International Publication Number: WO 98/36230
International Publication Date: 20 August 1998 (20.08.98)

International Patent Classification: F25C 7/12

(20) International Application Number: PCT/US98/03076
(22) International Filing Date: 17 February 1998 (17.02.98)
(30) Priority Data:
   08/801,190 18 February 1997 (18.02.97) US
   08/877,928 18 June 1997 (18.06.97) US


(72) Inventor; and
(75) Inventor/Applicant (for US only): NIECHCIAL, Roman [US/US]; Apartment 6, 1944 Hudson Street, Longview, WA 98632 (US).


Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

Title: ICE BLASTING CLEANING SYSTEM AND METHOD OF BLASTING

Abstract

An ice blasting cleaning system (20) including an ice maker (26) that creates ice particles (24), at least one separator (27) that separates snow (25) from the ice particles (24), a hopper (28) for receiving ice particles (24), and a blasting gun (32) that propels ice particles toward a surface to be cleaned. The separator may be an air blower (27), an ice breaker plate (42a, 42b), or a rotating brush (32). The present invention also includes an ice blasting cleaning method for cleaning a surface using ice particles. The method includes creating ice particles and snow (180), separating the ice particles from the snow, and propelling the ice particles toward a surface to be cleaned. Alternate embodiments of the apparatus and the method include spraying mist (304) into a hopper (302) which receives ice particles, and the ice particles being propelled toward a surface to be cleaned (306).
FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| AL | Albania          | ES | Spain        | LS | Lesotho       |
| AM | Armenia         | FI | Finland      | LT | Lithuania     |
| AT | Austria         | FR | France       | LU | Luxembourg    |
| AU | Australia       | GA | Gabon        | LV | Latvia        |
| AZ | Azerbaijan      | GB | United Kingdom | MC | Monaco       |
| BA | Bosnia and Herzegovina | GE | Georgia     | MD | Republic of Moldova |
| BB | Barbados        | GH | Ghana        | MG | Madagascar    |
| BE | Belgium         | GN | Guinea       | MK | The former Yugoslav |
| BF | Burkina Faso    | GR | Greece       | ML | Mali          |
| BG | Bulgaria        | HU | Hungary      | MN | Mongolia      |
| BI | Benin           | IE | Ireland      | MR | Mauritania    |
| BR | Brazil          | IL | Israel       | MW | Malawi        |
| BY | Belarus         | IS | Iceland      | MX | Mexico        |
| CA | Canada          | IT | Italy        | NE | Niger         |
| CF | Central African Republic | JP | Japan       | NL | Netherlands  |
| CG | Congo           | KE | Kenya        | NO | Norway        |
| CH | Switzerland     | KG | Kyrgyzstan   | NZ | New Zealand   |
| CI | Côte d'Ivoire   | KP | Democratic People's Republic of Korea | PL | Poland       |
| CM | Cameroon        | KR | Republic of Korea | PT | Portugal     |
| CN | China           | KZ | Kazakhstan   | RU | Romania       |
| CZ | Czech Republic  | LC | Saint Lucia  | SD | Sudan         |
| DE | Germany         | LI | Liechtenstein | SE | Sweden        |
| DK | Denmark         | LK | Sri Lanka    | SG | Singapore     |
| EE | Estonia         | LR | Liberia      | SI | Slovenia      |
| SK | Slovakia        | SN | Senegal      | SZ | Swaziland     |
| TD | Chad            | TG | Togo         | TJ | Tajikistan    |
| TM | Turkmenistan    | TR | Turkey       | TT | Trinidad and Tobago |
| UA | Ukraine         | UG | Uganda       | US | United States of America |
| UZ | Uzbekistan      | VN | Viet Nam     | YU | Yugoslavia    |
| ZW | Zimbabwe        |
ICE BLASTING CLEANING SYSTEM AND METHOD OF BLASTING

TECHNICAL FIELD

The present invention relates to a cleaning system that uses ice blasting and particularly to a system that uses coated ice particles as the cleaning agent.

BACKGROUND ART

Sand or grit blasting--propelling small granules of abrasives, such as sand or glass beads, towards surfaces such as walls, floors, and ceilings--has been widely used to clean surfaces that are dirty or have an unwanted coating (such as paint or graffiti). Grit blasting has several problems. For example, grit blasting is extremely abrasive which is damaging to the surface being cleaned. Also, the abrasives are expensive to obtain and become contaminated with the removed material after one use. Further, once the abrasives are contaminated they must be collected, a time consuming and often difficult proposition, and properly disposed since contaminated abrasives are usually not reusable. Since disposal costs are based on the weight of the material to be disposed, disposing of the abrasives along with the contaminants is extremely expensive.

Ice blasting, a process that uses ice or frozen material instead of traditional abrasives, solves some of the problems of grit blasting. For example, ice is generally not abrasive. Another example is that, if water is the frozen material, it is relatively inexpensive to obtain and is generally only needed in small quantities. Also, depending on where the ice blasting is being done and the type of coating that is being removed, the contaminated ice particles often can be allowed to melt and evaporate and thus little or no collection would be necessary. Still further, depending on the removed material, disposal may be done after the water has
evaporated which leaves only a small amount of removed material for disposal.

    Ice blasting has several other advantages. For example, it can remove soft or hard coatings such as grease, tar, paint, and even radioactive contaminants without damaging the underlying substrate. It is also dustless.

    Stratford et al. U.S. Patent No. 5,203,794, Fong U.S. Patent No. 4,038,786, Moore U.S. Patent No. 4,617,064, and Fong et al. U.S. Patent No. 4,389,820 disclose blasting apparatus that uses sublimable particles such as CO₂ as the cleaning agent. Although these devices are generally preferable to grit blasters, they still present several problems. For example, CO₂ generally comes in particles or in a dry ice block and is therefore expensive. Also, CO₂ is more difficult to obtain than water.

    Visaisouk et al. U.S. Patent No. 5,367,838, Ichinoseki et al. U.S. Patent No. 4,655,847, Westergaard U.S. Patent No. 4,703,590, and Kelsall U.S. Patent No. 4,965,968 are directed to ice blast cleaning systems that can use ice formed from water as the cleaning agent. The ice blasting systems disclosed in these patents are troublesome, complicated, limited in use, and very expensive.

    More specifically, the known ice blasting systems are troublesome to use because they have configurations that have ice flow that is very unstable and requires frequent adjustments. Further, these systems suffer from recurrent ice build-ups or ice plug-ups that cause expensive machine operation delays. These ice build-ups or plug-ups often occur when the temperature of a system raises above freezing and then goes below freezing again. Accordingly, known systems do not function properly in environments above freezing.

    To prevent ice build-ups and ice plug-ups, known systems use complicated designs because they must
stay below freezing in order to function. Accordingly, all or part of each of these systems has to be cooled down to below freezing which uses significant energy and adds complicated and costly cooling and control devices.

DISCLOSURE OF THE INVENTION

The ice blasting cleaning system of the present invention overcomes the aforementioned problems. In one embodiment of the system, the system preferably includes an ice maker that creates ice particles, at least one separator that separates snow from the ice particles, a hopper into which the ice particles enter, and a blasting gun that receives the ice particles and propels them toward the surface to be cleaned.

One embodiment of the separator is an air blower that preferably blows warm air. As shown, the airblower has a length of tubing having at least one aperture through which the warm air flows. In an alternate embodiment, the separator is an ice breaker plate set at a steep angle. In still other embodiments of the invention, the separator may be a heated or a cooled ice breaker plate. Other embodiments of the invention may include a mechanical separator such as a rotating brush.

Preferably the hopper has sides adapted to allow falling particles to settle thereon to form settleage. Preferably the sides have steps or rungs for this purpose. The settleage on the sides of the hopper serves two purposes: it keeps the temperature within the hopper cold and it melts to form meltage. The meltage keeps ice particles cold as they are being propelled toward the surface by the blasting gun.

The present invention also includes an ice blasting cleaning method for cleaning a surface using ice particles as the cleaning agent. The first step of the method is to create ice particles and snow. Then the ice particles are separated from the snow. The ice particles
then enter a hopper. Finally, the ice particles are propelled toward the surface to be cleaned. Except for the step of creating the ice particles, the method is generally accomplished in an above freezing environment.

An alternate embodiment of an ice blast cleaning system of the present invention may include an ice maker that creates ice particles, a hopper into which the ice particles enter, at least one mist nozzle that introduces a mist of water and air into the hopper, and a blasting gun that receives the ice particles and propels them toward the surface to be cleaned.

The present invention also includes an alternate ice blasting cleaning method for cleaning a surface using ice particles as the cleaning agent. The first step of the method is to create ice particles. The ice particles then enter a hopper in which they are sprayed with mist. Finally, the ice particles are propelled toward the surface to be cleaned. Except for the step of creating the ice particles, the method is generally accomplished in an above freezing environment.

The ice maker that is used preferably can create ice flakes of a predetermined size. The ice maker of this embodiment generally includes a water source, a cooled rotating drum, an ice breaker plate positioned at an angle to the rotating drum so that a scraping edge of the ice breaker plate is substantially adjacent to the rotating drum, and a sizer positioned at a sizing distance from the ice breaker plate and substantially adjacent an ice coating formed on the rotating drum. The sizer holds the ice coating on the rotating drum while the scraping edge of the ice breaker plate scrapes the ice coating off the rotating drum to create ice flakes. The sizing distance, which is preferably adjustable, substantially determines the flake size of the ice flakes.

The foregoing and other objectives, features, and advantages of the invention will be more readily
understood upon consideration of the following detailed description of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one embodiment of the ice blasting cleaning system of the present invention.

FIGS. 2A-2C are top views of alternate exemplary embodiments of a hopper.

FIGS. 2D-2E are cross-sectional side views of alternate exemplary embodiments of a hopper.

FIG. 3A is a cross-sectional side view of a blasting gun.

FIG. 3B is an enlargement of FIG. 3A taken along lines 3B-3B.

FIG. 4A is an exemplary ice maker with a sizing shield.

FIGS. 4B and 4C are cross sectional side views of exemplary embodiments of an ice maker with a sizing shield.

FIGS. 5A-5D are enlarged cross sectional side views of ice makers with alternate exemplary embodiments of separators.

FIG. 6 is an enlarged perspective view of an ice breaker plate.

FIG. 7 is a perspective view of an air blower embodiment of the separator.

FIG. 8 is a flow chart depicting one ice blasting method of the present invention.

FIG. 9 is a perspective view of an alternate embodiment of the ice blasting cleaning system of the present invention.

FIG. 10 is a top view of a hopper with a misting system.

FIG. 11 is a flow chart depicting an alternate ice blasting method of the present invention.
BEST MODE FOR CARRYING OUT THE INVENTION

The present invention is an ice blast cleaning system that is used for cleaning a surface with ice particles. FIG. 1 shows one embodiment of an ice blasting cleaning system 20 of the present invention is used for cleaning a surface 22 with ice particles 24. As shown, the system 20 generally includes an ice maker 26 that creates the ice particles 24 and snow 25, a separator (shown as square tubing 27) that separates the ice particles 24 from the snow 25, a hopper 28 that preferably has steps 30 (FIGS. 2A-2E), and a blasting gun 32 (FIGS. 3A-3B) connected to the hopper 28 by a hose 34.

An ice maker 26, 26', 26" as shown in FIGS. 4A-4C, preferably creates relatively small ice particles 24 and, depending on the ice maker, may also create snow 25. Alternate ice makers may also be used. However, the shown ice makers 26, 26', 26" are horizontal drum ice makers that create a specific type of ice particles 24 (or ice flakes) of relatively even and small size as well as snow 25.

More specifically, each ice maker 26, 26', 26" includes a water source for supplying water that is applied to a rotating drum 38. The water source may be a reservoir 36' (FIG. 4B) through which a rotating drum 38 rotates or it may be one or more sprayers 36" (FIG. 4C) that sprays a coat of water on the rotating drum 38. The rotating drum 38 is preferably cooled or refrigerated so that the coat of water freezes to form an ice coating 40 on the rotating drum 38.

The ice maker 26 also includes an ice breaker plate 42 with a scraping edge 44. The ice breaker plate 42 is preferably positioned at an angle to the rotating drum 38 so that the scraping edge 44 is substantially adjacent to the rotating drum 38. It should be noted that the scraping edge 44 should be far enough from the rotating drum 38 so that the drum can still rotate, but close enough to allow the scraping edge 44 to scrape the
ice coating 40 from the rotating drum 38 as it rotates. Notches 45 (FIG. 6) on the breaker plate 42 help to lift and separate the ice particles 24.

A sizer such as the sizing shield 46 is preferably positioned substantially adjacent the ice coating 40 on the rotating drum 38. The sizing shield 46 should precede the ice breaker plate 42 by a sizing distance 48 (FIG. 5A). The sizing shield 46 would be adjustable to accommodate different thicknesses of the ice coating 40 and different sizing distances 48. The size of the ice particles 24 is substantially determined by the sizing distance 48. As the sizing shield 46 holds the ice coating 40 on the rotating drum 38 the scraping edge 44 of the ice breaker plate 42 scrapes the ice coating 40 off the rotating drum 38. It should be noted that the sizer may be a roller, conveyer tape, or any other apparatus that limits the ice coating 40 from lifting off the drum 38. Further, the sizer may be made from any suitable material including plastic.

The separator 27, mentioned generally above, may include one or more of a combination of apparatus that, alone or together, separate snow 25 from the ice particles 24 as they are created or shortly thereafter.

For example, one type of separator is a heated ice breaker plate 42a, 42b such as those shown in FIGS. 5A and 5B. Ice breaker plates 42a and 42b are substantially identical except for the angle at which they are placed relative to drum 38. Using the steeper angle shown in FIG. 5b, it is less likely that ice particles 24 or snow 25 will stick to the ice breaker plate 42b. Also the angle of an ice breaker plate 42a, 42b can be varied or set to direct all or part of the falling particles 24 and snow 25 to the steps 30, 31 of the hopper 28, 28', 28", 29. The heated ice breaker plate 42a, 42b melts snow 25 that lands on it so that the snow 25 evaporates. Ice particles 24, on the other hand, are generally large enough to withstand the heating, and,
therefore, are pulled down by gravity into the hopper 28, 28', 28", 29.

Another type of separator is a cooled ice breaker plate 42a, 42b such as those shown in FIGS. 5A and 5B. The cooled ice breaker plate 42a, 42b slows the snow 25 sufficiently, particularly if the plate is at the angle shown in FIG. 5B, so that it drifts slowly to the sides of the hopper 28, 28', 28", 29 and attaches itself thereto. Ice particles 24, on the other hand, are more likely to bounce off the sides of the hopper 28, 28', 28", 29.

FIG. 5C shows another possible separator that includes a tubing 27 (shown as square) with at least one perforation 50. FIG. 7 shows a perspective view of the tubing 27 with perforations 50. As shown in FIG. 1, air from an air source 150 is supplied to the tubing 27 through a series of pipes or hoses 151. A flow control valve 152 or other controls 154 may be used to regulate the supply of air to the tubing 27. As shown, the air from the air supply 150 flows through the tubing perforations 50 along the area of the ice maker 26 at which the snow 25 and ice particles 24 are created. Because the snow 25 is light, the air blows the snow 25 upward and causes it to evaporate. On the other hand, ice particles 24 are generally too large to be blown upward or to evaporate significantly.

Yet another separator is shown in FIG. 5D. In this embodiment the separator is a roller brush 52 that rotates across the particles 24 and snow 25 as they are created. The rotation of the brush 25 pushes the particles 24 and snow 25 outward. Because the snow 25 is smaller, it tends to evaporate as it falls. Also, the weight difference between the particles 24 and the snow 25 causes snow 25 to drift farther than the particles 24. It should be noted that in addition to a roller brush 52, other mechanical means such as a wiper (not shown) can be used as a separator.
As mentioned above, the angle of the ice breaker plate 42, 42a, 42b may be varied (two such positions are shown in FIGS. 5A and 5B) to direct the particles or to vary the rate of fall of the particles. Also, the angle of the ice breaker plate 42, 42a, 42b will tend to determine how often particles 24 and snow 25 contact the ice breaker plate 42, 42a, 42b. Each time a particle 24 contacts the ice breaker plate 42, 42a, 42b it has the potential to break into smaller pieces and to simultaneously create more snow 25. Also, as shown in FIG. 6, notches 45 may be included in the ice breaker plate 42, 42a, 42b. The notches 45 lift the ice coating 40 and cause breakage without adding additional forces on the ice coating 40. Also, the notches 45 assure that the ice particles 24 are broken to a specific size.

The ice particles 24 are preferably pulled down by gravity downward into a hopper 28, 28', 28", 29. Each hopper 28, 28', 28", 29 preferably has a first opening 80 through which the ice particles 24 (and sometimes snow 25) enter. A second opening 82 is connected to the hose 34. It should be noted that the first opening 80 of the hopper 28 preferably has a first diameter and the second opening 82 preferably has a second diameter. Preferably the second diameter is smaller than the first diameter and the diameter generally decreases from the first diameter to the second diameter. By decreasing the diameter of the hopper 28, 28', 28", 29 the ice particles 24 are generally directed downward toward the second opening 82.

FIGS. 2A-2E show exemplary embodiments of hoppers 28, 28', 28", and 29. FIG. 2A shows a hopper 28 that has generally rounded sides 84. As shown, the sides 84 have a series of steps 30 such as those shown in cross section in FIG. 2D. FIGS. 2B and 2C show rectangular variations 28' and 28" of the hopper. FIG. 2B also shows a variation 28' in which some sides 84 have steps 30 and some sides 86 do not have steps. FIG. 2E shows yet
another hopper 29. This hopper 29 has steps 31 that are similar to rungs on a ladder. These steps 31 function in a manner similar to steps 30, but would be less expensive to produce.

FIGS. 2D and 2E also show particles 24 and snow 25, herein after referred to as settlage 90 that has accumulated on the steps 30, 31 of the hoppers. In embodiments that direct snow 25 to the sides of the hoppers, snow 25 will form a substantial part of the settlage 90. In embodiments where the snow 25 is melted (FIG. 5C), most of the settlage 90 will be made of particles 24. The settlage 90 serves two main purposes. First, the settlage 90 acts as an insulator that keeps the temperature inside the hopper relatively cold.

Second, the settlage 90 slowly melts and becomes water, hereinafter referred to as meltage 92. The meltage 92 mixes with and coats particles 24 as they exit the hopper through the second opening 82. Because the meltage 92 is very cold it helps protect the ice particles 24 from melting.

From the hopper 28, the ice particles 24 and meltage 92 are preferably pneumatically conveyed to the blasting gun 32. Within the blasting gun 32 the mixture is further accelerated and propelled toward the surface 22 to be cleaned.

The preferred embodiment of the blasting gun 32, shown generally in FIG. 1 and in detail in FIGS. 3A and 3B, receives the ice particles 24 and meltage 92 and propels the ice particles 24 and meltage 92 toward the surface 22 to clean it. The blasting gun 32 is preferably connected to the hose 34 at an ice particle opening 156. The blasting gun 32 is preferably connected to air source 150 at an air opening 158 by an air hose 159. Air flow may be controlled by a blast air control valve 160. The combined ice particles 24, meltage 92, and air exits through the gun exit nozzle 162.
FIG. 3B shows that the air flow 163a (shown as dashed arrows) is introduced centrally through the central air flow nozzle 164 into the blasting gun 32. The ice particle flow 163b (shown as open arrows) flows essentially around the air flow 163a. The air flow 163a and ice particle flow 163b combine to become a combination flow 163c (shown as a the combined arrow) that flows through the gun exit nozzle 162. This configuration, and the added air flow 163a, acts as a venturi that pulls forward the ice particles 24 from behind the entrance of the air flow 163a. As mentioned above, the combined ice particles 24, meltage 92, and air exit through the gun exit nozzle 162.

Because the ice particles 24 that emanate from the gun exit nozzle 162 have been slowly melting as they travel through the system 20 and have collided and broken along the way, they may be of a small, medium, or large size. Each size serves a specific purpose as it emanates from the blasting gun 32 and impacts the surface 22. The smallest particles sublimate as they hit the surface 22 to help fracture the unwanted surface coatings. The medium sized particles melt into water as they hit the surface 22 and therefore assist in washing away the coating. The largest particles bounce off the surface 22 as they hit.

It should be noted that air source 150 is preferably compressed air. High, medium, and low pressure compressed air may be used and it may be any temperature. One of the features of this invention is that the compressed air may be at ambient temperature, so no cooling or drying equipment is required. The flow of the air pressure may be controlled through flow control devices 152, 154, and 160.

The present invention, as shown in FIG. 8, also includes an ice blasting cleaning method for cleaning a surface 22 with ice particles 24. The first step of the cleaning method is to create ice particles and snow in a
below freezing environment 180. As the ice particles and snow are being created, they are almost instantaneously separated from each other 182. After the ice particles and snow have been created and separated 184 gravity pulls the ice particles downward to the hopper 186. Some ice particles settle on the sides of the hopper to form settlage 188. This particularly true when a stepped hopper is used. The settled ice particles tend to act as insulation maintaining a relatively cool ambient temperature. However, some of the ice particles on the sides of the hopper melt to form meltage 190. The ice particles and meltage exit from the hopper as a vacuum pulls the ice particles and meltage through a hose to a blasting gun 192. Within the blasting gun compressed air is added to the ice particles and meltage 194. As is evidenced by condensation on the outside of the blasting gun, the combined ice particles, meltage, and compressed air is cooled and then forced through the blast gun onto a surface to be cleaned 196.

Referring to FIG. 9, an alternate ice blasting cleaning system 220 of the present invention is used for cleaning a surface 22 with ice particles 24. As shown, the system 220 generally includes an ice maker 226 that creates the ice particles 24, a hopper 228, at least one mist nozzle 230 directed into the hopper 228, and a blasting gun 32 connected to the hopper 228 by a hose 34.

The ice maker 226 is essentially identical to the ice makers 26, 26', 26" as shown in FIGS. 4A-4C and discussed above. In this embodiment, a separator may not be used.

The ice particles 24 are preferably pulled down by gravity downward into the hopper 228. Although hoppers such as the hoppers 28, 28', 28", 29 discussed above may be used, the hopper 228 preferably has smooth sides and a shape that can generally be described as conical.
As shown in detail in FIG. 10, at least one mist nozzle 230, and preferably two mist nozzles 230, is directed into the hopper 228 for introducing a mist 242 of water and air into the hopper 228. Preferably there are two mist nozzles 230 that are positioned at opposite ends of the hopper 228 so that the mist 242 swirls within the hopper 228. The air in the mist 242 turns the water into mist and a flow of air in which the ice particles 24 to swirl and collide. The water in the mist 242 coats the surface of the ice particles 24 during this swirling process.

The water that enters each mist nozzle 230 is provided by a water source 244 that may be cold water (not shown) from the ice maker 226. Alternatively, the water source 244 could be a separate source not affiliated with the ice maker. One or more flow control valves 248 can be used to control the amount of water provided to each mist nozzle 230. Air is provided to each mist nozzle 230 from an air source 250 and is preferably compressed air. An air flow control valve 252 may be used to control the flow of air to each mist nozzle 230. Other controls (shown generally as 254) may include a low pressure air circuit or a pressure reducing valve that may be used in conjunction with or alternatively to the flow control valve 252 to control air pressure.

The conical shape of the hopper 228 and the swirling mist 242 together serve to increase the velocity of the ice particles 24 and to cause the ice particles 24 to swirl within the hopper 228. The increased velocity is beneficial in that it adds to the speed in which the ice particles 24 travel through hose 34. The swirling motion is beneficial because it causes the ice particles 24 to separate from each other so that they do not enter the hose 34 in a bunch. Also, the swirling motion causes the ice particles 24 to collide. Ice particles 24 that collide break into smaller ice particles and "snow" that help to keep the other particles cool. The swirling also...
causes the ice particles 24 to travel in a spiral path that helps to prevent them from adhering to the walls of the hopper 228.

From the hopper 228, the ice particles 24, that are now coated with water, are preferably pneumatically conveyed to the blasting gun 32 and accelerated and propelled toward the surface 22 to be cleaned as discussed above.

FIG. 11 shows an alternate ice blasting cleaning method for cleaning a surface 22 with ice particles 24. The first step of the cleaning method is to create ice particles 300 which enter a hopper 302. A mist comprising of air and water is sprayed in the hopper so that the air and water mixture is sprayed onto the ice particles 304. The ice particles then flow, pulled by a vacuum or venturi, to the blasting gun 306. The ice particles and compressed air are then propelled onto a surface to be cleaned 308.

The alternate cleaning method may also include the step of sizing the ice particles using a sizer 310 such as a sizing shield. Further, the step of spraying mist 304 can be divided into two smaller steps: spraying a coating of water onto the surface of the ice particles 312 and spraying a stream of air that causes the particles to swirl and collide 314. Finally, the step of propelling the ice particles 308 may include the intermediate step of adding air to the ice particles.

The above apparatus and methods, unlike the prior art systems that only work in a cold environment (below freezing and generally in the range of 0°F to 15°F), works well in warmer environments. Although ice particles 24 are created at below freezing (or simply supplied), the rest of the system 20 functions in a generally warm environment that is above freezing. There are several advantages to this feature including that the system 20 does not require additional cooling and does
not experience the ice build-ups and plug-ups associated with previous systems.

Previous systems have been designed to work at below freezing temperatures because it was thought that to transport ice particles over any significant distance (or to prepare or handle ice in general) the particles would have to be kept below freezing. The present system 20, however, takes advantage of the fact that ice melts very slowly when it is at temperatures just above freezing. However, if previous systems were simply stripped of their cooling apparatus, they would not function because the ice particles would melt before they could be effective in ice blasting. Further, these stripped systems would be plagued by plug-ups and adherence problems as the ice particles stuck to the apparatus and each other. The system 20 of the present invention, however, has several temperature controlling features that keep the system 20 in a temperature range of just above freezing to up to 50°F. In this temperature range the ice particles 24 can be transported while they are slowly melting, but still effective for ice blasting cleaning.

The first temperature controlling feature is the insulation provided by the settling 90 on the steps 30 of the hopper 28. This insulation keeps the environment in the hopper 28 relatively cold. The second temperature controlling feature is that the ice particles 24 is mixed with meltage 92 as it enters the hose 34. The meltage 92, which is about 32°F, serves as a heat capacitor to protect the ice particles 24 from melting. This is true because it takes significant energy to raise the temperature of water such as the meltage even one degree. Comparatively, it takes very little energy to raise the temperature of air that in previous systems was used to maintain the temperature below freezing. The third temperature controlling feature is that the ice particles 24 travel very rapidly through the system 20.
In the alternate embodiment and method shown in FIGS. 9-11, one temperature controlling feature is that the ice particles 24 that collide break into smaller ice particles and "snow" which helps to keep the other particles cool. The collisions are generally caused by the swirling of the ice particles 24 within the hopper 228. Another temperature controlling feature is that the ice particles 24 are coated with water in the hopper 228. Generally, if the ice particles are uncoated, ice particles from an ice maker would start to melt as soon as the temperature went above freezing. This would cause the particles to decrease in size as a surface layer of water was formed thereon. However, in the present invention, the ice particles 24 are immediately coated with a thin layer of water. If the water is cool, the ice particles 24 would not have to melt to form the surface coating. The surface coating would then serve as an insulator to protect the ice particle from melting. Still another temperature controlling feature is that the ice particles 24 travel very rapidly through the system 220. The centrifugal action of the ice particles 24 in the hopper 228, along with other features described above, increase the speed of the ice particles 24 as they travel through the system 220.

The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.
I CLAIM:

1. An ice blasting cleaning system for cleaning a surface with ice particles, said system comprising:
   (a) an ice maker that creates said ice particles and snow;
   (b) at least one separator that separates said snow from said ice particles;
   (c) a hopper having a first opening and a second opening, said ice particles entering said hopper at said first opening; and
   (d) a blasting gun connected to said second opening of said hopper, said blasting gun receiving said ice particles and propelling said ice particles toward said surface.

2. The system of claim 1 wherein said at least one separator is an air blower.

3. The system of claim 2 wherein said air blower blows warm air.

4. The system of claim 2 wherein said airblower has a length of tubing having at least one aperture.

5. The system of claim 1 wherein said at least one separator is an ice breaker plate set at a steep angle.

6. The system of claim 1 wherein said at least one separator is a heated ice breaker plate.
7. The system of claim 1 wherein said at least one separator is a cooled ice breaker plate.

8. The system of claim 1 wherein said at least one separator is a rotating brush.

9. The system of claim 8 wherein said rotating brush rotates against said sizer so as to separate said snow from said ice particles as they are created.

10. The system of claim 1 wherein said ice maker is a horizontal drum ice maker, said ice maker comprising:

   (a) a water source for supplying water;
   (b) a cooled rotating drum coatable by said water, said rotating drum suitable to freeze an ice coating thereon;
   (c) an ice breaker plate with a scraping edge, said ice breaker plate positioned at an angle to said rotating drum, said scraping edge substantially adjacent to said rotating drum;
   (d) a sizer positioned substantially adjacent said ice coating on said rotating drum;
   (e) whereby said sizer holds said ice coating on said rotating drum while said ice breaker plate scrapes said ice coating off said rotating drum to create ice particles and snow.

11. The system of claim 1 wherein said hopper has sloped sides onto which some of said ice particles settle to form settlement.
12. The system of claim 11 wherein said
settle age melts to form meltage, said blasting gun
receiving said meltage and propelling said meltage toward
said surface.

13. The system of claim 1 wherein said hopper
has stepped sides onto which some of said ice particles
settle to form settle age.

14. The system of claim 1 wherein said hopper
has sides with rungs, wherein some of said ice particles
settle on said rungs to form settle age.

15. An ice blasting cleaning method for
cleaning a surface with ice particles, said method
comprising the steps of:
(a) creating said ice particles and snow;
(b) separating said ice particles and said
snow;
(c) said ice particles entering a hopper;
(d) propelling said ice particles toward said
surface.

16. The method of claim 15 wherein said step
of separating is performed simultaneously with said step
of creating.

17. The method of claim 15 wherein said step
of separating includes blowing warm air on said ice
particles and said snow.

18. The method of claim 15 wherein said step
of separating includes angling an ice breaker plate at a
steep angle.

19. The method of claim 15 wherein said step
of separation includes heating an ice breaker plate.
20. The method of claim 15 wherein said step of separation includes cooling an ice breaker plate.

21. The method of claim 15 wherein said step of separation includes applying a rotating brush to said ice particles.

22. The method of claim 15 further comprising the step of a portion of said ice particles settling on sides of said hopper to form settling.

23. The method of claim 22 further comprising the step of said settling melting to form meltage.

24. The method of claim 23 wherein said step of propelling said ice particles toward said surface further comprises the step of propelling said meltage toward said surface.

25. The method of claim 15 wherein said step of propelling said ice particles further comprises the step of adding air to said ice particles.

26. An ice blasting cleaning method for cleaning a surface with ice particles, said method comprising the steps of:
   (a) creating ice particles and snow in a below freezing environment;
   (b) separating said ice particles and snow;
   (c) increasing the velocity of said ice particles in an above freezing environment; and
   (d) propelling said ice particles toward a surface to be cleaned.
27. An ice blasting cleaning method for cleaning a surface with ice particles, said method comprising the steps of:
   (a) creating ice particles in a below freezing environment;
   (b) increasing the velocity of said ice particles in an above freezing environment; and
   (c) propelling said ice particles toward a surface to be cleaned.

28. An ice blasting cleaning system for cleaning a surface with ice particles, said system comprising:
   (a) an ice maker that creates said ice particles;
   (b) a hopper having a first opening and a second opening, said ice particles entering said hopper at said first opening;
   (c) at least one mist nozzle directed into said hopper for introducing a mist of water and air into said hopper; and
   (d) a blasting gun connected to said second opening of said hopper, said blasting gun receiving said ice particles and propelling said ice particles toward said surface.

29. A horizontal drum ice maker for creating ice flakes each of which having a flake size, said ice maker comprising:
   (a) a water source for supplying water;
   (b) a cooled rotating drum coatable by said water, said rotating drum suitable to freeze an ice coating thereon;
(c) an ice breaker plate with a scraping edge, said ice breaker plate positioned at an angle to said rotating drum, said scraping edge substantially adjacent to said rotating drum; and

(d) a sizer positioned substantially adjacent said ice coating on said rotating drum, said sizer positioned at a sizing distance from said ice breaker plate;

(e) whereby said sizer holds said ice coating on said rotating drum while said ice breaker plate scrapes said ice coating off said rotating drum to create ice flakes, said sizing distance substantially determining the flake size of said ice flakes.

30. An ice blasting cleaning method for cleaning a surface with ice particles, said method comprising the steps of:

(a) creating said ice particles;
(b) said ice particles entering a hopper;
(c) spraying mist onto said ice particles within said hopper;
(d) propelling said ice particles toward said surface.
Fig. 8

Creation and Separation of Ice Particles and Snow

Creating Ice Particles and Snow in Below Freezing Environment

Separating Ice Particles and Snow

Gravity Pulls Ice Particles Downward into Hopper

Some Ice Particles Settle on Sides of Hopper to Form Settlegage

Ice Particles on Sides of Hopper Melt to Form Meltage

Vacuum Pulls Ice Particles and Meltage Through Hose to Blasting Gun

Compressed Air Added to Ice Particles and Meltage

Cooled Ice Particles, Meltage, and Compressed Air Forced Through Blast Gun Onto Surface to Be Cleaned
Fig. 11

ICE PARTICLES CREATED

SIZE OF ICE PARTICLES CONTROLLED BY SIZING SHIELD

GRAVITY PULLS ICE PARTICLES DOWNWARD INTO HOPPER

AIR AND WATER MIXTURE SPRAYED ONTO ICE PARTICLES

WATER COATS SURFACE OF ICE PARTICLES

AIR STREAM CAUSES ICE PARTICLES TO SWIRL AND COLLIDE

VACUUM PULLS FLUIDIZED ICE THROUGH HOSE TO BLASTING GUN

ICE PARTICLES AND COMPRESSED AIR ARE PROPELLED THROUGH BLASTING GUN ONTO SURFACE TO BE CLEANED
A. CLASSIFICATION OF SUBJECT MATTER
   IPC(6) : F25C 7/12
   US CL : 451/38,39
   According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
   Minimum documentation searched (classification system followed by classification symbols)

   Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

   Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 402,968 A (RAILSBACK) 07 May 1889, see entire document.</td>
<td>1-30</td>
</tr>
<tr>
<td>A</td>
<td>US 2,549,215 A (MANSTED) 17 April 1951.</td>
<td>1-30</td>
</tr>
<tr>
<td>Y</td>
<td>US 2,699,403 A (COURTS) 11 January 1955, see entire document.</td>
<td>1-30</td>
</tr>
<tr>
<td>A</td>
<td>US 3,400,548 A (DRAVER) 10 September 1968.</td>
<td>1-30</td>
</tr>
<tr>
<td>A</td>
<td>US 3,494,144 A (SCHILL) 10 February 1970.</td>
<td>1-30</td>
</tr>
<tr>
<td>Y</td>
<td>US 5,623,831 A (MESHER) 29 April 1997, see entire document.</td>
<td>1-30</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.  
See patent family annex.

Date of the actual completion of the international search: 20 MAY 1998

Date of mailing of the international search report: 12 JUN 1998

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3220

Authorized officer: Sheila Veney
Paralegal Specialist
Group 3200

Telephone No. (703) 308-1824

Form PCT/ISA/210 (second sheet)(July 1992)*