METHOD AND APPARATUS FOR THE LARGE-SCALE PRODUCTION OF SNOW FIELDS FOR SPORTS USE

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This invention relates to a method and apparatus for producing a snow field, especially in a warm climate, of sufficient extent to be useful for outdoor winter-type sports such as skiing, tobogganing, and so forth. It is a primary object of the invention to produce a snow field of sufficient extent and thickness to be useful outdoors even in a warm climate having a temperature well above the freezing point of water, which can be operated on an economically feasible commercial basis for sports and similar use.

The interest in winter sports keeps increasing every year. Unfortunately, most natural ski areas are remote from population centers and have favorable snow conditions for only a few months out of the year. Quite often, even during those months when snow is expected, the weather may be such that it will be a costly and consequent loss of revenue to hotel owners, ski-lift operators, etc. The present invention proposes to make and distribute snow economically over a large area independently of the prevailing atmospheric conditions, so that any conveniently located area can be used for skiing, tobogganing, or other winter sports. It is a primary object of the invention to provide a system for doing this which is economically feasible for operation on a commercial basis.

The invention contemplates the use of artificial refrigeration to cool water into snow in a controlled atmosphere maintained below the freezing point of water, and using compressed chilled air or other suitable gas to immediately convey the snow through a duct and to distribute it over the desired area. It is an important feature of the invention that the snow is at all times, until it is distributed on the ground, maintained well below the freezing point of water, whereby it can be conveyed as a dry powder from the point of origin to the point of use. According to the invention, a closed gas circuit is used to furnish the freezing atmosphere for converting the water into snow, the gas being continually recirculated through the enclosed space, except for some which is diverted to convey the snow through a duct to the point of use, the amount of air which is thus removed being made up by supplying make-up directly to the enclosed space so as to avoid the necessity of drying the air.

Another feature of the invention lies in the collection and reuse of the melted runoff from the snow field to provide at least some of the water which is used in making the snow, in order to conserve refrigeration by utilizing the relatively low temperature of the run-off water.

Snow-making systems are known, as shown in Patent No. 2,646,471, for converting water into snow directly at the point of use for skiing, and so forth, but these are suitable only for use in low temperature situations under approximately normal winter conditions, and they are entirely impractical for use in situations where the normal ambient temperature is well above the freezing point of water.

The specific nature of our invention as well as other objects and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawings, in which:

FIG. 1 is a schematic perspective representation of a snow field area according to the invention, illustrating the manner in which the snow is produced and applied to the area;

FIG. 2 is a flow sheet showing a typical system for the production of snow according to the invention;

FIG. 3 is a schematic section view through a snow tower for converting water into snow, and for conducting the dry snow into a duct for use;

FIG. 4 is a flow sheet of another embodiment using a liquid refrigerant such as CO₂ for direct cooling and freezing of the water; and

FIG. 5 is a sketch of the air cooler.

Referring to FIG. 1, the snow field area 2 is preferably laid on a slope, constituted by the side of a hill 3 which may be either natural or artificially made for the purpose. Since the top of the ski or toboggan run should be at a good elevation, it will be assumed that the hill is in the order of 1500 feet high, and the slope should be well over a half mile in length if possible, although of course these dimensions can be varied in accordance with local conditions and available surface.

The skiing area 2 is surrounded by a header or duct 4 for conveying the dry snow, as will be described below. This header may be laid directly upon the ground, may be elevated above the ground, or may be buried below the ground except for the feeder ducts 6 through which the snow is applied to the field 2. Feeder ducts 6 are suitably spaced along the header 4, and are provided with suitable valves 7 and hose connections 8 whereby a hose line 9 having a suitable nozzle 11 may be attached, it being understood that any suitable number of such hose lines may be employed. In this manner, the snow issuing through nozzles 11 may be manually distributed over the area of use 2, in order to build up the thickness of the snow to the desired degree. Since the installation is typically intended for use in an area in which the temperature is well above the melting point of snow, it will be understood that the snow must be continually replenished, which is preferably done in the evening and the melted run off is collected in any suitable manner, schematically indicated by channels 12, into a return pipe 13, and flow back, preferably by gravity, into reservoir 15 for reuse in making snow as will be described below. This particular system is designed to make approximately 296,000 lbs./hr. of snow. It is described by way of example only. The flow rates and sizes of equipment will vary with the snow making capacity desired. Pressures and temperatures may also vary to achieve optimum economy depending on local conditions, power costs, size of installation, and so forth.

Snow for the system is made in snow tower 16 as will be described below, and passes from the snow tower into duct 14, which is supplied with cold air from blower 17 under a low positive pressure, e.g., 5 pounds gauge, to convey the snow through the header 4. The snow is made by freezing water droplets which are conducted to the snow tower via pipe 18 and pump 19 from water reservoir 15. When the system is in continuous operation, most of the water in the reservoir 15 will be run-off water from return pipe 13 as previously described.

The snow making tower 16 is an insulated tower typically 80 feet in diameter by some 40 feet high. The tower may be steel, aluminum, concrete, or other suitable construction material. The atmosphere in this chamber is maintained at 0°F. by a circulating air system. As best seen in FIGS. 2 and 3, the air enters on line 21 at a temperature of approximately —100°F. and leaves the chamber on line 22 at a temperature of approximately 0°F., having been warmed by the water which has been converted into snow. The air in line 22 passes through a filter 23 to remove entrained snow, and continues on line 24 to blower 26, which boosts the pressure from atmospheric to approximately
from the atomizing spray heads, to aid in the production of snow, while the make-up air is dried by this action, and the remaining liquid is then admitted into the dry air. This avoids the necessity for a separate air drier.

As shown in FIG. 3, the cooling tower 16 is preferably provided with an insulating jacket 58, and it will be understood that the duct 14, header 4, and all of the cold air lines of the system are similarly insulated in accordance with good practice to prevent any unnecessary temperature drop. While the system shown above is effective where LNG or a similar liquid gas is available as the primary coolant, the system can also be operated with conventional compression refrigeration as the primary cooling means, and can alternatively be operated with liquid CO₂ where this is available, supplied directly into line 21 in lieu of the cooling system shown. In this case, the liquid CO₂ is converted into a gas in the process of snow production, and passes in gaseous form through line 22, and thence either into the atmosphere or for any other suitable use.

The operating temperatures and pressures shown in FIG. 2 are by way of example only, and are intended to indicate typical ranges for use in a practical system. The system shown is intended to produce sufficient snow over an area in the order of 500 feet wide and at least a half mile long, with an elevation head, assuming a wind speed of 15 miles per hour, of 15 meters per second, and a capacity of snow production of 5 to 100 inches per day, which will enable the system to be used outdoors even in a normally mild climate.

In initially starting this system, the header 4 should be pre-cooled before snow is sent through the line, in order to avoid the possibility of snow melting in the line and clogging the system. This can be done by passing air from blower 17 through line 14 and through the header at 0°F., but without any snow, for a sufficient time to cool the entire header system down well below the freezing point.

FIG. 4 shows an alternative system using liquid CO₂ initially stored in tank 61, and passed through pump 62 and line 63 to water pre-cooler 64 for precooling water from pump 19 to a temperature of 40°F. in line 49, from which it is supplied to the spray nozzles 51, the gas atomizing being provided by CO₂ gas in line 48. CO₂ gas is also passed on line 65, through valve 66 which is controlled by a suitable automatic flow controller 67, and into the snow tower 16'. Here the CO₂ expands and rises counter-current to the atomized water, freezing it into the desired snow form. If desired, co-current flow may also be used as previously explained. The warm CO₂ can be vented into the atmosphere through line 69 or could, alternatively, be compressed, cooled and liquefied in the conventional refrigeration cycle and returned to tank 61.

The partially vaporized CO₂ from exchanger 64 is split into two streams 48' and 71, the stream in line 48' being used, as previously described, to atomize the water in a suitable spray nozzle, and the CO₂ in line 71, under control of valve 72 and automatic pressure control 73, being used to furnish the conveying gas medium for the snow in line 6.

A warm bypass line 74 is shown in this example to keep the CO₂ from forming a solid on expansions through valve 67 and plugging the line. The falling water, after freezing into snow, is fed into the tower by a suitable means such as star valve 28' previously described, which prevents the snow from being blown back into the tower.

Alternatively, the tower can be operated at higher pressure than the pipe line 6, although this would necessitate a more expensive tower.

The water particle size required to form a satisfactory "snow" will vary with the operating conditions in general, but the particle size should be controlled so that the particles are fine enough, carrying a sufficient resistance to be formed. Although a fairly skiable "snow" can be made by crushing ice, it is preferable to produce a snow as nearly as possible similar to natural snow, both because this provides a superior skiing surface, and also...
because of its superior insulating qualities, which tends to reduce the melting rate. It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of our invention as defined in the appended claims.

We claim:

1. Method of making and distributing snow for sports use at above-freezing temperatures, which comprises:
   (a) making artificial snow in a controlled chamber in an atmosphere maintained below the freezing point of water,
   (b) passing snow from said chamber into a duct,
   (c) conveying the snow through said duct by entraining it in chilled air under pressure and at a temperature below the melting point of the snow, and causing said air to move along the duct,
   (d) distributing the snow from the duct to a remote point of use.

2. Method as recited in claim 1, including the further step of recovering the melted snow, from the point of use, in the form of cold water, and using this water to make more snow in step (a) of the preceding claim.

3. A method of making an artificial snowfield for sports use comprising the following steps:
   (a) making artificial snow in an enclosed chamber by atomizing feed water and bringing the atomized water particles into contact with chilled air at a below-freezing temperature,
   (b) distributing the snow from the chamber to an area of use which is at a temperature above the melting point of the snow, whereby the snow melts during use into run-off water,
   (c) collecting the cold run-off water at the site of use of the snow, and conveying it back while at a low temperature to said enclosed chamber for re-use in making more snow.

4. The method according to claim 3, wherein said feed water as atomized by the use of pre-cooled gas under pressure.

5. A method of making artificial snow for sports use comprising the following steps:
   (a) making artificial snow in an enclosed chamber by atomizing feed water and bringing the atomized water particles into contact with chilled air at a below-freezing temperature,
   (b) passing snow from said chamber into a duct,
   (c) conveying the snow through said duct by entraining it in chilled air under pressure and at a temperature below the melting point of the snow, and causing said air to move along the duct,
   (d) atomizing said feed water by the use of pre-cooled gas under pressure.

6. Method of making artificial snowfield for sports use comprising the following steps:
   (a) making artificial snow in an enclosed chamber by atomizing feed water and bringing the atomized water particles into contact with chilled gas at a below-freezing temperature,
   (b) passing snow from said chamber into a duct,
   (c) conveying the snow through said duct by entraining it in chilled gas under pressure at a temperature below the melting point of the snow, and causing said gas to move along the duct,
   (d) distributing the snow from the duct to the ground at the point of use,
   (e) chilling the gas in step (a) by heat exchange with a low temperature fluid in a substantially closed gas circuit including said chamber and the heat exchanger, and pumping the gas through said closed circuit,
   (f) diverting a small amount of the gas from said closed circuit to said duct to provide the chilled gas for step (c).

7. The method as claimed in claim 6, including the further steps of
   (a) replacing said diverted gas from step (f) with atmospheric gas,
   (b) introducing said atmospheric gas into the system in the closed snow-making chamber to remove entrained moisture from the gas.

8. Apparatus for making and distributing snow for artificial snowfields comprising:
   (a) a snow-making chamber having therein means for atomizing water and means for blowing pre-chilled air countercurrent to the atomized water to convert it into snow,
   (b) valve means for conveying the snow from said chamber into a duct,
   (c) means for blowing pre-chilled air through said duct to entrain the snow and to carry entrained snow along the duct to a point of use.

9. Apparatus according to claim 8, including
   (a) means for chilling air to a temperature well below the freezing point of water,
   (b) heat exchanger means and means for passing exhaust air from said chamber, after giving up heat to the atomized water, into heat-exchange relationship, in said heat exchanger, with a refrigerating fluid at a low temperature, to re-chill said air,
   (c) means for pumping said chilled air into said chamber,
   (d) said means for blowing air through said duct including means for diverting some of said chilled air, at a temperature below the freezing point of water, into said duct for use in entraining and transporting said snow.

10. Apparatus according to claim 9, and means for supplying make-up air to the system including pump means for pumping atmospheric air into said chamber into contact with said pre-chilled air and with said atomized water, for removing moisture from said make-up air in said chamber.

11. Apparatus according to claim 8, including means for distributing snow from said duct onto a snowfield area to build up a layer of snow thereon for sports use, means for collecting melted snow from said snowfield as cold water, and means for returning said water to said chamber for re-use in making snow.

12. Apparatus according to claim 8, and means for pumping water to said chamber for atomization, and heat exchanger means for pre-cooling said water.

13. The invention according to claim 12, said last heat exchanger means including an intermediate methanol heat exchanger; means for cooling the methanol in said heat exchanger by heat exchange with a primary refrigerant at a temperature far below the freezing point of water.

14. The invention according to claim 13, said primary refrigerant being liquid natural gas (LNG), and heat-exchange means utilizing said LNG for chilling the air supplied to said chamber, said LNG being also used to pre-chill the air supplied to said chamber.

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