ABSTRACT: An apparatus for dispensing at sonic velocity a jet stream of a dispersion of flowable material in a gas. The apparatus includes a container for storing a body of flowable material and a mixing chamber associated with the bottom of the container. The mixing chamber contains an orifice communicating the chamber with the body of material. A tube connects the chamber with the pressurized head space above the material. The pressure drop through the tube provides a pressure differential metering material through the orifice into the chamber.
ABRASIVE PROPELLANT APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a novel and an improved apparatus for dispensing finely divided flowable material and, more particularly, the present invention relates to an improved apparatus for metering abrasive grains into a dispensing gas in a single, simplified operation.

2. Description of the Prior Art

The uses of propelled mixtures of gas and flowable ablating material are expanding quite extensively. Since there is no contact between the tool and the workpiece, a gas-propelled suspension of abrasive particles cannot cut without shock and without substantially raising the temperature of the workpiece. The little heat produced is immediately removed by the propellant gas. A wide variety of hard and brittle materials can be cut, shaped, deburred, cleaned, drilled, etched, or abraded. These operations can be performed on semiconductors, ceramics, glass, fragile crystals, and other materials likely to shatter, melt, or otherwise deteriorate with the use of ordinary cutting or abrading tools.

Apparatus presently available for this purpose utilize vibration to create a suspension of the particles in the gas and utilize suction to mix the suspension with the propellant stream. Such apparatus are very complicated and require specifically manufactured intricate parts and have poor maintenance records rendering the cost of construction and operating these apparatus relatively expensive.

OBJECTS AND SUMMARY OF THE INVENTION

Therefore, an object of this invention is the provision of an apparatus for dispensing a metered quantity of flowable material dispersed in a stream of gas and for delivering this mixture as a compound jet stream to a workpiece for variety of purposes and operations.

A further object of the invention is to provide such an apparatus in a simplified and inexpensive form and which operates with no moving parts and high reliability for long periods of operation with substantially few parts being subject to wear and replacement.

Yet another object of the invention is the provision of an abrasive blast apparatus including a simplified and convenient variable adjustment of the amount of flowable material present in the jet blast stream.

Still another object of the invention is the provision of an apparatus capable of dispensing flowable material in solid form, liquid form, or combination thereof of various specific gravities and viscosities which can be delivered to a workpiece at sonic velocity.

A further object of the invention is to provide a simple, inexpensive and reliable abrasive dispensing apparatus constructed of readily available conventional parts and operable without the use of electric power.

These and other objects and many attendant advantages of the invention will become apparent as the description proceeds.

These objectives are accomplished according to the invention by an apparatus which generally includes a container for storing a body of flowable material, means for applying gas pressure to the head space of said container above the body and mixing means associated with a lower portion of the container. The mixing means includes a mixing chamber communicating through an orifice with the body of material and through a length of tubing with the head space whereby an adjustable pressure drop is created across the orifice. Thus, flowable material passes into the chamber only when a differential pressure exists across the orifice.

This pressure drop is provided without the necessity of moving parts and is adjustable so that the amount of flowable material entering the chamber and the rate of flow may be increased or decreased by simply adjusting the pressure in the head space in the same direction as it is desired to change the flow rate of the material into the chamber. The range of flow rate of the material may be further adjusted by increasing or decreasing the orifice size. The gas entering the chamber through the tubing fluidizes the material to form a jet stream. The apparatus may further include a conduit communicating with the outlet of mixing chamber. The conduit is preferably formed of a flexible material resistant to the pressures of the system and terminating in a nozzle for delivering the mixture of flowable material and gas in a compound jet stream at sonic velocity to the article or workpiece to be polished, cut, shaped, or worked as desired. A clamp valve may be applied to the flexible conduit near the nozzle.

The invention will now become better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front plan view partly in section illustrating an embodiment of the apparatus of the invention;

FIG. 2 is a side view partly in section illustrating the details of the hand piece; and

FIG. 3 is a side view of an alternate barrel structure for the hand piece.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the FIGS. 1 and 2, the apparatus according to the invention generally comprises a container 10 for flowable material 12, a gas supply system 14 for pressurizing the container, a gas and flowable material mixing chamber 16, and an abrasive jet delivery section 18. The container may be formed of a transparent material such as plastic or glass and may contain a generally cylindrical upper portion and a tapered funnel-shaped lower portion providing a natural feed of the flowable material toward the mixing chamber 16.

The gas supply system includes a high-pressure gas source 20, such as a compressor or a high-pressure storage bottle and a high-pressure regulator 22, for coarse adjustment, low-pressure regulator 23 for fine adjustment, and a pressure gauge 25. The abrasive jet delivery system includes a nozzle 27, valve 29 and a flexible conduit 31 connecting the nozzle 27 to the mixing chamber 16.

An outwardly facing lid receiving flange 24 is part of the top of the container. A sealing gasket 26 is disposed between the flange 24 and lid 28. A gas tight assembly is formed by a portion of a two part clamp 30 having an upper portion 32 gripping the lid and a lower member 34 gripping the flange. The clamp is assembled by inserting a plurality of threaded bolts 38, through the clamping portions 32 and engaging the threads of the bolts with the threads provided in lower member 34 to press the lid 28 against the flange 24.

The pressurizing gas conduit 37 terminates in a quick disconnect 33, each mating part of which when separated closes to shut off the gas flow from the gas source 20 and to maintain the pressure within the container 10. The mating half 35 of the quick disconnect connected to the container may be either the male or the female portion. The portion 35 may be a threaded fitting extending through the lid 28. The threads extending below the lid 28 are further connected to an inlet fitting 44 having side openings 46 such that the flow of inlet gas is directed away from the top of the body of flowable material 12.

It is preferred to provide a flowable material inlet 50 on the lid 28 of the container rather than to open the clamp and remove the lid each time it is desired to refill the container with abrasive or change the type of abrasive. The inlet may take many forms and as shown, may comprise an aperture 52 in the lid covered by a plate 54. The outer upper edge of the plate is relieved at 56 to form a seat for an O-ring 58. The plate 54 is pivotally mounted on a threaded pin 60 extending through the lid 28. The pin 66 which has a knurled head 62 is surrounded by a spring 61. By grasping the knurled head 62 between two fingers and depressing the spring, the plate will
swivel to the side to expose the aperture 52 to the interior of the container 10. When the plate 54 is closed and the container is pressurized, the pressure in the container forces the plate 54 tightly against the lid 28, deforms the O-ring and thus seals the plate 54 from leakage.

The mixing chamber 16 is formed of a right angle fitting 100 the upper portion of which is threaded at 102. The upper portion of fitting 100 is inserted through a threaded bore in the bottom of the container 10 for a sufficient distance to expose at least a portion of the threads 102. A cap 104 is threaded onto the exposed threads 102. The cap is provided with a small diameter flowable material inlet orifice 106. A threaded aperture 108, which is larger than the orifice 106, is also provided in the cap 102 and a length of tubing 110 terminates in a threaded end 103 which is inserted into the aperture 108. The tubing extends through the body of material 12 into the head space 105 of the container 10. The tubing 110 preferably is bent at 116 to face away from the opening inlet 50 so as not to be filled with flowable material during refill.

The lower portion of the fitting 100 contains the outlet 125 to the chamber 16. The fitting terminates in a short length of metal tubing 126 connected to the outlet 125. The exterior of the fitting 100 is threaded at 128. The flexible conduit 31 is connected to the chamber 16 by means of an internally threaded cap 130 having an aperture 132 for receiving the flexible conduit 31. The cap 130, when tightened, on the thread connection between the cap 130 and the short length of metal tubing 126. The body forming the chamber may be straight or L-shaped as shown depending on the configuration of the final instrument.

The nozzle 27 and valve 29 may be incorporated in a single hand piece 150. The nozzle 27 is threaded onto the outside end of the hand piece head 158. The end of the tubing 31 is connected to the inside end of the hand piece 158 by means of an adjustable clamp 152. A barrel 159 is inserted over the tubing 31 and is threaded to the hand piece head 158. The valve 29 is preferably held in a normally closed position by a spring 160. The valve includes a pinching lever 162 which is bent to form a leg 156 which compresses the flexible conduit 31 against the inner wall of the barrel 159. The pinching lever 162 is held in position by a shoulder screw 154. The spring 160 surrounds a screw 154 and is contained between two centering washers 164 inserted through a clearance hole in the pinching lever 162. The screw 154 is finally threaded into a threaded hole provided in the barrel 159. Depressing pinching lever 162 releases the clamping leg 156 to release the cramped tubing 31 and open the valve 29 and allow the flow of the jet stream.

In assembling the apparatus, the mixing chamber fitting 100 is threaded into the bottom of container 10 and a cap 104 having an orifice 106 of the desired diameter is threaded onto the exposed threads 102. A length of tubing 110 is screwed into the cap 104 and the bend 116 is placed such that the end of the tube faces away from the opening inlet 50.

The end of a length of flexible tubing containing a hand piece 150 including a nozzle 27 and a normally closed clamping valve 29 is inserted through the aperture 132 in cap 130 and onto the tubing 126 extending from the end of the chamber body 100. The cap is tightened on to seal the flexible tubing to the chamber body.

A gasket 26 is placed between the flange 24 and the lid 28 containing preassembled filling plate 54 and quick disconnect 33. The top and bottom clamping portions 32 and 33 are fastened by means of bolts 38. The filling plate 54 is opened and flowable abrasive grains 12 are filled into the container 10. The abrasive grains are sized such that particles are present having a diameter larger than that of the orifice 106 in the cap 104 of the filling chamber. The quick disconnect coupling 33 of the gas inlet is coupled and the regulators 22 and 23 set to the desired range to pressurize the system.

When the clamping valve lever 162 is depressed to release the pinched flexible tubing 31 a mixture of gas and powder exits through the nozzle 27. Since the absolute pressure upstream of the nozzle can be regulated to a pressure larger than twice the downstream absolute pressure at the nozzle, the mixture can exit at the speed of sound.

Powder is metered into the mixing chamber 16 due to a pressure differential existing across the orifice 106. The pressure on the upstream side of the orifice is approximately the same as the pressure in the head space of the container 10 which is transferred to the orifice through the substantially incompressible body of the flowable material. However, the pressure on the downstream side of the orifice inside the chamber 16 is slightly lower due to the pressure drop experienced by the gas flowing through the length of tubing 110 from the head space to the cap.

The pressure drop experienced is caused by wall friction and change of direction of the gas as it traverses the tubing. Any incremental adjustment of the regulators controlling the pressure of the gas supplied to the head space of the system affects an associated incremental adjustment of the pressure drop across the orifice thereby providing adjustment of the amount of flowable material being metered into the mixing chamber and therefore being dispensed at the nozzle. Change of the orifice size will change the range of material flow rate achievable by varying the pressure in the head space.

All parts of the system should be constructed to withstand the operating pressure in the system typically, about 80 to 100 p.s.i. including safety factors. The system may then be turned on, set at the desired pressure and pressure corresponding to the desired flow rate of the flowable material and the clamp valve 29 on the flexible conduit near the nozzle may be utilized to turn the blast of abrasive jet on or off. In fact, a simple clamp valve is much preferred since an ordinary valve cannot be as readily utilized to initiate and terminate flow due to the severe abrasion caused by the high velocity powder particles which would wear out the valve body after a few cycles of operation. However, creating a valve by simply pinching the flexible hose is an ideal design due to the high resistance of the hose to abrasion and also due to the quick and inexpensive way of replacing the hose if required.

The gas is preferably a gas inert to the abrasive particles and the workpiece such as nitrogen or air and the abrasive is suitably aluminum oxide grain having a particle size of 11 microns to 55 microns utilized with an orifice having a diameter of about 0.029 inch to 0.035 inch. The nozzle diameter for particles of this size range will vary from about 0.010 inch to 0.040 inch. The largest particle diameter of the flowable material is preferably less than one-half the minimum diameter of the nozzle. Other suitable abrasive materials are glass beads, silicone carbide and opacification powders. Nonabrasive polishing particles such as sodium bicarbonate or liquids may also be utilized in the apparatus of the invention. A range of abrasives with larger or smaller particle size may be utilized by increasing or decreasing the orifice size and nozzle diameter accordingly.

The apparatus is particularly suitable for use in laboratories and manufacturing facilities for removing and cutting hard materials such as ceramic, steel, copper, brass, gold, platinum, glass and the like, especially since the apparatus does not touch the work or transfer or create heat or shock stresses while being worked. The apparatus is absent moving parts and has proved extremely reliable in operation. Typical industrial applications include use by wire-wound potentiometer manufacturers, semiconductor and electrical contacting device manufacturers, precision metallic and nonmetallic parts manufacturers, dentists and dental laboratories.

Typical dental operations include carving porcelain, rolling fossa for a very natural toothlike appearance, removing porcelain for inside restorations, removing surface oxides, abrading all investment material, satin polishing, precious as well as other metals and cleaning and removing cement and investment material.

The wire-wound potentiometer or rheostat manufacturers require a method of removing baked-on varnish of the wire winding where the wiper travels. If the potting compound is
removed with a tool, a slight variation in wire diameter is experienced, thereby rendering the potentiometer or rheostat nonlinear, whereas, with the inventive apparatus, the abrupt stream removes only the potting material and none of the copper of which the wire is made. The apparatus can also be used to strip unwanted baked-on varnish from motor-stator cores.

The apparatus can be utilized in the manufacturing of metallic and nonmetallic parts which require microscopic deburring and which cannot be presently accomplished with a tool touching the workpiece and for working into irregular cavities or where direct approach is not available with a regular tool. For this reason the present production yield is only a percentage of the total production.

Virtually every electrical contact point, as are incorporated in relays and other devices, can be cleaned with the use of the apparatus. Again, if a tool is employed to clean the contact points, some of the parent material is sure to be removed in the process. The apparatus of the present invention would only remove the buildup or the carbon deposit. The apparatus can be used in the opaquing or shading on glass sheeting; the advantage being of the fine control which is available on the small areas which the nozzle can cover.

It is apparent that only the preferred embodiments of the invention have been disclosed. Therefore, this invention may be practiced by suitable substitutions, alterations, and modifications without departing from the scope of the invention as defined in the following claims.

What is claimed is:

1. An apparatus for dispensing a fluidized suspension of flowable abrasive material in a propelling gas comprising in combination:
   a closed container including a tapering lower wall portion for receiving a body of said material, an upper wall portion defining a head space above said body and a top member releasably connected to said upper wall portion;
   propellant gas inlet means sealingly received through said top member and having a first end terminating within said head space, said end containing radially directed apertures for pressurizing said head space; and
   mixing chamber means including a hollow, tubular member having a first end sealingly received within the bottom of the tapering wall portion and a second end disposed exterior to said container, a first cap member having a first small diameter material inlet orifice and a second larger diameter dispensing gas inlet orifice received over said first end, a length of tubing having a first end received within said first orifice and a second end disposed within said head space and a second cap member having an outlet tubing receiving aperture, said second cap being sealingly received over the second end of said tubular member.

2. An apparatus according to claim 1 further including flowable material filling means comprising an aperture defined in said top member, a closure plate larger than said aperture disposed on the inside surface of the top member and a rotatable, upwardly biased knob means connected to said plate.

3. An apparatus according to claim 1 further including a length of flexible tubing having a first end received within said second cap member and a second end received within a rigid handpiece, a nozzle and shutoff pinch valve and mounting means for mounting said nozzle and valve on said handpiece.

4. An apparatus according to claim 3 in which said handpiece includes a hollow rigid barrel member having a forward end and a rearward end; fastener means on said forward end for engaging said nozzle; clamping means inside and barrel adjacent said forward end for engaging the second end of said tubing; and said valve means includes a pinching lever including a downwardly depending and rearwardly facing flange portion for pinching said tubing closed against the inner wall within the rearward open end of the barrel, a forwardly facing handle portion and an aperture between said portions, pivot means mounted on said barrel adjacent said rearward end and extending through said aperture and bias means mounted on said pivot means for biasing said lever into closed position.

5. An apparatus according to claim 1 further including a source of pressurized gas and a pressure regulator interposed between said source and gas inlet whereby on selected adjustment of said pressure the rate of metering material into said chamber is controlled.