# United States Patent [19]

**Burns, Jr.**

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[54] **SNOW MAKING APPARATUS AND METHOD**


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[51] **Int. Cl.**$^2$ .......................................... **F25C 03/04**

[58] **Field of Search** .............. 239/2 S, 14, 405, 406, 239/493


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[57] **ABSTRACT**

A snow making apparatus and method utilizing water and compressed air, wherein the water is atomized by hydraulic pressure and discharged as a hollow, conical spray. The high pressure gas is ejected through the same water exit nozzle along the axis of the hollow, conical spray and cooled sufficiently to form ice nuclei which interact with the supercooled water droplets in the water spray to thereby form snow.

**11 Claims, 4 Drawing Figures**

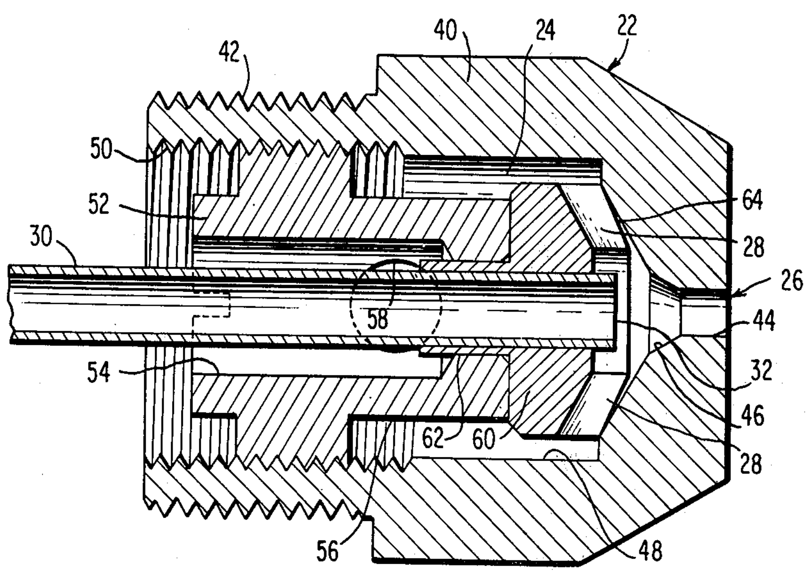



FIG.1

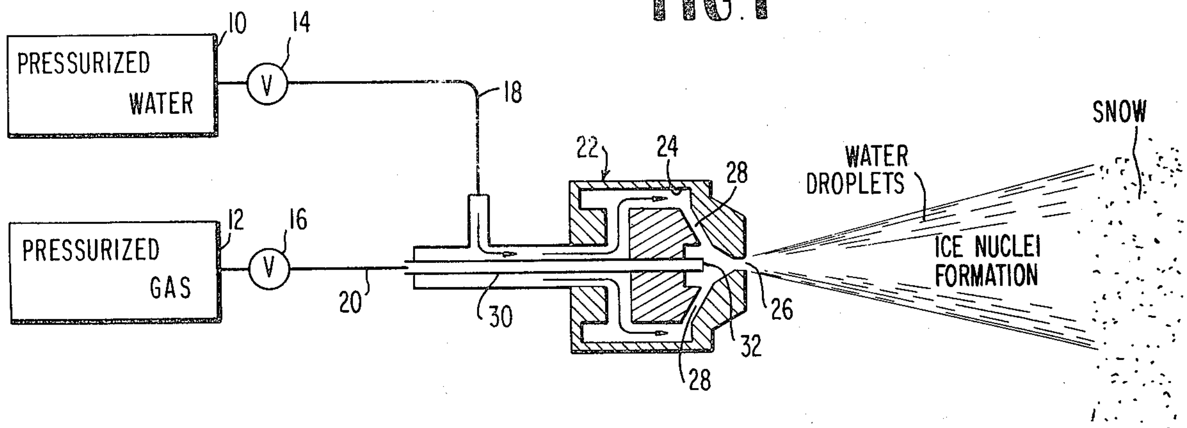



FIG.2

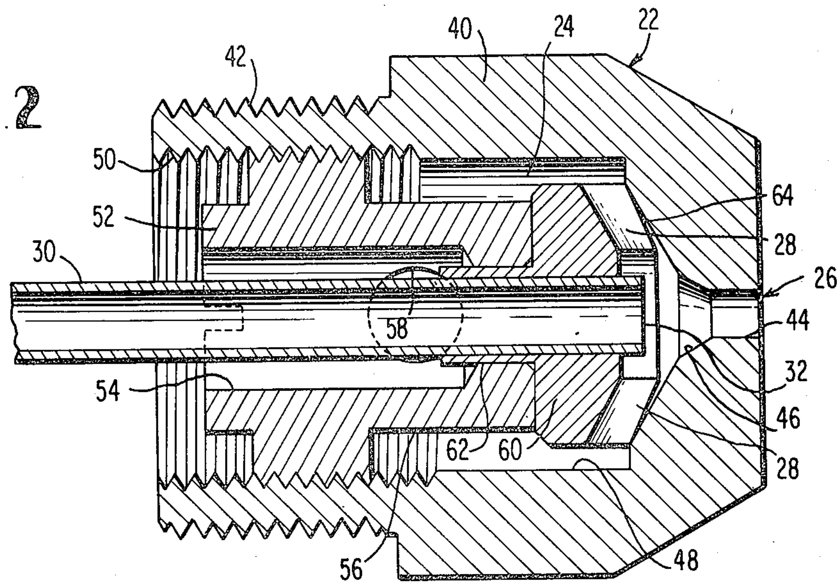



FIG.3

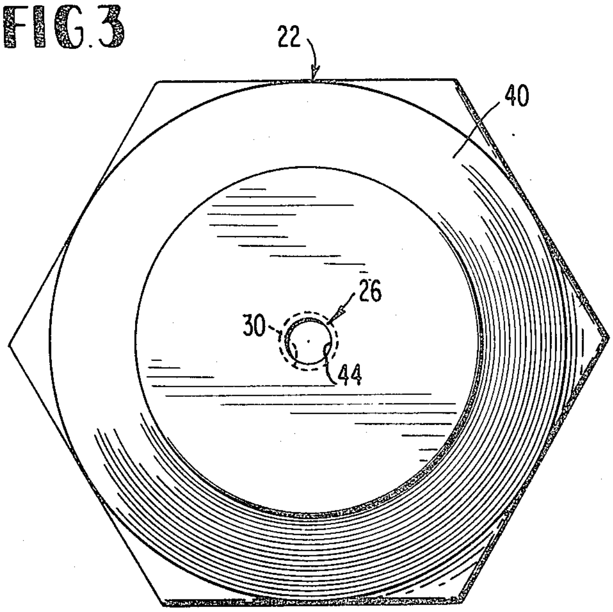
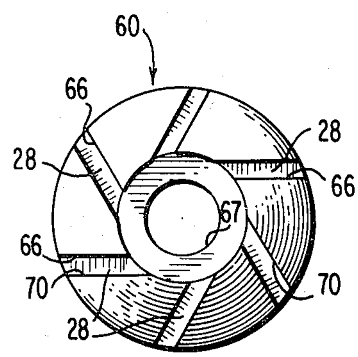



FIG.4



# SNOW MAKING APPARATUS AND METHOD

## BACKGROUND OF THE INVENTION

The invention relates to the making of artificial snow, and more particularly to a novel snow making device which uses hydraulic energy for producing a water spray and compressed gas exiting through the same exit nozzle for producing ice nuclei in the center of the spray to thereby react with the spray water droplets after they have been supercooled by sub-freezing ambient air to form snow.

During the past decade, many ski resorts have resorted to the use of artificial snow making machines to improve the quality of skiing during the winter season when natural snow fall is inadequate, and in areas with limited natural snow fall, to provide snow for skiing which otherwise would be impossible.

It is advantageous to make snow at sub-freezing temperatures as close to **0**°C. as possible. It is not possible to form snow by merely spraying water droplets into environmental air which is below **0**°C. because the droplets sub-cool and fall to the ground as liquid rather than snow where they freeze into an ice glaze. To form snow crystals, a means must be present to counter the sub-cooling effect.

The fundamental principles utilized by all snow making processes are covered in U.S. Pat. No. **2,676,471** to Pierce. The method as described utilizes compressed air mixed with pressurized water to both atomize the water into droplets and to produce small ice crystals which act as "seeds" to crystallize the droplets, which have been sub-cooled by exposure to the sub-freezing ambient air, into snow like particles. The Pierce Patent also pertains to nozzles with which this method can be accomplished.

Different types of apparatus have subsequently been developed for the production of artificial snow. The most widely used class pertain to apparatus which produce snow substantially in the same manner as described in the Pierce patent. A partial listing of others include U.S. Pat. Nos. **3,010,660; 3,298,612; 3,301,485; 3,393,529; 3,761,020** and **3,774,842.** The process described in all of these patents is characterized by the internal or external mixing of relatively large quantities of compressed air with cold pressurized water and discharging the pneumatically atomized droplets into sub-freezing environmental air to form ice crystals, or snow.

Another class of apparatus is described in U.S. Pat. Nos. **3,703,991; 3,733,029; 3,567,117;** and **3,774,842.** The system described in these patents is characterized by the use of a nozzle located in one zone for the formation of ice nuclei and a second nozzle located in a distinct separate zone to form the water spray particles which, after being sub-cooled by propelling large quantities of below freezing ambient air past the droplets, are mixed in a third separate and distinct zone, where the ice nuclei infect the droplets to form snow.

Another type of apparatus which has been used is shown in U.S. Pat. Nos. **3,760,598; 3,596,476;** and **3,567,116.** In these patents, a single nozzle is used for producing both the ice nuclei and the water particles which are converted into snow. A relatively small quantity of pressurized compressed air is injected into the water channel prior to atomization in such a manner as to provide small air bubbles in the water. The water droplets are produced essentially by hydraulic pressure atomization and the function of the air is primarily to form the required ice nuclei. In each of these patents, rotation is imparted to the water-gas mixture by use of either tangential or angled ports, a feature of most hydraulic pressure atomizing nozzles. The disadvantage of this method is that to inject the air into the water requires that the air pressure be higher than the water pressure. One patent utilizes a venturi nozzle to partially alleviate this disadvantage. To keep the air pressure at a practical level, the water nozzles must be selected to provide the proper size droplets with a low water pressure, resulting in the requirement for a large number of low capacity nozzles. The small water passageways of such nozzles tend to clog creating operational problems. Moreover, the small quantity of compressed air metered to each nozzle requires restricting air passageways or ports which tend to freeze, creating further operational problems.



It is the object of the present invention to provide an improved snow making device and method of operation.

It is further object of the invention to provide a novel snow making device which utilizes hydraulic pressure to atomize the water into droplet sizes which can be efficiently converted into snow by effective infestation with ice nuclei.

Another object is to provide a novel apparatus and method for producing ice nuclei through the use of a pressurized gas such as compressed air which interacts with only a very small portion of the water mass, thereby requiring only a minimal consumption of the pressurized gas to produce ice nuclei. The ice nuclei so formed react with additional small water particles to provide ice nuclei growth in the central portion of the water spray at a time when the larger water spray droplets are being supercooled after which the ice nuclei are dispersed into the water droplets by reason of the flow patterns to thereby efficiently infect the water droplets to produce snow. In the preferred form of the device, both the spray droplet water and the pressurized gas flow are through the same exit nozzle of the snow making device.

Still another object of the invention is to provide a novel snow making device and method wherein the water spray is produced in a hollow, conical pattern and the ice nuclei are formed by a high velocity air stream which interacts with a small portion of the water associated with the formation of the conical spray to thereby form and breed ice nuclei along the axis of the hollow, conical spray simultaneously with the supercooling of the water droplets so that snow is formed when the ice nuclei intermix with the droplets.

The present invention is characterized by its small size and in part by the fact that the gas pressure may be considerably lower than the water pressure. In this manner, the water pressure and nozzle size can be selected for optimum efficiency in producing the desired size droplets and the pressure of the compressed gas can be the minimum pressure required to form the ice nuclei. For a typical design, the air pressure could be between **1**/**5** and ⅓ the water pressure, dependent upon the size nozzle employed.

Another novel and extremely beneficial aspect of the invention is that the relatively small port required to properly meter the small amount of compressed air utilized is formed by a moving hollow tube of water which will not freeze as will stationary passageways or orifices formed of metal or other solid material as is used in most other snow making apparatus.

In its preferred form, the water is applied at a pressure relatively low for hydraulic atomization of between **100** psig and **200** psig and atomized into the proper size droplets by hydraulic energy. Lower water pressures can be used but the nozzles become too small for practical and trouble-free operation. The water spray has a hollow, conical configuration resulting from a swirling action in the exit nozzle which produces a hollow center core in the water as it passes through the nozzle. The gas emitted under pressure is ejected thorugh the hollow center portion of the exit nozzle, the air flow being confined and restricted by the converging inner walls of the shell of water passing through the exit nozzle. As the compressed air expands to a high velocity through the hollow core of the water, which is passing thorugh the exit nozzle at a lesser velocity, it is cooled to a temperature at least as low as necessary for the formation of ice nuclei along the axis of the hollow cone of the water spray.

These and other objects of the invention will become more fully apparent from the claims, and from the description as it proceeds in connection with the drawings, wherein:

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic showing of the snow making apparatus of the present invention;

FIG. **2** is a view of the front end of the nozzle apparatus as shown in FIG. **1**;

FIG. **3** is an elevation in section of the nozzle apparatus shown in FIG. **2**; and

FIG. **4** is a front view of the member which imparts rotational movement to the water to provide the hollow core in the water jet as it passes through the exit nozzle and hence, the hollow cone spray.

## DETAILED DESCRIPTION

Referring now to the drawings, the method and apparatus used for making snow in accordance with the present invention uses, as is conventional, a source **10** of pressurized water and a source **12** of a pressurized gas such as air. Typically, the water pressure should be of the order of magnitude of **150** psig and the air pressure approximately **50** psig, with relative capacities of approximately **1** cu. ft. of air per minute or less for each gallon of water per minute. As is well known to those skilled in this art, the ability to efficiently make snow depends on water temperature and atmospheric conditions, and it is desirable therefore to have pressure sources capable of producing somewhat higher pressures than the representative numbers given above as the pressures can be reduced or increased by adjustment to the pressurizing equipment or by valves **14** and **16** to regulate the precise pressure of the water applied through line **18** and of the air or other gas applied through line **20** in the interest of obtaining maximum operating economy under varying conditions.

The snow making device, which is also shown in FIGS. **2, 3,** and **4,** comprises essentially an outer, hollow annular chamber **24** which carries water having a temperature as near **0**°C. as can be conveniently obtained. The water passes from chamber **24** to nozzle **26** through a plurality of channels which extend from the outer annular chamber **24** toward a central region in a direction at an angle with the radius as best shown in FIG. **4** to thereby provide a swirling action to the water without requiring any moving parts. The water is then forced through nozzle **26** in the form of a swirling hollow core liquid jet. Shock waves are created as the hollow water jet passes into the environmental air and these shatter the thin cylindrical liquid sheet into droplets at or near the face of the nozzle. Such devices are well known in the art and available commercially from a number of sources.

A hollow cone spray is conventionally referred to as a spray in which most of the droplets are concentrated at the outer edge of the conical pattern. The pattern is symmetrical with respect to the nozzle axis and has a well defined spray angle. Such devices are commercially available which have spray angles that vary between **45**° and **90**° depending upon the configuration of the nozzle and vanes, as well as the water pressure and the flow rate. For the purpose of making snow, it is preferable to use the larger angles since this pattern produces a finer and more uniform spray although snow can be produced with nozzles with smaller spray angles.

In accordance with the present invention, the conventional hollow cone hydraulically atomizing spray device is modified by the insertion of a tube **30** of a material such as metal which has one end connected to the pressurized air source **12** and the other end **32** terminating at a location adjacent nozzle **26.** The tube **30** should be axially aligned with the axis of nozzle **26** and have a diameter sufficiently large relative to the diameter of nozzle **26** so that the air flow restriction is provided by the annular layer of swirling water that is present in nozzle **26** when the system is in operation. The swirling inner surface of the hollow water core is a gas-water interface which serves as a boundary surface that restricts the flow of gas through the nozzle, thereby accelerating the gas to a high velocity in the converging section of the hollow core. A low temperature gas stream is produced as the gas expands forward along the axis of the exit nozzle. Sufficient water is stripped or torn from the interface of the swirling body of water in nozzle **26** and combined with particles that have been entrained into the central portion of the hollow core water jet to provide the moisture required for the production of ice nuclei. The decrease of gas temperature which accompanies the constriction of the gas flow as it expands through the exit nozzle reaches the temperature below that required for the formation of ice nuclei. Accordingly, water particles are crystallized to form ice nuclei as the stream of gas passes through the hollow center of the water jet.

It is known by those skilled in the art what when growing ice crystals are present in below freezing ambient air containing sub-cooled water droplets that nucleation occurs at undercooling of less than **0.5**°C. This phenomenon, known as isomorphic nucleation, is believed to be caused by the shedding of dendrites grown on the surface of the parent crystals. It is further known that formation of ice nuclei by isomorphic nucleation increases with agitation. Therefore, ice nuclei formation and growth continue to occur in the turbulent expanding jet of moist compressed air after exiting from the nozzle, all conditions necessary for nucleation being present.

By the time the water droplets in the spray pattern have exhausted into the atmosphere a few feet beyond nozzle **26,** the droplets of water will havve been cooled below 0°C. by evaporation of a portion of the droplet, ice nuclei will have formed in the center of the spray in large quantities, and the intermixing of the ice nuclei with the water spray will cause the droplets to crystallize into snow-like particles. To produce snow of satisfactory quality, the droplets must remain suspended in the sub-freezing ambient air for a sufficient time to allow complete or nearly complete freezing of the droplet.

With reference to FIGS. 2 and 3, the snow making device **22** may comprise a body member **40** which has an outer hexagonal surface and a rearward threaded portion **42.** The forward or nose portion contains an exit nozzle **26** which includes a cylindrical wall portion **44** and a tapered, conical rear portion **46.** The inner end of wall portion **46** communicates with a central cylindrical opening defined by walls **48** which serve as the outer wall of water chamber **24.** At the rearward portion of wall **48,** internal threads **50** are provided to mate with the external threads on a screw pin **52.** Screw pin **52** has a central through bore defined by cylindrical wall **54** and is open at is forward portion. The outer wall **56** serves as the inner wall portion of annular chamber **24.** Chamber **24** communicates with the inner bore of screw pin **52** through a plurality of openings **58.** The rear end of screw pin **52** is suitably connected to a pipe carrying water from conduit **18** and pressurized water source **10,** as shown in FIG. **1.**

To produce the desired water spray a water distributor member **60** is provided which has a boss **62** on its rear portion that extends into the inner bore of screw pin **52.** The forward face **64** of water distributor member **60** is forced against the rear wall portion of the body member **40** along water channel **28** by the tightening of screw pin **52.**

Referring now to FIG. **4,** the forward face of water distributor member **60** includes a plurality of channels formed by a U-shaped groove having sidewalls **66** which are tangent to the diameter of an inner bore **67** and sidewalls **70** which are substantially parallel to sidewalls **66.** The water distributor member **60** as described is of a design provided by the nozzle manufacturer to provide a hollow, conical spray. The basic hydraulic pressure atomizing nozzle is available from the Delavan Manufacturing Company as Type LDA in sizes with the diameters of the nozzle **26** available in the range of between **0.055** and **0.150** inch and suitable for operation at pressures up to **500** psi. For snow making, pressures between **100** and **200** psig are recommended, the optimum pressure being dependent upon the size of the nozzle. A general rule is that the larger the nozzle, the higher the pressure required to produce droplets within the proper size range. Pressures above **200** psig tend to produce too many small droplets which float away rather than settle to the surface of the snow being formed. Lower pressures produce too many large droplets which are difficult to freeze and result in wet snow being produced unless very small nozzles are used which present problems as a result of the small passageways of such nozzles clogging and freezing and also because of their limited flow capacities.

To introduce air into the exit nozzle **26,** a central bore **67** which has a diameter roughly equal to the diameter of the cylindrical wall portion **44** of exit nozzle **26** has been drilled in water distributor member **60.** A tube **30** of a suitable material such as copper is shrink-fitted into the central bore in water distributor member **60** to provide a fluidtight joint.

The rear end of pipe **30** is connected to a source of pressurized gas such as an air compressor. The forward end **32** of pipe **30** is preferably located forward to a point where the walls of tube **30** do not interfere with the hydraulic action or water flow through the nozzle. With no air flow through pipe **30,** the forward end **32** should make no perceptible change in the hollow conical spray pattern or droplet size produced from the exit nozzle **26** as is characterized with the nozzle without the air pipe **30.** If the end **32** of pipe **30** is located to the rear of the preferred location, snow can still be produced but a higher air pressure is required. This is because an excessive back pressure exists in this region of the water channel, i.e., before the hollow core is completely formed, and the air pressure must be sufficiently high to overcome this pressure and to atomize the interfering water quantity. If the end **32** of pipe **30** is located too far forward into the exit nozzle, the hydraulic characteristics of the nozzle are interfered with.

The preferred form of the method appears for nozzle air tube **30** to be as large as can be physically fitted into the limited space without interfering with the hydraulic performance characteristics of the nozzle and for tube end **32** to be full size so that maximum expansion occurs as the air passes through the moving hollow core of water passing through nozzle **26.**

With tube end **32** properly positioned, the pressure in pipe **30,** if open to the atmosphere, will be slightly positive to atmospheric when water is flowing through the nozzle. For a representative size device with exit nozzle **26** of approximately **0.110** inch diameter and air tube **30** of **0.125** inch outer diameter, with water pressure in annular channel **24** on the order of magnitude of **150** psig, and the air pressure in pipe **30** being approximately **50** psig, the air flow rate in terms of standard cubic feet per minute is, in the preferred manner, metered by the restriction of the approximate **0.062** inch diameter opening in the swirling water jet passing through exit nozzle **26,** and not by the larger diameter air tube **30.** The pressure will be either slightly positive or atmospheric depending upon the water flow rate, due to the swirling action of the water as it exits through nozzle **26.** The sheath of water spirals along walls **46** of a thickness of approximately one-fourth of the diameter of nozzle **26,** leaving a substantially open circular center portion with a diameter at its narrowest point of approximately one-half the diameter of nozzle **26.**

The diameter of the open center area varies from approximately **0.3** of the exit nozzle diameter for the smaller size nozzles to over **0.75** for largest nozzles. The diameter is also affected by the water pressure, the higher the pressure for a specific nozzle, the smaller the diameter of the open core.

As air pressure is gradually increased in pipe **30,** there is a gradual narrowing of the water spray angle. A nozzle which has a spray angle of approximately **80°** with no air being passed through the hollow core of the exit nozzle will have a spray angle of only about **45°** when air at, say **50** psig, is expanded through the hollow core. The effect of the air is less on nozzles which have spray patterns with narrower angles when no air is flowing but in all cases, the air jet acts to decrease the spray angle to some degree.

The air flow rate in terms of cubic feet per minute is controlled not by the diameter of pipe **30**, but instead by the area of the opening in the swirling water jet passing through exit nozzle **26.** With the air flow rate restriction occurring in the exit nozzle and being determined by the diameter of the opening in the swirling water, maximum air velocity and minimum air temperature are achieved in the region where a large number of very small water particles are present. The minute particles, being entrained in the air stream as it undergoes a cooling to temperature sufficient to produce ice nuclei, at least **–15**°C., and possible as low as **–40**°C., first sub-cool and then nucleate into small ice crystals, to produce an ice fog or mist as the air emerges from the exit nozzle.

With reference to FIG. **1**, in the central region along the axis of the hollow conical water spray, a stream of high velocity air is produced which carries sufficient water particles to form ice nuclei within a conical region having boundaries on the order of **15**° to **20**°. The conditions in the center area of the spray are conducive to ice nuclei growth. As the ice nuclei grow to an effective size and quantity, the water particles in the water spray are contemporaneously being supercooled, i.e., cooled to a temperature below **0**°C., by evaporation of a portion of the droplet to the surrounding atmosphere under conditions when snow making is possible. The spray droplets having been given a rotational velocity due to the swirling action along walls **44** of exit nozzle **26** intermix with the growing ice nuclei in the turbulent expanding air stream which infect the water particles in the water spray. The foregoing procedures produce the effects necessary for the formation of snow, as is well known in the art.

During one test, snow was made utilizing the apparatus, as described and with the method of the present invention, when the environmental air temperature was **–2**°C. and at **75** percent relative humidity. In this snow making operation, the water temperature was **6**°C. and the compressed air temperature at the nozzle was **4**°C. The water pressure was **150** psig and the air pressure was **55** psig. The ratio of air to water was **1** cubic foot of air to **1** gallon per minute of water. The diameter of the orifice **26** was **0.110** inch, the basic nozzle before modification being a product of Delavan Manufacturing Company designated as Model No. LDA–**80.**

In summary, the snow making apparatus of the present invention does not require adjustments at the location of the nozzle when installed for actual use. By the nature of the device, the water spray characteristics are determined by hardware and the water flow rate through the nozzle, by the size of the exit nozzle and by the water pressure applied, such nozzles inherently performing a metering function as well as atomization of the water. The formation of ice nuclei is related to the velocity of the compressed air which is a function of the air pressure and the size of the opening through which the air passes, the quantity of air flowing being a function of the air pressure. For a specific size nozzle with a specific water flow rate, the diameter of the air passage is established providing an air velocity high enough to produce a sufficiently low temperature required to form ice nuclei by nucleation merely requires maintaining an adequate air pressure at the nozzle. The air quantity is otherwise of little importance and consumption of compressed air can be kept to a minimum simply by selecting nozzles that, with the water operating pressure utilized, develop relatively small diameter hollow cores through which the air must pass. The restricted air passage formed by the moving cylindrical sheet of water, which is confined by the walls of the exit nozzle, and water being virtually incompressible, provide metering of the air through the exit nozzle. Thus, both air flow and water flow are regulated by system conditions which are readily controlled at the point of pressurizing the two fluids. This inherent self-metering characteristic of both fluids is particularly advantageous where a number of nozzles supplied by common headers are used as will be the general case. The flow of both fluids through the nozzle is stable in that pressure variations in water flow over a fairly wide range do not materially affect air flow as the air is introduced at a point substantially atmospheric pressure. In a like manner, the air pressure can be varied over a wide range to establish varying quantities of flow and hence, velocities that are required to produce ice nuclei under varying conditions of water temperature without perceptibly affecting the water flow or spray characteristics.

One of the major advantages of the present invention is that in the formation of both the ice nuclei and the water droplets which are converted into snow, the present invention uses air pressure at the nozzle which is at a pressure substantially less than the applied water pressure. Also, the ratio of the volume of air used to the volume of water used is materially less than required by the only method in widespread use and compares favorably or is less than some newer methods which are not so widely used. As ice nuclei are formed inside the hollow particle water spray pattern, sufficient humidity and additional water are inherently available to assure that the formed ice nuclei will increase in number and size rather than evaporate or burn, and hence there is a more efficient production of ice nuclei to convert with great efficiency the hydraulically formed water droplets in the spray into snow. Hydraulic pressure is thus used to atomize the water mass and air pressure is used only to the extent necessary to produce the ice nuclei, which thereby allows for the use of a small unit of simplified construction that is relatively free of maintenance and operational problems.

A hydraulic pressure atomizing nozzle of the sizes suitable for snow making does not project the atomized droplets sufficiently to keep them suspended in the ambient air for the time required to permit complete or nearly complete freezing of the snow crystals. The air required to provide air velocity of a magnitude to create a temperature low enough for nucleation has sufficient velocity pressure to induce the droplets and a quantity of sub-freezing ambient air to completely or nearly completely freeze the droplets before they contact the ground. In this manner, a motor driven fan is not essential to the invention as is the case with most snow making apparatus which utilize hydraulic pressure atomization to produce the droplets. However, a fan could be employed if desired to more positively control the distribution of the snow formed.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiment is, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and intended to be covered by Letters Patent is:

1. Apparatus for making snow comprising:
a source of pressurized water;
a source of pressurized gas;
a snow making device located in an atmosphere having a temperature below 0°C. and having a water channel including a hollow annular chamber, a central exit nozzle with a predetermined diameter and having a flow axis, and flow channels including a fixed wall transverse to the flow axis of the exit nozzle between said chamber and said nozzle for producing a substantially hollow conical spray pattern of water particle flow from said nozzle to become supercooled in said atmosphere;
said device having a gas conduit having a discharge end extending through said transverse wall, sealingly engaged thereby and including a gas discharge opening with an internal diameter at least as large as the central exit nozzle diameter and being oriented to direct gas flow through said exit nozzle along the axis of said conical spray pattern, and means locating the discharge end of said gas conduit at a location near the entrance area of said exit nozzle and in alignment with the flow channels but without perceptibly affecting the hydraulic characteristics of the water flow through said exit nozzle when there is no gas flow through said conduit;
means for connecting said water source to the water channel of said device; and
means for connecting said gas source to the gas conduit of said device, the pressure of the gas in said conduit being sufficiently high so that the gas flow rate at the exit nozzle is restricted by the water flowing through the exit nozzle by an amount to reduce the gas temperature sufficiently far below 0°C. to cause ice nuclei to form in the gas stream following along the axis of the hollow conical spray pattern of water particle flow and thereafter to convert the supercooled water particles into snow.

2. Apparatus for generating snow comprising:
a source of pressurized water having a temperature near freezing;
a source of pressurized gas having a pressure below the pressure of the water;
a snow-making device having an exit nozzle with a predetermined diameter and a flow axis, a water channel and a gas channel;
means for connecting said source of pressurized water to said water channel;
means for connecting said source of pressurized gas to said gas channel;
fixed inducing means for creating a swirling hollow water flow through said exit nozzle, said inducing means communicating with said water channel and with said exit nozzle and including a wall transverse to the flow axis of the exit nozzle;
means for introducing gas from said gas channel to said exit nozzle, said means including a tube having an internal diameter at least as large as the predetermined diameter with an end portion aligned with the nozzle and aligned with the exit nozzle, said tube including a discharge end projecting through the transverse wall and sealingly engaged thereby, whereby said gas is accelerated to a high velocity thereby entraining water from a gas-water interface of said exit nozzle which entrained water is crystallized within said nozzle; and
a generally hollow conical jet of water droplets emanating from said nozzle which subcool simultaneously with the growth of ice nuclei in the expanding turbulent air jet in the center region of the spray, the entrained crystallized water particles mixing with the subcooled water droplets to generate snow.

3. The apparatus of claim 2 wherein:
said source of pressurized gas is a source of pressurized air.

4. The apparatus of claim 3 wherein:
said source of pressurized water supplies water having a pressure 3 to 5 times the pressure at which said source of air delivers air.

5. The apparatus of claim 4 wherein:
said water pressure is approximately 150 psig; and
said air pressure is approximately 50 psig.

6. The apparatus of claim 2 wherein:
said nozzle comprises a metering orifice for both said gas source and said water source.

7. In snow-making apparatus having means for connection with a source of pressurized water, means for connection with a source of pressurized gas, an improved nozzle means for combining pressurized gas and pressurized water to form snow comprising:
a body member having an internal bore with internal threads at an end thereof, and an orifice coaxial with the bore and having a predetermined diameter;
a screw pin threadably received by the internal threads of the body member, having an outer wall spaced radially inwardly from the internal bore to define an annular chamber therebetween, and having a plurality of generally radial openings to provide fluid communication between the inner bore and the annular chamber;
a distributor member having a boss received by the screw pin, an inner bore coaxial with the screw pin, a forward face with a transverse wall portion and with a conical portion which has a plurality of grooves generally tangentially oriented relative to the inner bore to provide swirl inducing fluid communication between the annular chamber and the orifice, and the distributor member being fixed in position by engagement with the screw pin and the body member; and
a gas tube having an internal diameter at least as great as the predetermined diameter, coaxially mounted in the inner bore of the distributor member, and having a forward end projecting through the transverse wall portion in general alignment with the tangential grooves and the orifice.

8. A method for the making of snow comprising:
providing a snow making apparatus having an exit nozzle and means for generating spiral flow of water through said nozzle;
applying water at a temperature greater than 0°C. to said apparatus at a pressure and flow rate to create a predominantly hollow conical pattern of water particle flow from said nozzle into an atmosphere having a temperature less than 0°C.;

providing a gas supply conduit having a gas discharge opening sufficiently large so as not to materially restrict the gas flow rate;

locating the axis of the opening in said gas supply conduit near the center of the spiral water flow at said exit nozzle and orienting the conduit opening to direct the gas flow substantially along the direction of the axis of said hollow conical pattern of water particle flow; and

supplying gas to the gas supply conduit at sufficient pressure and temperature to accelerate the gas to a high velocity centrally of the spirally flowing water in the nozzle thereby entraining in the gas water particles from the gas-water interface and crystallizing the entrained water particles; and

exhausting the gas, the entrained crystallized water particles, and the liquid water from the nozzle into the atmosphere whereupon the crystallized water particles interact with the conical pattern of water particle flow to generate snow.

**9.** A method of artifically generating snow from low temperature pressurized water and pressurized gas comprising the steps of:

providing a converging nozzle having an inlet and an exit;

inducing a hollow, swirling flow of the pressurized water through the converging nozzle adjacent to the wall of the nozzle;

introducing a flow of the pressurized air coaxially to the nozzle inlet such that the flow of pressurized water through the nozzle is unaffected;



entraining water particles into the gas within the nozzle from a gas-water interface;

crystallizing the entrained water particles by the reduced gas temperature of the accelerating gas;

exhausting both the flow of water and the flow of gas with entrained crystallized water particles to the atmosphere when the temperature thereof is below **0°C**;

generating snow externally of said nozzle by the interaction of the crystallized water particles with the exhausting flow of water and gas.

**10.** The method of claim **9** wherein the step of exhausting includes the step of:

hydraulically atomizing the hollow, swirling flow of pressurized water to a mist of water droplets while exhausting a high velocity flow of pressurized gas to atmospheric pressure.

**11.** The method of claim **10** wherein said step of generating includes the steps of:

subcooling the mist of water droplets by exposure to the atmospheric air;

forming additional crystallized water particles in the flow of gas from moisture contained therein;

intermixing the mist of subcooled water droplets and the crystallized water particles within a turbulent expanding jet to crystallize the water particles into snow-like particles.

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