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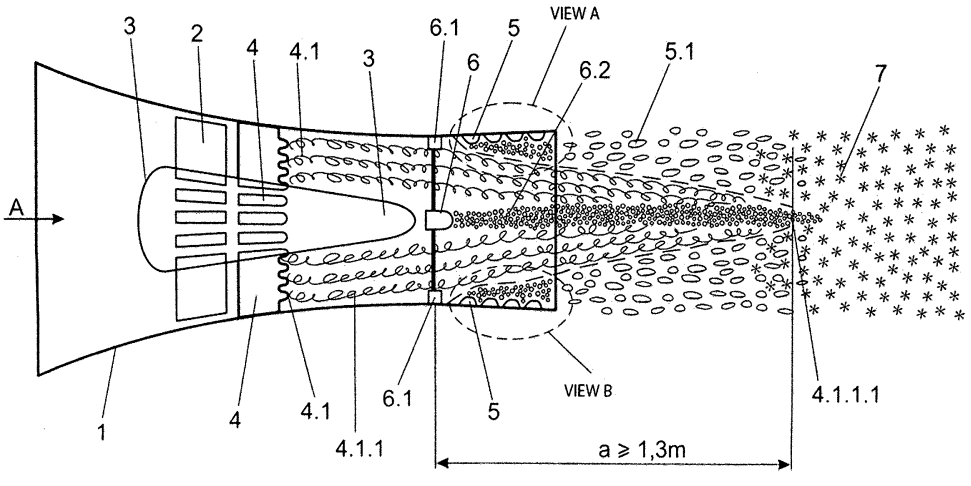
(54) APPARATUS FOR MAKING ARTIFICIAL SNOW

(57) The proposed invention is a new product, designed as an apparatus for making artificial snow - snow cannon, comprised of a certain quantity of assembled parts and assemblies, installed inside the snow cannon housing (1), inside the central part of which there is installed a special snow cannon electric motor 3, behind which as observed in the direction of air flow a nucleator 6 is positioned in the centre, immediately behind the tip of the electric motor stator's 3 aerodynamic shape, and at the air flow exit A there is a round tube with one or several annular segments 5.0.2 with water nozzles 5. The nucleator 6 ejects into the atomizing space small quantities of water under high pressure to create a water mist 6.2, that is a narrowly focused jet, which then mixes with the water droplets 5.1 coming from the water nozzles 5 at a minimum distance of $a \geq 1{,}3$ m. The mixing is made possible because the fan blades 2 create a strong enough vortex air flow 4.1.1, which mixes with the water 5.1 from the nozzles 5 and the icy water mist 6.2 from the nucleator no sooner than in point 4.1.1.1, and so in point 4.1.1.1 the icy mantle formed around supercooled water droplets 6.2 coming from the nucleator 6 is mixed with water 5.1, and in the continuation of the air flow A the mixture is converted into artificial snow 7.

Fig. 1



EP 3 040 657 A1

Description

[0001] Apparatuses for making artificial snow - the snow cannons - have not changed significantly considering the state of technology as determined upon their invention: they consist of a rotary part - the rotor - with a strong fan, and a stationary part - the stator -, formed as a whole together with the housing of the snow cannon in the shape of a hollow cylindrical body, through which air flow is forcibly ventilated. The gaseous air at the entrance of the fan forms a turbulent flow and picks up droplets of water at the exit, thereby making artificial snow at the exit from the apparatus. In order to make snow, it is necessary to ensure a proper environment or operate at an environmental temperature that is low enough to make snowflakes, created by blowing out cold air mixed with water droplets. Provided this process is well dimensioned and technically designed and it takes place in a proper environment, we are able to produce artificial snow for outdoor spaces, suitable for winter sports. The process is similar indoors, but we have to ensure a low enough temperature for the surfaces on which the artificial snow is deposited, so we use an additional technique of cooling the floors and the space (building) itself.

[0002] Another crucial technical factor for a successful use of snow cannons as apparatuses for making artificial snow is to ensure an adequate pressure of water and air as media for making snow, realized by means of pressuring the water into the apparatus by force and supplying air with a compressor. Based on this we discern high-pressure and low-pressure technical solutions and variants of apparatuses for making artificial snow.

[0003] In high-pressure artificial snow making apparatuses the air and water are mixed inside the cannon. It is basically a de Laval nozzle, in which compressed air under pressure of between 7 and 12 bar is mixed with water, and this compressed air at the same time also serves as process air and activator of crystallization seeds. The mixture of air and water is totally broken up in the nozzle under the influence of sound shocks, after which it rapidly leaves the nozzle driven by expansion. The compressed air also ensures the cannon's range. The disadvantages of this system are deafening noise and an enormous energy consumption. The advantage lies in the possibility to make snow at higher temperatures, as the mixture is supercooled upon expansion. Such cannons remain today in conditional use.

[0004] In low-pressure snow cannons, the compressed air only takes care of crystallization grains, but is not used as the driving medium. These cannons are divided into "giraffes", which will be described in detail later, and propeller cannons. Our innovative solution, described in this patent application, belongs among the latter group.

[0005] Such concept of artificial snow making and state-of-the-art has persisted to this day, whereby people, especially developers in the field of fluid technology, have perfected and technically improved the preparation of air and water as two crucial components for making artificial snow to the point where we can find many different variants of technical solutions for covering surfaces with snow by means of artificial snow making apparatuses.

[0006] In this context, there are different systems that are widely employed above all in open spaces serving as ski slopes for all kinds of winter sports. There are apparatuses for making artificial snow shaped in the form of elongated rods, rotating or fixed in space, and having at least one water nozzle through which water under pressure is fed. Different outflow systems have been developed, such as: outflow of water through a nozzle wherein the air is fed together with the water; outflow of water through the nozzle with the air being supplied around the nozzle; a number of nozzles arranged in one or several lines with air being supplied by means of one of the two already mentioned systems. The system of rods, also known as a "giraffe", has been developed in a dozen of different technical variants that are suitable for different terrains and surfaces being covered with artificial snow. In a "giraffe", the water nozzles are elevated as high from the ground as possible and water is then being ejected from them. The range in this system is ensured by the height of the support leg and the length of the exit neck into which water nozzles are inserted. These cannons also have atomizers blowing grains of ice into the basic jet in order to make snow.

The second technical variant of covering with artificial snow involves installing one or several pipes along the whole length of the terrain, or s part of the terrain that is suitable and must be covered with artificial snow. Exit nozzles are installed on the pipes in certain spacing, through which water under high pressure is pushed into space where the supercooled water turns into artificial snow. This system is suitable when we dispose with strong enough compressor devices, an unlimited supply of water and very low environmental temperatures. There also single-pipe or multi-pipe systems, erected vertically on the terrain, with bundles of nozzles installed at certain heights, through which a mixture of water and air is ejected to form water mist, which is then converted into artificial snow.

One disadvantage of all said systems lies in the fact that a significant part of water, up to 30 %, is lost in the form of sleet, which accumulates on the floor as ice and eventually encases in ice the apparatus itself, causing additional concerns and costs for the operators of these systems.

The most common technical solution uses a round hollow system into which a motor - fan is positioned as a separate apparatus with an additional compressor and water pump. Its function is to make high forces for pushing water as the main medium for making artificial snow. These are called low-pressure propeller-driven snow cannons, where the compressed air only takes care of crystallization grains, but is not used as the driving medium. In propeller-driven cannons the driving medium is external

air, accelerated by constant pressure blowers - fan propellers past the nozzles where the water mist is ejected. Right next to the nozzles are nucleators that blow out a mixture of compressed air and a small quantity of water. Once this mixture comes out of the nozzle, it freezes instantly and as these grains of ice arrive inside the basic jet of water and air, they are mixed with water droplets, which start accumulating around the grains as snowflakes.

[0007] The proposed invention is a new product for making artificial snow - a snow cannon with a modified system for supplying compressed air and water and system for mixing air and water, designed in the submitted patent application as a propeller fan, installed inside the housing of a snow cannon, composed of a very strong electric motor, designed with a special structure and shape according to a technical solution, presented in this patent application.

[0008] The second crucial innovative solution according to this patent application lies in the concept of the nucleater, positioned right behing the cone-shaped exit part of the motor's stator, onto which the propeller fan is installed. A constant small quantity of narrowly focused mist of water and ice grains is supplied into the basic jet of water droplets, obtained and supplied from the exit water nozzles.

[0009] The third technical solution rounding up our innovation is an arrangement of exit water nozzles which makes it possible for the exiting water jets not to overlap and to uniformly supply air pressure to the mouth of every nozzle for continually cutting the water jet at the mouth of the nozzle with air. We achieved this by changing the design and concept of the motor's stator into an aerodynamic dome shape, and by clamping it into the housing with two or more toothed blades, which carry out the function of creating maximum turbulence of air flows to create empty air space between the exits for water jets in the nozzles and the water mist created in the nucleator. At the exit of water flows we have positioned a segment with an increased number of water nozzles. We have also designed at least one ring-shaped segment onto which the water nozzles are installed. Each ring segement is controller individually for optimal water supply and the capability to adapt the quantity of water to the existing weather conditions. In the example of implementation, presented on the drawings below, we have used four ring segments, but the number of these can also be 1 + **n**, arranged in the form of a funnel with small number α when observed from the direction of air and water exits. In this way we have achieved maximum cutting of jet at the exit from the nozzle that is crucial for preventing the formation of ice in the area of ring segments.

[0010] The technical solution and fundamental innovation of our patent solution lies in the fact that we have achieved an optimum length of space where water from the nozzles is not mixed with the water mist, as observed along the direction of line of air, water and water mist from the nucleator. It is about the realization that we have achieved the formation of a snowflake around the ice mantle created around the water droplet upon exit from the nucleator. The main problem of low-pressure cannons lies in the crystallization grains being mixed into the basic mixture of water and air too quickly. Because of the short length the water droplets are unable to cool down adequately and a large part of ice grains is molten instead of serving as a nucleus around which a snowflake is formed. This phenomenon is known in the nature as sleet, where the atmospheric temperature is lower than the temperature of the water droplet. A thin ice mantle forms around the droplet, breaking upon impact with a solid object and the droplet freezes instantly. This is why large clumps of ice form at the water and air exit side during operation, making it difficult to work and operate the apparatus. The apparatuses are usually portable and are used on different localities of the terrain that has to be covered with artificial snow.

[0011] In our case, the problem was solved by the design of the cannon so that the ice grains meet the water droplets no closer than 1,3 m from the water nozzles, whereby the fan uses a relatively high dynamic pressure to create a hollow air cone inside the basic jet, into the tip of which the crystallization grain are blown in. The advantage lies in the fact that the water from the nucleator gets cooled down more compared to the other cannons, which do not have such a large mist jet from the nucleator, because more ice grains are used in the process compared to the snow cannons with a small jet coming from the nucleator. In the latter snow cannons, the ice grains are blown in too close to the water nozzles and as the water droplets are unable to cool down adequately, a large part of ice grains melt and fail to do its function.
The operating principle of propeller cannons making artificial snow from water mimics the natural process, but accelerates it greatly and the process looks like a fast-forwarded video of a snowflake forming in nature. The speed of formation causes the snowflake to "mutate", so it does not attain the magical form of complex geometrical shapes and instead looks like a miniature raspberry.

[0012] A strong fan provides large quantities of process air, into which as fine as possible water mist is blown through water nozzles. The air flow carries the mist into the air, removing the heat from it as it travels and "slowly" cooling the droplets to the mean temperature of process air - water mist mixture. We used the quotes because it all happens in tenths of a second and rarely a snowflake flies in the air for more than a couple of seconds.

[0013] As the water droplets fly in the air stream, they are relatively still as they are carried in the embrace of the jet. The droplets are only slower than the jet as they provide some air resistance. Owing to the relatively quiet flight, an ice mantle quickly forms on the droplet and insulates the inside from freezing. The outer parts of the mantle cool down significantly, but there is liquid water inside, and as this formation of liquid water wrapped in a thin layer of ice falls to the ground, the ice mantle breaks and it all freezes instantly. This phenomenon in the nature

is called sleet. It is therefore impossible to obtain snow in this way, only first-class ice.

[0014] The solution is to mimic the nature, which brings crystallization grains into the clouds and the snowflakes than form around these seeds. In snow cannons, the crystallization grains are provided by special nozzles known as nucleators, through which air under pressure with the addition of small quantities of water is blown out. Upon exiting the nozzle, the pressure of the air-water mixture falls abruptly by 4-6 bar and the mixture cools down instantly, forming an icy mist. These small grains are blown directly into the basic jet of water and air, so the snowflakes start to form around the icy mantle of water droplets coming from the nucleator. A chain reaction begins at once and snow is created.

[0015] The blowing of water mist into the basic jet is shown in Figure 1, which will be described in detail below. This is the most simple formulation and explanation of the conversion of water droplets into artificial snow by using the system of blowing water mist into the basic jet from the desired distance, where we optimally use the formation snow wrapping, created by the water droplet from the basic jet binding with an icy droplet from the nucleator.

[0016] Generally all the cannons up to our invention, presented in this patent application, have been blowing this icy mist into the basic jet way too fast and long before the point when the average temperature is established between the process air and the water ejected into it and where the conditions for the formation of snow are the best as the water has the lowest possible temperature. The rate of blowing in mist is evident from the pictorial materials on the websites of renowned world manufacturers of snow machines, such as: Sufag, Techno Alpin, Demac Lenko, SMI and other manufacturers around the world. For example, the American manufacturer of snow cannons Pole Cat has a solution that appears similar to ours, but the nozzles have too much impact power - pressure (kinetic energy), and the propeller is too weak (there is not enough dynamic pressure), so the droplets close the path of mist too quickly and the water is not yet cool enough to make snow well.

[0017] In researching the innovative idea from the aspect of applied patents we have discovered that there are tens of different patent applications, mostly related to different implementations and design solutions for clamping electric motors with fans, to systems for supplying water and air through the apparatus and different technical implementations of atomizers, diffusers that equate in our patent application to nucleators, and to different implementations with a round or polygonal exhaust system in which the water nozzles are installed.

[0018] We will present some of these patents, which we believe are close to our solution, but focus on the key technical characteristics and design solutions that do not concern our innovation presented in this patent application.

[0019] US 3761020 proposes a rod-type snow cannon with at least two exit nozzles and the capability of precooling the exit water and air, supplied through an additional double pipeline. Tens of patent applications around the world are similar to this invention, but the closest are the following patents: US 3010660, US 8535168 and WO2010025501.

[0020] EP 0977968 B1 also proposes a single vertical rod-type snow cannon with the nucleator places in the center, and the water nozzles arranged around a round pipe on the bottom side. The following already applied patents follow this invention with very similar technical solutions: CH 682 694 05, US 500 4151 and DE 40 33 310 A1.

[0021] The inventions mentioned above mainly deal with rod-type snow cannons having a nucleator or a different system for blowing in grainy mist and with different effects in the exploitation.

[0022] The closest to our idea solution is the invention applied under Nr. EP 011 29558 A1, proposing a snow cannon with tunnel air supply and forced circulation by means of an electric motor. In this invention, packages of water supply nozzles are inserted in a polygonal shape so the implementation example shows a heptagonal planar body with several sets of nozzles in the horizontal. Another characteristic of this invention is that water and air pressure are mixed in the supply pipe along the individual segments of planar assemblies.

[0023] The Canadian invention CA 2847320A1 proposes a snow making apparatus including the basic assemblies such as: collector, annular chamber-shaped nucleator and a set of water nozzles. The nucleator as an annular chambers is configured to receive the air-water mixture from the first discharge, whereby the first discharge is oriented tangentially to the direct mixture of air and water in the nucleator. The nucleator therefore consists of an annular chamber directing the water mist, a significant difference from our innovative idea of a nucleator.

[0024] All web videos of rival cannons mentioned above clearly show a strong turbulent flow of process jet. As soon as the jet leaves the snow cannon, heavy turbulence starts to roll and is clearly visible. All this begins on the stator blades.

[0025] The innovative touch of our technical solution, which deviates from the previously manufactured, patented and non-patented technical implementations and solutions of snow cannons lies in the fact that we changed the nucleator system and enabled the icy mist to mix with the basic jet at the point or directly behind the point where the average temperature of all elements in the basic process jet evens out.

[0026] To achieve this, we have proceeded as follows:

1. a high-performance fan with an adequate dynamic pressure was used to cut the water cone right next to the nozzles,
2. we used special nozzles using the Coanda effect to break water into smaller particles with low inertia

that are easier to carry by the air jet,

3. we installed a central nucleator unit, blowing icy mist through the empty space of the atomizer into the centre of the jet,

4. the electric motor's stator is clamped with toothed blades at the air pressure exit by making a wall on this side with one or several nipples to create maximum turbulence of air flows,

5. we installed 1+n ring segments with water nozzles, arranged in the shape of a funnel as observed in the direction of air and water exit, with a small opening angle α,

6. we arranged the water nozzles in the shape of a funnel so the ejected water jets do not overlap with the jets from the adjecent nozzles.

[0027] Owing to the high-performance propeller on the fan and low inertia of water droplets, droplets are drawn from the air nozzles along the path of the air jet and a 1,3-1,5 m long hollow cone with no water due to draft is formed in the middle of the air jet.

[0028] Central nucleators blow the icy mist directly into the tip of the air cone, to extend as much as possible the distance between the water nozzles and the point of contact with icy mist, giving the water the opportunity to even out the temperature with the process air. In our case, this distance exceeds 1,3 m and this is more or less a rule for all cannons.

[0029] This is why our snow cannon is significantly more capable and outperforms the competition in all parameters known to us. In Lech we made a test making artificial snow at -1,5 °C wet-bult temperature. No other propeller snow cannon is capable of that. The competitors start making snow between -2,5 °C and -2,8 °C. Comparable cannons use between 26-30 kW of power, and our cannon uses 21 kW at most. In Lech we only used 17 kW because the nozzle heaters could stay turned off due to warm weather.

[0030] The best competitors produce snow at -5 °C wet-bulb temperature using 120-150 l/min of water, while we are able to make the same snow using 190 l/min of water - a 25-60 % difference at 24-33 % lower power consumption.

[0031] The tests have proven that the snow cannon's energy consumption can be reduced by 2-2,5 kW while keeping the same performance. The essence of the technical solution according to our invention, proposed in this patent application, is that all or nearly all icy mist participates in making snow. In addition to thermodynamically improving the performance, we have also improved the aerodynamics at the exit of the water jet and further of snowflakes of artificial snow, blown out by our snow cannon. We achieved this by giving the first segment next to the nucleator the smallest radius, the second segment a larger radius and so forth, so the necessary quantity of ring segments are arranged in the shape of a funnel.

[0032] In the products of manufacturers using blowing in of icy mist at a distance of 50 cm from the water jet, only a small part of the icy mist participates in making snow, i. e. the particles that accidentally hit a sufficiently supercooled wate droplet or are able to drift far enough from the snow cannon through empty space between the droplets to hit a cool enough water droplet. All other grains of ice simply melt upon contact with water that is too warm. Up to 75 % of icy grains from the water mist are wasted in this way.

[0033] Using our concept of snow cannon with a special aerodynamic shape of the electric motor's stator, a funnel-shaped arrangement of ring segments and the technology of manufacturing the nucleators, and further with the arrangement of water nozzles and individual activation of ring segments with water nozzles we have reduced the financial burden to our users, as we have managed to largely reduce the manufacturing costs and thereby the products cost, on the other hand raising the technical level of the snow cannon, so it uses less energy for better results.

[0034] On the other hand, considering the maintenance work after a long period of operation, we have reduced it to a minimum effort for preventive check and maintenance, as the water nozzles in the exit tube wear less due to infrequent icing up. For this purpose we installed additional heating of these nozzles, which is not a subject of this patent application.

[0035] The servicing procedures are simplified and the servicing costs are considerably lower, influencing the technical recognisability of our snow cannon, made with a special electric motor, nucleator and exit tube with annular segments having installed 1+n water nozzles according to the present patent application.

[0036] What has been written above is a fact and it is certain that nobody to this day has created such a design concept of a snow cannon, which is on the one hand simple to manufacture, and on the other hand enables proper and long-lived exploitation in extreme environments where such apparatuses operate. Some design solutions on the electric motor and its clamping into the structure, on the nucleator and the exit tube with annular segments with nozzles, described in detail later as we describe the individual parts, are presented in Figure/Drawing 1, and a detailed overview of the concept of annular segments and the arrangement of water nozzles on them are presented in Figures 2 and 3.

[0037] On the other hand, by researching the known technical solutions for similar apparatuses on the global level we have come to a conclusion that our solution is unique and presents a novelty in this field, as shown in this patent application and its patent claims.

[0038] The main novelty is in a different design and solution of technical problems that surfaced during the design process because the bar was set very high, but this is the most important characteristic of designing the new way of using the bearing blades of electric motor stator, the simplicity of the nucleator's design, reflected in the perfection and achievement of the set goal and the form-technical installation of annular segments and wa-

ter nozzles in the exit tube of the snow cannon, which makes it entirely possible to cut the water jet at the nozzle exit, but without hindering or influencing the operation of nearby nozzles. At the same time, the product is highly commercially viable and has been widely implemented on all ski slopes owing to the unexpected results, usability and quality, which make it possible to operate at higher environmental temperatures, where similar products only work with half the efficiency rate and consume more energy.

[0039] We will present our invention using the Drawing 1, showing the side view of our snow cannon, consisting of a round hollow strong housing into which an electric motor with strong fan blades is inserted, its blades being adapted by design and shape to the required capacity for an optimum production of artificial snow, a nucleator for creating the water mist, and at the exit a tube with water nozzles. Furthermore, we will use Drawings 2 and 3 to present the technical solution of individual annular segments and the arrangement of water nozzles thereon.

[0040] To better understand the announced short description of fundamental drawings of our innovative idea, realised in the form of a snow cannon and its fundamental assemblies as a breakthrough product, developed based on the design of our innovative idea, presented in this patent application, and its drawing, described later in the text.

Drawing 1: Side view of the snow cannon

Drawing 2: Cross-sectioned side view of water rings with individual supply of nozzles on the segment

Drawing 3: Developed view of annular segments with the arrangement of water nozzles

[0041] To better understand the individual terms and the elements of individual assemblies, we are going to list below the positions and the related terms and names of individual parts,

A -	direction of air flow
a -	minimum size of hollow dry air mixture cone
1	snow cannon housing
2	fan blades
3	snow cannon electric motor
4	electric motor stator attachment blades
4.1	toothed side of a stator blade with air nipples
4.1.1	mixture of positive pressure and negative pressure boundary air layer
4.1.1.1	cone-shaped turbulent flow of water mist
5	water nozzles
5.0.1	water supply pipe
5.0.2	annular segment
5.0.3	system for mutual interlocking of segment rings
α	segment ring opening angle
5.1	water droplets
6	nucleator
6.1	water supply to nucleator
7	artificial snow

[0042] Drawing 1 presents the side view of our invention, the assembled snow cannon with a round hollow housing 1, inside of which an electric motor 3 is installed with at least two stator attachment blades 4. On the electric motor 3 on the air entry side 3 there is a fan with blades 2, designed by structure and shape so as to ensure an optimum air flow A through the housing 1 of our snow cannon. When observed along the horizontal in the direction of air flow A, the stator of electric motor 3 is shaped aerodynamically, with the nucleator 6 positioned immediately after its tip, connected to the housing 1 with at least two tube-shaped attachment supports, through which water is delivered to create water mist 6.2. Continuing the description of the horizontal view of our Drawing 1, there is a tube at the exit of the snow cannon with several rows of annular segments 5.0.2, presented in Drawings 2 and 3, through which jets of water and water droplets 5.1 under high pressure are supplied. The water nozzles 5 are arranged about the round circumference of tube or annular segment 5.0.2, Drawing 3, being a part of the housing 1 of our water cannon in at least 1 + n configuration. The point of this non-uniform arrangement lies in the fact that the nozzles blow out the water jet 5.1 during the operation phase without hindering the water jet at the next nozzle 5, observed in the direction of blowing out. Another key characteristic is cutting the water jet 5.1 right at the exit from nozzle 5 due to the turbulence, the pressure of air flows 4.1.1 and the designed arrangement of annular segments 5.0.2 under angle α shown in Fig. 2, representing the opening angle of funnel-shaped segment rings and spanning the range from 2-8 degrees.

[0043] This is necessary to achieve the minimum distance **a**, representing the minimum size of the hollow dry air cone of 1,3 m, the air mixture necessary to achieve the optimum mixture of water 5.1, Drawing 1, coming from nozzles 5, with the water mist 6.2 coming from nucleator 6, and the vortex air flows 4.1.1 or a mixture of positive pressure and negative pressure boundary air layer coming from the electric motor 3. The icy mixture shown in Drawing 1 is formed in the tip of the cone-shaped turbulent flow of water mist 4.1.1.1: at this distance we have achieved such a temperature drop of ice mantle around the water droplets in the mist 6.2 that ice balls are easily formed from the water mist 6.2 by means of the air flow 4.1.1, onto which water droplets 5.1 bind to form snowflakes 7. For a better understanding we will present the thermodynamics of air 4.1.1 and water flows 5.1 and 6.2, which form at the mouth of our snow cannon.

[0044] The vortex air flow on a classic stator is caused by the effect of fan blades 2 up to the separation of the boundary air layer 4.1.1. A stagnation rotor - vortex flow, hereinafter referred to as the rotor - is formed on the last edge of the stator, with the amplitude equal to the thickness of the boundary air layer 4.1.1. The number of rotors

of mixture of positive pressure and negative pressure boundary air layer 4.1.1 precisely equals the number of stator blades 4, and they emit a sound similar to wind howling over a slightly thicker steel wire. These stagnation rotors of the mixture of positive pressure and negative pressure boundary air layer 4.1.1 create a larger rotor, and the jet exiting from the cannon has a turbulence with the number of basic rotors of mixture of positive pressure and negative pressure boundary air layer 4.1.1 equal to the number of stator blades 4. This mixing by all means wastes a lot of energy, and there is also the disadvantage of losing the heaviest droplet from the jet, as the centrifugal force throws them out of the jet and they fall down as extremely wet snow 7. The issue is solvable, but at the expense of the total efficiency and above all the range of the snow cannon. This turbulence can be clearly seen on the basic websites of companies Sufag and Demac Lenko, where the snow cannons are abundantly throwing snow into the clear skies, but this is pure turbulence and nothing more.

[0045] In our new product, manufactured according to this patent application as a prototype for the purposes of testing and presented in Drawings 1, 2, and 3, we made at least three rounded teeth - nipples 4.1 at the exit edge of every stator blade 2. In our case too there is a separation of boundary layer and the mixing of positive pressure and negative pressure boundary air layer 4.1.1 on the negative pressure of stator's blades 4, but these teeth-nipples 4.1 make sure the mixing of positive pressure and negative pressure boundary layer 4.1.1 is somewhat longer. The additional energy compresses the negative pressure boundary layer/the mixture of positive pressure and negative pressure boundary air layer 4.1.1 back to the blade 4 and the mixing of both layers yield enough energy to rotate the mixing branch/the mixture of positive pressure and negative pressure boundary air layer 4.1.1 at the teeth/nipples 4.1, so it leaves the tip of the tooth/nipple 4.1 in the shape of a small vortex 4.1.1. Considering every blade 4 has three teeth 4.1 and there are thirteen blades, there are 39 small rotors or mixtures of positive pressure and negative pressure boundary air layers 4.1.1 at the exit of the snow cannon, which are compressed and small enough to mimic laminar flow.

[0046] The fact that our cannon directs the air flow better is revealed by a surprising characteristic: if our cannon is observed during operation and compared visually to competitors' products or our older products, one gets a feeling that its capacity must be at least 2/3 lower and its range considerably shorter than for any competitor product. But the reality is completely the opposite and we explain it with the fact that our jet flies a lot less turbulently and there are a lot less opportunities that one of the snowflakes shines in the sun, because they are simply not being spun around and they do not face the sun several times a second. We have proven this by testing our snow cannon in Lech, where the air flow was seen to be completely laminar at least at a distance of **a** = 1,5 m away from the cannon. A careful observation reveals a slightly richer pillar in the middle of the jet 4.1.1.1, Drawing 1, these are the crystallization grains 6.2 blown out with the compressor. The crystallization grains 6.2 and the water droplets 5.1 meet directly in point 4:1.1.1, where the basic jet is then rotated into artificial snow 7.

[0047] This solution is important to establish an as long as possible hollow dry cone 4.1.1 in the basic jet, surrounded by the external water jet 5.1 and the internal water mist 6.2. Drawing 2 shows the design of the tube with four segment rings 5.0.2 into which the water nozzles 5 are installed, as well as their individual connections to the pipes 5.0.1 that deliver the water to the nozzle 5. The essence of this solution lies in the fact that we are able to design the snow cannon with as many annular segments 5.0.2 as demanded by the user. Observed in the direction of air flow A, Drawing 1, these annular segments are arranged in the shape of a funnel with opening angle α, representing the spreading angle of inclination of segment rings and designed to be in the range between 2 and 8 degrees. The two annular segments 5.0.2, Drawing 2 and 3; are attached with special self-tightening clamps'5.0.3, which also make it technically possible to adjust/regulate the inclination angle α.

[0048] The second and very important innovative solution is non-uniform line arrangement of water nozzles 5, shown in Figure 3, where the water jet from the nozzle 5 does not overlap with the jet from the adjecent nozzles 5. In this way we have achieved the maximum spread of water droplets 5.1, as shown in Drawing 1, which then bind in the continuation of exit path to icy water droplets 4.1.1.1, ejected under pressure by means of a compressor through the nucleator 6. By testing and regulating the water pressures the compressor air pressures and the air vortex flows 4.1.1, Drawing 1, we have ascertained the optimum distance/spot for mixing of icy water droplets 4.1.1.1 and water droplets pushed out by water pumps is at least **a** = 1,3 m.

[0049] The text above only describes concrete parts of our snow cannon and compares it to similar apparatuses, which are already in operation but only offer a very short range of water mist jet. Our snow cannon has been made according to this patent application and has been realised with the described key parts, as presented in the implementation case and substantiated with the attached drawing and its details - views A and B. The implementation case represents a snow cannon with an electric motor - fan, connected to the housing of the snow cannon by means of thirteen stator blades, a nucleator and an exit part for air and water, looking like a tube made of annular segments, into which nozzles for discharging water at high pressure are positioned.

[0050] The operating principle of all the above mentioned parts can be summarized as follows: the water from the reservoir is supplied through pumps and filters at high pressure to the nozzles, where it is atomized and supercooled in an air flow at the temperature under 0 °C. Supercooled rain is formed, known from the nature as sleet, or from aeroplanes where a supercooled droplet

hits a wing and freezes onto it. This is taking place on the outer nozzle ring, where there are several nozzle ring that can be activated partially according to the requirements to change the water/air ratio.

[0051] In the centre behind the aerodynamically shaped electric motor's stator there is a nucleator-atomizer, where a small quantity of water is mixed with the air from the compressor to produce a mist, that is injected into the air flow created by the fan's propeller, situated behind all the nozzles.

[0052] The fan is considerably stronger compared to the known systems and pushes the water water droplets from the nozzles (outer rim) and the mist from where it is formed considerably farther than the existing systems. As they travel this longer distance, the water droplets are supercooled considerably more than in the existing systems, and as they come in contact with the mist from the nucleator in the space for water mist atomization (acting analogous to crystallization seeds in cooling of molten metal or dust particles in cloud formation), the state of matter immediately changes from water to snow. This releases the so called latent heat, which prohibits snow from forming if the water droplets are not supercooled enough. The water droplets are supercooled by extending the path of mixing with the water mist from the nucleator. In the case of our patent application, the minimum length is 1,3 m.

[0053] In other systems, where the water droplets travel a shorter path, the droplets are not supercooled as much and a lower environmental temperature is required to make snow. The new system, proposed in this patent application, is therefore able to operate at higher environmental temperatures, which represent a constant problem at the ski resorts. This is why snow is usually made only during the night and if the night is not cold enough, there will be no snow. According to the finding from our field tests, the cannons manufactured according to our innovative solution are able to make snow at no less than 30 % higher temperatures/warmer atmosphere than the other snow cannons known to us. The tests have revealed we are able to make snow at -1,8 °C, while the others are unable to start making snow over -2,6 °C. This is a 30 % difference or, put otherwise, at -5°C we are able to make at least 30 % more snow than our competitors spending approximately the same amount of energy and water. The difference is even higher, but some back-up capacity will probably not hurt.

[0054] The advantage of our system compared to the existing systems lies in its ability to work at higher environmental temperatures, it produces more snow, it can be arbitrarily adjusted (by activating/deactivating the rings with water nozzles), and there is no regulating of water pressure as in other systems that is very expensive.

Claims

1. *Apparatus for making artificial snow - snow cannon* ***is designed so*** *it is comprised of a certain quantity of assembled parts and assemblies, installed inside the snow cannon housing (1), inside the central part of which there is installed a special snow cannon electric motor (3), behind which as observed in the direction of air flow a nucleator (6) is positioned in the centre immediately behind the tip of the electric motor stator's (3) aerodynamic shape, and at the air flow exit (A) there is a round tube with annular segments (5.0.2) onto which one or several water nozzles (5) are installed).*

2. *The apparatus for making artificial snow - snow cannon, according to Claim 1* *is designed so* *the electric motor (3) installed inside the apparatus is attached with no less than two attachment blades (4), having on their exiting side, as observed in the direction of air flow A, one or several air nipples (4.1).*

3. *The apparatus for making artificial snow - snow cannon, according to Claim 1* ***is designed so*** *there is an electric motor (3) installed inside it functioning as a fan, having strong fan blades (2), adapted to the internal hollow circumference of the snow cannon's housing (1).*

4. *The apparatus for making artificial snow - snow cannon, according to Claim 1* ***is designed so*** *that at the centre of air flow there is a nucleator (6), connected to at least two pipe supports (6.1), through which water is being fed to the nucleator (6).*

5. *The apparatus for making artificial snow - snow cannon, according to Claim 1* ***is designed so*** *that at the exit of the air flow A there are one or several annular segments (5.0.2) installed inside a round tube, having installed one or several water nozzles (5) arranged so the water jet and the water droplets (5.1) do not hinder the water jets from the other nozzles (5).*

6. *The apparatus for making artificial snow - snow cannon, according to Claim 1* ***is designed so*** *that one or several annular segments (5.0.2) are positioned as observed towards the exit of air flow (A) to form a funnel with angle α, representing the spreading angle of inclination of segment rings and designed to be in the range between 2 and 8 degrees.*

7. *The apparatus for making artificial snow - snow cannon, according to Claim 1* ***is designed so***

that the clamping of two annular segments (5.0.2) is implemented using special self-tightening clamps (5.0.3), which also make it technically possible to adjust/regulate the inclination angle α.

8. *The apparatus for making artificial snow - snow cannon, according to Claim 1*
is designed so
that multiple water nozzles (5) arranged in a line form a segment or a ring (5.0.2), which may be fed with water (5.1) independently from the other segments (5.0.2), so the operation of individual annular segments (5.0.2) can be activated or deactivated independently of the other annular segments (5. 0.2).

9. *The apparatus for making artificial snow - snow cannon, according to Claim 1*
is designed so
*that the annular segments (5.0.2) with one or several water nozzles (5) according to the configuration 1+**n** can be positioned inside the housing of the snow cannon (1).*

10. *The apparatus for making artificial snow - snow cannon, according to Claim 2*
is designed so
that the function of air nipples (4.1) is to create and whirl the air flows (4.1.1) of the mixture of positive pressure and negative pressure boundary layer.

11. *The apparatus for making artificial snow - snow cannon, according to Claim 4*
is designed so
*that the nucleator (6) ejects - feeds into the atomizing space small quantities of water under high pressure to create a water mist (6.2), that is a narrowly focused jet, which then mixes with the water droplets (5.1) coming from the water nozzles (5) at a minimum distance of **(a)** = 1,3 m.*

12. *The apparatus for making artificial snow - snow cannon, according to Claim 9*
is designed so
*that the mixing of water mist (6.2) from the nucleator (6) with the water droplets (5.1) from the water nozzles (5) is realised at a minimum distance of **(a)** ≥ 1,3 m, because the fan blades (2) create a strong enough vortex air flow (4.1.1), which mixes no sooner than in point (4.1.1.1) with the water (5.1) from the nozzles (5) and the water mist (6.2) from the nucleator (6).*

13. *The apparatus for making artificial snow - snow cannon, according to Claim 10*
is designed so
*that in point (4.1.1.1) the ice mantled supercooled water droplets (6.2) flowing from the nucleator (6) are mixed with water droplets (5.1), and in continuation of the air flow (**A**) at a distance of **a** ≥1,3 m are converted to artificial snow (7).*

Fig. 1

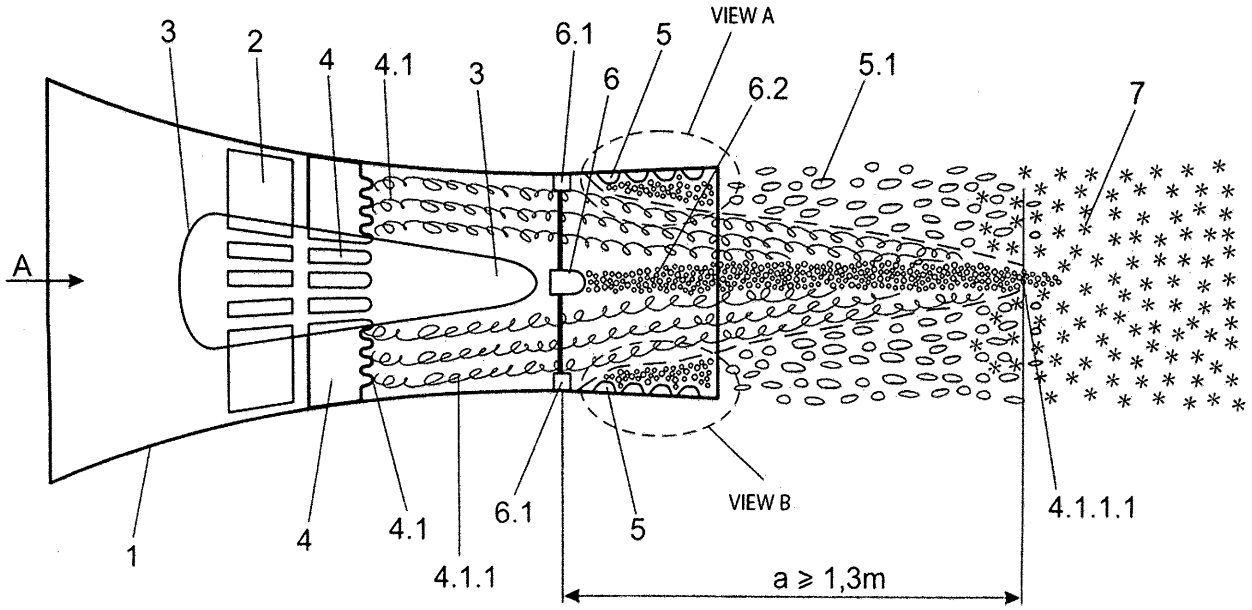


Fig. 2

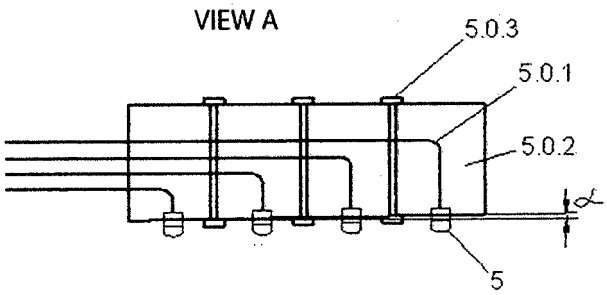
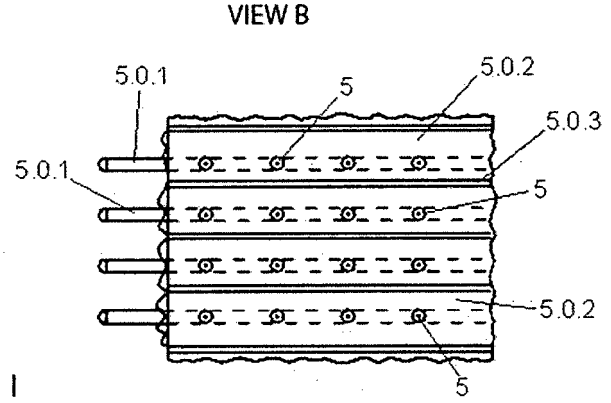


Fig. 3



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Application Number
EP 15 00 3474

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The present search report has been drawn up for all claims

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The Hague	27 May 2016	Bejaoui, Amin

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