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(72) Inventor: **Hedin, Fredrik**
269 41 Östra Karup (SE)

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(74) Representative: **Bengtsson, Peggy Katrin**
Awapatent AB,
P.O. Box 11394
404 28 Göteborg (SE)

(71) Applicant: **Hedin, Fredrik**
269 41 Östra Karup (SE)

(54) Method and device for producing snow

(57) In accordance with the present invention a method and a device are provided for continuously producing and distributing snow and/or fine water droplets, using water and compressed air.

The method comprises the measures of atomising the water into small water droplets and distributing said water droplets essentially in a narrow spreading pattern (12), which extends essentially in parallel with the vertical plane.

The device comprises a nozzle member which is connected to a source of water and to a source of compressed air. The nozzle member is arranged to atomise the water into small water droplets and it is arranged to spread said small water droplets essentially in a narrow spreading pattern (12) that extends essentially in parallel with the vertical plane.

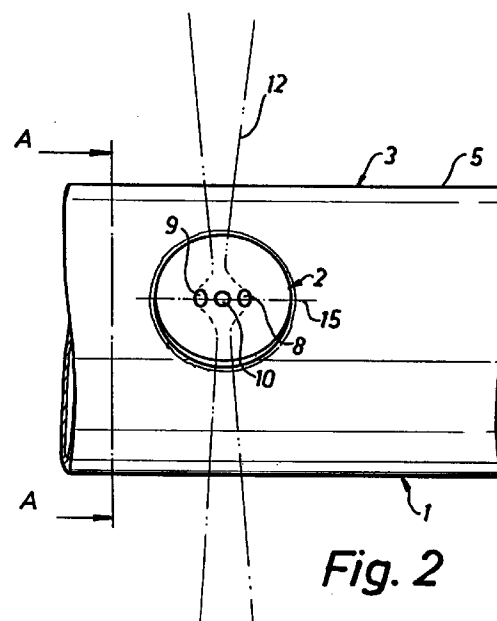


Fig. 2

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Description

The present invention relates to a method of continuously producing and spreading snow and/or fine water droplets, and to a device for performing the inventive method.

Alpine sports are practised by a large number of people all over the world, both on amateur and professional levels. Essentially without exception all alpine sports depend on the existence of a surface layer of snow and/or ice, although attempts have been made to simulate surface layers of this kind. The reason therefor is that, as is well known, the supply of snow is highly erratic and among other things depends on the season, the weather, and so on.

On account of such uncertainty factors many alpine establishments are equipped with so called snow guns, i.e. devices designed to produce and spread snow, or rather fine water droplets which freeze into ice crystals in the ambient cold atmosphere. A plurality of devices of this kind are known, all of which operate on essentially the same principle. In accordance with this principle a water jet and an air jet are mixed, and the resultant mix is broken up into smaller droplets which freeze into ice crystals on their way to the ground.

The most fundamental technology for forming ice crystals seems to be described in US-A-2 676 471. In a device disclosed in this publication water and air are mixed in a plurality of e.g. carriage mounted nozzles whereupon the mixture is forced out through minute openings at a high pressure and thus are spread over the piste. The mixture is effected in a chamber disposed in the front part of the nozzle, the air, upon its passage into said chamber, being made to draw along water fed up to an annular gap defined in the interior of the chamber. In order to form small droplets in the water-air mixture a convex surface is arranged in the chamber on which convex surface the jet passing into the chamber impinges. In another device known from this publication compressed-air channels are disposed around a water channel. Jets of compressed air from the compressed-air channels are made use of to displace, by ejector force, a water jet being discharged from the water channel to the ambient atmosphere where the water jet is atomised by the compressed-air jets into small water droplets which are spread across the piste.

For the purpose of among other things, improve the spreading of the droplets thus formed and to increase the efficiency it is known from US-A-3 814 319 to mount a device of the type known from US-A-2 676 471 on top of a mast having a length of at least 3 meters (10 feet).

Although prior-art devices of this type function satisfactorily as concerns production of snow, they do nonetheless suffer from certain disadvantages, only some of which will be mentioned herein. One of the more serious drawbacks is the comparatively high energy consumption (kWh/m³) in connection with the production of snow.

A further disadvantage is that on account of the limited

efficiency and spreading capacity usually a comparatively large number of devices are required in order to cover for instance a piste intended for down-hill skiing.

In addition, it has been found that the nozzle is very sensitive to freezing, which more often than not results in plugging of the nozzles. Freezing problems may arise also in the device relying on the ejector effect since the condensate in the compressed-air may freeze into ice, blocking the compressed-air channels. Constant surveillance of the prior-art devices thus is required, which is a labour-intensive task.

One way of solving these problems is disclosed in SE-9302062-6 filed by the applicant of this application. This publication discloses the use of a device discharging water and compressed air into the ambient atmosphere wherein water and compressed air are forced to pass an obstacle in the form of a spreading and atomising surface, causing fine water droplets and/or snow to form in the atmosphere.

As mentioned in the foregoing the ice crystals are produced essentially by the water droplets being cooled by the surrounding cool atmosphere. In prior-art devices the mixture is emitted from the nozzles essentially in a spreading pattern that extends in parallel with the horizontal plane. The disadvantage of this arrangement is that water droplets from adjoining nozzles may enter into each other's spreading patterns, reducing the cooling effect from the surrounding cold atmosphere in these areas. Spreading in the horizontal plane causes the water droplets to fall from a nozzle along flight paths or parabolic trajectories that occupy a comparatively large area in the horizontal plane. In this case, the cooling effect preferably is produced by the surrounding atmosphere above and below the water droplets as they are falling along said parabolic trajectories. The ambient atmosphere is heated by the water droplets along the parabolic trajectories, with resulting impaired cooling in this area. In compensation therefor, less water is used for a given volume of air in the prior-art devices, with the result that the efficiency is impaired and the energy consumption increased in these devices.

Another disadvantage inherent in prior-art devices is the comparatively high noise level during operation.

A novel device and a novel method have now been developed in order to further increase the possibility of reducing the problems outlined above.

One object of the present invention thus is to suggest a method of continuously producing and distributing snow and/or fine water droplets.

Another object of the present invention is to produce a device for implementing the inventive method.

A third object of the present invention is to provide a device which uses less energy to form and distribute the same amounts of snow as prior-art devices.

A fourth object of the present invention is to provide a device having a higher capacity per time unit to produce and distribute snow compared with the prior-art technology.

A fifth object of the present invention is to provide a

device allowing enhanced flexibility in the positioning of the device, for instance in a piste.

A sixth object of the present invention is to provide a device having a lower operational noise level than prior-art devices.

The device in accordance with the present invention otherwise has to meet the same demands as prior-art "snow guns" of the high pressure type i.e. it must be connectable to existing water pipes and compressed-air lines. In addition, the inventive device should be essentially maintenance-free and lend itself to installation at a distance above ground.

These and other objects are achieved in accordance with the present invention by means of a method of continuously producing and distributing snow and/or fine water droplets and by means of a device for implementing the inventive method as defined in the appended claims.

Other particularities and advantageous embodiments will appear from the dependent claims.

A preferred embodiment of the present invention will be described in the following in more detail with reference to the accompany drawings, wherein

Fig. 1 is a partly sectional schematic perspective view of the inventive device, the latter being attached to pillars which could for instance be pylons forming part of a lift system, light-carrying masts, poles mounted in concrete foundations, or the like.

Fig. 2 is a schematic broken view which illustrates the inventive device from the front and which specifically illustrates the spreading pattern relating to an inventive nozzle member.

Fig. 3 is a schematic broken and partly sectional view of the inventive device.

Fig. 4 is a schematic sectional view taken on line A-A in Fig. 2.

Reference is now made to the drawing figures illustrating a presently preferred embodiment of an inventive device for producing and spreading snow and/or small water droplets, said device being indicated generally by reference 1. In accordance with the embodiment illustrated the device 1 comprises a nozzle member, generally designated by reference 2, and a source, generally designated by 3, said source in accordance with the embodiment illustrated being tubular and comprising an outer tube 5 and an inner tube 4, the latter being disposed inside said outer tube 5. In accordance with the embodiment shown the inner tube 4 is connected to a compressor or equivalent means (not shown) and it is filled with compressed air, whereas the outer tube 5 is filled with preferably pressurised water. This arrangement is the one preferred at the moment. It is easily understood, however, that the source 3 need not be tubular and that it is equally possible for a water-filled tube to form the inner tube or to arrange two separate discrete tubes, one for compressed air and one for pres-

surised water.

In accordance with the embodiment shown the nozzle member 2 is connected to the interior of respectively tubes 4 and 5. This is achieved in accordance with the embodiment shown (see Fig. 3) by arranging the nozzle member 2 in recesses 6, 7 formed in respectively the outer tube 5 and the inner tube 4. In accordance with the embodiment shown, the nozzle member 2 comprises two channels 8, 9 by means of which the interior of the tube 5 is in communication with the surrounding atmosphere. In accordance with the embodiment shown, the nozzle member 2 is likewise formed with a channel 10 by means of which the interior of the tube 4 communicates with the ambient atmosphere. In accordance with the embodiment illustrated, the channels 8, 9, 10 are positioned in a common plane. After connection of the device 1 to the existing pipeline systems for respectively water and compressed air and after making the corresponding pump and compressor operative, or after connection of the device 1 directly to a corresponding pump respectively compressor, after said pump and compressor having been made operative, water is supplied to the outer tube 5 of the device 1 in accordance with the embodiment described and compressed air to the inner tube 4 of the device 1. Water jets then are discharged from the channels 8, 9, said water jets intersecting in a spreading and atomising area 11. The flow of compressed air, which upon operation is ejected from the channel 10, likewise intersects the water flows in this spreading and atomising area 11.

Simultaneously with the cooling of the water by the compressed air and the surrounding atmosphere, the water jets being discharged from the channels 8, 9 are atomised by the force of impingement between the various flows into very small water droplets in the area 11, these drops, as they are falling down to the ground, freezing into ice crystals in the surrounding cold atmosphere, forming a layer of snow on the ground. In order to cover a large area it is preferable to mount the device along a distance between the top of the lift-system masts, lamp masts and the like. An advantage of this arrangement is that skiing may be practised also during the distribution of the "artificial" snow.

In order to obtain the desired cooling effect from the compressed air the flow velocity V_a of the compressed air in the spreading and atomising area 11 should be considerably higher than the flow velocity V_w of the water in the same area 11, i.e. $V_a \gg V_w$.

The water jets preferably intersect at an acute angle α , which preferably amounts to 60° and the compressed-air channel 10 preferably is disposed half way between the water channels 8, 9, ensuring that the flow of compressed air intersects the water flows at the centre of the angle α .

In accordance with the shown, preferred embodiment a spreading pattern 12 of the water droplets and the ice crystals formed thereby is produced, as illustrated in Fig. 2. The spreading takes place essentially in a comparatively narrow plane which in contrast to prior-

art devices extends in parallel with a vertical plane. The spreading pattern is produced for instance by arranging the plane in which said channels 8, 9, 10 are disposed at an angle relatively to the vertical plane, whereby a centre line 15 passing through the channels 8, 9, 10 in Fig. 2 will extend essentially perpendicularly to the vertical plane along the horizontal plane.

The source 3 is extended along the horizontal plane as seen in Fig. 2. However, it is easily understood that the source 3 could be arranged at an angle to this plane, for instance when arranged at the angle of inclination of a slope. The centre line 15 through the nozzle member 2 should, however, also in this case preferably extend essentially perpendicularly to the vertical plane along the horizontal plane.

Fig. 4 illustrates the arrangement according to a preferred embodiment of the nozzle member 2 at an angle relatively to the horizontal plane. The mixture emitted from the nozzle member 2 thus will follow a parabolic trajectory or flight path.

The inventive method of continuously producing and spreading snow and/or small water droplets is essentially characterised by the steps of atomising the water into small water droplets and spreading said water droplets essentially in a narrow spreading pattern 12 extending essentially in parallel with the vertical plane.

Because the spreading patterns 12 of the inventive device 1 are narrow and essentially vertical, problems caused by intermingling of spreading patterns from neighbouring nozzle members 2 need not arise. Because the spreading patterns 12 are essentially vertical, extending in narrow, essentially spaced-apart planes, the cooling effect from the cold surrounding atmosphere takes place essentially at the sides of the spreading patterns 12, for instance along the above-mentioned parabolic trajectories or flight paths. In this manner, the contact of cold air in the ambient atmosphere with the mixture being discharged from the device 1 is made more easily than in the case of prior-art technology, according to which the spreading patterns are at least partly horizontal, the reason being that the mixture does not "fall through" and consequently to a lesser extent heats the cold air at the sides of the spreading patterns 12. In accordance with the preferred shown embodiment the plurality of nozzle members 2 are disposed along the extension of the source 3. Supplementary lines to each individual nozzle member 2 are not required, contrary to the case in the prior art. Owing to the narrow spreading patterns 12 formed essentially in the vertical plane, neighbouring nozzle members 2 may also be disposed closer to one another than is the case according to prior-art technology. Thus, a method and a device are provided for continuous production and spreading of snow and/or small water droplets, which device has a high capacity of producing and spreading snow and/or small water droplets. Thanks to the excellent cooling effect accomplished by the inventive spreading pattern in the surrounding atmosphere, the

mass flow of water that is being discharged through the nozzle member 2 may in accordance with one embodiment be at least 60 times the mass flow of compressed-air that is being discharged through the nozzle member 2.

In accordance with one embodiment the source 3 is manufactured from two aluminium tubes. Recesses 7 are formed for instance by drilling holes at pre-determined intervals in a first tube 4. Thereafter threads are formed in the recesses 7 in the tube 4 and the nozzle members 2 are secured in the recesses 7 by screwing and/or gluing, insuring that the transitional zone between the threads and the nozzle member 2 is sealed. Thereafter recesses 6 are formed, e.g. by drilling holes in the second tube 5 in a corresponding way at predetermined intervals, said second tube 5 being of larger diameter-size than tube 4. Tube 4 is inserted into tube 5, whereupon the nozzle members 2 are forced outwards through the recesses 6 in the tube 5 to which they are sealingly secured by welding.

It is easily understood that it is possible to position new nozzle members 2 afterwards along a device 1, for instance in a source 3 positioned adjacent a pillar as illustrated in Fig. 1. This may be achieved for instance by making new recesses 6, 7 in the tubes 5 and 4, respectively, which tubes may be fitted with nozzle members 2. In accordance with one embodiment the channels 8, 9, 10 and/or the recesses 6, 7 of the nozzle members 2 may be sealable, for instance by fitting one or several plugs therein. The feature allowing sealing and/or provision of new nozzle members 2 along the extension of the source 3 is a highly advantageous one, since it creates a flexible device 1 whereby the snow production may be concentrated to certain areas along the extension of the source 3.

Because the distributing and atomising area 11 in accordance with the shown preferred embodiment is arranged in the very atmosphere and is not formed by a stationary part in which ice may form also the risk of ice formation with consequential operational stoppages is greatly reduced in the inventive device compared with the prior-art. Owing to the positioning in accordance with the preferred embodiment of the tube 4, which is filled with compressed air, inside the tube 5, which is filled with water, also the risk of the condensate contained in the compressed-air freezing into ice is reduced. Because the water and compressed-air jets leave the channels 8, 9, 10 through comparatively small-size holes and because the jets impinge on one another in an area 11 in the atmosphere, a device is produced the noise level of which during operation is lower than in the case of prior-art devices.

It is easily understood that certain deviations from the described embodiment are possible. For instance, nozzle members producing different spreading patterns than the illustrated, essentially vertical preferred spreading pattern 12 may be arranged along a source 3. Although the advantages found with such spreading patterns 12 are not obtained, this modification offers the

advantages of producing a flexible device in which new nozzles may be added or removed/sealed along the source. All varieties and modifications comprised by the basic inventive idea should however be considered to be within the scope of the appended claims.

Claims

1. A method of continuously producing and spreading snow and/or small water droplets using water and compressed air, **characterized** by the steps of atomising the water into small droplets, and spreading said water droplets essentially in a narrow spreading pattern (12) extending essentially in parallel with the vertical plane.
2. A method as claimed in claim 1, **characterized** by the steps of discharging the water and the compressed air in the form of flows into the ambient atmosphere, and producing a spreading and atomising area (11) in the paths of flow of respectively the water and the compressed air.
3. A method as claimed in claim 2, **characterized** in that the spreading and atomising area (11) is produced by the measures of discharging the water in at least two flows which intersect in the spreading and atomising area (11), and of discharging the compressed air in at least one flow in such a manner that said air flow intersects the water flows in said area.
4. A method as claimed in claim 3, **characterized** by the steps of directing the water and compressed-air flows essentially in one plane, arranging the water flows in such a manner that said flows intersect at an acute angle (α) and arranging the flow of compressed air in the middle of said flows of water in such a manner that said flow of compressed air intersects the flows of water in the middle of said acute angle (α), and arranging said plane at an angle relatively to the vertical plane to ensure that said spreading pattern (12) extends essentially in parallel with the vertical plane.
5. A device for continuous production and spreading of snow and/or small water droplets, using water and compressed air, **characterized** by the provision of a nozzle member (2), said nozzle member being connected to a source of water and to a source of compressed air, being arranged to atomise water into small droplets, and being arranged to distribute said small water droplets essentially in a narrow spreading pattern (12) which extends essentially in parallel with the vertical plane.
6. A device (1) as claimed in claim 5, **characterized** in that the nozzle member (2) is formed with channels (8, 9, 10) through which water and compressed air in the form of flows are discharged into the ambient atmosphere, said flows being directed to intersect in an area (11) in the ambient atmosphere where said atomisation and spreading are effected.
7. A device (1) as claimed in claim 6, **characterized** in that the nozzle member (2) is formed with at least two water channels (8, 9) arranged to direct said flows of water in such a manner that said flows intersect at an acute angle (α) in said area (11), said acute angle (α) preferably being in the range of 50-70°, and particularly about 60°, and in that said nozzle member (2) is formed with at least one channel (10) for compressed air, said channel arranged to direct the flow of compressed air in such a manner that said flow intersects the flows of water in said area (11).
8. A device (1) as claimed in claim 7, **characterized** in that the mouths of respectively the compressed-air channel and the water channels are disposed essentially in one plane, that the mouth of the compressed air channel (10) is disposed in the middle between the mouths of the water channels (8, 9), whereby the compressed air flow will intersect the water flows in the middle of said acute angle (α), said plane being arranged at an angle relatively to the vertical plane, thus causing said spreading pattern (12) to extend essentially in parallel with the vertical plane.
9. A device (1) as claimed in any one of claims 5-8, **characterized** in that the mass flow of water being discharged from the nozzle member (2) is at least 60 times the mass flow of compressed air being discharged from the member (2).
10. A device (1) as claimed in any one of claims 5-9, **characterized** in that several nozzle members are connected to a source (3), preferably in the form of a tubular structure, said source (3) comprising at least one channel (4) for compressed-air and at least one channel (5) for pressurised water, said compressed air channel (4) preferably being disposed in the interior of the water channel (5).

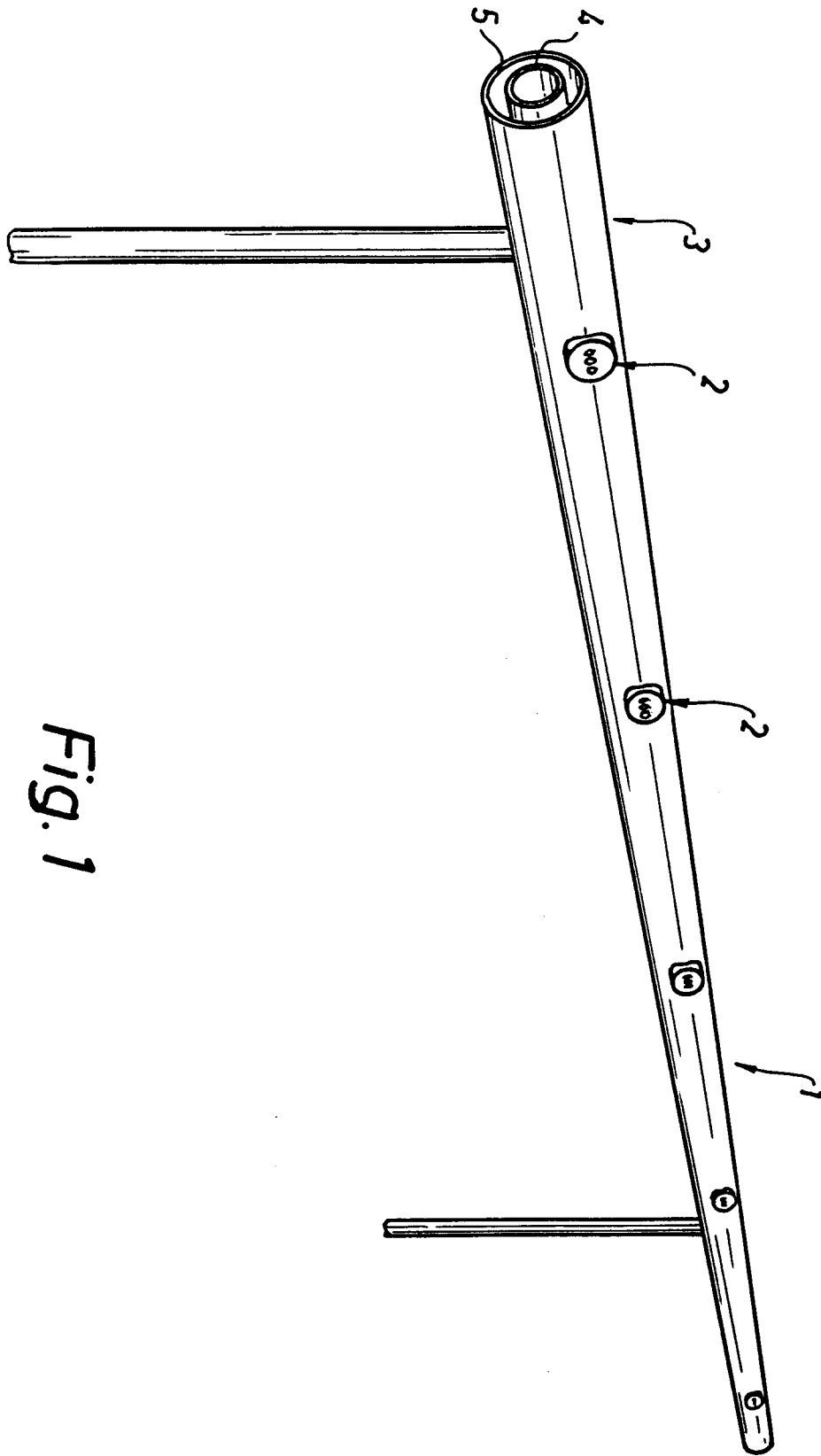
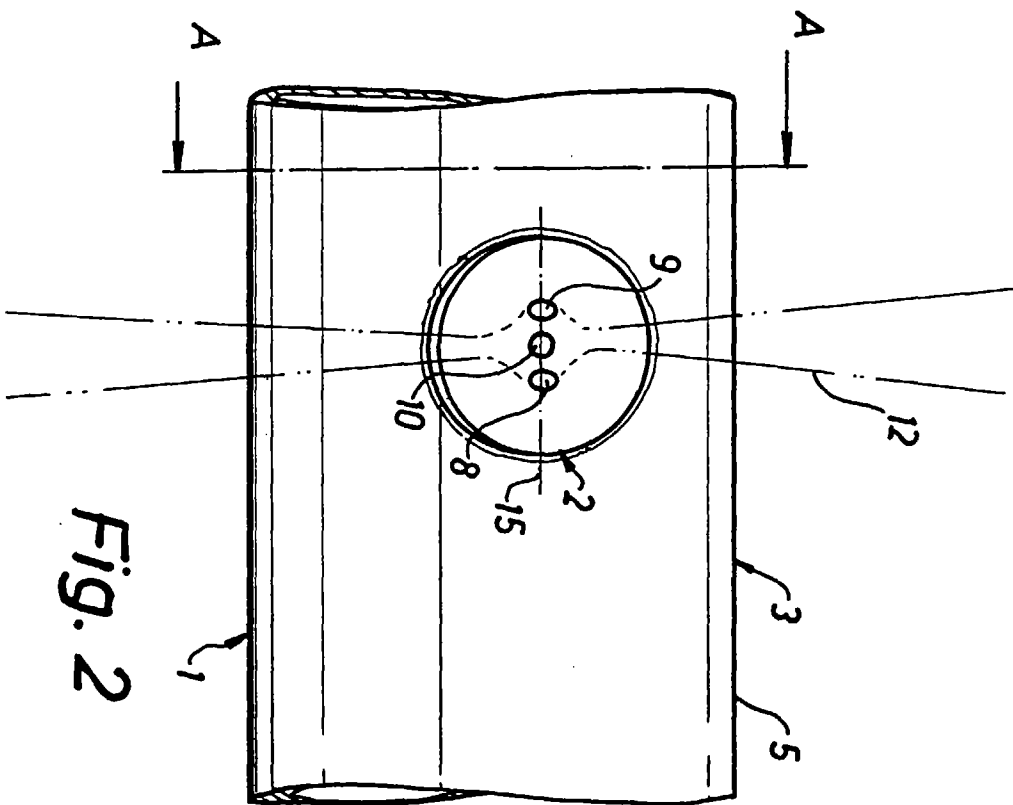
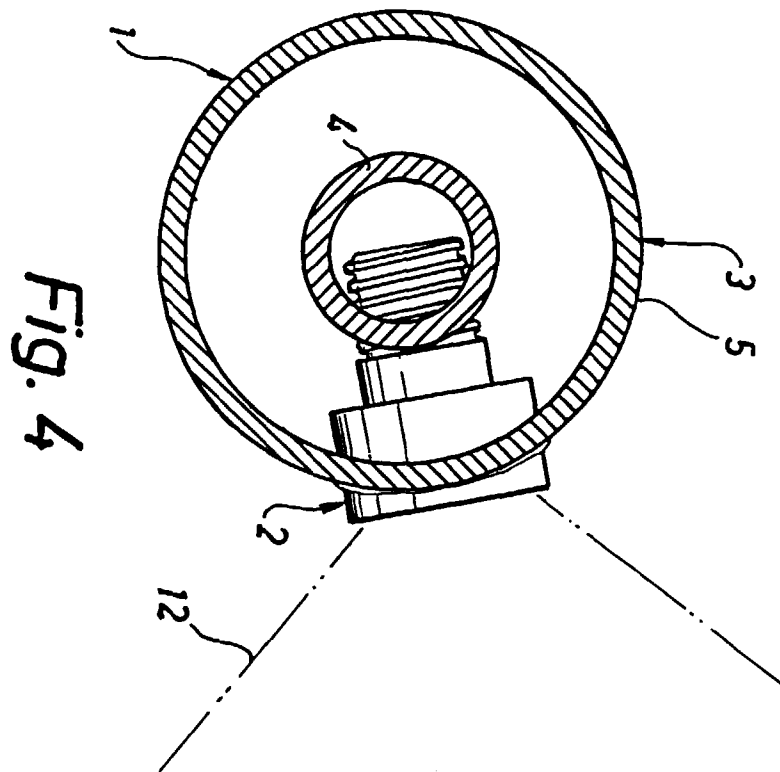
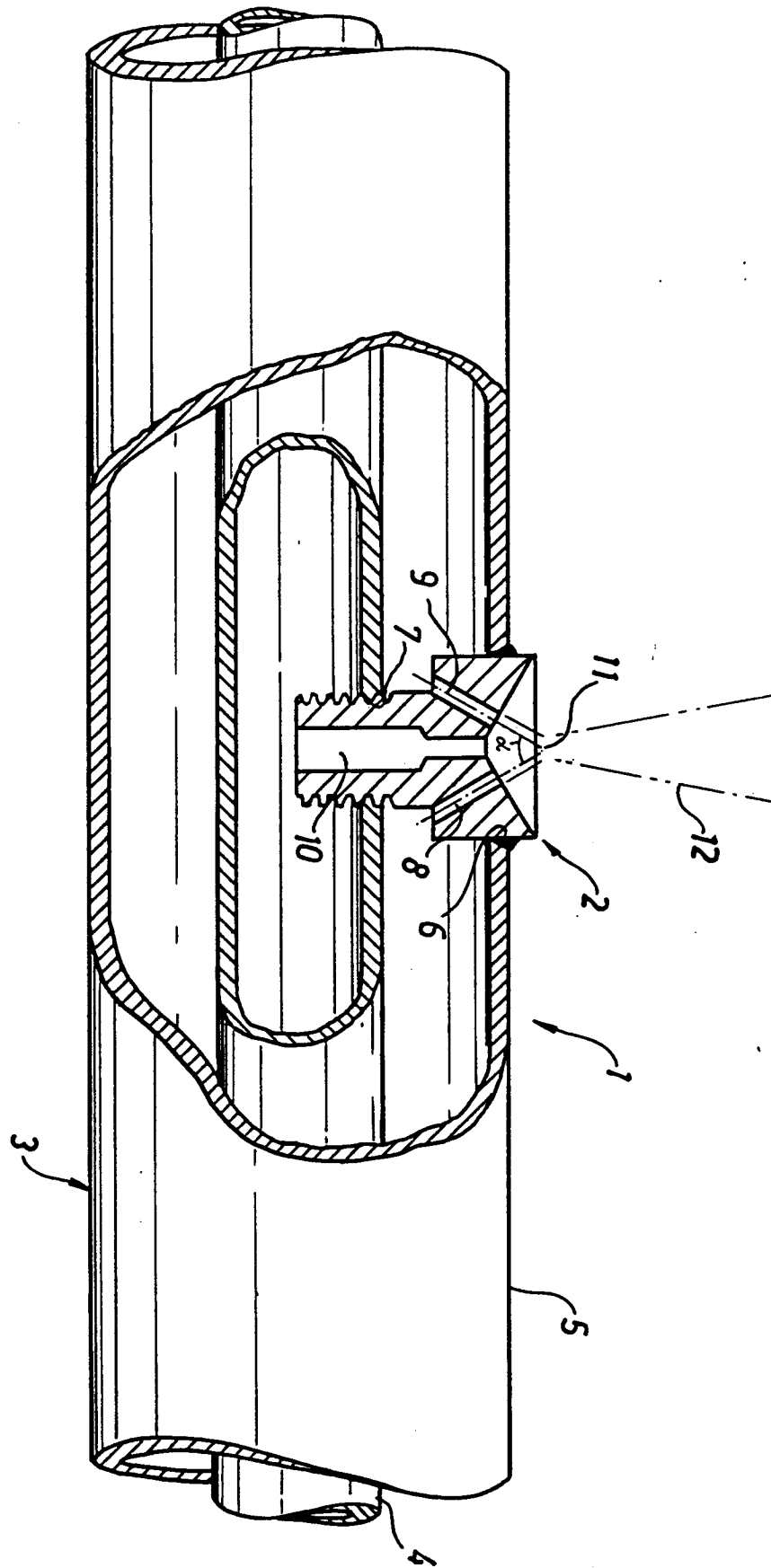


Fig. 1







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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 1288
Page 1

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.6)
A	US 4465230 A (ASH), 14 August 1984 (14.08.84) * figures 3,7,8, and adherent text *	1-10	F25C 3/04
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A	US 4194689 A (ASH), 25 March 1980 (25.03.80)	1-10	
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A	US 4593854 A (ALBERTSSON), 10 June 1986 (10.06.86)	1-10	
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A	US 2676471 A (W.M. PIERCE, JR), 27 April 1954 (27.04.54)	1-10	
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A	US 3814319 A (LOOMIS), 4 June 1974 (04.06.74)	1-10	TECHNICAL FIELDS SEARCHED (Int. Cl.6) F25C

The present search report has been drawn up for all claims			
Place of search STOCKHOLM		Date of completion of the search 22 May 1997	Examiner INGER LÖFVING
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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