(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 710 519 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.10.2006 Bulletin 2006/41

(51) Int Cl.:
F25C 3/04 *(2006.01)* ***B05B 7/00*** *(2006.01)*

(21) Application number: **06445012.5**

(22) Date of filing: **05.04.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **08.04.2005 SE 0500783**

(71) Applicant: **Lenko Snow AB**
831 03 Östersund (SE)

(72) Inventor: **Nilsson, Lennart**
831 03 Östersund (SE)

(74) Representative: **Modin, Jan**
Ehrner & Delmar Patentbyra AB
Box 10316
100 55 Stockholm (SE)

(54) A method and device for snow making

(57) A method and a device for the production of artificial snow are disclosed. The device is of the kind having a spray assembly (4) which is positioned relatively high above the ground and which comprises nozzles for ejecting pressurized water and air. The spray assembly is directed so that the flow is substantially horizontal. The spray assembly comprises, on the one hand, a central set of bulk water nozzles, providing a central, unitary bulk water stream (B) diverging along the main direction (A) and, on the other hand, a surrounding set of atomizing nozzles ejecting a curtain (C) consisting of air mixed with very small, atomized water drops, so called nuclei, which surround the central bulk water stream. The nuclei freeze into snow particles directly upon flowing out of the atomizing nozzles and merge thereupon with the bulk water stream, so that the snow particles rapidly grow into larger snow particles.

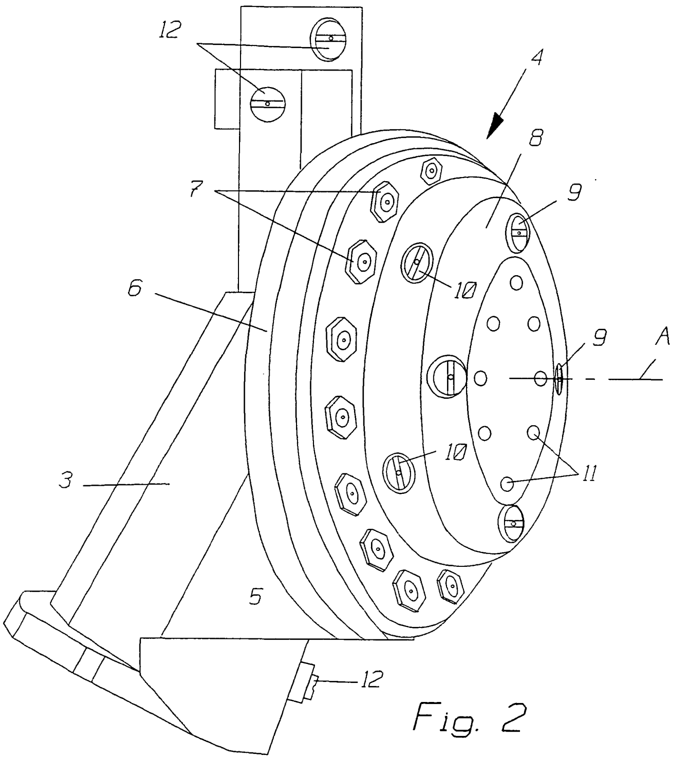

Fig. 2

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The invention relates to a device for the making of artificial snow by bringing pressurized water and air to flow from a spraying device. Various kinds of such devices are previously known, e.g. in the form of so called snow canons, where a strong fan provides a central, strong air flow in which water jets are injected inwardly-forwardly, or so called "sticks" having air and water channels communicating with a spray assembly located high above the ground, wherein water flows out in a sprayed beam while forming small snow particles, under the influence of adjacent air streams, said snow particles growing into larger snow particles before falling onto the ground. The invention relates to a device of the latter kind, comprising a spray assembly located relatively high above the ground, e.g. 3-10 m.

Prior art

[0002] In previously known devices of this kind, one normally uses spray heads having closely located nozzles for pressurized water and air, wherein an associated air nozzle, disposed adjacent to each water nozzle, is adapted to provide a sturdy air beam breaking the adjacent water beam flowing from the water nozzle so as to atomize the water into small drops which thereby freeze into ice or snow particles and grow into larger particles while interacting with the flowing, atomized water. See e.g. US-6,032,872, US-6,182,905 and US-6,547,157 (all in the name of Dupre).

[0003] A problem with such devices is that a large amount of pressurized air is required, thus consuming a great deal of energy, in order to sufficiently atomize the water sprays by means of the transverse water sprays, so that a desired capacity is obtained. Thus, the snow making becomes rather costly since the associated compressors require a high power. Furthermore, it is difficult to avoid that the artificially made snow has a high content of water in each snow particle at temperatures close to 0°C and at high moisture content of the ambient air. In this way, the snow becomes heavy and icy and is not suitable for skiing or snow boarding.

Summary of the invention

[0004] An object of the present invention is to reduce the required amount of energy when making snow by the method indicated above and to improve the snow quality by creating snow particles having a relatively low content of water and ice.

[0005] This object is achieved by a method and an apparatus, respectively, the features of which are defined in the appended claims. Thus, one uses a set of central water nozzles which together form a central, unitary bulk water stream which diverges along a main direction and which is driven forwardly along said main direction primarily by means of the water pressure, in combination with surrounding atomizing nozzles providing a plurality of surrounding, essentially in parallel to said main direction oriented beams composed of air and a mixture of very small, atomized water drops, forming so called nuclei, which form an external curtain which at least in a region adjacent to the spray assembly encloses the central bulk water stream, wherein these nuclei will freeze into snow particles, immediately upon flowing out from the atomizing nozzles, and thereupon join into the bulk water stream. Then, they rapidly grow into larger snow particles having a low content of water and ice.

[0006] According to the invention, the water is atomized into very small drops and are mixed with air, in the form of so called "nuclei", and not primarily by breaking the water jets by means of air streams. The central bulk water stream can hereby retain its flow energy to a large degree and be thrown further away from the spray assembly before it is transformed into snow particles by interaction with the nuclei. By way of the flow velocity of the bulk water stream, there is also created a static low pressure, which will cause the enclosing curtain of nuclei to be drawn inwardly towards the water in the bulk water stream.

[0007] In this way, it has turned out that it is possible to achieve the required capacity at a much lower energy consumption (compressor power) and thereby at lower cost.

[0008] The water jets should be formed as a planar layer, preferably diverging from the centre of the nozzle in order to achieve the best possible interaction with the surrounding nuclei curtain. Preferably, a large number of atomizing nozzles are provided in an outer ring, so that a curtain is obtained which is substantially continuous in the circumferential direction.

[0009] A very good operation is obtained if the nozzles are oriented such that the planar water jets are mutually parallel, preferably in different horizontal planes. Hereby, a uniform snow distribution is obtained and the aggregation of snow bumps or heaps is avoided. Moreover, this arrangement operates very well against the wind.

[0010] It has also turned out that the best possible operation is obtained if the bulk water stream is directed along a substantially horizontal main direction, which will provide the longest possible dwell time in the air for the growing snow particles before they reach the ground.

[0011] Further features and advantages will appear from the detailed description below of a preferred embodiment of a device according to the invention.

Brief description of the drawings

[0012]

Figures 1 and 1 a show, in schematic side views, a device for the making of artificial snow in accordance with the invention, wherein figure 1 a shows, in a larger scale, a spray assembly forming part of the device;

Figure 2 shows, in a perspective view, a first embodiment of the spray assembly;

Figure 3 shows the spray assembly according to figure 2 in a front view;

Figure 4 shows, in a perspective view, a second embodiment of the spray assembly;

Figure 5 shows the spray assembly according to figure 4 in a front view;

Figure 6 shows, in central longitudinal section, at a larger scale, an atomizing nozzle forming part of the spray assembly according to figure 3 or 4, and

Figure 7 shows, partially in a central longitudinal section and at a larger scale, a water nozzle forming part of the spray assembly according to figure 3 or 4.

Description of a preferred embodiment

[0013] The device shown in figures 1 and 1a comprises a device 2, anchored to the ground 1 in a manner known per se adjacent to a region to be covered by snow, having a mast 3, alternatively denoted "rod" or "stick", preferably extending obliquely upwards and being provided at the top with a spray assembly 4. The device 2 comprises various apparatus, including a pressurized water connection, which is coupled to a pump station for the supply of water under a relatively high pressure, normally 15-35 bar, and an air compressor for the supply of pressurized air at a lower pressure, normally about 5-7 bar, as well as an electric control circuitry for the device. There are separate conduits for pressurized water and air extending from the device 2 through the mast 3 up to the spray assembly 4, which is provided with a plurality of neighbouring nozzles for water and a mixture of pressurized air and atomized water drops, respectively, as will be explained further below. In figure 1a, there is shown schematically a central bulk water stream, which is directed forwardly along a main direction A (in parallel to the axis of the spray assembly), and an annularly surrounding curtain consisting of said mixture of pressurized air and very small water particles, so called sprouts or nuclei. The central bulk water stream diverges somewhat in the main direction A, but in an axial region R near the spray assembly, the curtain C, consisting of the nuclei and driven by the pressurized air, will enclose the central bulk water stream B.

[0014] In the region R, the curtain C has the shape of a cylindrical shell, which is substantially continuous circumferentially and which encloses the inner bulk water stream B, which diverges somewhat in the main direction A. In the curtain C there is a large amount of small nuclei, which are created, in a manner known per se, by atomizing nozzles (figure 6), so that a cloud consisting of a mixture of air particles and water particles will propagate in a direction in parallel to the main direction A. When the nuclei leave the atomizing nozzles in the spray assembly they expand momentarily and are cooled rapidly to a very low temperature (of the order of -20°C), so that they immediately chrystallize and form very small snow particles. This will occur already in the region R, i.e. before they join into the central, inner bulk water stream. When the substantially cylindrical curtain, containing very small snow particles, merge with the diverging bulk water stream, the small snow particles will interact with the water jets in the bulk water stream, so that the snow particles rapidly grow and form larger snow particles.

[0015] In order for this interaction to be effective, the water jets should be planar and preferably diverge as a fan.

[0016] Tests have shown that such a spray assembly, disposed relatively high above the ground, normally at a height of 3 to 10 m, will give a uniform distribution of snow on the ground adjacent to the device 2. The artificial snow will also have a high quality in that it is relatively light and has a low water content, namely in the order of about 400 kg per cubic meter.

[0017] The spray assembly according to the invention will now be described in detail with reference to the drawing figures 2 to 7.

[0018] The embodiment of the spray assembly shown in figures 2 and 3 consists essentially of an aluminium structure having a connection piece 5, comprising separate channels for water and pressurized air, a substantially circular, disc-like body 6 having an outer ring of atomizing nozzles 7 and a central head 8 with a number of water nozzles 9, 10 disposed in an annular arrangement. The central head 8 has a smaller diameter than the disc-like body 6. In a manner not shown, the atomizing nozzles 7 in the disc-like body 6 are connected to separate pressurized air and pressurized water channels, whereas the nozzles 9, 10 in the head 8 are connected to water channels only. On the drawing there are also shown a number of screws 11, by means of which the head 8 is fastened onto the disc-like body 6. The latter consists of number of different parts, which are mutually secured and mounted onto the connection piece 5. The spray assembly also includes four further water nozzles 12, disposed radially outwardly of the annularly arranged atomizing nozzles 7.

[0019] In the shown embodiment, there are eight water nozzles on the head 8, namely four nozzles disposed annularly around the axis A on an annular, chamfered portion of the head 8, so that they are directed obliquely outwardly from the axis A at an angle of about 20-30°. The remaining four water nozzles 10 are arranged on the substantially cylindrical outer part of the head 8 and are obliquely directed in such a way that they are forwardly directed at an angle of about 60° relative to the axis A.

[0020] The atomizing nozzles 7 in the disc-like body 6 are uniformly distributed in a circular ring, radially outside the head 8, and are all directed essentially in parallel to the axis A. The atomising nozzles 7 are of a larger number that the water nozzles 9, 10, namely 16 in the shown embodiment. See also the schematic view in fig. 3, seen from the front on the axis A. In this view, the outer water nozzles 12 are not drawn. In the embodiment according to figures 2 and 3, the water nozzles 9, 10 are directed in such a way with their elongated, slit-like orifices 91 (figure 7) that these slit-like orifices are oriented substantially tangentially along the circumference relative to the axis A. Hereby, the planar, diverging water jets from the water nozzles 9 and 10 will likewise be oriented with their planes oriented tangentially relative to imaginary circles extending through each ring of water nozzles. The nozzles 9 will thus form an inner ring, whereas the nozzles 10 form a second ring at a somewhat larger distance from the axis A.

[0021] Since the nozzles 9 and 10 are obliquely oriented in relation to the axis A, viz. with different angles (30° and 60°, respectively), the central bulk water stream from the water nozzles 9, 10 will diverge forwardly along the axis A (see fig. 1), so that the surrounding, essentially cylindrical curtain C with nuclei or small snow particles will reach and, partially through suction, merge with the bulk water stream somewhat outside the region R.

[0022] A second, modified embodiment of the spray assembly is schematically shown in figures 4 and 5, wherein the main difference is that the bulk water nozzles 9' are disposed in one single, inner ring with the slit-like outlet orifices being oriented in mutually parallel planes. The planar water beams will flow in five mutually parallel planes. Preferably, these planes are all horizontal, and such an arrangement has turned out to be especially advantageous by providing a very uniform distribution of the snow material on the ground, without any heaps in the form of bumps or humps, and this embodiment will operate very well even against the wind in that the mutually parallel flow layers are kept together even far away from the spray assembly.

[0023] As atomizing nozzles 7 one should preferably use nozzles of the kind disclosed in the published international patent application WO 9701392. In the nozzle, the pressurized air is led through a central, axial channel 71, whereas pressurized water is supplied via a cylindrical chamber inside the outer cylindrical wall 73 of the nozzle and via helical channels 74 into a whirl chamber 75 having a central, axial outlet orifice 76. From this orifice, a mixture of air and very small water particles flows outwardly as a diverging cone, so as to generate the above-mentioned sprouts or nuclei. The latter will expand substantially while flowing through the outlet orifice 76 and be transformed into very small snow particles, provided of course that the ambient temperature permits this. However, it is possible to produce snow particles in this way even if the ambient temperature is a few degrees above 0°C. A is well-known to those skilled in the art the humidity is also very important, and the drier the ambient air, the higher can the air temperature be and still permit the production of snow.

[0024] In fig. 7 there is shown a somewhat less complicated embodiment of the respective water nozzle 9, 9'. Here, only water is supplied under a relatively high pressure, typically about 20-30 bar, and the water flows out via an elongated, slit-like orifice 91, so that a fan-like, diverging, planar water beam is formed.

[0025] In this context, it should be mentioned that the atomizing nozzles, as shown in fig. 6, have been used previously in connection with snow making, namely in so called snow canons. Such snow canons operate quite differently than the present device. A snow canon has a strong fan which generates an air stream flowing through a cylindrical tube having a funnel-like opening. In this opening, there are a number of nozzle rings, which inject water beams into the air stream. A nozzle ring located closest to the opening are provided with the atomizing nozzles according to fig. 6, and the flow conditions are substantially different from those of the device according to the present invention.

[0026] In the device according to the present invention it has turned out that the diverging bulk water stream and the cylindrical, surrounding curtain with nuclei are maintained a relatively long distance axially from the spray assembly. It has also turned out that the cylindrical curtain with nuclei will be sucked radially inwardly towards the central bulk water stream, which can be explained by the fact that the latter has an axial main flow direction which, due to the axial flow, will provide a static lower pressure. Hereby, the curtain with its nuclei will merge very well with the central bulk water stream and generate good conditions for a rapid growth of the snow particles.

[0027] Provided that the air temperature and the relative humidity in the ambient air are sufficiently low, it is also possible to activate the outer water nozzles 12 (figures 2 and 4), and it has turned out that these water jets will also be sucked in towards the nuclei curtain and merge with the rest of the stream, so that these water jets from the nozzles 12 will also generate snow particles. Preferably, in a first step, only the atomizing nozzles 7 and the water nozzles 9 and 10 (and 9' respectively) are activated, whereupon, in a subsequent second step or in several subsequent steps, the outer water nozzles are activated. This can be done in response to a sufficiently low air temperature and/or a sufficiently low relative humidity in the ambient air. Alternatively, it is of course possible to control the flow continuously.

[0028] For a good yield the number of atomising nozzles should be substantially higher than the number of bulk water nozzles, so that the surrounding curtain with nuclei will be substantially continuous circumferentially. Advantageously, the number of bulk water nozzles are about 6 to 12, preferably 7 to 10, in particular 8, and the number of atomizing nozzles should be 10 to 30, preferably 14 to 20, in particular 16.

[0029] Those skilled in art may modify the shown embodiment in various ways. The rings with bulk water nozzles and atomizing nozzles may be configured in a different manner, for example in more elongated, preferably closed configurations, e.g. oval. However, it is essential that the atomizing nozzles surround the bulk water nozzles, so that the curtain with nuclei will surround the bulk water stream substantially all around circumferentially.

Claims

1. A method for producing artificial snow by bringing pressurized water and air to flow from closely located nozzles in a spray assembly (4; 4'), which is positioned relatively high over the ground, e.g. 3 to 10 m, wherein the water flows in a central bulk water stream (B), which is propagated forwardly along a main direction substantially by means of the water pressure, and generates, under the influence of radially surrounding, substantially in parallel directed beams consisting of air being mixed with very small, "atomized" water drops, so called sprouts or nuclei, small snow particles which grow into larger snow particles before they reach the ground, **characterized in that** said bulk water stream (B) and said air beams with mixed water drops are brought to flow through an integrated spray assembly having at least a radially inner ring of water nozzles and an outer radially surrounding ring of 10 to 30 atomizing nozzles, so as to generate a central set of planar water jets and a surrounding, circumferentially substantially continuously enclosing curtain of nuclei, which are generated in the atomizing nozzles and, directly upon flowing out therefrom, freeze into snow particles and, at a distance downstream of the spray assembly, merge with and interact with the planar water jets, whereupon the snow particles rapidly grow into larger snow particles.

2. The method defined in claim 1, wherein said merger of the nuclei (C) with the bulk water stream (B) occurs, at least partially, by way of the nuclei being sucked in towards the bulk water stream by a low pressure generated by the flow of the water jets.

3. The method defined in claim 2, wherein the bulk water stream (B) and said surrounding curtain (C) are directed along a substantially horizontal direction (A).

4. The method defined in any one of claims 1-3, wherein at least some of said water jets are obliquely oriented relative to said main direction (A), so that the bulk water stream (B) diverges.

5. The method defined in any one of claims 1-4, wherein, radially outwardly of said curtain (C), a number of further water jets are brought to flow in such a direction that these further water jets are mixed into the rest of the flow and thereby accomplish a further growth of said snow particles.

6. The method defined in any one of claims 1-5, wherein, initially, said central bulk water stream (B) is activated with a first feed pressure, e.g. at least 15 bar, and said curtain (C) is activated with a lower, second feed pressure, which is less than half of the said first feed pressure, e.g. not exceeding 7 bar.

7. The method defined in claim 6, wherein, after said initial activation of the bulk water stream (B) and said curtain (C), further water jets are activated radially outside said curtain in one or more subsequent steps.

8. The method defined in claim 7, wherein said one or more subsequent steps are activated in response to a lowering temperature and/or air humidity.

9. A device for the production of artificial snow, comprising pressure sources for pressurizing water and air, respectively, a spray assembly (4; 4'), which is connectable to said pressure sources and having at least two sets of adjacent nozzles for spraying pressurized water and air, respectively, along a main direction (A), and a holding arm (3) for carrying the spray assembly at least 3 m above the ambient ground, **characterized in that** the spray assembly (4;4') comprises an integrated casing (4;4') having at least a radially inner ring of bulk water nozzles (9,10; 9') adapted to spray a central set of planar water jets, and at least one outer, radially surrounding ring of 10 to 30 atomizing nozzles, so as form a central set of planar water beams and a surrounding, circumferentially substantially continuously enclosing curtain of nuclei, which are generated in the atomizing nozzles and, directly upon flowing out therefrom, freeze into snow particles and, at a distance downstream of the spray assembly, merge and interact with the planar water jets, whereupon the snow particles rapidly grow into larger snow particles.

10. The device defined in claim 9, wherein said main direction (A) is substantially horizontal.

11. The device defined in claim 10, wherein said inner ring (9,10; 9') is substantially circular.

12. The device defined in claim 11, wherein at least some of the bulk water nozzles (9, 10) are obliquely oriented in relation to the main direction (A) of said bulk water stream (B), so that the bulk water stream (B) diverges.

13. The device defined in claim 12, wherein the bulk water nozzles (9, 10) are arranged in two concentric inner rings and are obliquely oriented at different angles in relation to said main direction.

14. The device defined in any one of claims 9-13, where-

in the bulk water nozzles (9,10; 9') are adapted to generate water jets which are planar in one or more planes, which are mutually parallel and preferably substantially horizontal.

15. The device defined in any one of claims 9-14, wherein the bulk water and atomizing nozzles (7, 9, 10; 7, 9') are located and arranged in such a way that said enclosing curtain (C) of nuclei are at least partially sucked into the central bulk water stream (B) by means of a low pressure generated by the water flow.

16. The device defined in claim 9, **characterized in that** the number of atomizing nozzles (7) is greater than the number of bulk water nozzles (9, 10; 9').

17. The device defined in claim 16, wherein the number of bulk water nozzles (9, 10: 9') is 6 to 12, preferably 7 to 10, and the number of atomizing nozzles (7) is 10 to 30, preferably 14 to 20.

18. The device defined in claim 9, wherein a number of further water nozzles (12) are disposed radially outwardly of said atomizing nozzles (7) for injecting further water jets outwardly of said curtain (C) of nuclei.

19. The device defined in claim 18, wherein the device is adapted to operate in steps, namely by activating only the bulk water nozzles (9, 10; 9') and the atomizing nozzles (7) in a first step, and activating said further water nozzles (12) outwardly of said curtain (C) in one or more subsequent steps.

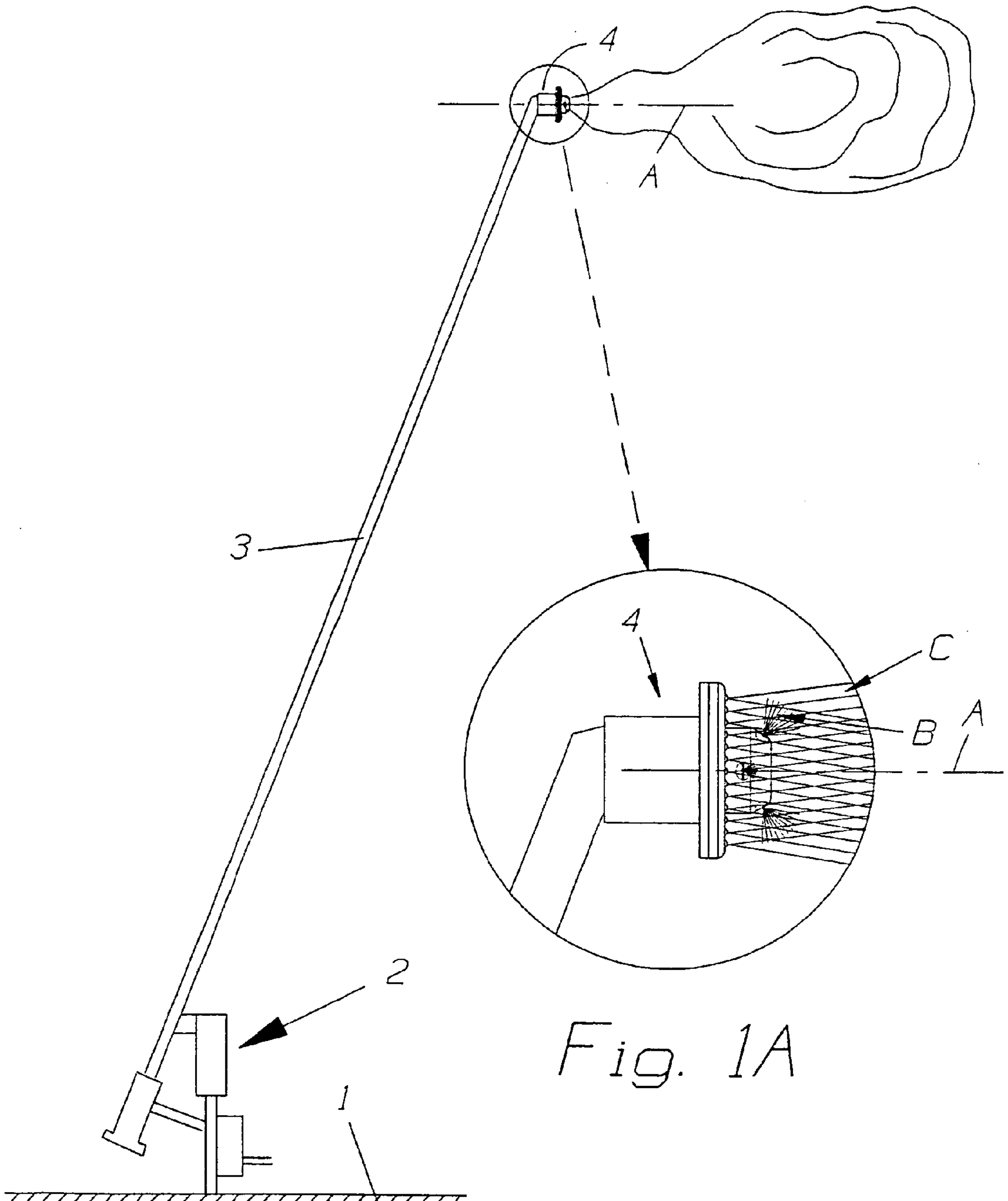

Fig. 1A

Fig. 1

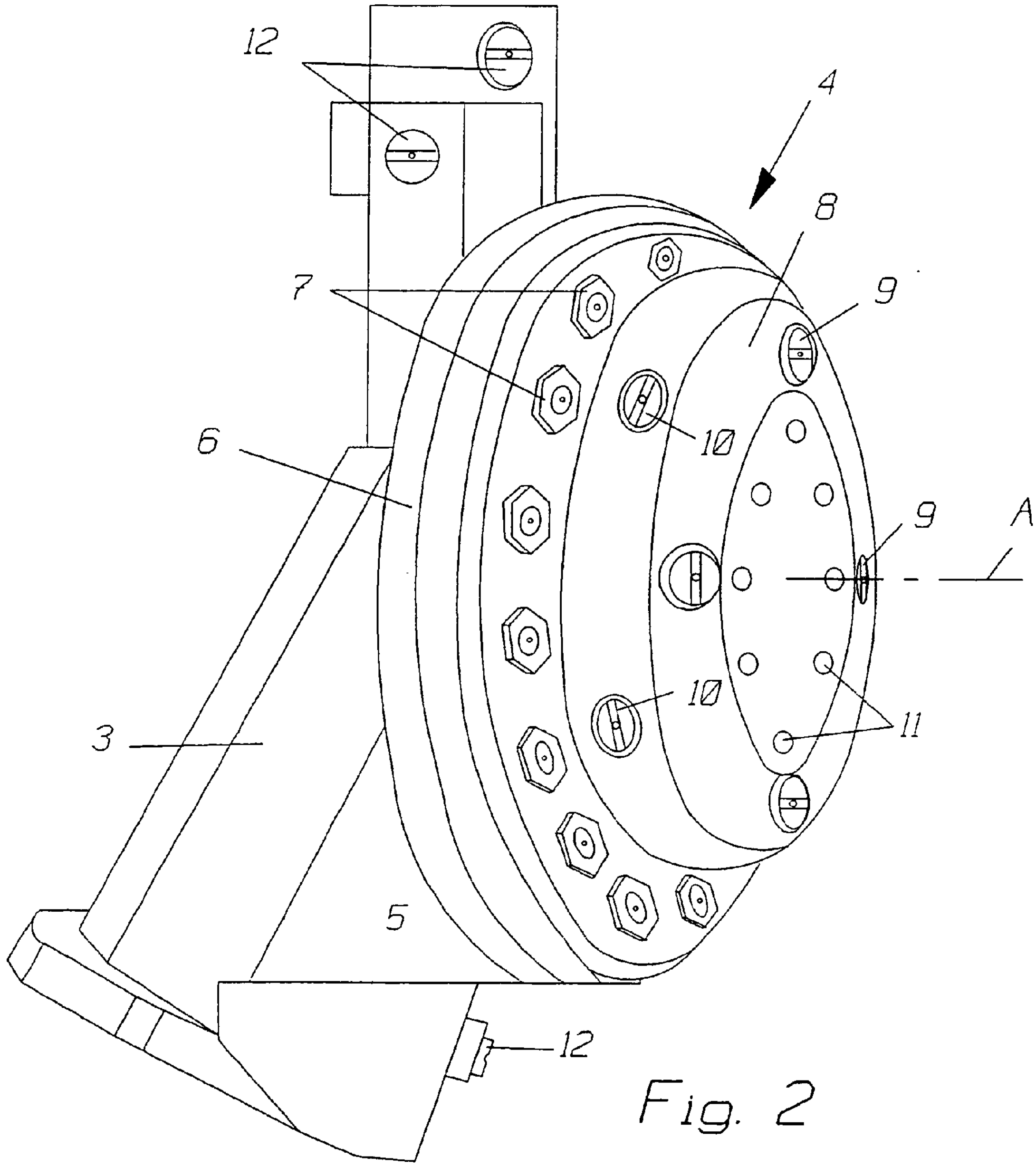

Fig. 2

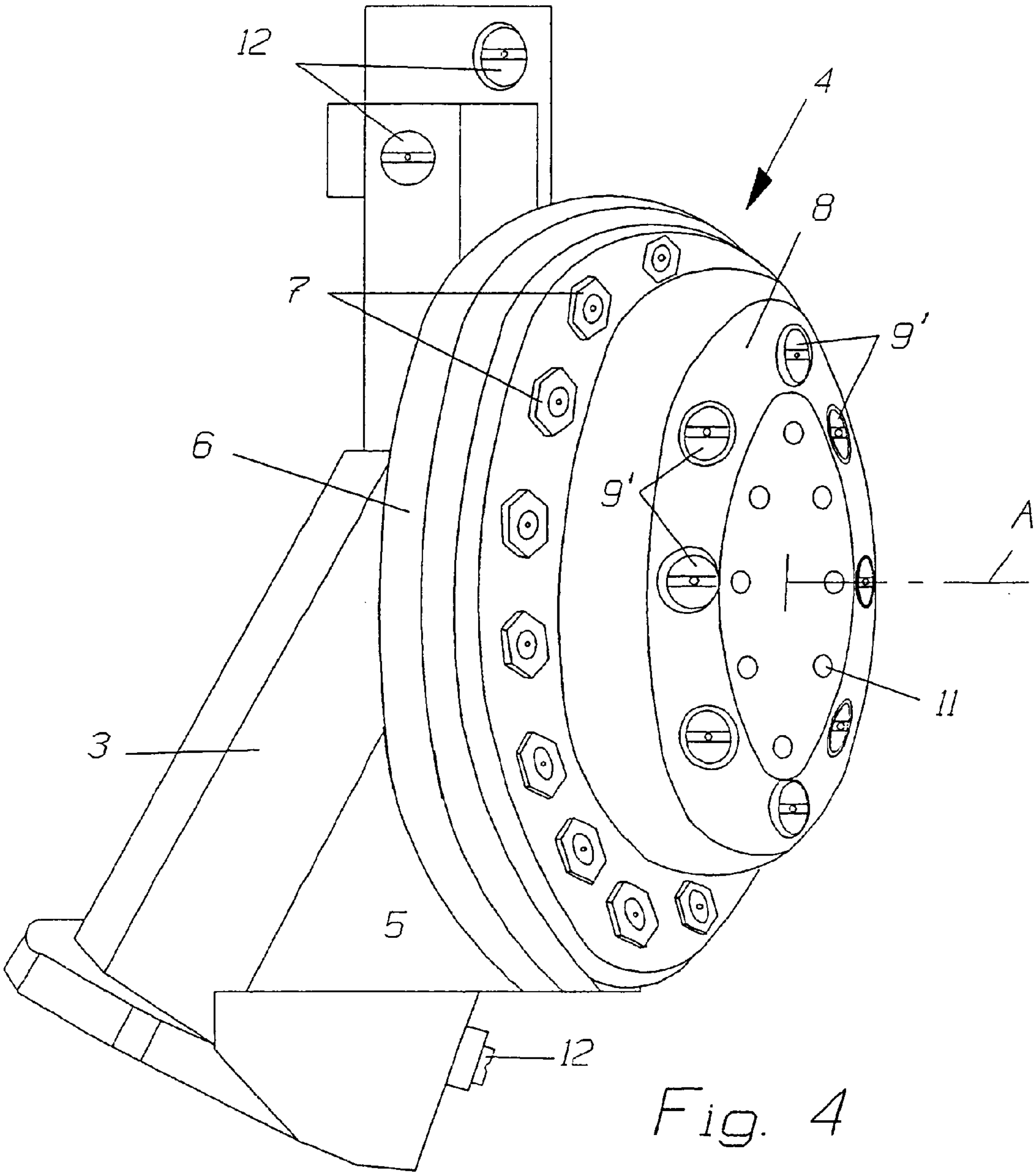

Fig. 4

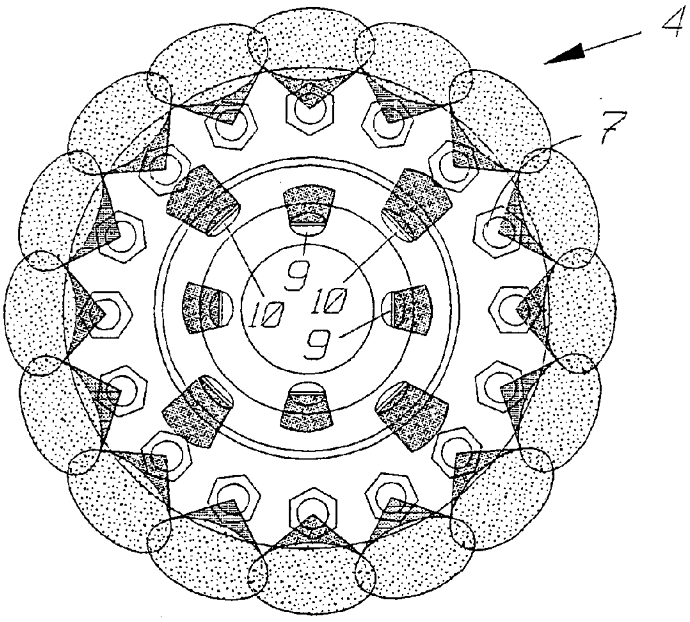

Fig. 3

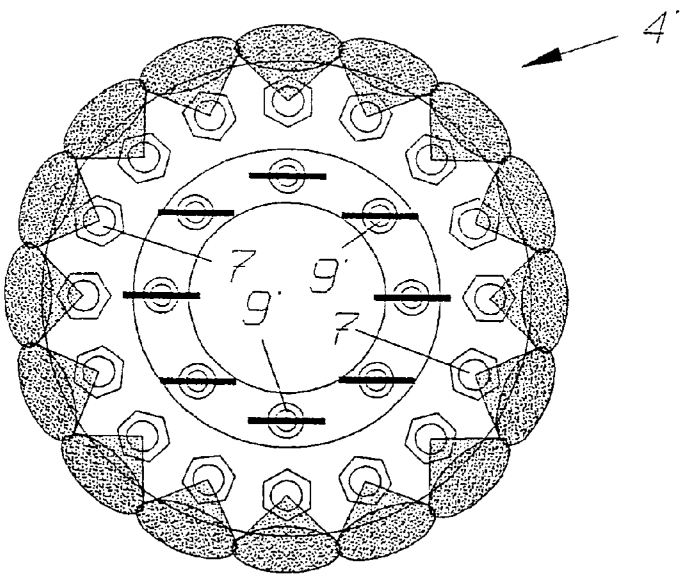

Fig. 5

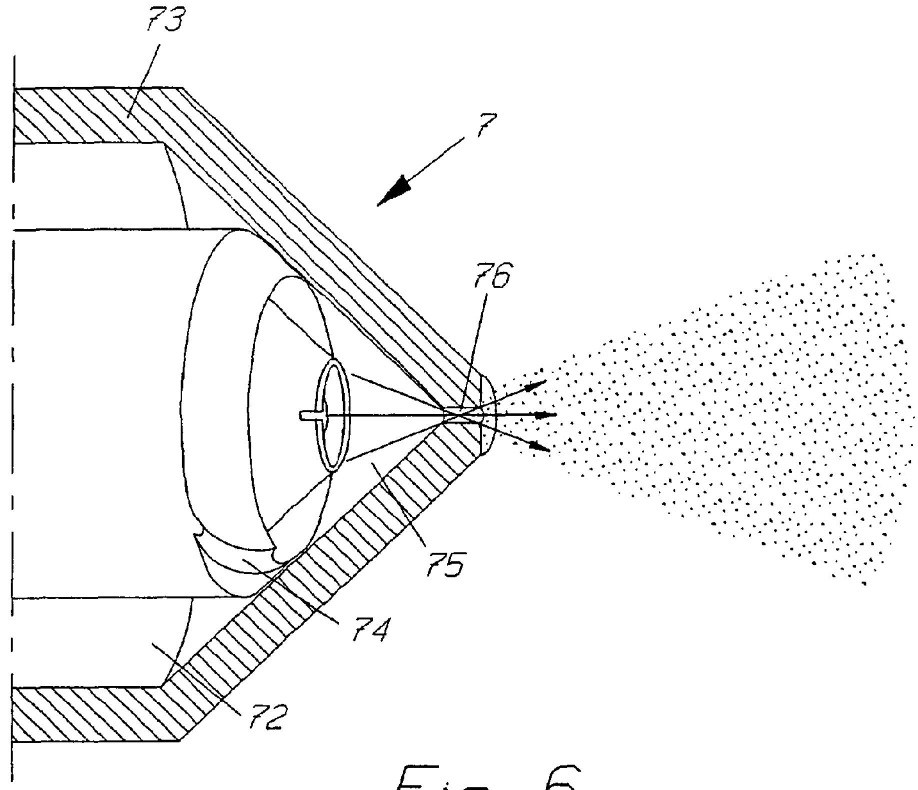

Fig. 6

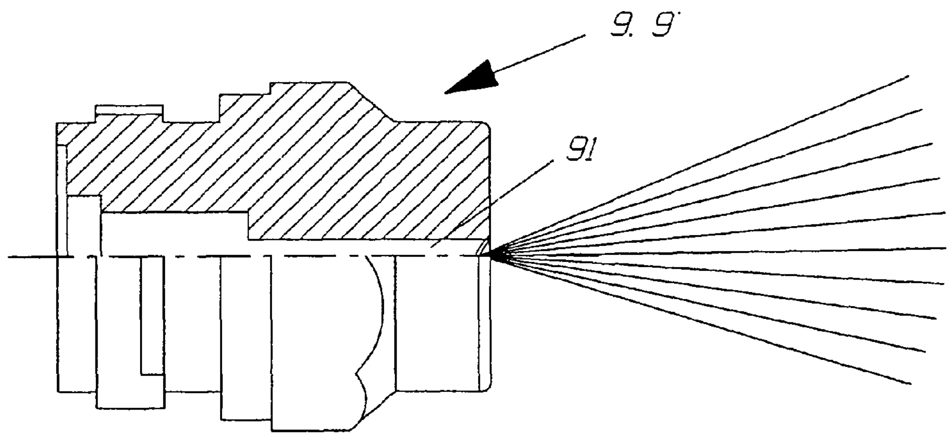

Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 44 5012

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 6 129 290 A (NIKKANEN ET AL) 10 October 2000 (2000-10-10) * the whole document * -----	1-3,5, 9-11,14 4,12	INV. F25C3/04 B05B7/00
X	EP 0 787 960 A (MARCANTONI, LUCIANO; MARCANTONI, IVANO) 6 August 1997 (1997-08-06) * figure 1 * -----	1,9	
Y	US 5 884 841 A (RATNIK ET AL) 23 March 1999 (1999-03-23) * figure 3 * -----	4,12	

TECHNICAL FIELDS SEARCHED (IPC)
F25C
B05B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	20 June 2006	Eberwein, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 44 5012

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-06-2006

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6129290	A	10-10-2000	NONE			
EP 0787960	A	06-08-1997	IT	VR960004	U1	04-08-1997
US 5884841	A	23-03-1999	AT	228635	T	15-12-2002
			DE	69809729	D1	09-01-2003
			DE	69809729	T2	18-09-2003
			EP	0977968	A1	09-02-2000
			WO	9849504	A1	05-11-1998

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6032872 A **[0002]**
- US 6182905 B **[0002]**
- US 6547157 B **[0002]**
- WO 9701392 A **[0023]**