufacturing cost and time may be unnessesarily high as some parts require fine precision drilling.
- There may be issues with the reliability of the snow lances during operation due to ice nucleator nozzle malfunction.
- Maintenance cost and time may be unnecessarily high as a consequence of the ice nucleator nozzle malfunctioning.

Summary of invention

[0004] In the light of the above, it is an objective of the present inventive concept to provide a snow making device, a method for producing artificial snow, and a system for producing artificial snow, wherein advantages may be obtained with respect to reduced manufacturing cost and time, improved reliability, and reduced maintenance cost and time. Additionally, advantages may be obtained with respect to creating an inexpensive and reliable control mechanism for the water nozzles.

[0005] The inventors have realized that there are several challenges to be overcome when designing a snow lance head in order to achieve said advantages.

[0006] One challenge is that water nozzles and ice nucleator nozzles operate best at different water pressures. A water nozzle preferably operates at a relatively high volumetric flow rate and, therefore, needs a relatively high water pressure. A ice nucleator nozzle, on the other hand, preferably operates at a relatively low volumetric flow rate and, therefore, it is advantageous to use a relatively lower water pressure for operating an ice nucleator nozzle compared to a water pressure at a water nozzle. If the ice nucleator nozzle is connected to the same water pressure as the water nozzle, the outlet hole of the ice nucleator nozzle must be made very small in order to have a low volumetric flow rate. This increases the manufacturing cost and time due to the high precision required to drill a small hole. Furthermore, a small outlet hole makes the ice nucleator nozzle prone to clogging during operation.

[0007] Another challenge is that the water used often contains particles which can clog the ice nucleator nozzle. The particles can come from the natural water source from which the water is collected or from dirt entering the water supply system when hoses etc are changed during maintenance. To avoid particles reaching the ice nucleator nozzle extra care may need to be taken during maintenance. Furthermore, prior art snow lances generally include a filter element, typically in the form of a mesh, which in itself requires additional maintenance as it needs to be cleaned or changed from time to time.

[0008] Another challenge is that if several ice nuclei and water nozzles are used then each ice nucleator nozzle can only sustain a certain number of water nozzles depending on temperature of the atmosphere. The colder temperature the more water nozzles may be turned on, while allowing the water output by the water nozzles to fully be converted into snow. For this reason there is a need to to create a control mechanism which can open and close one or more of the water nozzles which may be situated several meters above ground. Electrical control mechanisms may be used but these are often expensive to install as this requires electrical cables to each snow lance. Also, as the snow lances operate in cold temperatures, there is a risk that valves controlled by electrical control mechanisms freeze and therefore stop being operational.

[0009] Said challenges, as realized by the inventors, are at least partly addressed in the following aspects of the inventive concept:

[0010] According to a first aspect of the inventive concept, there is provided a snow making device, comprising:

a main channel which is arranged to receive and to guide water, and which has a first portion, a second portion downstream of the first portion, and a third portion downstream of the second portion, wherein the second portion presents a constriction with a reduced cross-section compared to the first portion and the third portion for creating a reduced water pressure at the constriction;

at least one diversion channel which has an inlet connected to the main channel at the constriction of the second portion and is arranged to divert part of the water from the main channel as a diverted water flow of reduced pressure; and

at least one ice nucleator nozzle which is arranged to create ice nuclei from said diverted water flow and compressed air.

[0011] According to a second aspect of the inventive concept, there is provided a method for producing artificial snow, comprising:

receiving a main water flow having a main pressure in a first portion of a main channel;

guiding said main water flow sequentially through a second portion and a third portion of the main channel, the second portion having a constriction with a reduced cross-section compared to the first portion and the third portion, for creating a reduced water pressure at the constriction;

diverting part of the main water flow at the constriction as a diverted water flow of reduced pressure into an inlet of a diversion channel connected to the main channel at the constriction, wherein the direction of the diverted water flow at the diversion channel inlet forms an angle to the direction of the main water flow at the constriction such that particles in the water are more likely to follow the main water flow than the diverted water flow due to the inertia of said particles, thereby making the diverted water flow at least partly filtered;

guiding the at least partly filtered diverted water flow of reduced pressure to an ice nucleator nozzle to form an ice nuclei jet by combining said filtered water of reduced pressure with compressed air;

guiding a non-diverted part of the main water flow in the third portion of the main channel to a water nozzle for generating a spray of water droplets;

guiding the spray of water droplets into the ice nuclei jet for producing artificial snow.

[0012] According to a third aspect of the inventive concept, there is provided a system for producing artificial snow, comprising:

a water supply;

a compressed air supply; and

at least one snow lance; comprising:

- a vertically inclined tubular body which is configured to be erected from a ground, and which comprises: at least a main water supply channel and a compressed air channel, both channels extending from a ground end to a top end of the tubular body;
- a ground socket which is connected to the tubular body at the ground end thereof and comprises: a water inlet, a ground socket water channel, a compressed air inlet, and a ground socket compressed air channel; and
- a snow lance head which is mounted at the top end of the tubular body and includes at least one device according to the first aspect.

[0013] An advantage of the above aspects of the inventive concept is that the water pressure at the constriction is reduced through the Venturi effect. In the present disclosure, the term water pressure refers to the static pressure of the water. As the water moves from the first portion into the constriction of the second portion the water velocity increases due to the reduced cross-section of the main channel. The increased velocity may give rise to an increased dynamic pressure and thereby a decreased static pressure. The water that is diverted from the main channel into the diversion channel consequently has a low water pressure, defined by the static pressure at the constriction. An ice nucleator nozzle which is connected to the diversion channel therefore does not have to have a very small outlet hole which makes it easier to manufacture. As the non-diverted water in the main channel continues to flow from the second portion into the third portion the water velocity again decreases due to the increased cross-section of the main channel and the water pressure may consequently increase to a level suitable for the water nozzles.

[0014] A second advantage is that the increased water velocity at the constriction may result in an increased velocity of unwanted particles that may be present in the water. By placing the diversion channel at the constriction said particles are more likely to follow the main water flow than the diverted water flow due to their inertia. A faster moving particle may be less likely to change its direction than a slower moving particle. This may give rise to a filtering effect where particles preferentially stay in the main channel and do not enter the diversion channel where they may clog the ice nuclei nozzles. The particles may instead be transported to the water nozzles which may be less susceptible to clogging.

[0015] A third advantage is that since the ice nucleator nozzle can have a larger outlet hole due to the reduced water pressure in the diversion channel the risk of clogging is further reduced.

[0016] A fourth advantage is that thanks to the moving particles not being transported to the ice nuclei nozzles, but rather being able to be output with water through the water nozzles, there may be no need of a particle filter in the device in order to prevent clogging of the nozzles. Thus, as no particle filter may be needed, less maintenance of the device may be needed, as there may be no need to replace the particle filter from time to time.

[0017] According to an embodiment, the device is a snow lance head. Thus, the device may be configured to be installed at a top end of a snow lance body in order to provide a well-controlled ice nuclei jet and spray of water droplets for producing artificial snow.

[0018] According to an embodiment, the main channel extends from the first portion to the third portion along a straight line. This implies that water flow will not be diverted in the main channel such that turbulence may be avoided in the water flow.

[0019] However, it should be realized that, e.g. depending on a design of the snow making device, the main channel may make, preferably wide, turn(s) between the first portion and the second portion.

[0020] According to an embodiment, the water in the main channel presents a main flow direction at the constriction of the second portion, and wherein the at least one diversion channel is so connected to the constriction of the main channel that the direction of the diverted flow at the at least one diversion channel inlet forms an angle to the main flow direction at the constriction of the second portion. This implies that the water flow will change direction from the main channel in order to enter the diversion channel. Hence, a filtering effect of preventing particles to enter the diversion channel may be accentuated, because particles having a larger moment of inertia than water will tend to proceed along the main water flow in the main channel rather than being diverted towards the diversion channel.

[0021] According to an embodiment, said angle is at least 30°. This implies that water flow is diverted into the diversion channel while making a relatively small change of direction. Thus, there may be a low risk of turbulence being created in the diversion of the water flow into the diversion channel.

[0022] According to another embodiment, said angle is at least 90°. This implies that water flow makes a relatively large change of direction in being diverted into the diversion channel. Thus, a risk of particles entering the diversion channel is very low.

[0023] According to an embodiment, the device may further comprise at least one output channel which has an inlet connected to the main channel at the third portion; and at least one water nozzle which is connected to said at least one output channel, and is arranged to create water droplets which when combined with said ice nuclei may freeze to form artificial snow. Thus, the main water flow through the main channel may be connected to an output for providing a spray of water droplets for the forming of artificial snow.

[0024] According to an embodiment, the constriction has a cross-section area which is less than a quarter of the cross section of the main channel in the third portion at the output channel inlet. This implies that a desired relation between the water pressure provided to the diversion channels and to the output of water through water nozzles may be provided.

[0025] A water nozzle may be controlled or replaced in order to change an area through which water is output by the water nozzle. Varying the area may control a water pressure in the constriction, which may be useful for controlling the water pressure in the diversion channel for providing a suitable water pressure in ice nuclei generation.

[0026] According to an embodiment of the system, said water supply is arranged to deliver water to the ground socket water inlet, said ground socket is arranged to guide said water from the ground socket water inlet through the ground socket water channel into the water supply channel of the tubular body at the ground end thereof, and said water supply channel is arranged to guide the water to the first portion of the main channel of the snow lance head as a main water flow. Thus, water supply may be provided to the ground socket enabling connecting the system to water supply at a ground level, which facilitates installation of the system. Further, the water may be guided through the water supply channels of the ground socket and the tubular body for reaching the snow lance head.

[0027] According to an embodiment, said compressed air supply is arranged to deliver compressed air to the ground socket compressed air inlet, said ground socket is arranged to guide said compressed air from the ground socket compressed air inlet through the ground socket compressed air channel into the compressed air channel of the tubular body at the ground end thereof, and said compressed air channel is arranged to guide the compressed air to a compressed air inlet of the snow lance head. Thus, compressed air supply may be provided to the ground socket enabling connecting the system to compressed air supply at a ground level, which facilitates installation of the system. Further, the compressed air may be guided through the compressed air channels of the ground socket and the tubular body for reaching the snow lance head.

[0028] According to an embodiment, said snow lance head is arranged to

- guide said main water flow, taken from the water supply channel of the tubular body, sequentially through the second portion and the third portion of the main channel;
- divert part of the main water flow at the constriction as a diverted water flow of reduced pressure into the diversion channel, wherein the direction of the diverted water flow at the diversion channel inlet forms an angle to the direction of the main water flow at the constriction such that particles in the water are more likely to follow the main water flow than the diverted water flow due to the inertia of said particles, thereby making the diverted water flow at least partly filtered;
- guide the at least partly filtered diverted water flow of reduced pressure to the ice nucleator nozzle to form an ice nuclei jet by combining said filtered water of reduced pressure with compressed air from the compressed air channel of the tubular body;
- guide the non-diverted part of the main water flow in the third portion of the main channel to a water nozzle for generating a spray of water droplets;
- guide the spray of water droplets into the ice nuclei jet for producing artificial snow.

[0029] Thus, the snow lance head of the system may be configured to control water flow so as to provide filtered water of reduced pressure to an ice nucleator nozzle for generating the ice nuclei jet and provide water flow to a water nozzle for generating a spray of water droplets that combined with the ice nuclei jet may produce artificial snow.

[0030] According to an embodiment, the pressure of the water supply and the cross-sections of said second and third portions of the main channel are configured to provide a water pressure between 10 and 100 bar in said third portion of the main channel and a water pressure between 1 and 10 bar in said diversion channel when the system is in use.

[0031] This implies that a relatively low water pressure may be provided to the ice nucleator nozzle which may facilitate forming of ice nuclei. Further, a relatively high water pressure may be provided to the water nozzle for forming droplets that may combine with the ice nuclei to form artificial snow.

[0032] According to an embodiment, the pressure of the water supply and the cross-sections of said second and third portions of the main channel are configured to provide a volumetric flow rate between 50 and 300 liters per minute per water nozzle in said third portion of the main channel and a volumetric flow rate between 0.05 and 0.5 liters per minute per ice nucleator nozzle in said diversion channel when the system is in use.

[0033] This implies that a relatively low volumetric flow rate is provided to the ice nucleator nozzle which may facilitate forming of ice nuclei. At the same time, a relatively large volumetric flow rate may be provided to the water nozzle for providing a high output of water from the water nozzle such that a large amount of artificial snow may be generated.

[0034] According to a fourth aspect of the inventive concept, there is provided a water controller for a snow lance head, comprising:

a flow valve comprising a valve cavity with a valve cavity inlet and a valve cavity outlet;
a sealing element which is configured to controllably seal the valve cavity inlet and/or valve cavity outlet; wherein the sealing element is movable between a closed position, where the sealing element is arranged to close the valve cavity inlet and/or the valve cavity outlet to prevent water from flowing from the valve cavity inlet to the valve cavity outlet, and an open position, where the sealing element is arranged to allow water to flow from the valve cavity inlet to the valve cavity outlet, wherein the sealing element has a control end facing a control cavity for controlling movement of the sealing element from the open position towards the closed position;
a water supply;
a valve inlet channel which is arranged to receive water from the water supply and to guide the water to the valve cavity inlet;
a control tube which is arranged to extend inside the valve inlet channel to the control cavity, said control tube having a inlet end and an outlet end, the control tube being arranged to provide a water flow to the control cavity for acting on a control end of the sealing element for moving the sealing element from the open position towards the closed position; and
a control valve for selectively activating water flow through the control tube to the control cavity for activating movement of the sealing element from the open position towards the closed position.

[0035] The water controller provides an ability to reliably control output of water from a water nozzle of a snow lance head. The sealing element may be selectively arranged in a closed or open position for selectively closing or opening a valve cavity outlet. The valve cavity outlet may be connected to a channel for outputting water through a water nozzle. Thus, output of water through the water nozzle may be controlled.

[0036] Having a controlled water nozzle may be highly advantageous in that it may allow controlling a volumetric flow rate of water being output by the snow lance head such that the snow lance head may be adapted to a temperature of the atmosphere. For instance, if a low temperature prevails, snow generation may proceed at a higher speed such that a higher volumetric flow rate of water from the snow lance head may be sustained.

[0037] The water controller allows the control of a valve remotely. Thus, the control valve may be accessed at a ground level, which may facilitate operating the control valve. The control valve may be set for manual or automatic control.

[0038] Thanks to the control tube being arranged to extend inside the valve inlet channel, the control tube may be immersed in water. This implies that there is low or no risk freezing of the control tube such that functionality of the water controller may be affected.

[0039] The water controller may control the sealing element between a closed and an open position in order to turn water flow on or off. However, it should be realized that the water controller may also control a position of the sealing element between a fully closed and a fully open position, for regulating output of water through the water controller.

[0040] It should be realized that the water controller of the fourth aspect may be combined with the snow making device, the method and/or the system of the first, second, and third aspects for combining a controlled output of water from a water nozzle with the control of water flow to an ice nucleator nozzle, while enabling water flow also to a water nozzle. However, the water controller of the fourth aspect may be separately installed and need not necessarily be combined with the concepts of the first, second and third aspects.

[0041] According to an embodiment, the sealing element may comprise a plunger. The plunger may provide a simple movement between an open and a closed position, which may imply that a simple set-up of the water controller may be provided.

[0042] According to an embodiment, the water controller further comprises a plunger seat arranged at the valve cavity inlet. Thus, the plunger may be configured to engage with the plunger seat for turning water flow off.

[0043] According to an embodiment, the water controller may further comprise a resilient element, which is arranged in the control cavity and is arranged to apply a force on the plunger in the direction from the control end to a sealing end of the plunger. The resilient element may aid in moving the plunger towards the closed position, which may imply that a lower water pressure may be needed to be provided in the control cavity for moving the plunger towards the closed position.

[0044] According to an embodiment, the control tube may be arranged to extend through the plunger. This implies that the control tube may be arranged within the valve inlet channel extending to the plunger and may then pass through the plunger for providing a connection through the control tube to the control cavity.

[0045] According to an embodiment, the control valve may be a pressure valve comprising a water supply port, a control tube port and a pressure relief port. The control valve may be controlled such that the water supply port may be selectively connected to the water supply, the control tube port may be connected to the control tube inlet, and the pressure relief port may be selectively connected to an outlet of lower pressure than the water supply. Thus, by arranging the control valve in a desired position, the control tube inlet could selectively be connected to the water supply for providing water flow to the control cavity or to an outlet of lower pressure for relieving water from the control cavity.

Brief description of the drawings

[0046] The above, as well as additional objects, features and advantages of the present inventive concept, will be better understood through the following illustrative and non-limiting detailed description, with reference to the appended drawings. In the drawings like reference numerals will be used for like elements unless stated otherwise.

Figure 1 is an exploded view of a snow lance comprising a snow making device according to an embodiment.

Figures 2-3 are schematic views illustrating operation of the snow lance.

Figure 4 is a detailed exploded view of a snow lance head.

Figure 5 is a side view of the snow lance head.

Figure 6 is a bottom view of the snow lance head.

Figure 7 is a cross-sectional view of the snow lance head taken along the cross-sectional plane shown in Figures 5 and 6.

Figure 8 and 9 are perspective views of an ice nucleator nozzle.

Figure 10 is a cross-sectional view of the ice nucleator nozzle.

Figure 11 is a cross-sectional view of an ice nucleator nozzle mounted in the snow lance head.

Figure 12 is a cross-sectional view of a water nozzle mounted in the snow lance head.

Figure 13 is a side view of the snow lance head.

Figure 14 is a bottom view of the snow lance head.

Figure 15 is a cross-sectional view of the snow lance head taken along the cross-sectional plane shown in Figures 13 and 14.

Figure 16 is a cross-sectional view of a water controller showing a closed position of a valve.

Figure 17 is a cross-sectional view of a water controller showing an open position of a valve.

Figure 18 is a side view of a ground socket.

Figures 19-20 are cross-sectional views of the ground socket showing a control valve in an apply pressure position for providing water flow to a control cavity for closing a flow valve of the water controller.

Figures 21-22 are cross-sectional views of the ground socket showing a control valve in a relieve pressure position for relieving water from the control cavity.

Detailed description

[0047] The present invention will now be described more fully with reference to the accompaning drawings, which show an embodiment of the invention. The invention may, however, be embodied in many different forms and should not be construed as limited to the the disclosed embodiment, which is rather provided for thoroughness and completeness, and for fully conveying the scope of the invention to the skilled person.

[0048] Figure 1 illustrates an embodiment of a snow lance 500 which comprises a snow lance head 400, a tubular body 30 and a ground socket 10, all preferably made of material which can withstand freezing temperatures and does not corrode when in contact with water, such as e.g. stainless steel or aluminum. In an embodiment, the snow lance head 400 comprises an ice nucleator nozzle segment 100, a water nozzle segment 200, and a controlled water nozzle segment 300.

[0049] Two ice nucleator nozzles 150 are connected to the ice nucleator nozzle segment 100. In other embodiments the number of ice nucleator nozzles 150 may be one only or more than two. Two water nozzles 250 are connected to the the water nozzle segment 200. In other embodiments the number of water nozzles 250 may be one only or more than two. Two controlled water nozzles 350 are connected to the the controlled water nozzle segment 300. In other embodiments the number of controlled water nozzles 350 may be one only or more than two.

[0050] In a more simple embodiment, the controlled water nozzle segment 300 may be completely absent.

The controlled water nozzle segment 300 may be used for controlling a volumetric flow rate of water being output for controlling an amount of snow that is produced. However, in a simple embodiment, such control may not be necessary.

[0051] The controlled water nozzles 350 connected to the controlled water nozzle segment 300 may or may not be identical to the the water nozzles 250. In the illustrated embodiment the parts 10, 30, 100, 200, 300 all lie along a common axis. However, the invention may also be embodied in other ways. For example, the snow lance head 400 may be mounted along an axis inclined in relation to the axis of the tubular body 30.

[0052] Water supply may be provided to the ground socket 10. Water flow may be provided through the hollow, tubular body 30 and may be guided into channel(s) in the snow lance head 400 through inlet(s) further described below.

[0053] Compressed air supply may also be provided to the ground socket 10. The air may be guided through a tube 32 extending through the tubular body 30 for connecting the air flow to a compressed air inlet of the snow lance head 400.

[0054] In the present disclosure, the terms "top" and "bottom" will be used such that "top" refers to a point of the snow lance 500 which is in the direction of the controlled water nozzle segment 300, and "bottom" refers to a point in the direction of the ground socket 10.

[0055] Figure 2 and 3 show the operation of a snow lance 500. In an embodiment, the snow lance 500 is erected form a ground 98 at an inclined angle so that the produced snow 96 falls some distance away from the ground socket 10. The snow is produced by the snow lance 500 from water taken from a water supply 92 and compressed air taken from a compressed air supply 93. Figure 2 shows the snow lance 500 with the controlled water nozzle segment 300 turned off, while Figure 3 shows the snow lance 500 with the controlled water nozzle segment 300 turned on.

[0056] In an embodiment of the snow lance 500 in operation as illustrated in Figures 2 and 3, each ice nucleator nozzle 150 is constantly producing an ice nuclei jet 158, comprising ice nuclei, and each water nozzle 250 is constantly producing a water spray 258, comprising water droplets. Each water spray 258 overlaps with at least one ice nuclei jet 158 so that the ice nuclei may act as seeds for the crystallization of the water droplets, whereupon snow flakes 96 may be formed.

[0057] Furthermore, in an embodiment of the snow lance 500 in operation, the controlled water nozzle segment 300 may be turned on if needed, so that each controlled water nozzle 350 of the controlled water nozzle segment 300 is producing a water spray 358, comprising water droplets. Each of said water sprays 358 overlaps with an ice nucli jet 158 so that more snow may be formed when both water sprays 358 and water sprays 258 are operating as compared to when only water sprays 258 are operating. When the controlled water noozle segment 300 is turned off, the water spray 358 is absent and less snow is produced.

[0058] Figure 4 shows a detailed view of the snow lance head 400 illustrating that in an embodiment the ice nucleator nozzle segment 100, the water nozzle segment 200 and the controlled water nozzle segment 300 are separate parts which can be assembled into one unit by one or more screws 410. This is facilitated by clearance holes 370 in the controlled water nozzle segment 300, clearance holes 270 in the water nozzle segment 200 and threaded blind holes 170 in the ice nucleator nozzle segment 100.

[0059] The seal between the different parts of the snow lance head 500 may be made water tight by the use of two O-rings 180 between the ice nucleator nozzle segment 100 and the water nozzle segment 200 and one O-ring 280 between the water nozzle segment 200 and the controlled water nozzle segment 300.

[0060] As further illustrated in Figure 4, the ice nucleator nozzles 150 may in an embodiment be formed as separate parts which can be screwed into threaded seats 190 in the ice nucleator nozzle segment 100. In a similar manner, the water nozzles 250 may be separate parts which can be screwed into threaded seats 290 in the water nozzle segment 200; and the controlled water nozzles 350 may be separate parts which can be screwed into threaded seats 390 in the controlled water nozzle segment 300.

[0061] By making the snow lance head 400 in several separate parts, the manufacturing process is made simple as all internal channels, which may be constricting and expanding as well as branching, can be made by e.g. drilling, milling or reaming. A multi-part design also makes maintenance easier as the different parts may be disassembled and cleaned or replaced individually. However, the snow lance head 400 may of course also be made in fewer parts or even as a single part by some more advance manufacturing process such as e.g. 3D printing.

[0062] Figures 5 to 7 show a detailed view of an embodiment of the snow lance head 400. Figure 5 is a side view of the snow lance head 400. Figure 6 is a bottom view of the snow lance head 400. Figure 7 is a cross-sectional view of the snow lance head 400 where the cross-sectional plane 50 is shown in Figure 5 and 6. It should be noted that the cross-sectional plane 50 is broken such that the cross-section of the ice nucelator nozzle segment 100 is not in the same plane as the cross-secions of the water nozzle segment 200 and the controlled water nozzle segment 300. This implies that a cross-section of the ice nucleator nozzle 150 may be seen in the same view as a cross-section of the water nozzles 250 and 350.

[0063] Figure 6 illustrates a main channel water inlet 114, a secondary channel water inlet 116, and a compressed air inlet 118. The snow lance head 400 takes water for the ice nucleator nozzles 150 and the water nozzles 250 from the main channel water inlet 114, water for the controlled water nozzles 350 from the secondary channel water inlet 116, and compressed air for the ice nucleator nozzles 150 from the compressed air inlet 118.

[0064] Figure 7 illustrates how some of the internal channels of the snow lance head 400 are connected to the main channel water inlet 114. A main channel 102 extends from the main channel water inlet 114 through the ice nucleator nozzle segment 100 into the water nozzle segment 200. The main channel 102 comprises a first portion 104, a second portion 106, and a third portion 208. The second portion 106 of the main channel 102 presents a constriction 112 with a reduced cross-section compared to the first portion 104 and the third portion 208.

[0065] Two diversion channels 122 are formed in the segment 100 and are both fluidly connected to the main channel 102 at a respective diversion channel inlet 120 at the constriction 112. Only one of the diversion channels 122 is shown in Fig. 7. Each diversion channel 122 extends from the constriction 112 to an associated ice nucleator nozzle 150.

[0066] Furthermore, two output channels 222 are formed in the second segment 200 and are connected at a respective output channel inlet 220 to the third portion 208 of the main channel 102. Each output channel 222 extends to an associated water nozzle 250.

[0067] In operation, the main channel 102 receives a main water flow 130 from the main channel water inlet 114. The main water flow 130 is sequentially guided through the first portion 104 into the second portion 106 of the main channel 102. At the constriction 112 in the second portion 106, part of the main water flow 130 is diverted as a diverted water flow 132 into the diversion channel inlet 120. The non-diverted part of the main water flow 134 is subsequently guided into the third portion 208 to which the output channel 222 is connected which receives an output water flow 136.

[0068] The water pressure changes from the first portion 104 to the second portion 106 to the third portion 208 as a consequence of the changing cross-section of the main channel 102 and the Venturi effect. As the water moves from the first portion 102 into the constriction 112 of the second portion 106, the water velocity increases due to the reduced cross-section. The increased velocity may give rise to an increased dynamic pressure and thereby a decreased static pressure. As a result, the diverted water flow 132 will present a relatively lower water pressure, defined by the static pressure at the constriction, which is more suitable for the operation of the ice nucleator nozzles 150. As the non-diverted part of the main water flow 134 in the main channel 102 continues to flow from the second portion 106 into the third portion 208, the water velocity again decreases due to the increased cross-section of the main channel 102 and the water pressure may consequently increase so that the pressure in the third portion 208 is higher than at the constriction 112. The output water flow 136 to the water nozzles 250 may consequently have a relatively higher water pressure, defined by the static pressure in the third portion 208, which is more suitable for the water nozzles 250.

[0069] The skilled person will understand that the water pressure modification as described above operates best with minimal turbulence. For this reason, the second portion 106 may preferably narrow into the constriction 112 in a tapered manner and then again expand in a tapered manner, as illustrated in Figure 7, rather than narrow and expand abruptly.

[0070] It should be realized that the tapered narrowing of the main channel 102 towards the constriction 112 and tapered expansion of the main channel 102 from the constriction 112 may be provided in many different manners. The tapering may provide a linear change in cross-section along the main channel 102, but may also provide a non-linear change. Further, the tapered narrowing need not be equal to the tapered expansion. As another alternative, the main channel 102 need not comprise a portion in which the cross-section is continuously narrowed or expaned. Rather, the narrowing or expanding cross-section may be provided in several portions, which may be separated by portions having a constant cross-section.

[0071] Figure 8 to 10 show an embodiment of an ice nucleator nozzle 150. The ice nucleator nozzle 150 has an inlet end 174 and an expelling end 176, and comprises a nozzle water channel 160 which recieves water from a water inlet 162 and expells it at a water outlet 164. The nozzle 150 further comprises at least one compressed air channel 166 which extends from the inlet end 174 to the expelling end 176. At the expelling end 176, there is a compressed air outlet 168 extending circumferentially around the water outlet 164. The ice nucleator nozzle 150 further comprises external threads 172, so that it can be screwed into the ice nucleator nozzle seat 180, and an O-ring 175 fitted on the outside of the water channel, so that it can connect to the diversion channel 122 in a water tight manner.

[0072] Figure 11 shows a detailed cross-sectional view of the ice nucleator nozzle seat 180 with the ice nucleator nozzle 150 in its mounted position and with water and compressed air flowing through the nozzle 150. When the ice nucleator nozzle 150 is mounted, the O-ring 175 ensures that the diverted water flow 132 from the diversion channel 122 is guided through the nozzle water channel 160 to the water outlet 164. Simultaneously, compressed air is delivered to an air cavity 178 formed at the inlet end 174 of the ice nucleator nozzle 150. The air cavity 178 is connected to the compressed air inlet 118 for receiving an air flow. The compressed air is guided as a compressed air flow 138 through the at least one compressed air channel 166 to the compressed air outlet 168. Water from the water outlet 164 and compressed air from the compressed air outlet 168 may subsequently mix and form an ice nuclei jet 158 which may be cooled by the expansion of the previously compressed air.

[0073] Figure 11 furthermore illustrates an embodiment where the diversion channel 122 is so connected to the constriction 112 of the main channel 102 that the direction of the diverted flow 132 at the diversion channel inlet 120 forms an angle to the main flow direction at the constriction 112 of the second portion 106. This angle is here termed diversion channel angle 140. In a preferred embodiment the diversion channel angle 140 is at least 30°. This implies that water flow makes a relatively small change of direction into forming the diverted flow 132, which may be advantageous in that turbulence may be avoided in the diverted flow 132.

[0074] In another embodiment, the diversion channel angle 140 is at least 90°. This implies that water flow makes a relatively large change of direction into forming the diverted flow 132, which may be advantageous in ensuring that particles in the main water flow 130 are not diverted into the diverted flow 132. However, in such an embodiment it is advantageous if the diversion channel 122 does not extend along a straight line. Rather, the diversion channel 122 may make a turn within the ice nucleator nozzle segment 10, so that the ice nucleator nozzle 150 may be pointed in a direction for forming an ice nuclei jet 158 that is directed away from the ground 98 when leaving the ice nucleator nozzle 150.

[0075] Figure 12 shows a detailed cross-sectional view of the water nozzle seat 280 with the water nozzle 250 mounted and with water flowing through the nozzle. The output water flow 136 is guided through a water nozzle channel 252 to a water nozzle outlet 254 where the water spray 258 may be formed.

[0076] During operation, the pressure of the water supply 92 and the cross-sections of the second 106 and third portions 208 of the main channel 102 are preferably selected to provide a water pressure between 10 and 100 bar in the third portion 208 of the main channel 102 and a water pressure between 1 and 10 bar in each diversion channel 122. Furthermore, the pressure of the water supply 92 and the cross-sections of the second 106 and third portions 208 of the main channel 102 are preferably configured to provide a volumetric flow rate between 50 and 300 liters per minute per water nozzle 250 in the third portion 208 of the main channel 102 and a volumetric flow rate between 0.05 and 0.5 liters per minute per ice nucleator nozzle 150 in each diversion channel 122. Such an embodiment delivers a smaller volumetric flow to each ice nucleator nozzle 150 than to each water nozzle 250. The water flow to the ice nucleator nozzles 150 may be enough to create the required amount of ice nuclei, in relation to the water flow to the water nozzles, but not more. In this way, the compressed air flow can be kept at a minimum in order not to create excessive energy costs. By lowering the pressure in the diversion channels, such a small volumetric flow to each ice nucleator nozzle 150 can be maintained without the need for a small nozzle water channel 160 and water outlet 164. Thereby, the risk of unwanted particles in the water clogging the ice nucleator nozzle 150 may be reduced.

[0077] In an embodiment, the constriction 112 has a cross-section area which is less than a quarter of the cross section of the main channel 102 in the third portion 208 at the output channel inlet 220. Such an embodiment may result in a sufficient pressure reduction in the diversion channel 122.

[0078] Figure 13 to 16 show a detailed view of an embodiment of the snow lance head 400. Figure 13 is a side view of the snow lance head 400. Figure 14 is a bottom view of the snow lance head 400. Figure 15 is a cross-sectional view of the snow lance head 400 providing a controlled water spray where the cross-sectional cut 52 is shown in Figure 13 and 14.

[0079] Figure 15 illustrates a water controller 600 providing secondary water output, which may be controlled for turning a secondary water spray 358 on or off. It should be realized that a water spray 358 output by the secondary water output may be regulated to control a volumetric flow rate of the water spray 358.

[0080] In Fig. 15, a secondary water channel 602 is shown. The secondary water channel 602 extends through the ice nucleator nozzle segment 100 and the water nozzle segment 200 towards the controlled water nozzle segment 300. The secondary water channel 602 connects to an outlet 604 for providing output of a secondary water spray 358.

[0081] The water controller 600 may control a valve for selectively opening or closing the connection between the secondary water channel 602 and the outlet 604. As shown in Figure 15, a sealing element 606, here in the form of a plunger, may seal the connection between the secondary water channel 602 and the outlet 604.

[0082] Referring now to Figures 16 to 17, a flow valve for controlling the opening or closing of the connection between the secondary water channel 602 and the outlet 604 will be further described. In Figure 16, the flow valve is shown in a closed configuration, whereas in Figure 17 the flow valve is shown in an open configuration.

[0083] The flow valve comprises a valve cavity 608, which may have a valve cavity inlet 610 and a valve cavity outlet 604. The valve cavity inlet 610 is connected to the secondary water channel 602. The valve cavity outlet 604 may be connected to an outlet channel, which may connect to a water nozzle channel to a water nozzle outlet of a water nozzle 350 mounted in a water nozzle seat, similar to the output water flow described above in relation to Figure 12 for water nozzle 250.

[0084] The plunger 606 is movably arranged in a channel 612 between a closed position and an open position. In the closed position, the plunger 606 may engage with a plunger seat 614 for sealing the valve cavity inlet 610. In the open position, the plunger 606 may be moved in the channel 612 to a position such that a connection from the secondary water channel 602 via the valve cavity inlet 610 through the valve cavity 608 to the valve cavity outlet 604 is unobstructed.

[0085] Movement of the plunger 606 may be controlled via a control tube 616. The control tube 616 may provide a water flow to a control cavity 618 arranged in the channel 612. A water pressure in the control cavity 618 may act on a control end 620 of the plunger 606 so that the plunger 606 may be pushed towards the closed position.

[0086] The control tube 616 may extend through the secondary water channel 602. The control tube 616 may have an inlet end arranged in the ground socket 10 and may extend through the tubular body 30 and further through the secondary water channel 602. The control tube 616 may thus be arranged to be immersed in the water flow to the snow lance head 400 which may prevent a risk of water freezing in the control tube 616. Thus, the water controller 600 may safely work, even in freezing conditions.

[0087] The control tube 616 may be configured to extend through the plunger 606 to connect to the control cavity 618. This may provide a simple arrangement of the control tube 616 in the snow lance head 400 to provide a connection to the control cavity 618.

[0088] A resilient element 622 may be arranged in the control cavity 618. The resilient element 622 may aid the movement of the plunger 606 towards the closed position. This implies that a lower water pressure may be necessary in the control cavity 618 for moving the plunger 606 towards the closed position. The resilient element 622 may also ensure that the plunger 606 is not fully retracted to engage with an end wall of the control cavity 618 in the open position, which may facilitate providing a water flow into the control cavity 618 when the plunger 606 is to be moved to the closed position.

[0089] Referring now to Figures 18 to 22, the water controller 600 may comprise a control valve 630 for selectively activating water flow through the control tube 616 to the control cavity 618 for activating movement of the plunger 606 from the open position towards the closed position.

[0090] The control valve 630 may be arranged in the ground socket 10, such as to provide easy access for an operator of the snow lance. However, it should also be realized that the control valve 630 may be automatically operated and need not be manually operated.

[0091] Figure 18 is a plan view of the ground socket 10, illustrating cross-sections A and B, which are shown in Figures 19 and 20, respectively, for an apply pressure position of the control valve 630, and in Figures 21 and 22, respectively, for a relieve pressure position of the control valve 630.

[0092] The control valve 630 may comprise a water supply port 632, a control tube port 634 and a pressure relief port 636. The control valve 630 may be turned between an apply pressure position and a relieve pressure position.

[0093] In the apply pressure position illustrated in Figures 19 and 20, the water supply port 632 of the control valve 630 is connected to a water supply channel 640 provided in the ground socket 10. Further, the control tube port 634 is connected to an inlet of the control tube 616. Thus, water from the water supply 92 may be connected to the inlet of the control tube 616 for guiding water throught the control tube 616 to the control cavity 618 and thereby apply water pressure of the water supply to the control end 620 of the plunger 606 via the control tube 616 so that said water pressure, possibly together with the resilient element 622, may place the plunger 606 in the closed position.

[0094] In the relieve pressure position illustrated in Figures 21 and 22, the pressure relief port 636 of the control valve 630 is connected to a relief channel 642 in the ground socket 10 extending to an opening in the ground socket 10. Further, the control tube port 634 is connected to an inlet of the control tube 616. Thus, in the relieve pressure position of the control valve 630, water pressure from the control end of the plunger via the control tube so that the water pressure from the control cavity 618 may be relieved through the control tube 616 to outer atmosphere. Then, water pressure from water flow in the secondary water channel 602 may force the plunger 606 to assume the open position.

[0095] In the above the inventive concept has mainly been described with reference to a limited number of examples. However, as is readily appreciated by a person skilled in the art, other examples than the ones disclosed above are equally possible within the scope of the inventive concept, as defined by the appended claims.

Claims

1. A snow making device, comprising:

a main channel which is arranged to receive and to guide water, and which has a first portion, a second portion downstream of the first portion, and a third portion downstream of the second portion, wherein the second portion presents a constriction with a reduced cross-section compared to the first portion and the third portion for creating a reduced water pressure at the constriction;

at least one diversion channel which has an inlet connected to the main channel at the constriction of the second portion and is arranged to divert part of the water from the main channel as a diverted water flow of reduced pressure; and

at least one ice nucleator nozzle which is arranged to create ice nuclei from said diverted water flow and compressed air.

2. A device as claimed in claim 1, wherein said device is a snow lance head.

3. The device as claimed in claim 1 or 2, wherein the main channel extends from the first portion to the third portion along a straight line.

4. The device as claimed in any of the preceding claims, wherein the water in the main channel presents a main flow direction at the constriction of the second portion, and wherein the at least one diversion channel is so connected to the constriction of the main channel that the direction of the diverted flow at the at least one diversion channel inlet forms an angle to the main flow direction at the constriction of the second portion.

5. The device as claimed in claim 3, wherein said angle is at least 30°.

6. The device as claimed in claim 3, wherein said angle is at least 90°.

7. The device as claimed in any of the preceding claims, further comprising at least one output channel which has an inlet connected to the main channel at the third portion; and
at least one water nozzle which is connected to said at least one output channel, and is arranged to create water droplets which when combined with said ice nuclei may freeze to form artificial snow.

8. The device as claimed in claim 6, wherein the constriction has a cross-section area which is less than a quarter of the cross section of the main channel in the third portion at the output channel inlet.

9. A method for producing artificial snow, comprising:

receiving a main water flow having a main pressure in a first portion of a main channel;
guiding said main water flow sequentially through a second portion and a third portion of the main channel, the second portion having a constriction with a reduced cross-section compared to the first portion and the third portion, for creating a reduced water pressure at the constriction;
diverting part of the main water flow at the constriction as a diverted water flow of reduced pressure into an inlet of a diversion channel connected to the main channel at the constriction, wherein the direction of the diverted water flow at the diversion channel inlet forms an angle to the direction of the main water flow at the constriction such that particles in the water are more likely to follow the main water flow than the diverted water flow due to the inertia of said particles, thereby making the diverted water flow at least partly filtered;
guiding the at least partly filtered diverted water flow of reduced pressure to an ice nucleator nozzle to form an ice nuclei jet by combining said filtered water of reduced pressure with compressed air;
guiding a non-diverted part of the main water flow in the third portion of the main channel to a water nozzle for generating a spray of water droplets;
guiding the spray of water droplets into the ice nuclei jet for producing artificial snow.

10. A system for producing artificial snow, comprising:

a water supply;
a compressed air supply; and
at least one snow lance; comprising:

a vertically inclined tubular body which is configured to be erected from a ground, and which comprises: at least a main water supply channel and a compressed air channel, both channels extending from a ground end to a top end of the tubular body;
a ground socket which is connected to the tubular body at the ground end thereof and comprises: a water inlet, a ground socket water channel, a compressed air inlet, and a ground socket compressed air channel; and
a snow lance head which is mounted at the top end of the tubular body and includes at least one device as claimed in claim 6.

11. The system as claimed in claim 9, wherein said water supply is arranged to deliver water to the ground socket water inlet, said ground socket is arranged to guide said water from the ground socket water inlet through the ground socket water channel into the water supply channel of the tubular body at the ground end thereof, and said water supply channel is arranged to guide the water to the first portion of the main channel of the snow lance head as a main water flow; and
wherein said compressed air supply is arranged to deliver compressed air to the ground socket compressed air inlet, said ground socket is arranged to guide said compressed air from the ground socket compressed air inlet through the ground socket compressed air channel into the compressed air channel of the tubular body at the ground end thereof, and said compressed air channel is arranged to guide the compressed air to a compressed air inlet of the snow lance head.

12. The system as claimed in claim 11, wherein said snow lance head is arranged to

- guide said main water flow, taken from the water supply channel of the tubular body, sequentially through the second portion and the third portion of the main channel;
- divert part of the main water flow at the constriction as a diverted water flow of reduced pressure into the diversion channel, wherein the direction of the diverted water flow at the diver-

sion channel inlet forms an angle to the direction of the main water flow at the constriction such that particles in the water are more likely to follow the main water flow than the diverted water flow due to the inertia of said particles, thereby making the diverted water flow at least partly filtered;
- guide the at least partly filtered diverted water flow of reduced pressure to the ice nucleator nozzle to form an ice nuclei jet by combining said filtered water of reduced pressure with compressed air from the compressed air channel of the tubular body;
- guide the non-diverted part of the main water flow in the third portion of the main channel to a water nozzle for generating a spray of water droplets;
- guide the spray of water droplets into the ice nuclei jet for producing artificial snow.

13. The system as claimed in claim 11, wherein the pressure of the water supply and the cross-sections of said second and third portions of the main channel are configured to provide a water pressure between 10 and 100 bar in said third portion of the main channel and a water pressure between 1 and 10 bar in said diversion channel when the system is in use.

14. The system as claimed in claim 11--, wherein the pressure of the water supply and the cross-sections of said second and third portions of the main channel are configured to provide a volumetric flow rate between 50 and 300 liters per minute per water nozzle in said third portion of the main channel and a volumetric flow rate between 0.05 and 0.5 liters per minute per ice nucleator nozzle in said diversion channel when the system is in use.

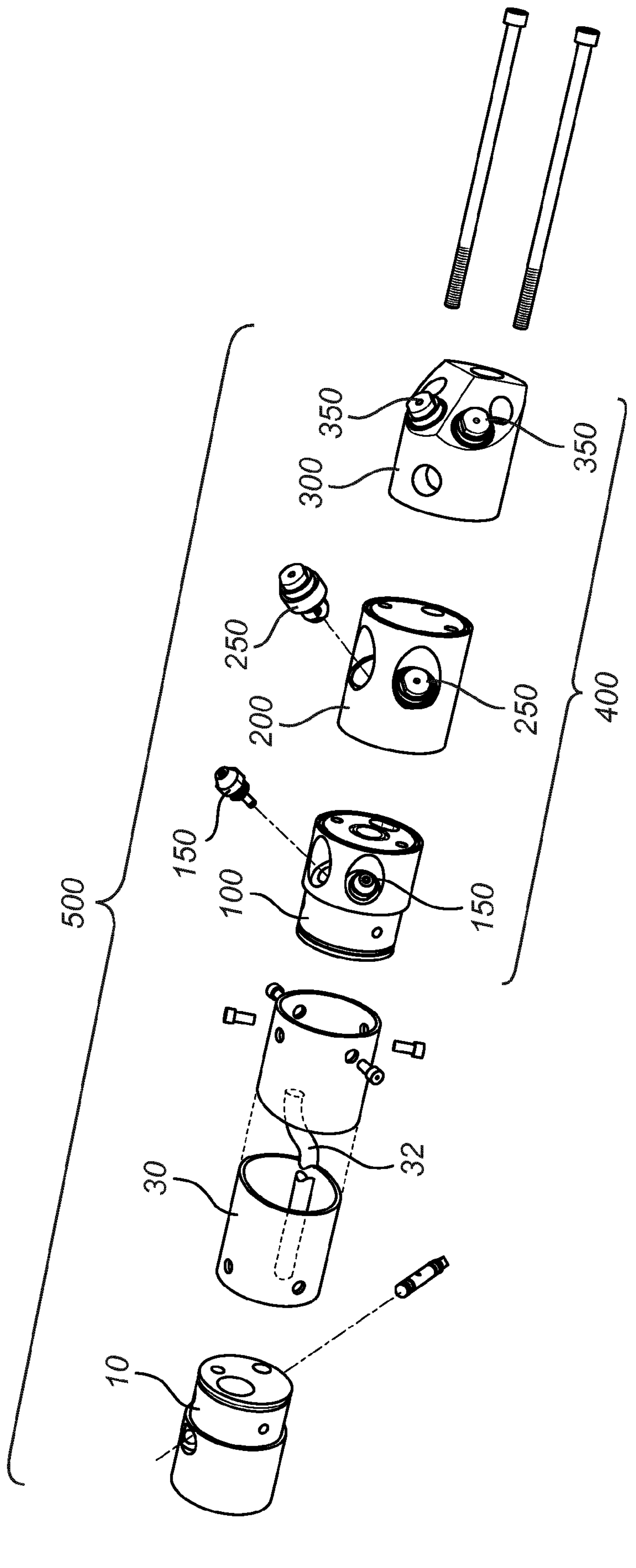

Fig. 1

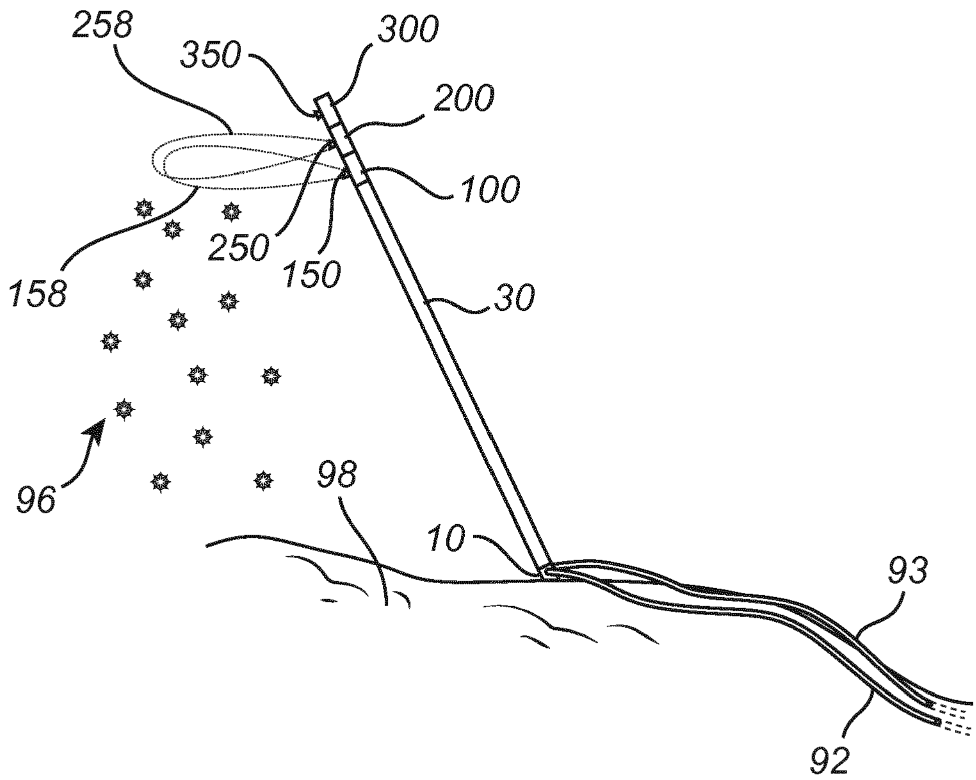
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Fig. 2

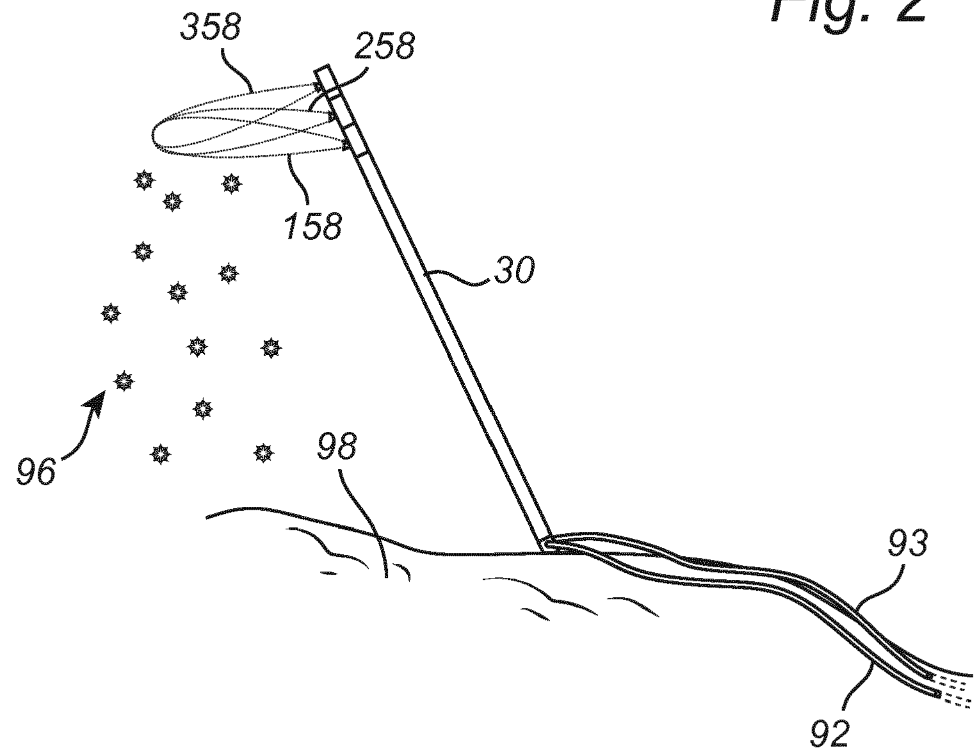
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Fig. 3

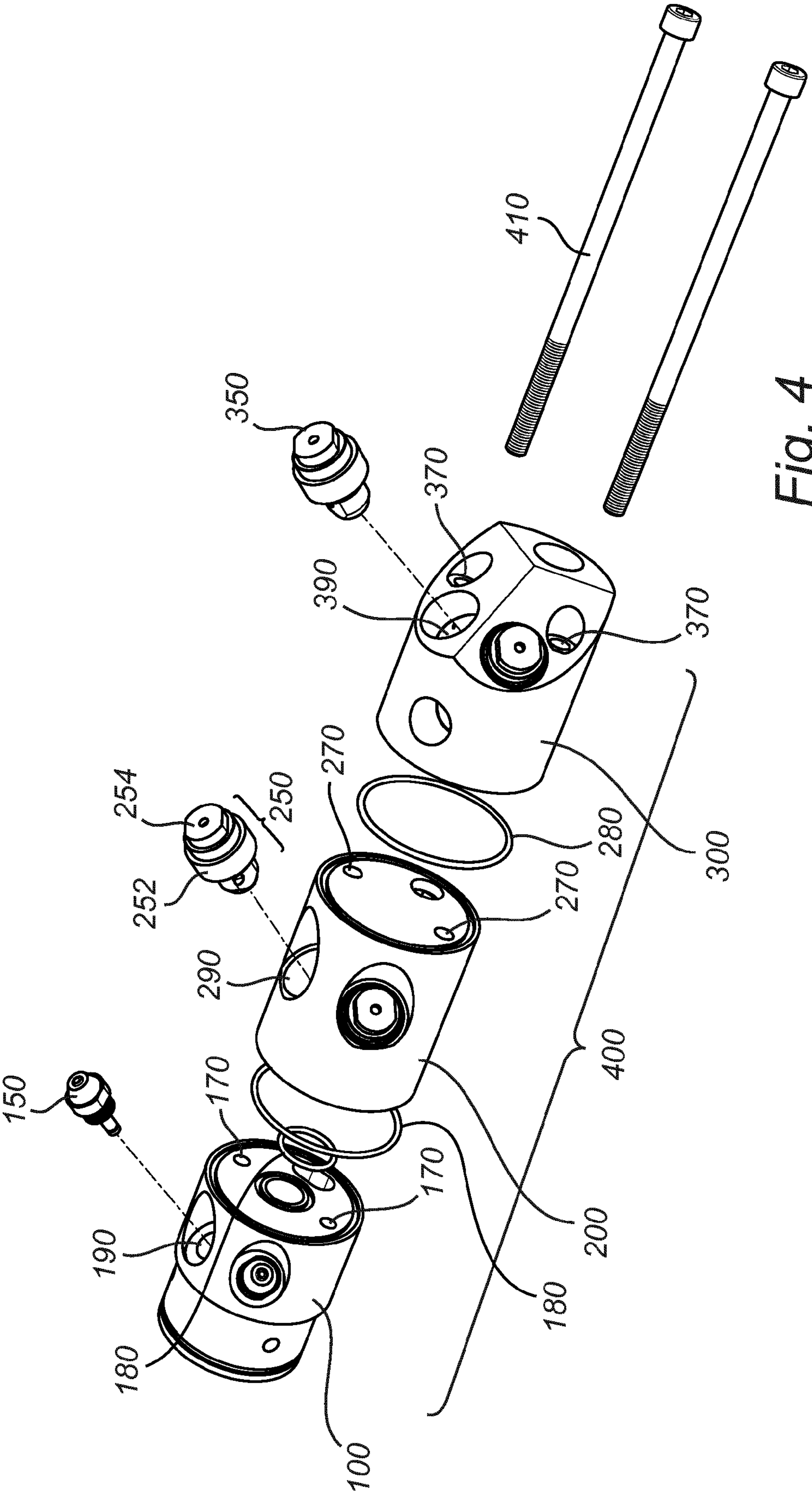
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Fig. 4

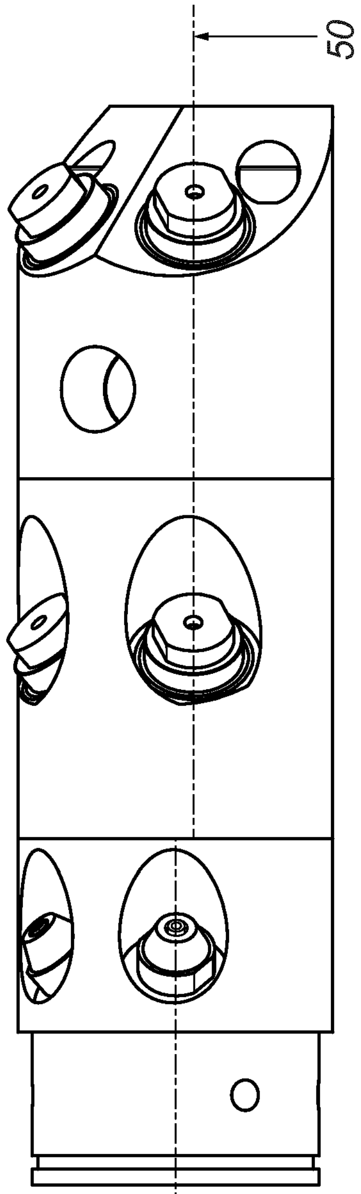

Fig. 5

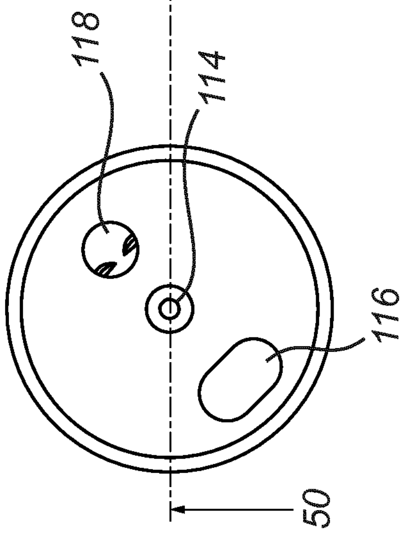

Fig. 6

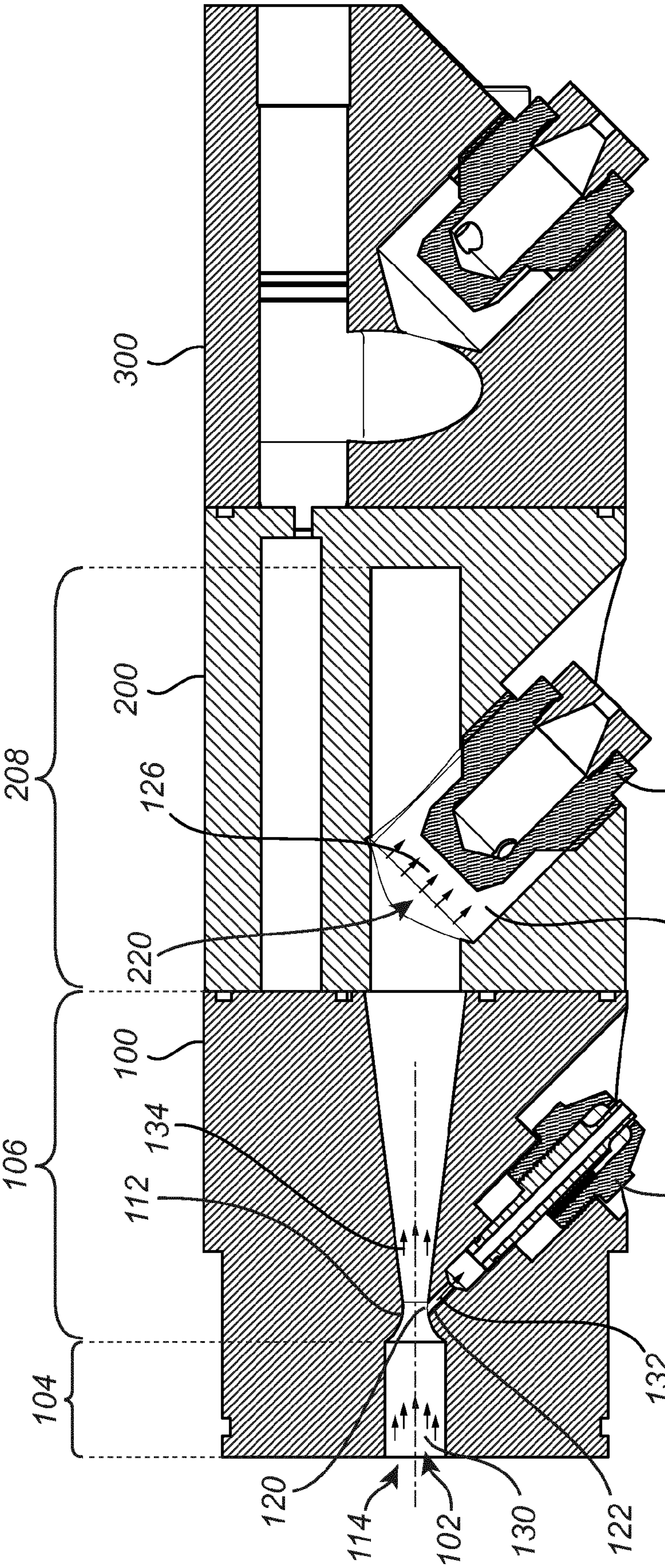
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Fig. 7

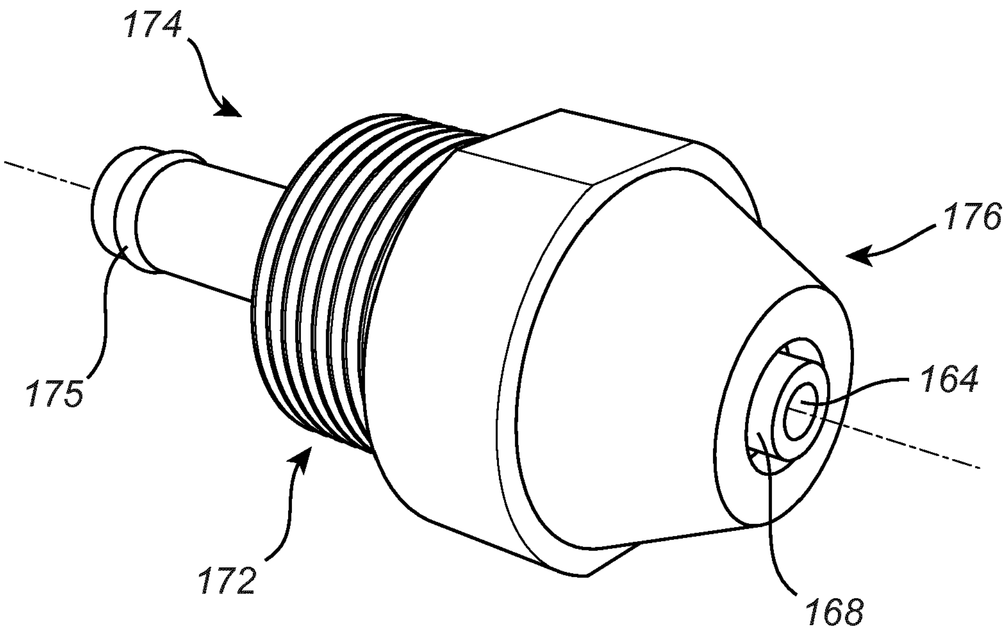

Fig. 8

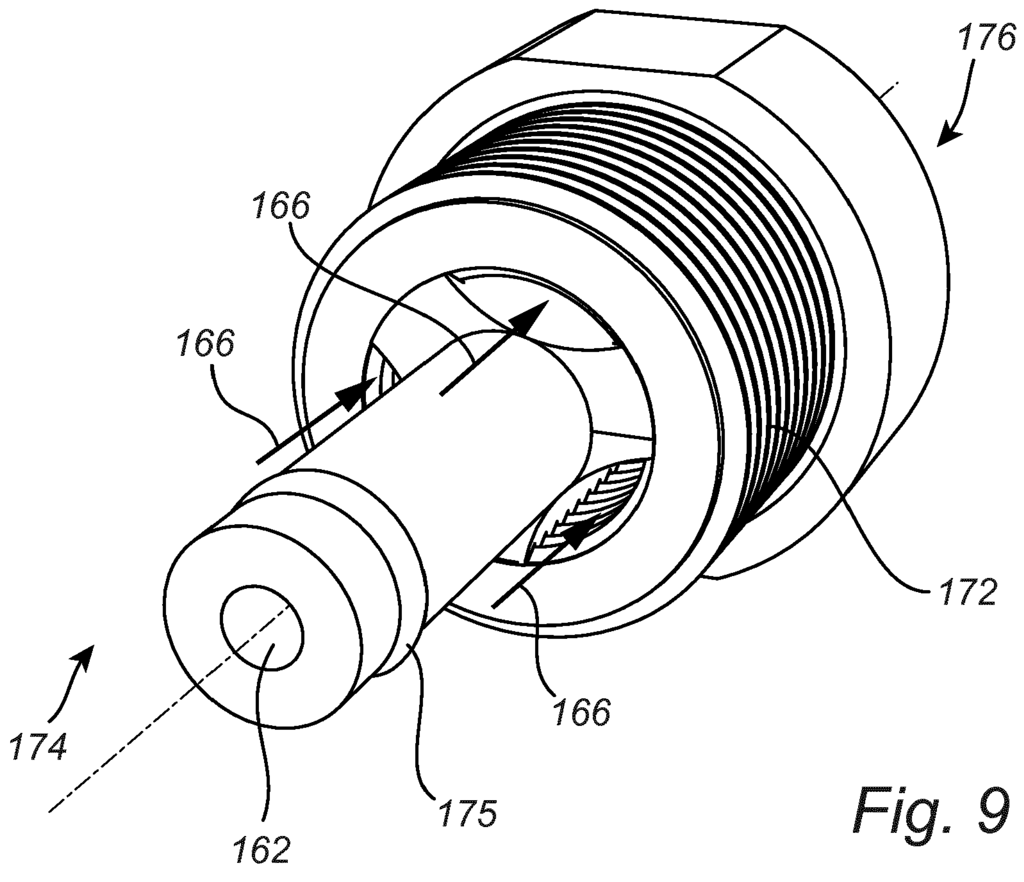

Fig. 9

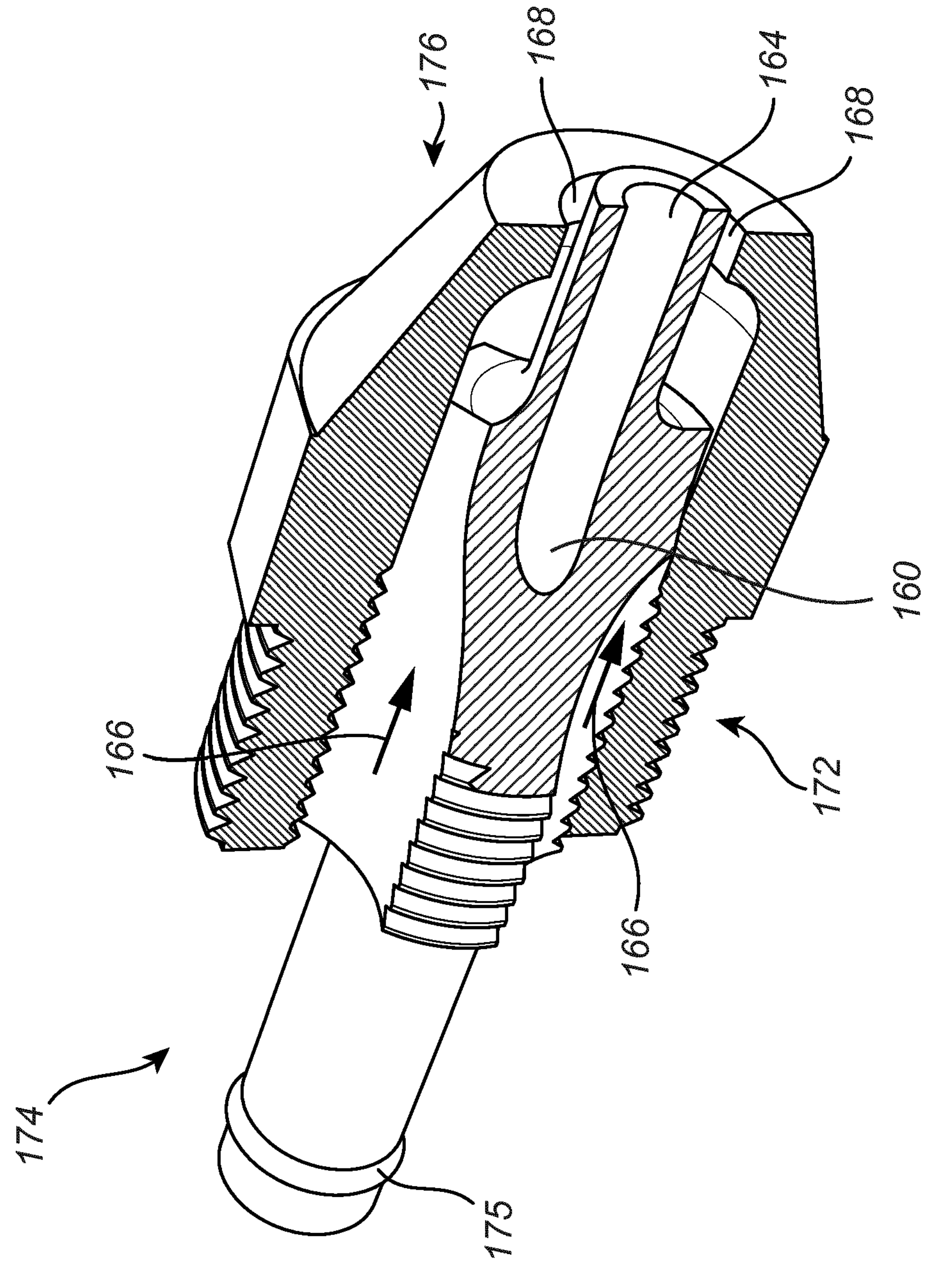

Fig. 10

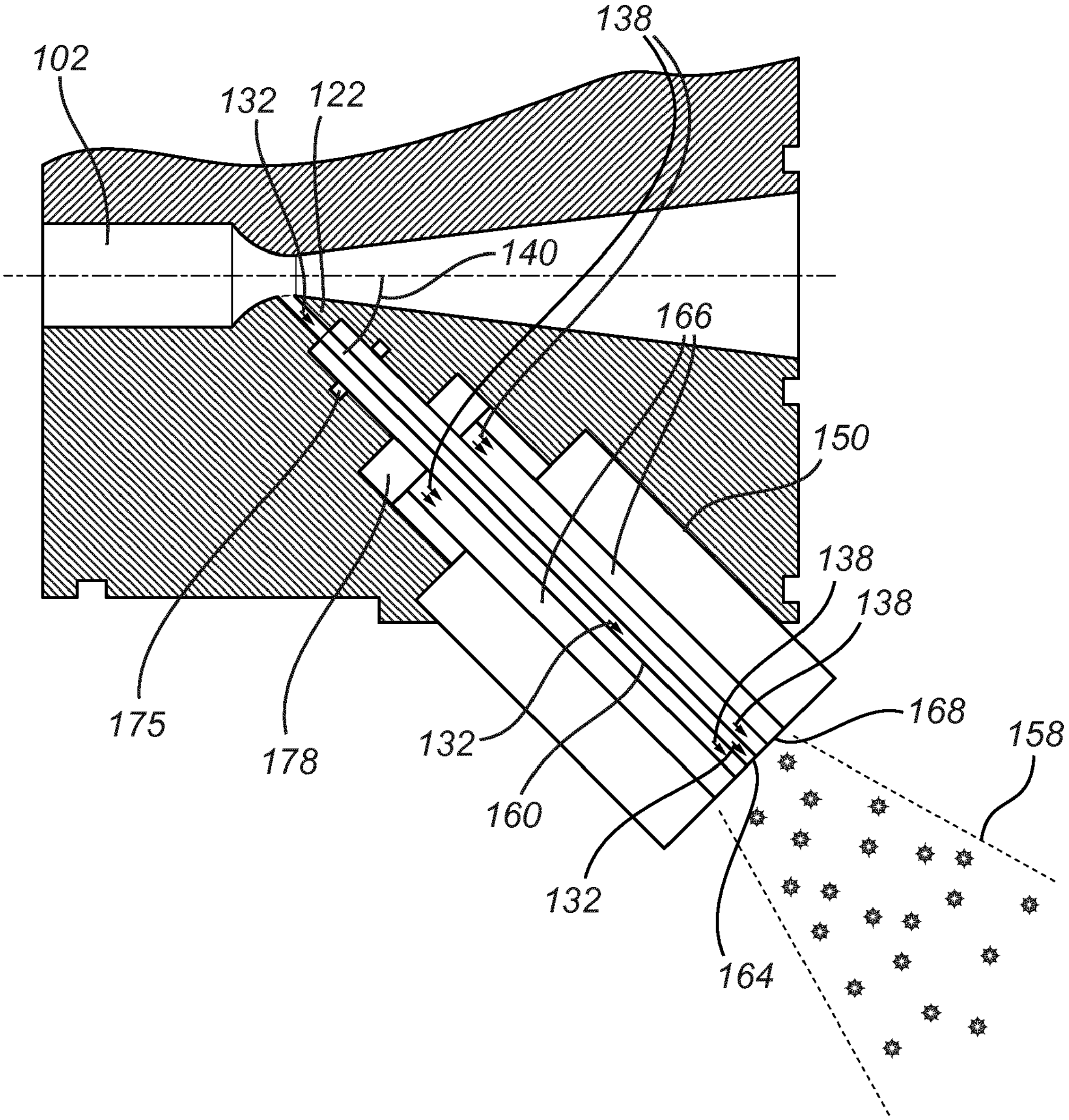
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Fig. 11

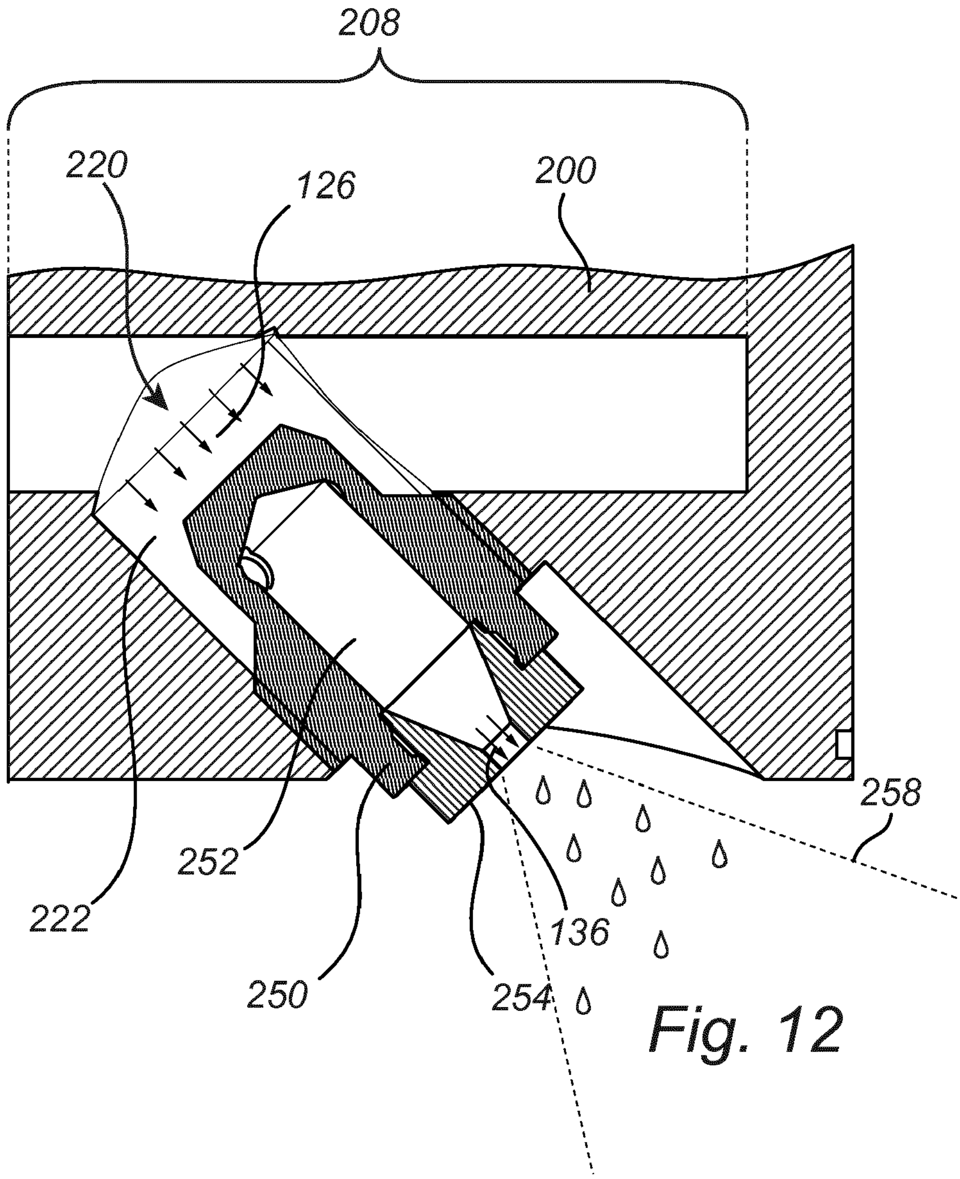

Fig. 12

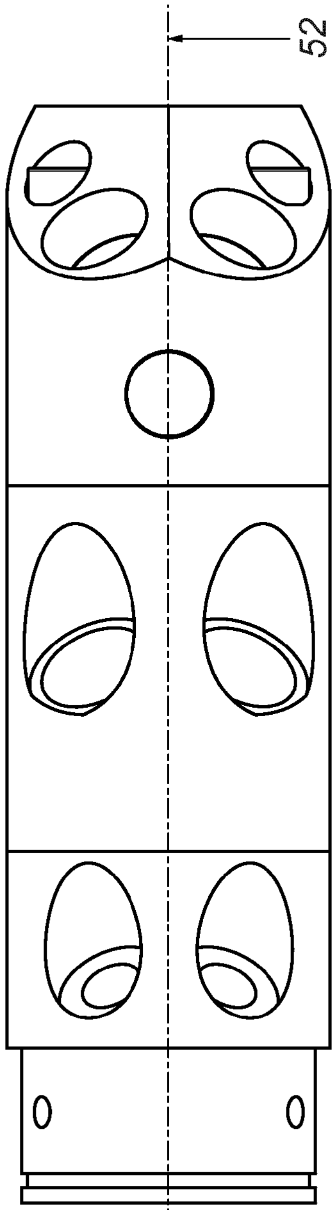

Fig. 13

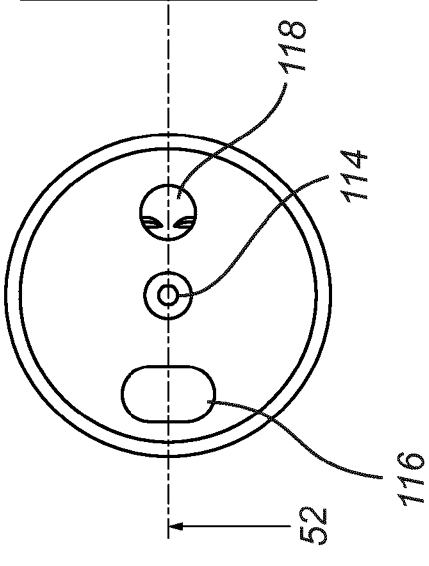

Fig. 14

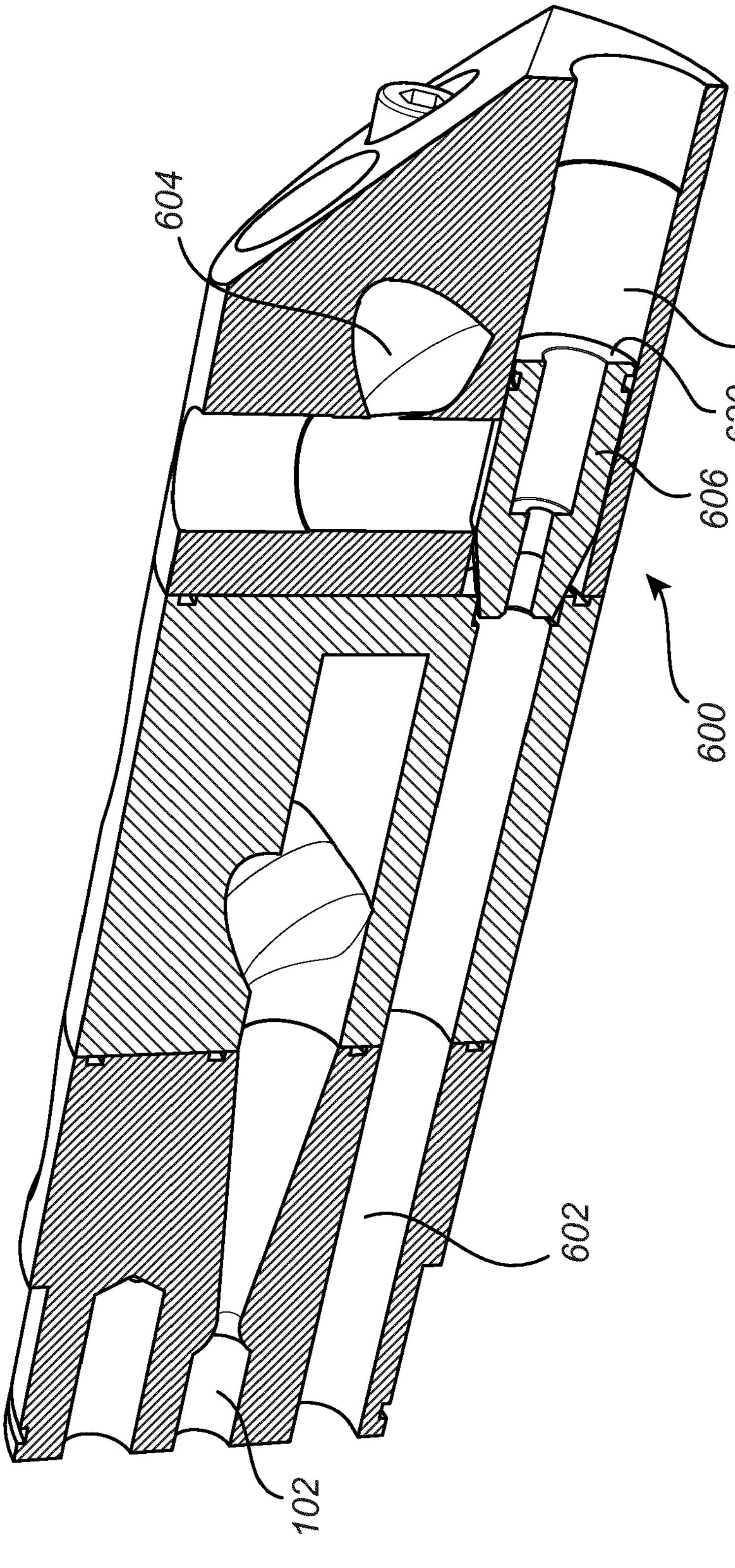

Fig. 15

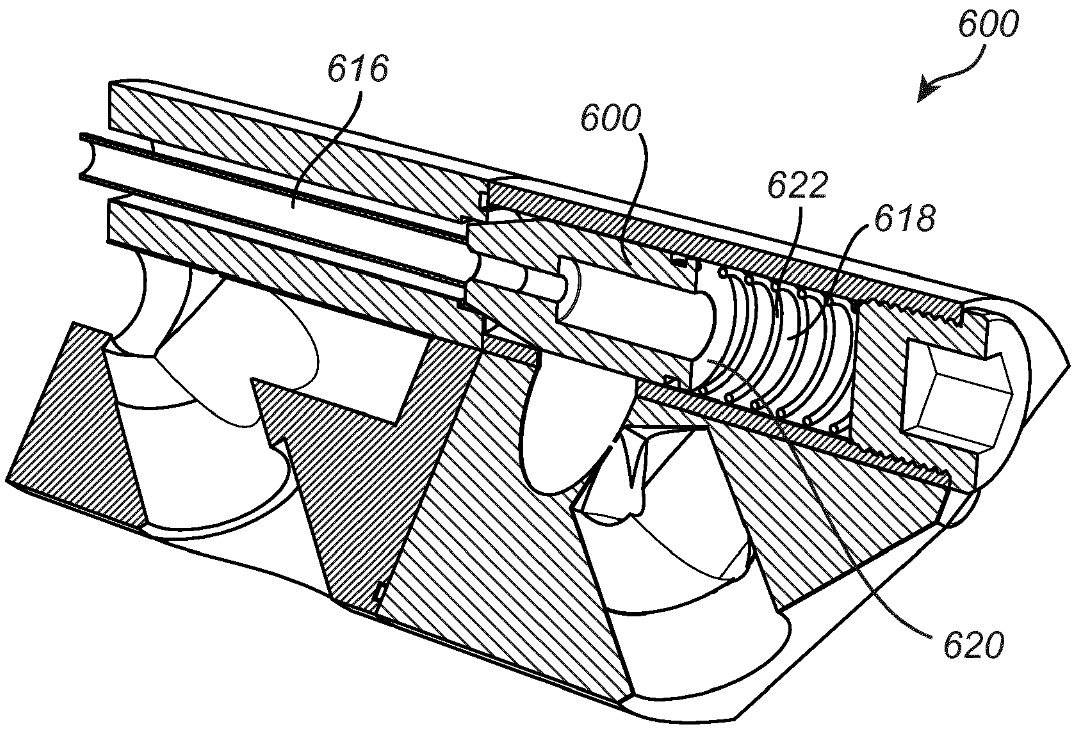

Fig. 16

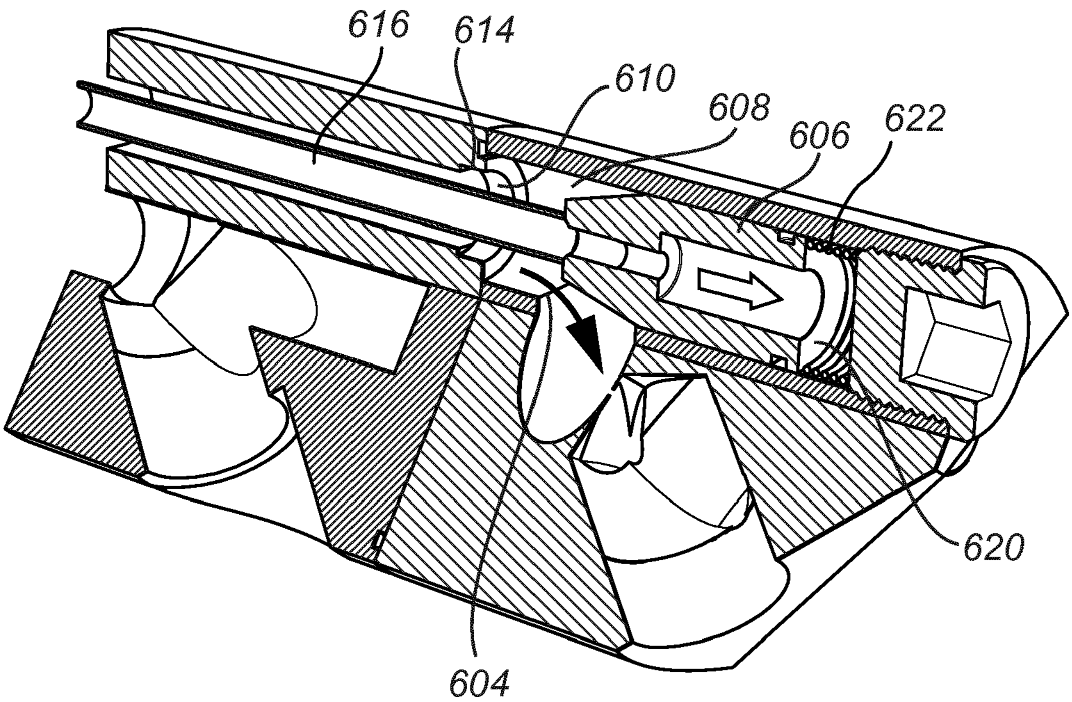

Fig. 17

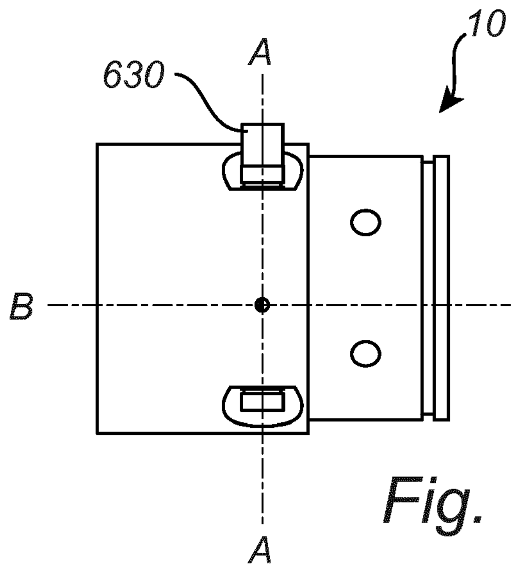

Fig. 18

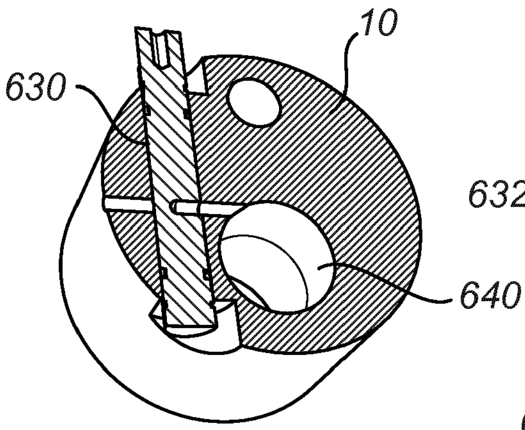

Fig. 19

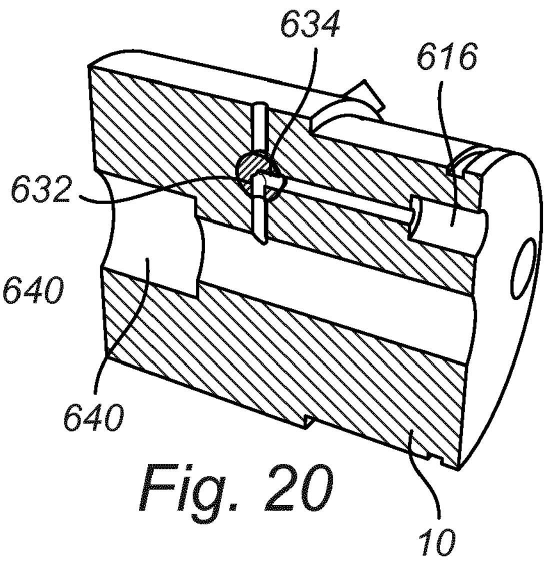

Fig. 20

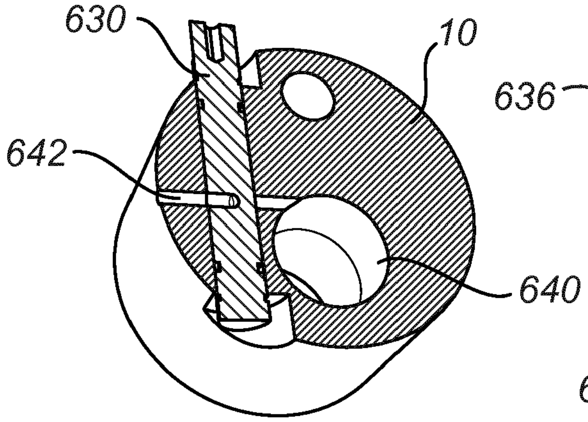

Fig. 21

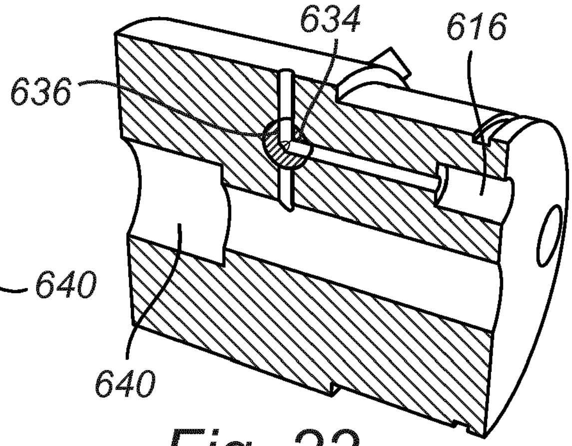

Fig. 22

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 9839

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2011/174895 A1 (RATNIK HELDUR R [US] ET AL) 21 July 2011 (2011-07-21) * paragraph [0038] - paragraph [0048] * * figures 2,7c * -----	1-14	INV. F25C3/04
A	US 2011/049258 A1 (LEHNER DANIELA [CH] ET AL) 3 March 2011 (2011-03-03) * paragraph [0014] - paragraph [0017] * * paragraph [0045] - paragraph [0050] * * paragraph [0051] - paragraph [0055] * * paragraph [0080] - paragraph [0098] * * paragraph [0106] - paragraph [0111] * * figures 2-5,9-22 * -----	1-14	
A	US 2015/241105 A1 (MENEUVRIER MATTHIEU [FR] ET AL) 27 August 2015 (2015-08-27) * paragraph [0076] * * paragraph [0155] - paragraph [0161] * * figure 10 * -----	1-14	
A	CA 2 258 444 A1 (MCKINNEY VERNON LORNE [CA]) 1 May 1997 (1997-05-01) * the whole document * -----	1-14	TECHNICAL FIELDS SEARCHED (IPC) F25C
A	CN 2 641 548 Y (LI LING [CN]) 15 September 2004 (2004-09-15) * abstract * * figures 1,2 * -----	1-14	
A	US 3 716 190 A (LINDLOF J) 13 February 1973 (1973-02-13) * column 1, line 3 - line 27 * * column 4, line 14 - column 6, line 25 * * figures 1-4 * -----	1	

The present search report has been drawn up for all claims

4

Place of search	Date of completion of the search	Examiner
The Hague	18 May 2018	Correia dos Reis, I

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 19 9839

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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18-05-2018

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