United States Patent [19]

Tropeano et al.

[11] **3,761,020**

[45] **Sept. 25, 1973**

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

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[22] Filed: **Feb. 17, 1972**

[21] Appl. No.: **227,126**

[52] **U.S. Cl.** ..... **239/2 S,** 239/14

[51] **Int. Cl.** **F25c 3/04**

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

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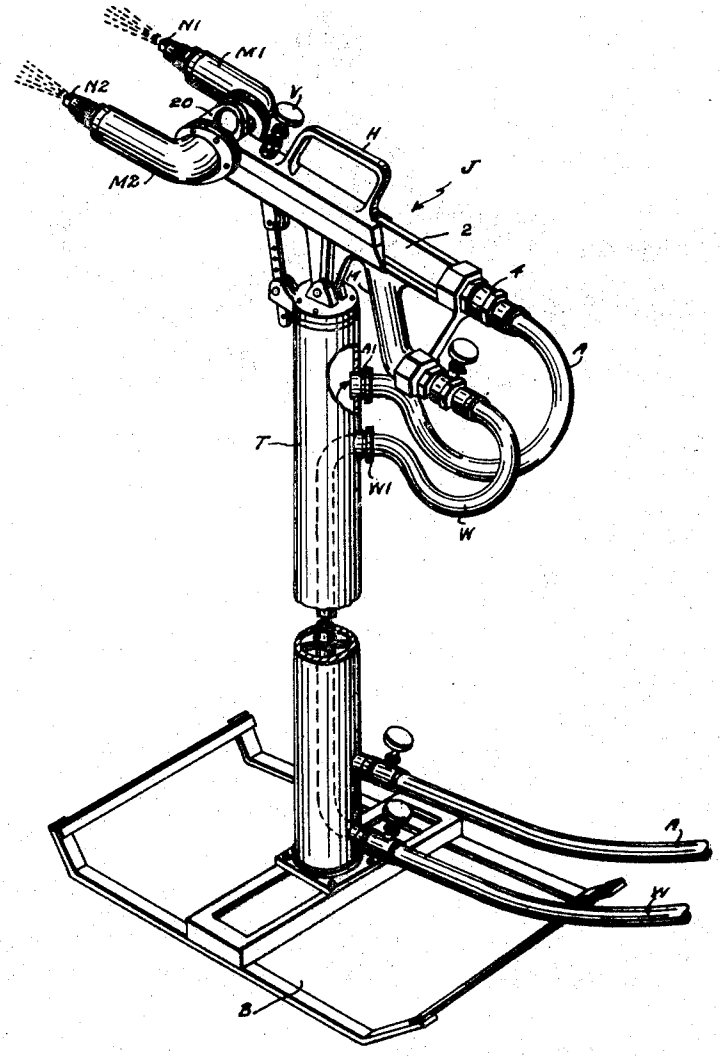
Assistant Examiner—John J. Love
Attorney—Munroe H. Hamilton

[57] **ABSTRACT**

High velocity streams of compressed air and pressurized water are furnished in a cold ambient atmosphere from two independent sources of supply and precooled by momentarily confining the high velocity streams in elongated passageways formed in a snow-making jet construction whose outer surfaces are exposed to the cold ambient atmosphere. Portions of the passageways in the jet structure are arranged in a manner such that the stream of water is precooled by the cold ambient atmosphere and an inner stream of compressed air undergoes peripheral precooling by means of the precooled stream of pressurized water. The precooled stream of air may undergo successive stages of expansion while in a confined state to further cool the mixture. Regulated quantities of the precooled compressed air may also be injected into the confined stream of water at predetermined points thereby to control snow characteristics. Precooling compressed air and water with the jet construction of the invention produces snow at efficiency levels not heretofore realized in the art of snow making, and the characteristics of the snow crystals or particles being desirably controlled.

3 Claims, 8 Drawing Figures



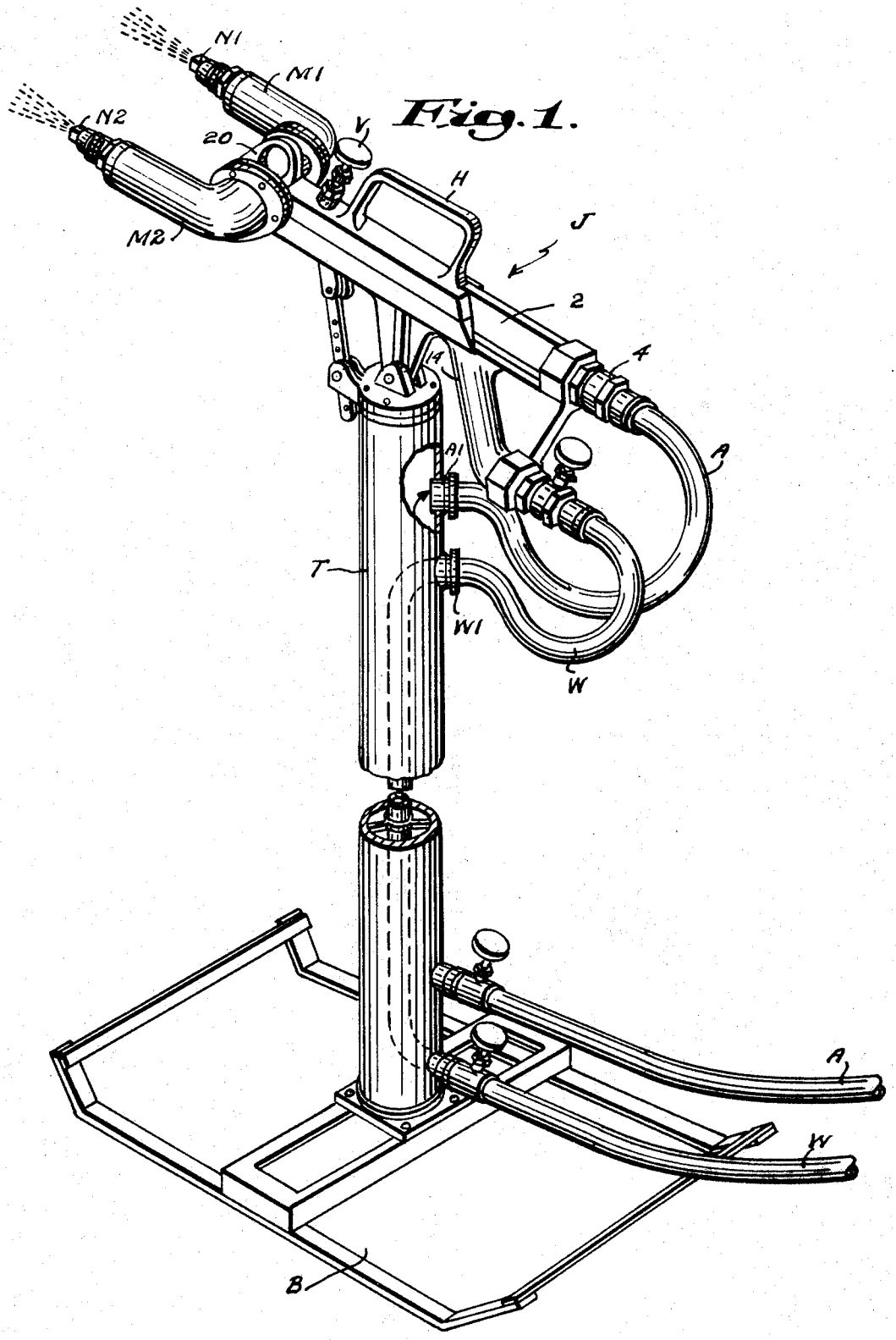


Fig. 1.

Fig. 2.

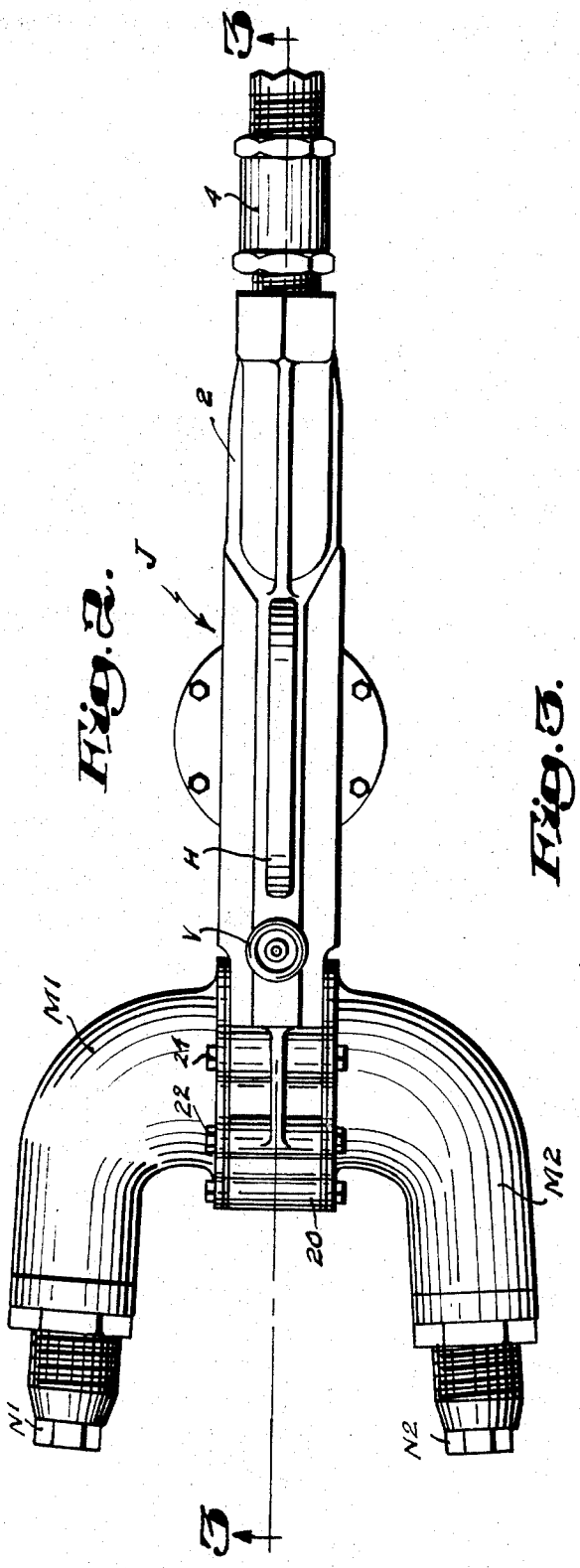
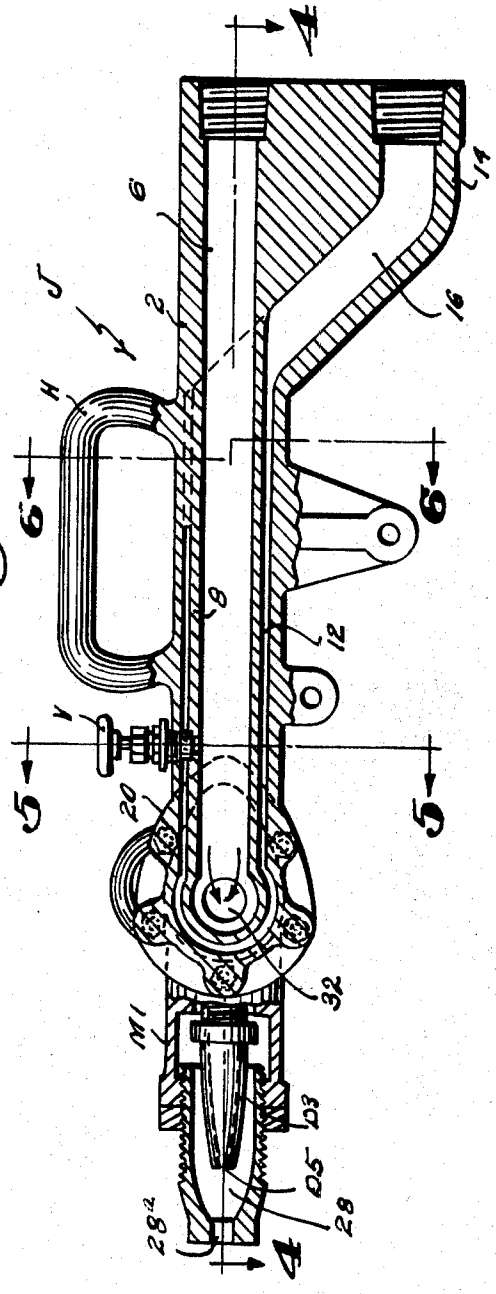

5
4
2
J
H
V
M1
M2
24
28
20
N1
N2
5

Fig. 3.


4
6
14
J
2
16
H
6
8
12
V
5
20
5
32
M1
D3
D5
28
28a
4

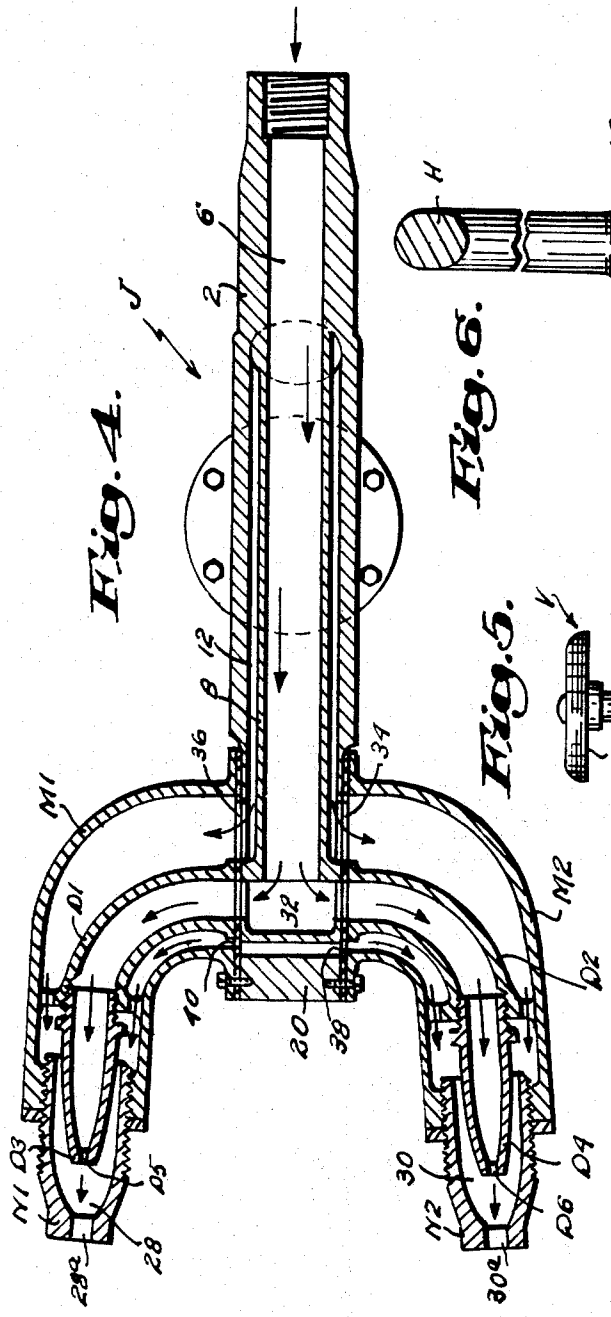


Fig. 4.

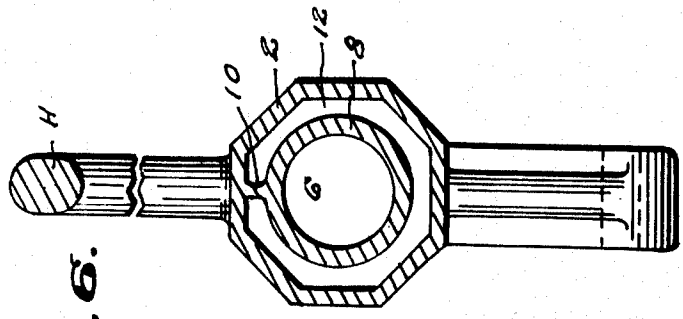


Fig. 6.

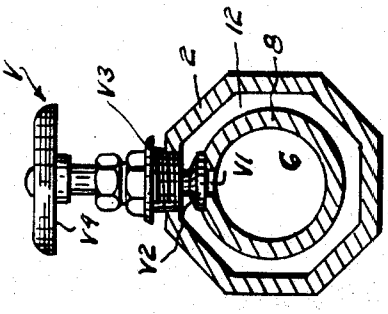
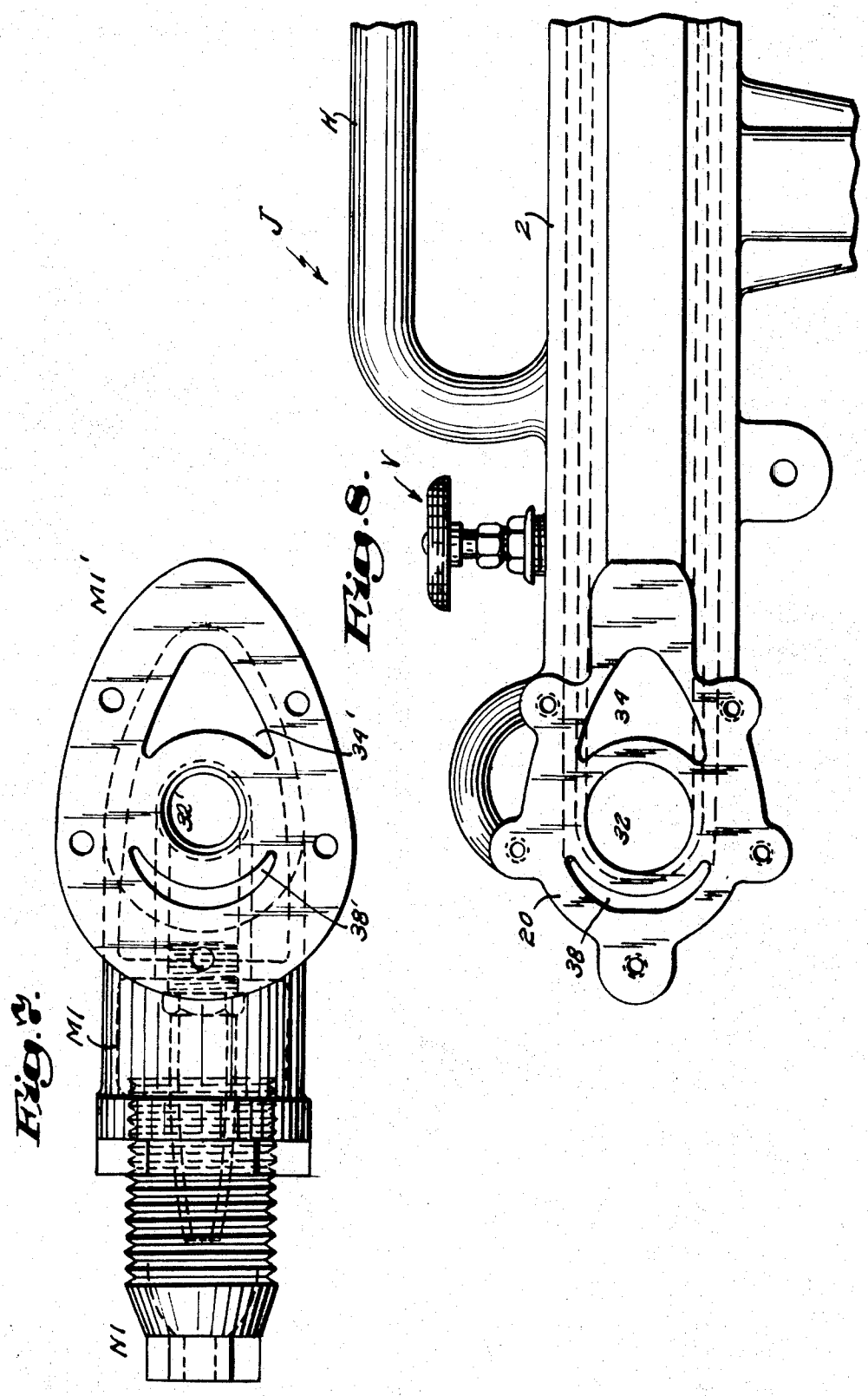


Fig. 5.


M1'
34'
32
38'
M1
N1
Fig. 7.
M2
J
2
V
34
32
20
38
Fig. 8.

METHOD AND APPARATUS FOR SNOW MAKING

This invention relates to a method and apparatus for making snow as commonly produced by snow-making equipment now in use in providing a cover of snow on winter recreational areas such as ski slopes and the like.

In conventional snow-making methods, limitations are present, both with respect to the amount of snow which can be produced in any given time interval, as well as the characteristics or quality of the snow particles which are made and spread over a ski slope surface.

As is well known, temperature of ambient air, where snow-making is to be carried out, must be in the freezing range, and preferably should be in a range of 28° F. and lower. We have determined that the effectiveness of the ambient atmosphere in converting an expanded mixture of air and water into snow particles may depend to some extent in the way in which the cold ambient air occurring in the immediate vicinity of the region of expansion is utilized. We have observed that if too great a demand for cold air occurs, efficiency in snow-making may drop appreciably. This is evidenced by the fact that relatively large flows of air and water mixtures in the terms of cubic feet per minute may not do as satisfactory a job of snow-making as a plurality of snow makers using relatively smaller flows of the mixture. We have also determined that another highly important factor is the snow particle condition or flake characteristics which are created by the snow-making process. For example, a wet, heavy form of snow particle is less desirable since it does not spread properly and may accumulate in objectionable piles. On the other hand, if the snow flakes or cyrstals are too fine, they may, when being producd in a windy area especially, be blown away or fail to cover properly with a satisfactory accumulation being realized in a desired portion of a ski slope.

It is a chief object of the invention, therefore, to provide an improved snow-making method and apparatus which is characterized especially by substantially greater efficiency than is obtainable with conventional snow-making equipment.

Another object of the invention is to increase the rate at which snow can be made in any given suitably cold ambient air atmosphere and to provide an improved snow-making jet construction suitable for this purpose.

Another object of the invention is to devise a method of precooling streams of compressed air and pressurized water to obtain greater efficiency in snow-making and to make possible the production of a snow cover at temperatures higher than those customarily relied upon for a successful snow-making operation.

Still another object is to control more effectively the characteristics of the snow flakes or snow cyrstals which are formed in a snow-making process.

Still another object is to devise an apparatus in which precooling of compressed air and water may be carried out in a novel manner.

And still another object is to devise an improved method of utilizing cold ambient air in a localized region of snow-making.

The nature of the invention and its other objects and novel features will be more fully understood and appreciated from the following description of a preferred emboidment of the invention selected for purposes of

illustration and shown in the accompanying drawings, in which:

FIG. 1 is a perspective view illustrating one preferred embodiment of snow-making apparatus of the invention;

FIG. 2 is a fragmentary plan view illustrating a nozzle section and supply conduit means;

FIG. 3 is a cross section taken on the line 3—3 of FIG. 2;

FIG. 4 is a cross section taken on the line 4—4 of FIG. 3;

FIG. 5 is a cross section taken on the line 5—5 of FIG. 3;

FIG. 6 is a cross section taken on the line 6—6 of FIG. 3;

FIG. 7 is a detail elevational view of a conduit portion of the snow-making apparatus of the invention with one of the nozzles removed therefrom;

FIG. 8 is a fragmentary elevational view further illustrating details of a conduit portion for the snow-making apparatus of the invention and special valve mechanism combined therewith.

With the foregoing objectives in view, we have conceived of an improved method for making snow wherein high velocity streams of compressed air and pressurized water are furnished in a cold ambient atmosphere from two or more independent sources of supply and the streams of air and water are precooled in a special jet structure before being mixed and discharged from nozzle means at the outer end of the jet structure.

Our improved method is devised to operate upon the principle of more efficiently utilizing the cold ambient atmosphere occurring in a localized area in which snow-making is desired to be carried out at any given period. Essentially, our improved method of operation is based on the idea of using cold ambient atmosphere to lower the temperature of streams of compressed air and water while separated and in a confined state ina snow-making jet structure. By means of precolling in this manner and in other ways hereinafter noted, we find that subsequent cooling realized from conventional expansion of the mixture in the cold ambient atmosphere results in a materially improved method of making snow.

In our improved method, one desirable form of precooling may, for example, be carried out by momentarily confining the high velocity streams in isolated relationship and in elongated restricted passageways formed in a special jet structure which is exposed at its outer surface to cold ambient atmosphere.

Portions of the passageways may be arranged in concentric relationship so that an inner stream of compressed air undergoes peripheral precooling by means of an outer cold stream of pressurized water which in turn is cooled by cold ambient atmosphere in which the conduit means is positioned.

We have also determined that important precooling may be accomplished by such steps as introducing controlled quantities of precooled air into the stream of water and by carrying out partial expansion of the mixture in a confined space in the nozzle section of the jet structure. The resulting precooled mixture may then be discharged through the nozzle means into a a cold ambient atmosphere to accomplish a final expansion of the mixture and formation of snow at efficiency levels not heretofore realized in the art of snow-making.

Referring to the drawings, the snow-making apparatus shown therein comprises one preferred embodiment of means for carrying out the invention method. It will be understood, howvever, that the invention is not intended to be limited to this apparatus and it may be desired to carry out the method in other ways.

In general, the apparatus employed includes a snow-making jet structure generally indicated by the arrow J, and means for furnishing independently supplied streams of compressed air and pressurized water, utilizing conventional air compressor and water pumping equipment which is not shown in the drawings, but is indicated in the form of compressed air and water pipes A and W respectively, as shown at the right hand side of FIG. 1.

In the preferred embodiment shown in FIG. 1, there is also illustrated a jet supporting tower member T mounted on a movable base B for locating the jet structure at any desired height above an area to be covered with snow. It may also be desired to utilize the jet structure of the invention indendently of the tower, and for this purpose a conventional sled or bracket structure may be utilized.

Considering in greater detail the jet structure J, components of which are indicated in FIGS. 2 to 8, inclusive, numeral 2 denotes an elongated enclosure body of generally tubular form having a handle part H. This enclosure body constitutes a basic component of our improved snow jet construction and consists in a multi-passageway conduit designed to conduct flows of compressed air and water and function as a novel means of precooling the flows. We have found that by using suitable dimensions for the length of the enclosure body as well as the size of the passageways, it becomes possible to carry out significant precooling of the fluids. In a typical snow jet construction of the invention, the length of the overall enclosure body may be, for example, approximately six inches, and the air passageway may be of a diameter of, for example. 1 and ½ inches, and the diameter of the annular passageway for water contained within an outer water jacket portion of the enclosure body may be, for example, of 3 and ½ inches.

In furnishing fluid flows through this elongated enclosure body 2, we provide at one end, a threaded connection 4 which is designed to have connected thereto the air pipe A. Communicating with this threaded connection 4 is an elongated air conducting passageway 6 which extends all the way through the enclosure body 2, as is most clearly shown in FIGS. 3 and 4.

In accordance with the invention, we further form the enclosure body 2 with an inner tubular section 8 which is supported in spaced relation to the outer tubular portion of the enclosure body 2 by means of a web 10. There is thus defined an outer annular water conducting passageway 12 which is concentrically arranged with respect to the air passageway throughout a part of the length of passageway 6, and outer portions of enclosure body 2 function as a water jacket section.

Formed integrally with enclosure body 2 at a lower side thereof, immediately below the passageway 6, is a water conduit portion 14 through which extends a water passageway 16, as best shown in FIG. 3. The water passageway 16, as also indicated in FIG. 3, is in communication with the water passageway 12 at a point of merging occurring directly below the handle portion H.

It will be observed that by means of the concentrically spaced tubular construction described, the passageways 6 and 12 are located in circumferentially spaced apart relationship and thus a flow of water in the passageway 12 completely surrounds a flow of air passing through the passageway 6 for a substantial distance of travel. Attention is directed to the fact that when the relatively thin outer water jacket portion of enclosure body 2 being exposed to a cold ambient atmosphere, cooling of water passing therethrough may be realized. It is pointed out that compressed air flowing inside of the relatively thin tubular portion 8 can derive a cooling effect from the surrounding body of relatively colder water.

In combination with this cooling structure made up of concentrically arranged tubular parts, as noted above, we may further construct the enclosure body 2 with a manifold supporting housing end 20. The housing part 20 is formed at two opposite sides with flat retaining surfaces against which are detachably secured a pair of manifold members M1 and M2 by means of fastenings 22, 24, etc., as shown in FIGS. 1 and 2. Supported at outer extremities of the manifold members M1 and M2 are spaced nozzle members N1 and N2 which are of hollow construction to provide mixing chambers 28 and 30 terminating in restricted orifices 28*a* and 30*a*.

An important feature of the invention consists in the provision of duct means for carrying out a further stage of precooling of the water and the compressed air. The duct means includes separated air and water outlets which are formed in opposite sides of the housing body 20 to guide air and water in isolated relationship to one another away from the passageways 6 and 12 and intthe manifold members M1 and M2. As shown, for example in FIGS. 3, 4 and 8, a transversely located opening 32 is formed in the housing to intersect at right angles the passageway 6, thus forming dual opposite outlets for the air. Likewise, the adjacent portions of the housing 20 are formed with transversely located apertures 34, 36, 38 and 40. These apertures are most clearly indicated in FIGS. 4 and 8 and occur on two opposite sides of the passageway 32.

Each of the manifold members M1 and M2 are formed with complementary flat faces through which extend openings corresponding to those in the housing 20. Thus, as shown in FIG. 7 the manifold face M1′ is formed with an air opening 32′ and water apertures 34′ and 38′ so that when the manifold is secured in place, a continuous passageway is realized, as shown in FIG. 4.

Extending away from the openings in faces of each of the manifolds are duct portions D1 and D2 which terminate in restricted tip portions D3 and D4 having openings D5 and D6. The ducts D1 and D2 are supported in spaced relation to the wall sections of the manifolds M1 and M2, as shown in FIG. 4, and this arrangement provides for water leaving the passageway 12 to pass through the manifold and around the duct portions D1 and D2 and their tips D3 and D4 to mix with compressed air leaving the orifices D5 and D6.

By means of this arrangement of parts, a further stage of cooling can be realized both by reason of cold water circulating around the duct members D1 and D2 and also by reason of the fact that some expansion of the compressed air occurs as the air leaves the orifices D5 and D6 just prior to being mixed with water and ejected

through the orifices **28***a* and **30***a* into the outer atmosphere where still another stage of cooling takes place.

It is pointed out that the stages of cooling accomplished by the method and apparatus described results in both the water and the air reaching the outer ambient atmosphere at an appreciable lowered temperature, with the result that the outer ambient air can operate more effectively in producing snow.

We have also determined that we can very desirably control the characteristics of the snow which is produced by the method described through the aid of a special valve mechanism V illustrated in FIGS. **1, 2, 3, 5** and **8.** As noted in FIGS. **3** and **5,** we form the inner tubular section **8** with a valve aperture V1 by means of which compressed air confined in the tubular member **8** may be released into the space enclosed by the tubular section **2.** Arranged to move into and out of sealing relation with a valve seat formed around this opening V1 is a valve head V2 which is rotatably supported in a threaded connection V3 in the enclosure body **2.** A hand wheel V4 provides for adjusting the valve head V2 as desired. We have found that by precooling air in the passageway **6,** and then allowing this precooled air to become injected in small quantities into a surrounding flow of water, there is accomplished a seeding of water crystals in the water and the quality of the snow particles ultimately produced in the ambient atmosphere outside the orifices **28***a* and **30***a* is regulated in size and wetness so that improved snow covering action can be realized and a more uniform distribution of snow can be accomplished.

As earlier pointed out, the invention, although not limited thereto, may be combined with a tower member T to accomplish a reverse precooling action to that which takes place in the enclosure body **2.** This is accomplished by introducing air through the passageway A into the interior of the tower T, as shown in FIG. **1,** so that this air with the turret surface being exposed to a cold ambient atmosphere undergores a degree of precooling. At the same time, water furnished through the pipe W is conducted through the tower T inside of this flow of precooled air until reaching an outlet port W1; similarly the air exits an outlet port A1. From these outlet ports, A1 and W1, the flows are reversed and conducted into the enclosure body **2** so that the air is located inside of the water to accomplish the precooling described.

From the foregoing description, it would seem that we have disclosed an improved method of making snow, and we have found that by means of the precooling stages described, we are enabled to operate at some temperature levels in the freezing range which are not normally feasilbe for conventional snow making. More importantly, we have found that by utilizing the precooling stages described, either in one form or another, it becomes possible, with relatively small snow-making units, to increase snow production as much as two or three times over that which can be reailized with conventional snow-making equipment. The jet structure described is compact and readily movable about a ski slope and requires a minimum amount of attention and handling by snow-making operators.

We claim:

1. In a method of snow-making, the steps which include furnishing streams of compressed air and pressurized water from two independent sources of supply, conducting the streams into an enclosure body in which precooling takes place and ejecting a mixture of the compressed air and water into a cold ambient atmosphere in which the mixture undergoes expansion and further cooling to produce snow particles, said precooling being carried out in successive stages including a first stage in which precooling is carried out by exposure to cold ambient atmosphere to lower the temperature of the said compressed air, a second state in which controlled amounts of the lowered temperature air is injected into the water while confined in the enclosure body, and a third stage in which portions of the lowered temperature air undergoes expansion and additional cooling while contained in the enclosure body.

2. In a method of snow-making, the steps which include furnishing streams of compressed air and pressurized water from two indendent sources of supply, conducting the streams into an enclosure body in which precooling takes place and ejecting a mixture of the compressed air and water into a cold ambient atmosphere in which the mixture undergoes expansion and further cooling to produce snow particles, said step of furnishing the streams of compressed air and water including leading the streams through independent cooling chambers in whice the inner cooling chamber conducts the water and an outer cooling chamber conducts the air, with the outer cooling chamber having a surface exposed to the cold ambient atmosphere.

3. A method of making snow in which a mixture of compressed air and water is ejected from a snow-making nozzle and expanded and cooled in a cold ambient atmosphere to form snow particles, the steps which include confining the high velocity streams of compressed air and water in an elongated enclosure body which is exposed to the cold ambient atmosphere and lowering the temperature of the confined streams of air and water while in isolated relationship, then injecting metered quantities of the relatively lower temperature air into the relatively higher temperature water, and thereafter ejecting a mixture of the air and air-injected water into the cold ambient atmosphere to form snow particles whose particle characteristics are controlled by the said injection of the internally injected air.

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