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Austin

[11] **3,793,785**

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[54] **PARTICLE BLASTING**

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[52] **U.S. Cl.** **51/12,** 251/7

[51] **Int. Cl.** **B24c 3/00,** B24c 7/00

[58] **Field of Search** 51/8, 12, 13; 251/5, 7

[56] **References Cited**

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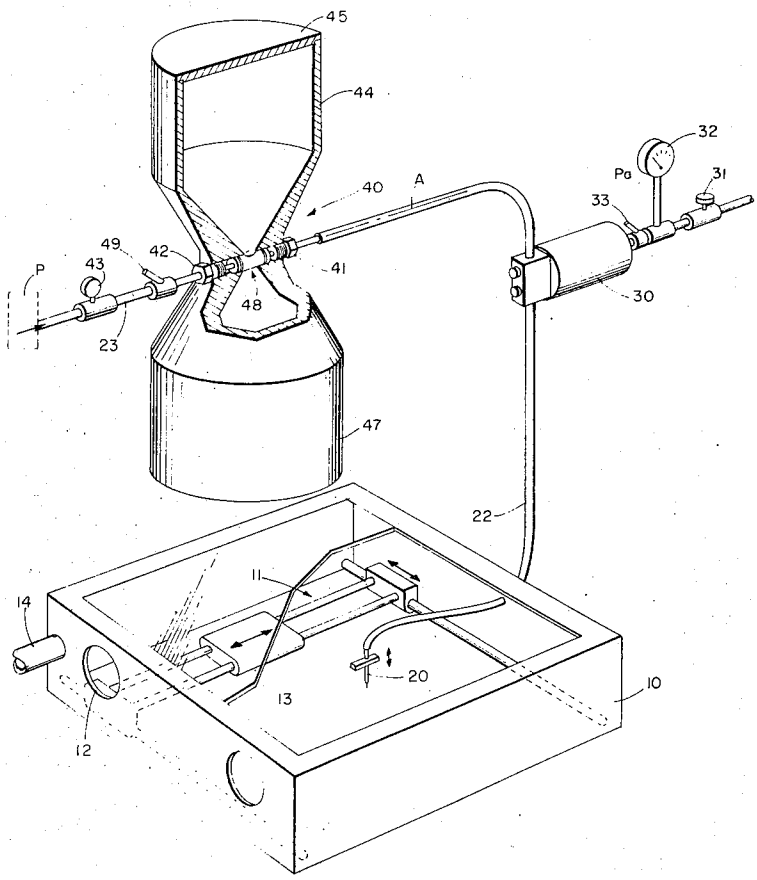
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Primary Examiner—Al Lawrence Smith
Assistant Examiner—James G. Smith

[57] **ABSTRACT**

Blasting system for particles, e.g., air blast of fine abrasive particles, having an non-clogging feed device and a reliable, long-lasting on-off valve system acting upon a resilient hose. The feed device features: hourglass type particle metering into an air stream; countercurrent air percolation from air conduit through the particle metering orifice; and air turbulence at the orifice in a constant diameter region of the conduit. The valve member features: a ball member pressed against a resilient passage toward a pair of opposing ball members; adjustment devices for adjusting initial depression of each of the pair of ball members into the hose; air pressure actuation of the one ball member; and actuation increasing the depression of each of the pair of ball members to urge the respective resilient wall portion into conformity with the opposite wall of the conduit and reverse depression effect at the central ball member, cooperating to choke off the flow. A removable metering member defining the hourglass configuration orifice and transverse air passage permits replacement of the most active, hence wear-exposed, portion of the system.

21 Claims, 10 Drawing Figures



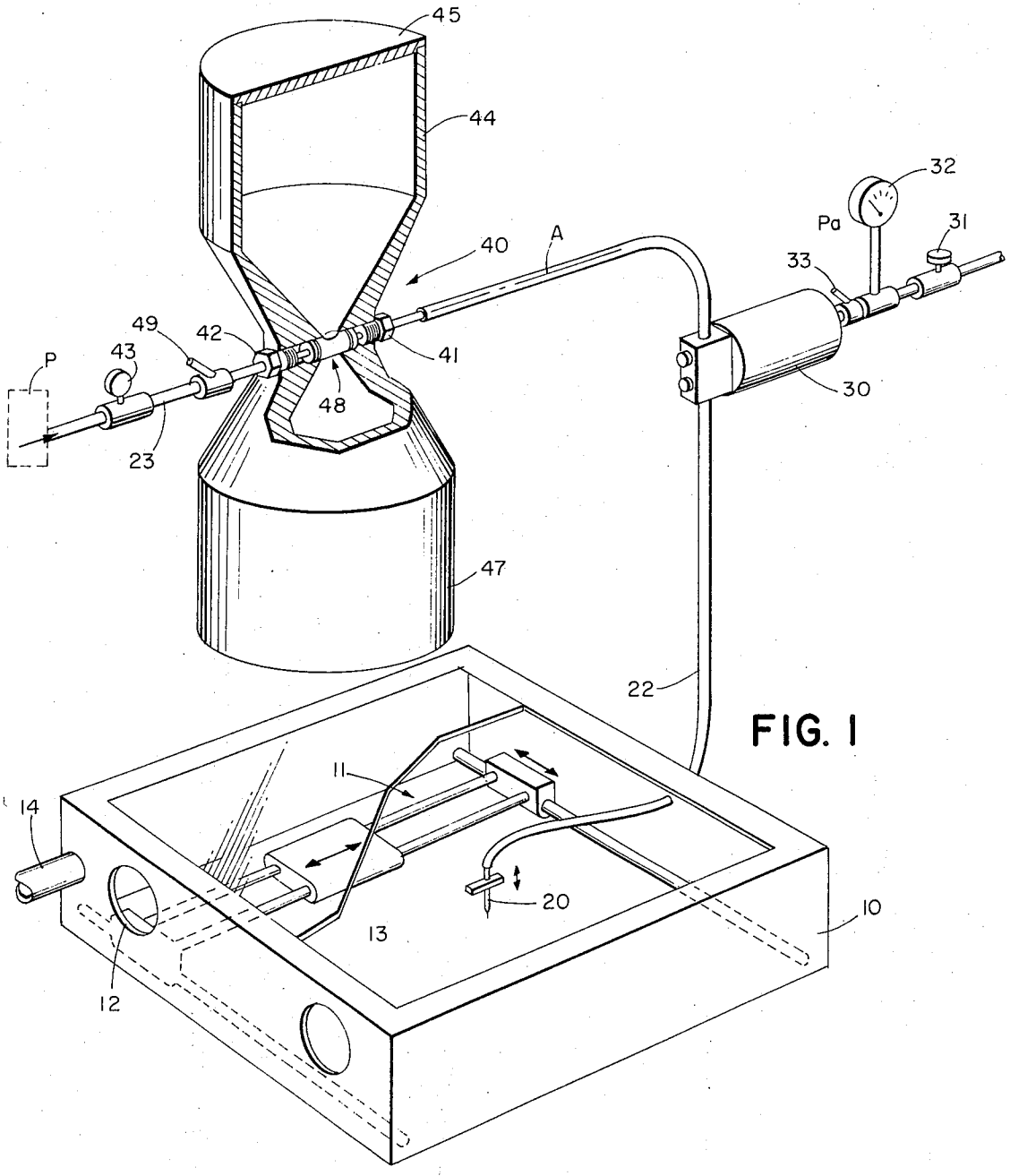

45
44
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Pa
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FIG. 1

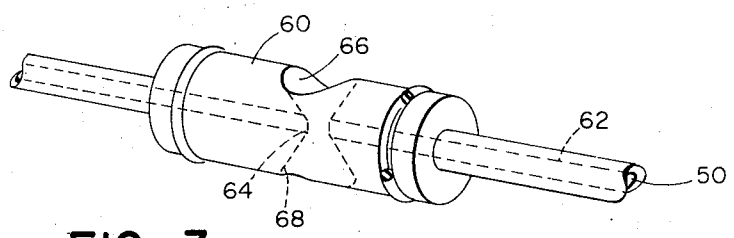

60
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64
68
50

FIG. 3

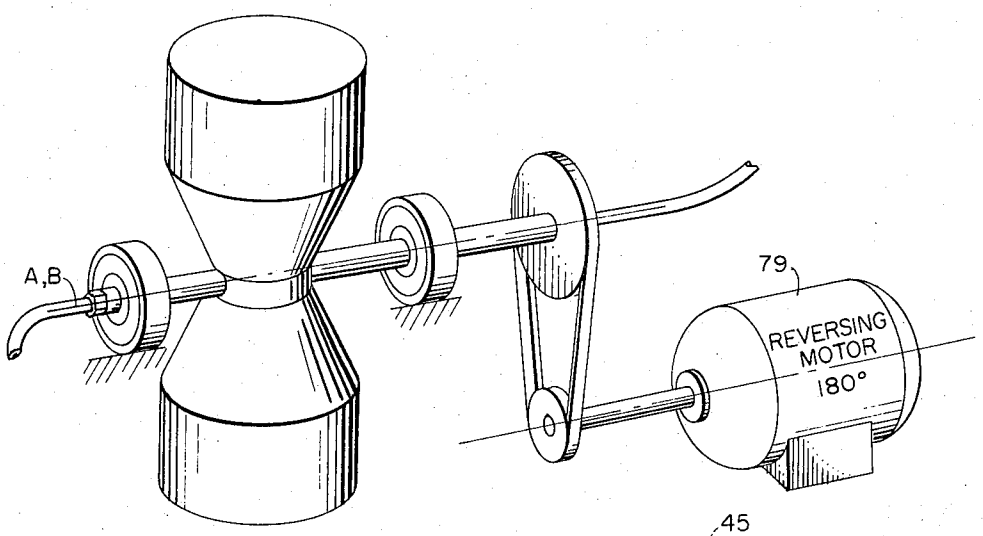


FIG. 4

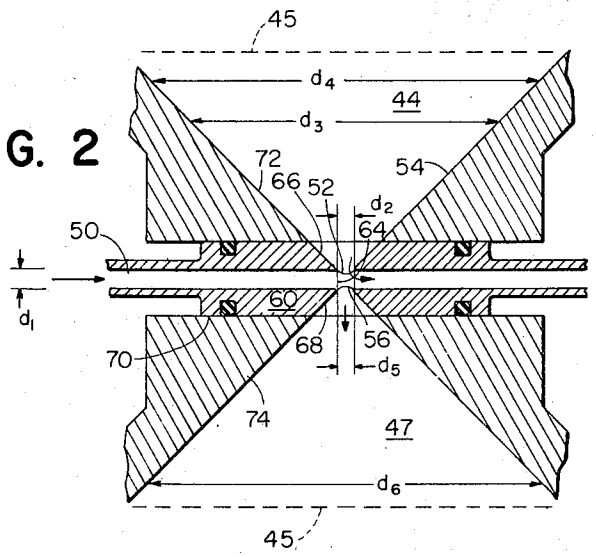


FIG. 2

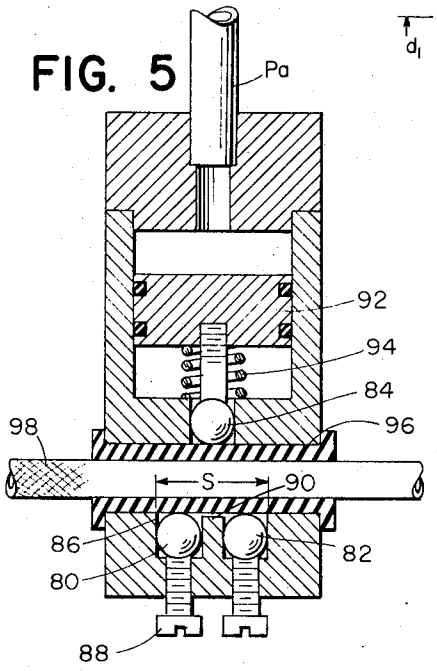


FIG. 5

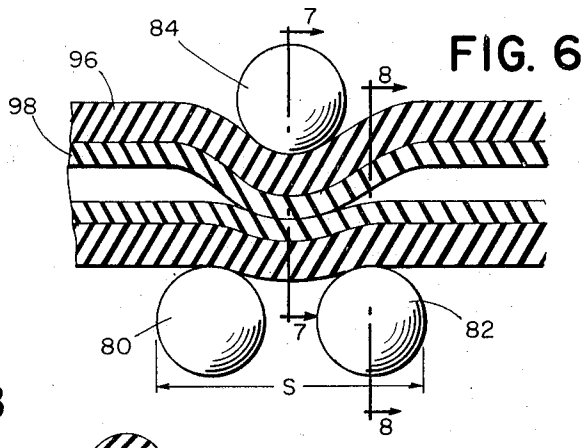


FIG. 6

FIG. 7

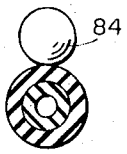


FIG. 7A



FIG. 8

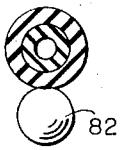




FIG. 8A

PARTICLE BLASTING

This invention concerns blasting systems of the type in which fine particles or abrading powders can be entrained and driven by a stream of air and directed against an object, e.g., for cutting, polishing, or depositing. Typical abrading substances have particle sizes in the 5 to 50 micron range, are such as aluminum oxide, silicon carbide, glass beads, ground corncobs, and baking soda, and area used for the purpose of trimming electrical resistors, polishing electrical parts and removing material from green carbide matrices prior to sintering for forming carbides.

Prior art particle blasting systems, particularly those for fine particles and powders, encounter: problems in maintaining non-clogging flow of the particles into the air stream over the range of operating flows; problems in avoiding clogging of the air lines during shut-off and start-up procedures; and problems in rapidly stopping the air-particle flow when desired, for instance, when removing and inserting new parts to be processed.

Other prior art problems involve complexity of mechanism and procedure, wear and short life of machine components, difficulty of maintenance, and high cost.

It is the object of the invention to provide a system having improved performance in these and other ways.

The invention concerns a blasting system including a conduit for air from a pressurized source, a supply chamber for particles, a device for introducing the particles to the air as it flows in the conduit, and a shut-off valve for rapidly terminating the flow of air-particle mixture. Features of the invention are: a supply chamber having an outlet in its bottom communicating with the conduit through a restricted orifice for gravity feed of particles to the air flow, the chamber being otherwise effectively closed and the orifice and conduit constructed and arranged so that air from the conduit passes through the orifice into the supply chamber in response to and to replace particles moving oppositely from the chamber through the orifice to the air flow; a second chamber below the conduit, the second chamber having an orifice positioned in the immediate vicinity of the first orifice to receive excess particles and to maintain particle flow even when the air flow is interrupted, and this arrangement in which the first orifice is positioned to discharge from the particle supply chamber into the air conduit and the second orifice is in substantial vertical alignment with the first orifice and extends downwardly to the second receiving chamber; any of the above constructions wherein the orifice of the supply chamber is smaller in flow cross section than the cross section of the air conduit or where the orifice is less than one-sixteenth inch in diameter and the conduit is less than one-eighth inch in diameter; any of the foregoing wherein the feeding device is formed by a removable member of solid material providing a passage defining the air conduit, a perpendicular hole (the orifice), diverging outwardly defining a funnel for particles from the supply chamber; and any of the above wherein the supply and secondary chambers combine to form effectively an hourglass configuration and the air conduit extends through the neck portion of the hourglass configuration at an angle to the hourglass-flow axis through the neck region. Also featured are a removable member defining the hourglass configuration metering orifice and means for rotatable oscillation of the assembly about an axis through the metering device. The shut-off valve member features a section of conduit downstream of the particle supply orifice, a pair of ball members positioned on one side of the conduit and a ball member positioned on the other side together with means for urging the one ball member relatively toward the other two to cooperatively deform the resilient conduit and choke flow therethrough, preferably with the ball members urged together in response to air pressure.

The invention also features an hourglass configuration of the supply and receiving chambers per se, in which the air conduit passes through the neck of the hourglass configuration at an angle to the undisturbed hourglass flow of particles; this configuration wherein the orifices of the two chambers are of identical cross section and the flow conduit is of constant cross section in the neck region of the hourglass configuration; and this configuration in which the two chambers are invertable.

These and other features and advantages of the invention will be understood from the following description of the presently preferred embodiment taken in conjunction with the drawings wherein:

FIG. 1 is a diagrammatic partially sectional assembly drawing of a preferred embodiment adapted for abrasive particle blasting;

FIG. 2 is a diagrammatic sectional view of the abrasive feed device of the embodiment;

FIG. 3 is a perspective view of the removable metering device of the assembly of FIG. 2;

FIG. 4 is a diagrammatic view of a rotatable, oscillatable embodiment of the system of FIGS. 1 through 3;

FIG. 5 is a cross-sectional view of the valve member of the preferred embodiment of FIG. 1;

FIG. 6 is a diagram of an operating portion of the embodiment of FIG. 5 with a different hose configuration;

FIGS. 7 and 7*a* are cross sections taken on line 7—7 of FIG. 6 at selected positions during operation; and

FIGS. 8 and 8*a* are views similar to FIG. 7 taken on line 8—8 of FIG. 6.

Referring to FIG. 1, the abrading system includes a dry box **10**, an air-abrasive blast nozzle **20**, an air-abrasive shut-off valve **30**, and an abrasive feed device **40** for introducing abrasive to the air flow. The box **10** includes an *x-y* slide assembly **11** for positioning a work piece beneath the nozzle **20**, hand access ports **12** for hand manipulation of the work piece beneath the nozzle **20**, transparent cover **13** for allowing the operator to observe the abrasive action, and vent **14** for evacuating the box. The nozzle **20** is adjustable vertically in the direction of the arrows and is supplied by flexible hose **22** which extends upstream through the shut-off valve **30** to the abrasive feed device **40**. The shut-off **30** is supplied with actuating air pressure P_a regulated by use of valve **31** and gauge **32**, actuation of on-off lever **33** being effective to apply the actuating pressure to the shut-off **30** to choke off the flow of air and abrasive particles. The hose **22** extends upstream from the shut-off **30** to a fitting **41** of the abrasive feed device **40** and a further hose **23** extends from the inlet fitting **42** of the device to a regulator **43** connected to a source of pressurized air maintained, for instance, at 100 psi. The abrasive feed device includes a supply chamber **44**

mounted above the hose **22** having removable cover **45** for filling with abrasive and sealable to the top of the chamber **44** during operation. Lower, receiver chamber **47** is positioned below the air hose and forms with the supply chamber **44** an hourglass configuration with the air conduit passing through the neck **48** of the hourlgass configuration. The supply chamber **44** and the receiver chamber **47** are rotatably invertable about axis A to reverse their functions thereby to reuse abrasive collected in chamber **47.**

Referring to the diagram of the abrasive feeding device of this preferred embodiment, FIG. **2,** the air conduit **50** cross section is constant throughout the abrasive feed region, of diameter d_1, 0.050 inch. The abrasive supply chamber **44** communicates through orifice **52** with conduit **50,** at the top thereof, the inlet diameter d_2 of the orifice (0.025 inch) being smaller than diameter d_1 of the conduit. The chamber walls **54** leading upwardly from orifice **52** diverge at a 90° angle progressively to diameters d_3 and d_4.

Below orifice **52** is receiving orifice **56** having a diameter d_5 equal to diameter d_2 and walls of the receiving chamber diverge downwardly to diameters d_6 and beyond.

Referring to FIGS. **2** and **3,** the preferred construction of this device comprises a cylindrical body member **60,** e.g., of wear-resistant metal, having a longitudinal coaxial bore **62** defining conduit **60** of FIG. **2** and a perpendicular bore **64** at the intersection of bore **62** and tapering outwardly to form conical sections **66** and **68.** In the neck region of the hourglass configuration of the supply and receiver chambers **44** and **47,** a bore **70** is provided for tightly fitting diameter with body member **60,** the latter which is inserted therein and sealed thereto. The neck regions of chambers **44** and **47** have diverging walls **72** and **74** respectively which align with the diverging tapers of the body member **60.**

In operation a number of phenomena occur depending upon operating conditions and all of which can contribute to effective operation. Assuming no air flow through the device, clogging conditions can be avoided by the hourglass operation of chambers **44** and **47** which meter a gradual flow of abrasive through orifice **52** across the conduit **50** and through orifice **56** into the receiver chamber **47.** During this flow, as abrasive particles move downwardly through orifice **52** under the force of gravity, a certain quantity of air percolates upwardly through orifice **52.**

Such continued dynamic abrasive flow conditions lead away from clogging problems. Also when the air supply P is activated, gravity displacement downwardly of the abrasive particles into the air stream from supply chamber **44** is accompanied, just as in an hourglass, with an upward percolation of air.

During operation, as air is forced through the conduit **50,** abrasive particles are entrained with the air, the amount of such particles entrained being dependent upon the flow velocity as well as on the selected diameters of the various passages and the specifications of the abrasive. Under these flow conditions as an increasing amount of abrasive falls into the air stream, so an increasing amount of air percolates upward, the concentration of such air movement being in the region of the narrowest passage, at orifice **52,** where the prior art clogging problem has occurred. This air flow is enhanced by the fact that the chamber **44** is closed and prevents entry of air from other regions to replace the exiting particles in the chamber. This countercurrent air flow tends to prevent packing of the particles together as would tend to cause clogging.

The stream of abrasive particles from orifice **52** into the air stream, and to varying extent through the orifice **56** depending upon how much of the abrasive particles are entrained by the air, constitutes in effect a resistance screen against which the inlet air of conduit **50** impinges. This has the effect of creating turbulent eddys in the region of the screen and an attendant pressure buildup, these air effects to an extent propagating upwardly to the orifice **52** as well as downwardly to orifice **56,** further agitate and air-lubricate the particles.

These various effects just mentioned participate in varying degrees, depending upon flow conditions, to produce non-clogging flow of abrasive particles at selected delivery rates and in concert provide assurance for non-clogging steady mixing conditions over a wide possible range of flow conditions.

By sizing the orifice smaller than the conduit, it serves as a go-no-go strainer preventing entry of oversized particles that can be caught in the downstream hose. Also, due to the air percolating and eddy effects, such particles can be dislodged upwardly, thus being prevented from clogging orifice **52** and stopping the operation.

The metering device per se is advantageously formed as an elongated cylinder having a central bore, providing the air conduit, and a radial bore provides the abrasive passage to the orifice at the intersection. The member is removably inserted into a complementary cylindrical opening in the chamber assembly and sealed thereto with appropriate detachable fittings which permit its replacement when worn. A conical diverging funnelling surface of the radial bore aligns with a complementary upwardly flaring conical surface of the supply chamber, the two cooperating to promote particle flow to the orifice.

The abrasive-laden air, after leaving the metering device, passes through valve **30,** then is directed to the dry box **10** where it impinges upon the work object. For maximum speed of production it is desired suddenly to stop this flow to enable work pieces to be moved or substituted. This is accomplished by the shut-off valve **30.**

Referring to FIG. **4,** the metering assembly of FIGS. **1** through **3** is rotatably mounted on axis B coincident with axis A of the air and metering conduit **50.** A 180° reversible motor **79** is connected to rotate the assembly and with suitable controls, not shown, the motor rotates the assembly to invert chamber **44** at which time the motor reverses to right the chamber, this rotary oscillation continuing repeatedly. This oscillation is effective to maintain in agitated condition the contents of the chambers. Thus even such a fine matrial as baking soda, which tends to adhere to the walls of the chamber, is loosened and caused to flow to the metering orifice.

Referring now to FIGS. **5** and **6,** the shut-off valve comprises three ball members, a pair **80** and **82** disposed upon one side of the resilient conduit, spaced apart along the length of the conduit, and ball member **84** disposed upon the opposite side. In the preferred embodiment the ball members are of equal diameter, three-eighths inch, the spacing S from outer edge to outer edge of the pair of ball members is seven-eighths

inch, and the ball member **84** is aligned with the center of this dimension. Ball members **80** and **82** reside in radial slots **86** relative to hose **98** which permit free ball rotation but no lateral movement along or across the resilient hose. Inward or radial adjustment of the ball members **80** and **82** is accomplished by adjustment screws **88.** In normal flow conditions the members **80** and **82** are adjusted inwardly to depress the ball members against the resilient hose and to rise above the intermediate land **90** extending between them. The ball member **84** is in the retracted position shown in FIG. **5.** When it is desired to choke the flow, air pressure P_a is actuated, forcing piston **92** inwardly, compressing spring **94,** and urging ball member **84** toward the pair of ball members on the opposite side of the hose. This has an immediate choking effect, compare FIGS. **7** and **8** of initial position to FIGS. *7a* and *8a* in choke position, this effect being gradual over an extent of the hose, and of a non-wearing manner. It is thus possible to choke air flow of a given pressure by means of a much lower pressure in the piston chamber. In FIG. **5** there is shown a resilient protective sleeve member **96** having a bore through which extends a dacron braided elastomeric hose **98** of smaller diameter.

During operation, as the ball members engage the hose, they do so with a gradually increasing effective surface, due to their spherical form, providing a gentle distortion and allowing time for the elastomer substance to adjust and resiliently displace. Similarly, the balls being free to rotate in any direction are able to yield and rotate with the elastomeric substance, thus providing for relief of tendencies to build up stress in the substance. The effect of all of this is to enable repeated choke of the air-abrasive mixture without undue wear of the resilient hose member so that a relatively long life is achieved.

The operation of the system as a whole is as follows:

It is assumed that a work piece is positioned in the box **10** and the supply chamber **44** is filled with abrasive particles. Thereupon, with no pressure applied through either valves **49** or **33** a fine stream of abrasive particles can flow from the chamber **44** into the receiver **47** ready at any time to add abrasive particles to the air stream. Upon actuation of valve **49,** actuating pressure P is applied to the conduit and initiates an air flow through the nozzle **20.** This flow purges the system of residual abrasive and entrains further abrasive particles from the orifice while the air conditions mentioned above maintain the abrasive particles in the region of the orifice under an air-lubricated and disturbed condition promoting free flow. Under these conditions the supply chamber **44** may be entirely full of abrasive particles, even of particles which have a high tendency to compress or clog and no intervening shakers or other members are required, the full height of the abrasive particles being directly exposed to the orifice of the hourglass configuration. When it is desired to increase the air flow, regulator **43** is adjusted. The pressure in the supply chamber **44** is dependent upon the pressure of the air flowing through the conduit in this preferred embodiment, and varies therewith.

When it is desired suddenly to stop the flow of this abrasive-air mixture, actuating pressure P_a is applied to valve member **30,** which urges the piston **92** and ball **84** inwardly against the two opposing balls which effectively chokes the tube and prevents further flow. Under these conditions, rather than the abrasive feeding device in the region of the conduit filling with particles, a steady flow may be maintained according to hourglass principles. When it is desired to reinitiate flow, lever **33** is again actuated to release air pressure P_a upon the valve **30** whereupon spring **94** returns the piston, the resiliency of the hose and more importantly the air pressure within the hose returning ball member **84** upwardly to cuase the hose to open and flow of the abrasive-air mixture resumes. With the air flow ranging from near zero velocity to the top speed operating velocity, the abrasive feed device maintains flow at the orifice and meters abrasive into the air stream in appropriate amounts.

It will be understood that the foregoing is a description of the presently preferred embodiment of the invention and that numerous variations therein are possible within the spirit and scope of the following claims.

What is claimed is:

1. A blasting system including a conduit for air from a pressurized source, a supply chamber for particles and a device for introducing the particles to the air as it flows in said conduit wherein said chamber has an outlet in its bottom communicating with said conduit through a restricted orifice for gravity feed of said particles to said air, said chamber being otherwise effectively closed, and the orifice and conduit constructed and arranged so that air passes through said orifice from said conduit into said chamber in response to, and to replace, particles moving oppositely from said chamber through said orifice into said air flow.

2. The system of claim **1** including a second chamber below said conduit in the region of said orifice of said supply chamber, said second chamber having an orifice positioned in the immediate vicinity of said first orifice to receive excess abrasive.

3. The system of claim **2** in which said first orifice is positioned to discharge from said supply chamber directly downwardly into said air conduit and said second orifice is in substantial vertical alignment with said first orifice and extends from said conduit downwardly to said second chamber.

4. The system of claim **1** wherein said orifice is smaller in diameter than the diameter of said conduit.

5. The system of claim **4** wherein said orifice is a single hole of less than one-sixteenth inch diameter and the conduit is less than one-eighth inch in diameter.

6. The system of claim **1** wherein an integral member has a passage formed therethrough defining a section of said conduit and a hole formed perpendicular to said passage defining said orifice, said hole opening outwardly from said orifice defining a funnel surface for directing particles from said supply chamber to said orifice.

7. The system of claim **2** wherein said supply and secondary chambers combine to provide effectively an hourglass configuration and said air conduit extends through the neck portion of said hourglass configuration at an angle to the hourglass flow axis.

8. The system of claim **1** comprising a section of conduit downstream of said orifice comprised of resilient material and a shut-off device for the particles and air mixture comprising three ball members, a pair positioned on one side of said conduit and one positioned on the other side in opposition thereto and means for

urging said one ball member relatively toward the other two thereby to choke said conduit.

9. The abrading system of claim **8** wherein said ball members are so urged together in response to air pressure.

10. A blasting system including a conduit for air from a pressurized source, a supply chamber for particles and a device for introducing the particles to the air as it flows in said conduit wherein said chamber has an outlet in its bottom communicating with said conduit through a restricted orifice for gravity feed of said particles to said air, a second chamber below said conduit in the region of said orifice of said supply chamber, said second chamber having an orifice positioned in the immediate vicinity of said orifice to receive excess particles, said chambers connected to provide an hourglass configuration, and said conduit extending through the neck of said hourglass configuration at an angle to the hourglass flow axis.

11. The system of claim **10** wherein the orifices of each of said chambers are of identical cross section and vertically aligned with each other.

12. The system of claim **11** including means to invert said hourglass configuration to reuse the particles which fall into said second chamber.

13. The system of claim **10** wherein said conduit is of constant cross section through the neck portion of said hourglass configuration.

14. A blasting system including a conduit for air from a pressurized source, a supply chamber for fine particles and a device for introducing the particles to the air as it flows in said conduit, wherein said chamber has an outlet in its bottom communicating with said conduit through a restricted orifice for gravity feed of said particles to said air, a section of conduit downstream of said orifice comprised of resilient material and a shut-off device for the particles and air mixture comprising three ball members, a pair positioned on one side of said conduit and one positioned on the other side in opposition thereto and means for urging said one ball member relatively toward the other two whereby to choke said conduit.

15. The system of claim **14** wherein said one ball member is of diameter greater than the spacing between said pair of ball members.

16. The system of claim **15** including adjustment means for adjusting each of said pair of ball members toward said resilient conduit.

17. The system of claim **15** wherein a pneumatic cylinder is associated with one ball member adapted to urge it against said resilient conduit.

18. A blasting system valve comprising a passage through which a resilient hose can extend, a pair of ball members on one side of said passage, one ball member on the other side of said passage and means for urging the one ball member toward said pair whereby to choke the flow through said passage.

19. The system of claim **18** wherein said ball members are constrained from translation but free to rotate about their respective centers.

20. The system of claim **18** wherein said pair of ball members are spaced from each other a distance less than the diameter of said one ball member.

21. The system of claim **18** wherein each of said pair of ball members is associated with an adjustment device for adjusting its depression into the wall of said hose and a pneumatic means for urging said one ball member toward said pair to increase said depression upon each of said pair of ball members while itself oppositely depressing said hose, cooperating to choke the flow.

* * * * *