

- [54] **ABRASIVE BLASTING SYSTEM WITH PERSONNEL PROTECTIVE FEATURES**
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[22] Filed: **Dec. 14, 1972**
[21] Appl. No.: **315,248**
[52] U.S. Cl. **51/12**
[51] Int. Cl. **B24c 3/00**
[58] Field of Search 51/8, 11, 12; 251/25, 47

- [56] **References Cited**
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2,830,784 4/1958 Placette 251/25
3,201,901 8/1965 Pauli 51/12
3,704,553 12/1972 Hehr et al. 51/11

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Assistant Examiner—Robert C. Watson
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[57] **ABSTRACT**

An abrasive blasting system comprising a tank for holding an abrasive material therein and a high pressure air-line for carrying abrasive from the tank to an article to be abraded. In one embodiment, a fluid controlled valve is provided connected between the tank

and the air-line at a point in the line and a second fluid controlled valve is connected in the air-line upstream of the first valve. Both valves are controlled by a pilot valve disposed adjacent to tank. The pilot valve is operative when pressurized to open both controlled valves. A remote control valve is provided adjacent the downstream end of the air-line and includes a first port connected via a first control air-line to the air-line and a second port connected via a second control air-line to the pilot valve. Means are provided to connect the first and second ports together to thereby pressurize the pilot valve. The pilot valve includes means for venting the second control air-line to the atmosphere. In another embodiment, a manually operable valve is provided for providing abrasive into the air-line and a diaphragm valve is provided in the air-line upstream of the manually operable valve. The diaphragm valve includes an inlet port, an outlet port, the inlet port being upstream of the outlet port, a control outlet port connected to the inlet port and to a first control air-line, a control inlet port connected to a diaphragm chamber and to a second control air-line and a venting port connected to said chamber. The diaphragm valve is operative when pressurized via the connection of the first and second ports in a remote control valve connected to said control lines to connect the inlet and outlet ports in the diaphragm valve together. A second diaphragm valve is provided to vent the tank when said first mentioned diaphragm valve is depressurized.

11 Claims, 8 Drawing Figures

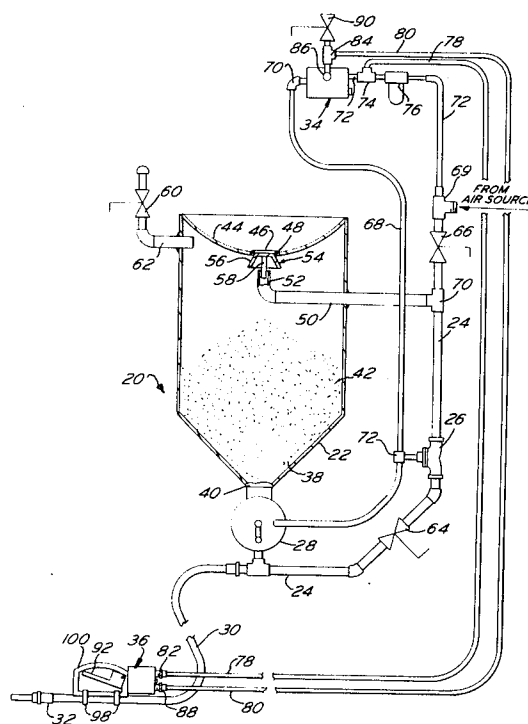


FIG. 1

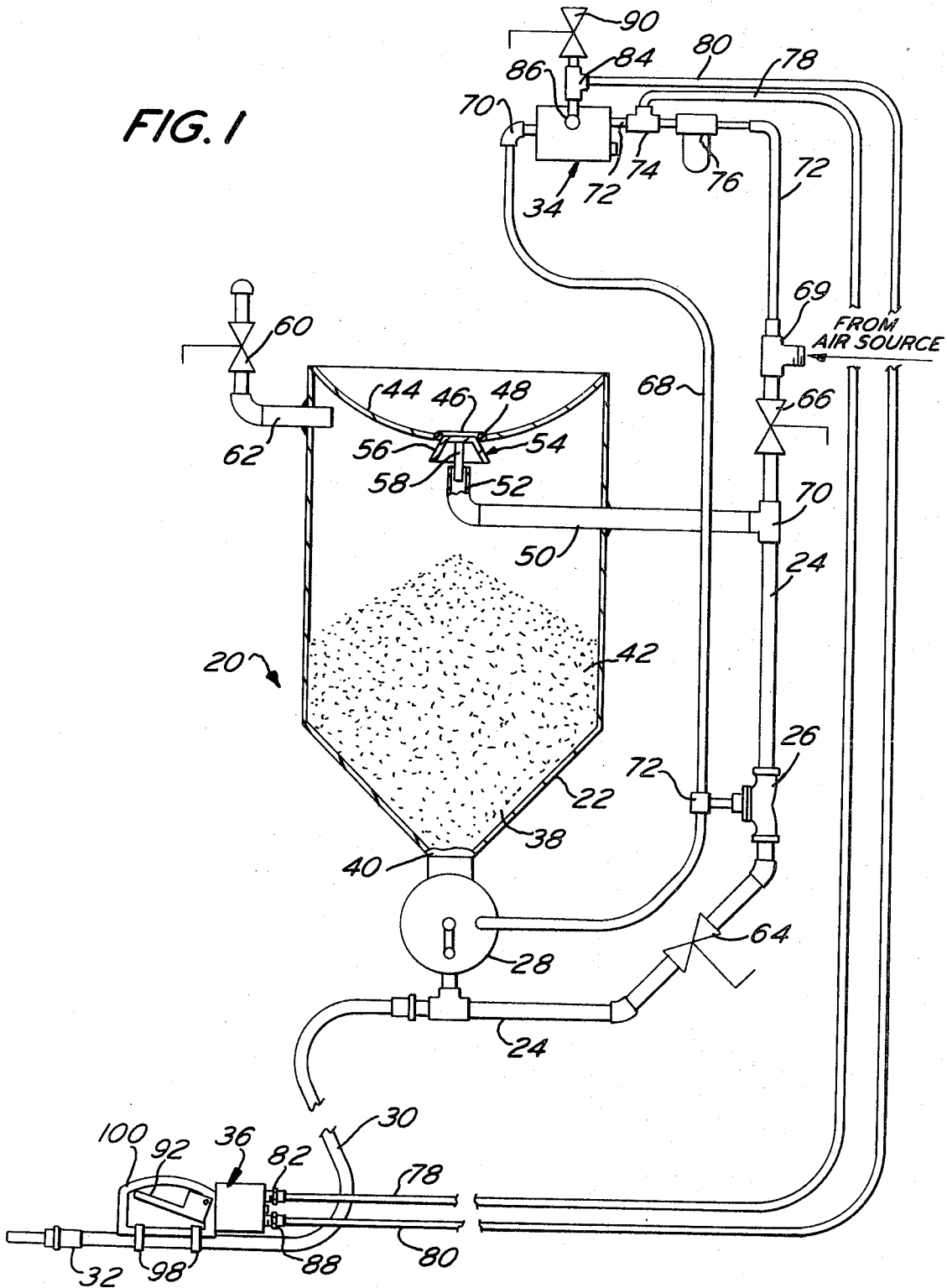


FIG. 2

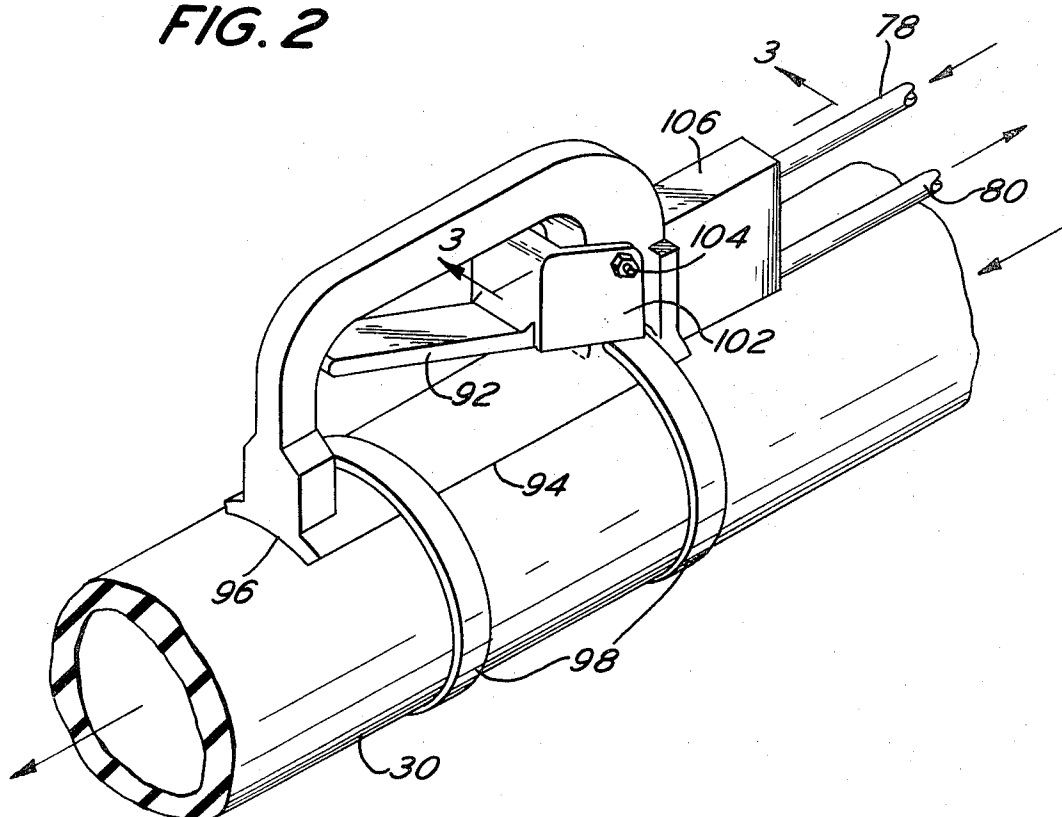
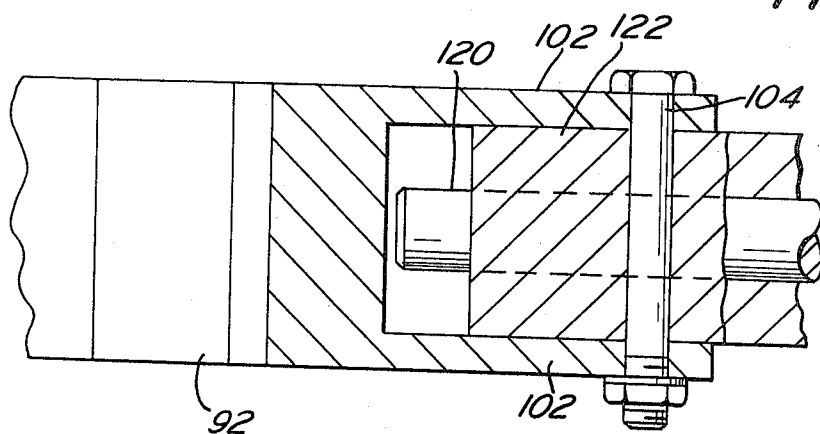


FIG. 4



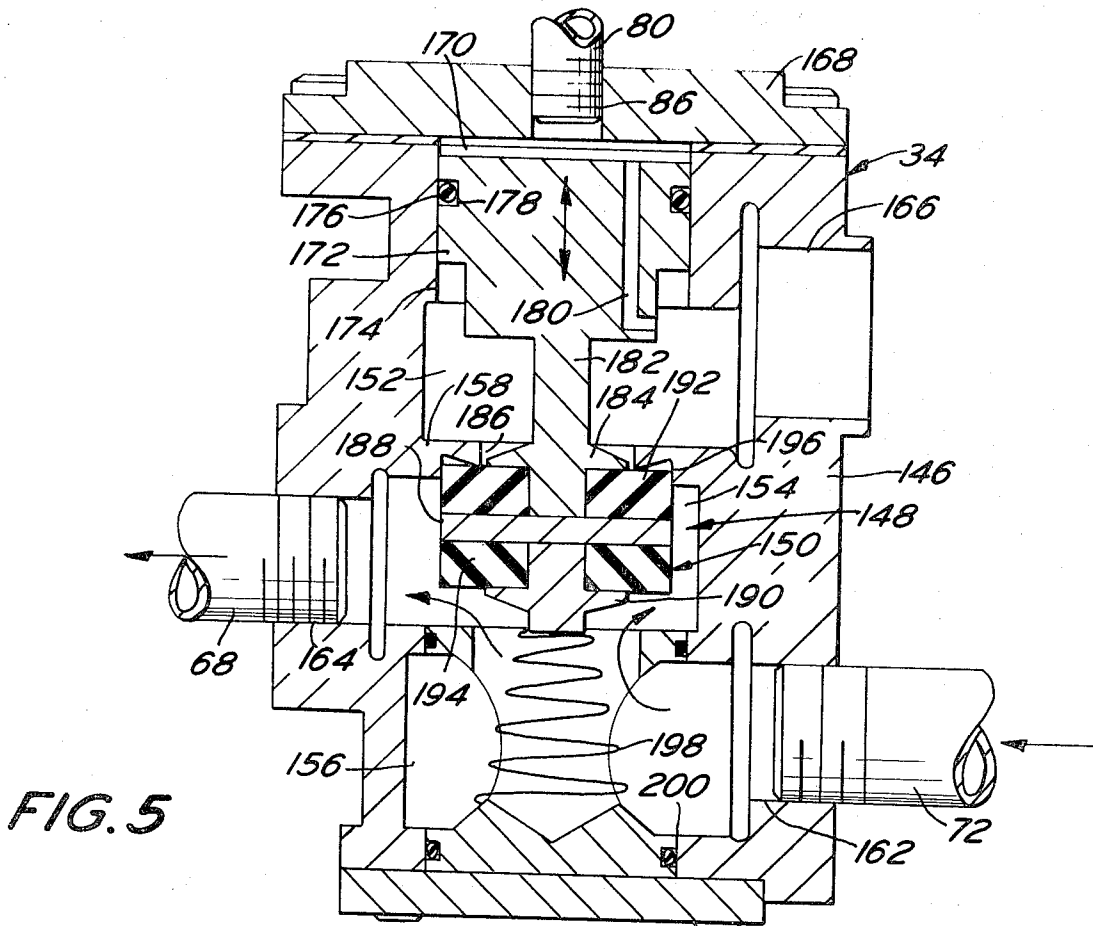
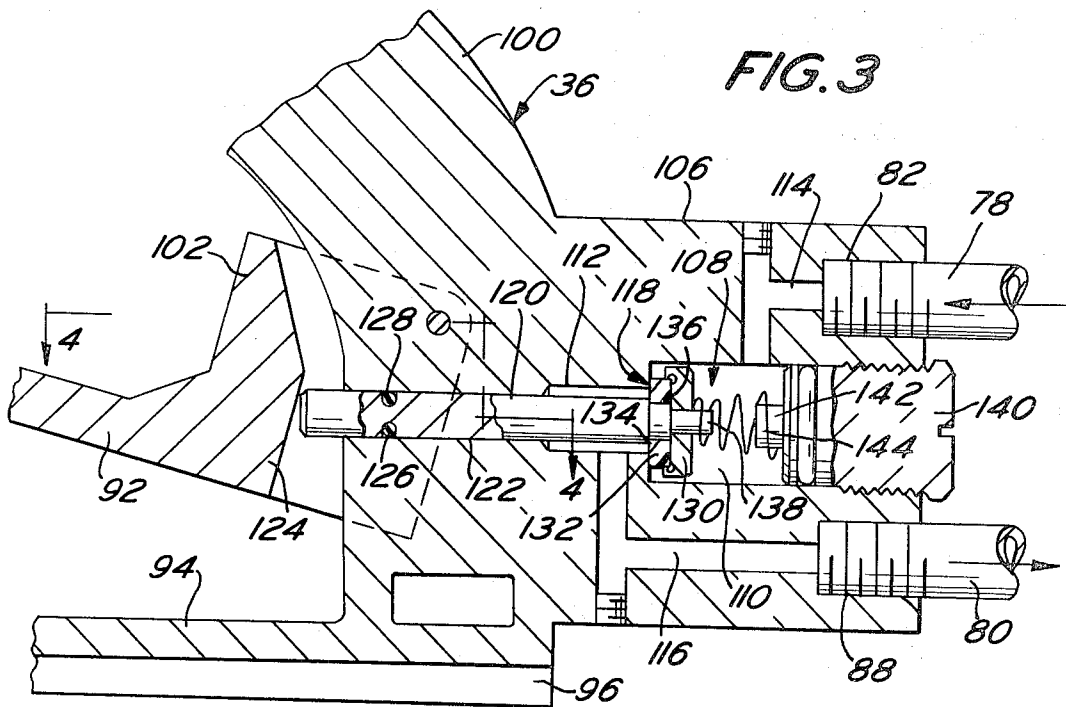
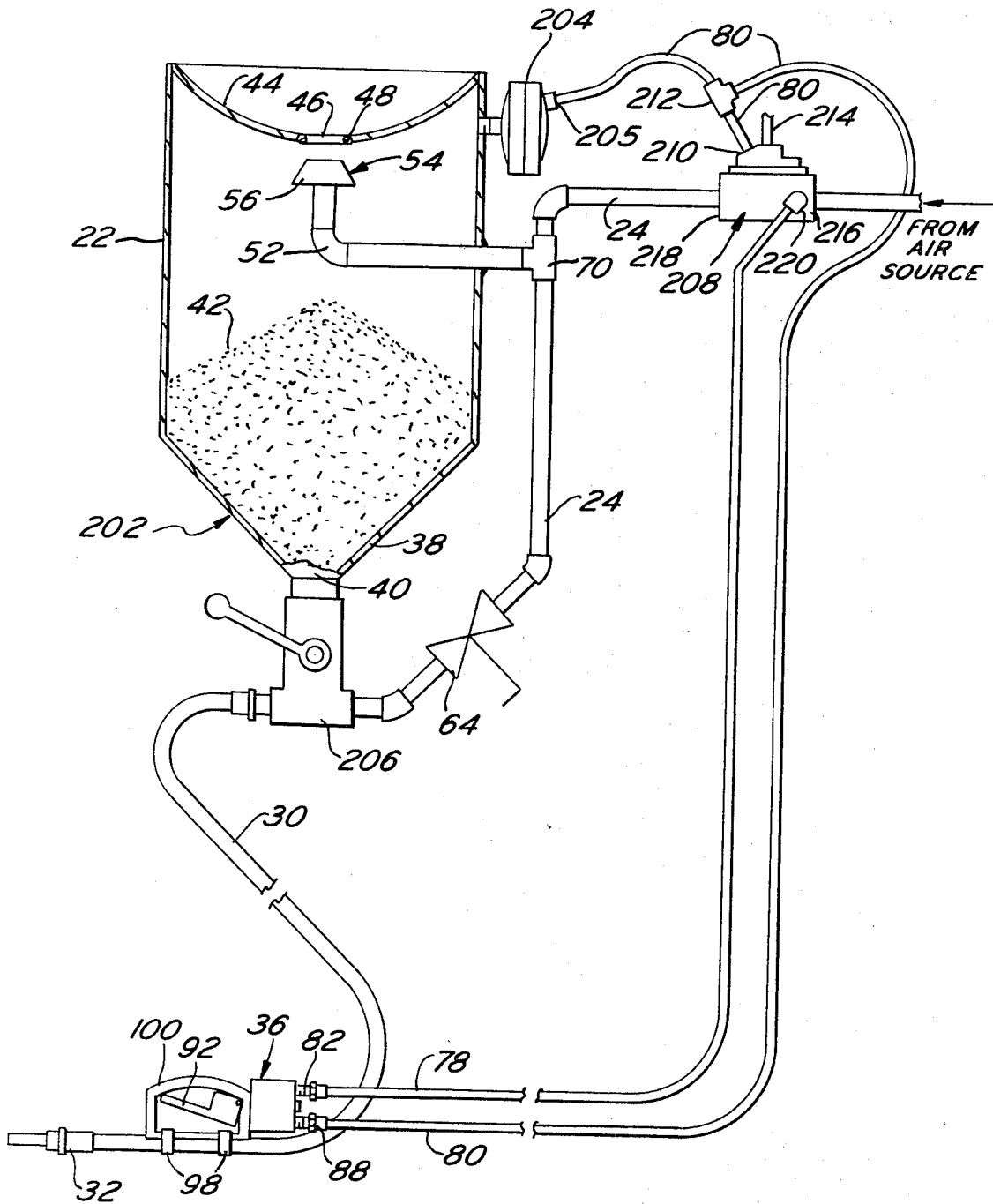
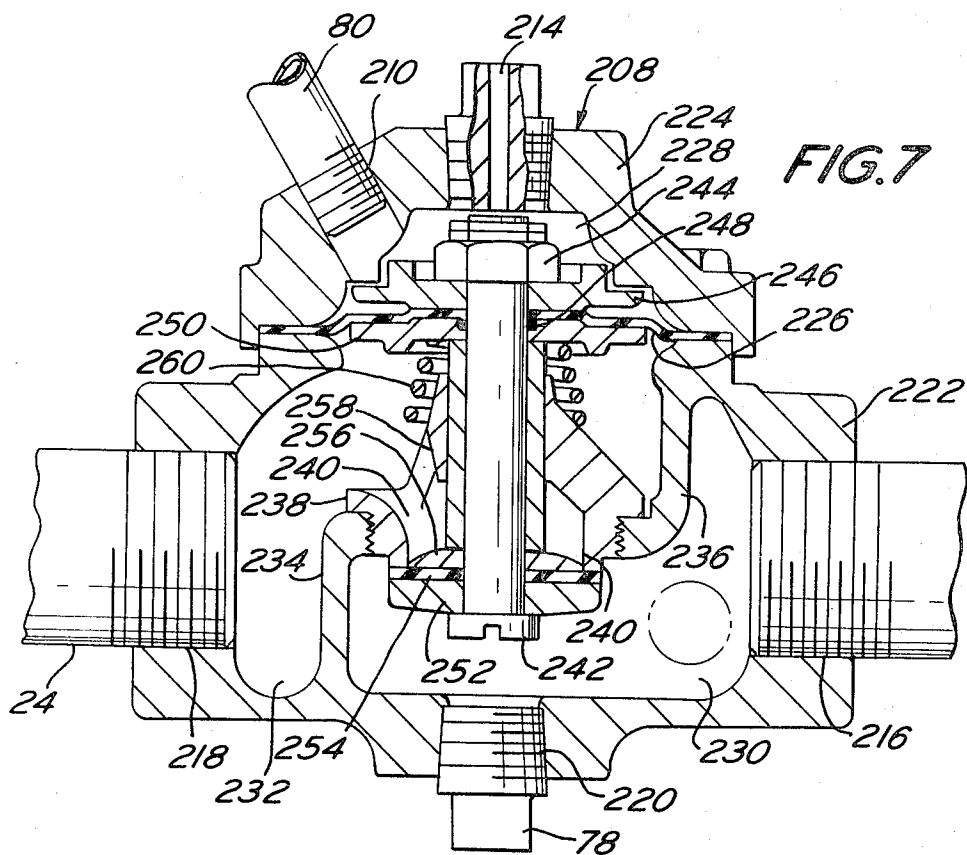
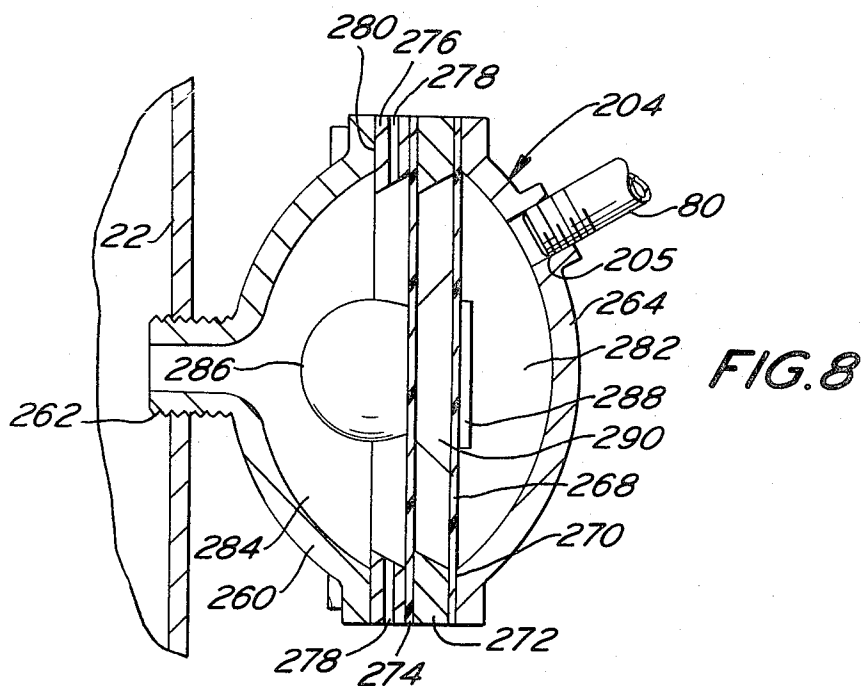


FIG. 6





ABRASIVE BLASTING SYSTEM WITH PERSONNEL PROTECTIVE FEATURES

This invention relates generally to an improved system for blasting the surface of articles with a stream of abrasive particles. More particularly the invention relates to an abrasive blasting system including means for controlling the operation of the system in order to preclude it from getting out of control.

Abrasive blasting equipment is commonly utilized to clean or otherwise treat the surfaces of building stone and brick work, metal castings, etc. Such equipment basically comprises a large tank for holding abrasive particles such as sand or glass beads, a source of high pressure air, a high pressure air-line or hose terminating in a nozzle, a controllable valve for connecting the source of air to the hose and another valve for providing the abrasive into the air-line such that the particles and the air form a blastant stream which can be directed by the nozzle at the article to be treated. The air hose may be quite long, e.g., 150 feet, to enable the operator to get into places too small for the tank to fit into or to enable the operator to cover large working areas without requiring the constant movement of the tank.

In order to permit a single operator to control the operation of the abrasive blasting system, it is a common practice to use a manually operated, remote control valve connected to the sand blasting nozzle at the end of the hose for controlling the valve which connects the source of air pressure to the air-line and in, the case of a controllable valve, for feeding abrasive for controlling said valve to provide abrasive particles and high pressure air into the air-line to effectuate blasting. To that end, a remote control valve commonly includes a manually operable mechanism which, when moved to a predetermined position, effects the energization of the other system valve, thereby opening same and enabling blasting to commence. The control valve is also operative to discontinue the blasting process by causing the valves in the system to close when the mechanism is returned to its non-blasting position.

In the interest of safety, the control valve can be of the "dead man" type, wherein the manually operative mechanism in the remote control valve is biased in a manner such that in order to blast, the operator must maintain the mechanism in a certain position and upon release of the mechanism it returns to its off position and blasting ceases.

In U.S. Pat. No. 3,201,901 (Pauli), there is disclosed an abrasive blasting system having a "dead man" type of remote control valve. In that system, a pilot valve is provided to control the opening and the closing of a first valve connecting a high pressure air source to the blasting hose and of a second valve for providing abrasive from an abrasive holding tank into the air hose. The pilot valve is arranged to open the first and second valves when it is pressurized and to close the first and second valves when it is depressurized. The pressurization of the pilot valve is controlled by the remote control valve which is connected at the nozzle end of the hose. A first high pressure control air-line is provided to an inlet port in the control valve. The remote control valve also includes an outlet port which is normally isolated from the inlet port by a movable valve stem and when so isolated, is in communication with the atmosphere via an exhaust port in the valve. A second con-

trol air-line is connected between the outlet port and the pilot valve. The valve stem is connected to an actuating lever such that when the lever is depressed by the blasting operator, the inlet port and the outlet port are connected together and isolated from the venting port, whereupon high pressure air flows from the first high pressure control air-line through the remote control valve inlet and outlet ports and the second control air-line to the pilot valve, thereby pressurizing same and effecting the commencement of the blasting operation. Upon release of the remote control valve actuating lever, air pressure from the first high pressure control air-line moves the valve stem to a position wherein the inlet port in the remote control valve is isolated from the outlet port thereof and the outlet port is connected to the exhaust port and hence the atmosphere. This action enables the second control air-line to vent through the remote control valve exhaust port to the atmosphere, whereupon the pilot valve depressurizes and effects the cessation of the blasting process.

While such an arrangement exhibits some safety features, it has been found that if during the blasting operation the second control air-line should become pinched, e.g., a car or truck driving over and stopping on the line, the pilot valve remains pressurized, irrespective of whether or not the operator has thereafter released the remote control valve actuating lever. Accordingly, blasting continues with the operator having lost all control over the system. Needless to say, such an occurrence presents a grave threat to safety of all personnel in the blasting area.

Therefore it is a general object of this invention to provide a novel abrasive blasting system which obviates loss-of-control hazards inherent in prior art abrasive blasting systems.

It is a further object of this invention to provide an abrasive blasting system including a remote control valve connected in the system by a pair of control air-lines, which system precludes the loss of control over the system by the operator in the event that the control air-lines are pinched during the blasting operation.

It is still a further object of this invention to provide an improved abrasive blasting system including a remote control valve connected in the system by a pair of control air-lines, whereupon pinching of the control lines results in the automatic cessation of the blasting operation.

It is yet a further object of this invention to provide an improved abrasive blasting system including a master valve which, when pressurized, via a pair of control air-lines, results in the commencement of the blasting operation, said valve being pressurized via a remote control valve connected between the control air-lines and being depressurized via means in said master control valve, whereupon pinching of the control air-lines results in the automatic cessation of the blasting operation.

These and other objects of this invention are achieved by providing an abrasive blasting system comprising a high pressure air-line having a downstream end, an abrasive tank having an abrasive outlet, and a first valve connected between the outlet and the air-line. The system also includes a second controlled, fluid pressure operated means connected in the air-line upstream of the first valve and master fluid pressure operated means located adjacent the tank and operative when pressurized for causing the second controlled

means to open. A remote control valve for controlling fluid flow to the master fluid pressure operated means is provided and is located adjacent the downstream end of the air-line and includes a first port connected via a first control air-line to a source of high pressure air, a second port connected via a second control air-line to the master fluid pressure operated means and manually operable means for connecting the first port to the second port, whereupon the master means is pressurized via the first and second control air-lines. The master means includes means for venting the second line to the atmosphere.

In one embodiment of the invention, the master fluid control means is a pilot valve, the second controlled fluid pressure operated means is a valve and wherein the first means is a controlled, pressure operated valve which is open in response to the pressurization of the pilot valve.

In another embodiment of this system, the master fluid control means is a diaphragm chamber of a diaphragm valve, and the second controlled fluid pressure means comprises the remaining portion of the diaphragm valve.

It is yet another object of this invention to provide an abrasive blasting system including a continuously pressurized abrasive holding tank and a remote control valve connected in the system by a pair of control air-lines, which system precludes the loss of control over the system by the operator in the event that the control air-lines are pinched.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is an elevational view, partially in section, of an abrasive blasting system in accordance with one embodiment of this invention;

FIG. 2 is an enlarged perspective view of a portion of the blasting system shown in FIG. 1;

FIG. 3 is an enlarged sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is an enlarged sectional view of a portion of the system shown in FIG. 1;

FIG. 6 is an elevational view, partially in section, of an abrasive blasting system in accordance with another embodiment of this invention;

FIG. 7 is an enlarged sectional view of a portion of the system shown in FIG. 6; and

FIG. 8 is an enlarged sectional view of a portion of the system shown in FIG. 6.

Referring now to the various figures of the drawing wherein like reference characters refer to like parts, there is shown in FIG. 1 an abrasive blasting system 20 in accordance with one embodiment of this invention. System 20 basically comprises a tank 22 for holding an abrasive material therein, a high pressure air-line 24 connected to a source of high pressure air (not shown), a controllable fluid pressure actuated valve 26 in air-line 24, another controllable fluid pressure actuated valve 28 for providing abrasive from the tank 22 into air-line 24, a flexible hose 30 connected to air-line 24 and terminating in a nozzle 32, a master control or pilot valve 34 for controlling the operation of valves 26 and 28 and a manually operable remote control valve 36

disposed adjacent nozzle 32 for controlling the operation of master control valve 34.

Tank 22 is of generally cylindrical shape and includes a tapered bottom portion 38 terminating in an opening 40 which communicates with the inlet port of the controllable valve 28. The tank 22 is adapted for receiving and holding therein abrasive particles such as glass beads or sand 42. The top wall 44 of the tank is of generally concave shape and has an opening 46 at its lowest point. The concave shape of the top wall 44 permits abrasive material to be funnelled directly into the tank via its opening 46. A sealing gasket 48 is provided about the periphery of opening 46.

Tank 22 is adapted to be pressurized from the source of high pressure air. To that end, high pressure air-line 24 includes a branch 50 passing through the side wall of the tank and communicating with the interior thereof. As can be seen, branch 50 includes an end portion 52 which is bent so as to extend vertically upwards. A sealing piston 54 having a flared cap 56 and a cylindrical shank 58 is provided to seal opening 46. The shank portion 58 of piston 54 extends within the hollow interior of end portion 52. Upon high pressure air entering line 50 and passing through end portion 52, piston 54 is moved upward whereupon its flared cap 56 firmly abuts gasket 48 and thereby closes opening 46 and enables the tank to become pressurized.

A manually operated blow-off valve 60 is connected via pipe 62 to the interior of tank 22. The blow-off valve 60 serves to depressurize the tank when said valve is opened.

The control valve 28 is operative, when opened, for enabling abrasive particles 42 to pass from the tank 22 into the high pressure air-line 24. Valve 28 is preferably a diaphragm type of valve having a controllable diaphragm chamber (not shown).

The controllable valve 26 is connected in the high pressure air-line 24 and is operative, when opened, to enable the high pressure air from the source (not shown) to pass through high pressure air-line 24, through hose 30 and out through nozzle 32. Like valve 28, valve 26 is preferably of the diaphragm type having a controllable diaphragm chamber (not shown).

As will be appreciated by those skilled in the art, upon the opening of valves 26 and 28, high pressure air passing through line 24 from the source is effective for carrying abrasive particles, provided in the air-line via the open valve 28, through hose 30 and nozzle 32. The stream of particles exiting the nozzle can be directed by the nozzle at an article to be surface treated. This operation is referred to as blasting.

As can be seen in FIG. 1, a manually operable valve 64 is connected between controlled valve 26, hereinafter referred to as the air-line valve, and a downstream point in the air-line 24 at which the abrasive particles are provided by controlled valve 28, which latter valve is hereinafter referred to as the abrasive supply valve. Another manually operable valve 66 is provided between coupling 69 which serves as the connection to the high pressure air source and coupling 70 which connects branch 50 to high pressure air-line 24. The manually operable valve 64 is provided to ensure that high pressure air does not carry any abrasive deposited in the high pressure air-line through the hose and terminating nozzle irrespective of whether or not valve 26 is opened. In this regard, valve 64 acts as a safety valve. Valve 66, when closed, prevents high pressure air from

the air source from pressurizing tank 22 when such pressurization is not desired.

The opening and closing of valves 26 and 28 is controlled by pilot valve 34 via control line 68. Control line 68 is connected to an outlet port of the pilot valve via coupling 70. Control line 68 is connected via a downstream coupling 72 to an inlet port of the diaphragm chamber of valve 26. The downstream end of control line 68 is connected to the inlet port of the diaphragm chamber of valve 28.

The valves 26 and 28 are arranged such that upon the pressurization of line 68 their respective diaphragm chambers become pressurized thereby resulting in the closure of said valves. Upon the depressurization of line 68, the diaphragm chambers of valves 26 and 28 are depressurized and the valves open, whereupon high pressure air from the air source passes through line 24 and valve 26 and whereupon abrasive particles pass through valve 28 into air-line 24 for mixture with the high pressure air therein to form a blastant stream.

High pressure air is provided to pilot valve 34 from the high pressure air source via air-line 72 and coupling 74. An air filter 76 is provided in line 72.

As will be considered in detail later, the pilot valve 34 is arranged such that when a portion thereof is pressurized, high pressure air from line 72 is precluded from entering line 68, whereas when said portion of the pilot valve is depressurized, high pressure air from line 72 is enabled to flow through the pilot valve into line 68 to thereby effectuate the pressurization of the diaphragm chambers of valves 26 and 28. The pressurization of the diaphragm valve is controlled via a pair of control lines 78 and 80 from remote control valve 36. Line 78 is connected between coupling 74 and an inlet port 82 in the remote control valve 36. Line 80 is connected between coupling 84, which coupling is connected to the pilot air-port 86 of pilot valve 34, and an outlet port 88 of remote control valve 36.

A manually operable valve 90 is also connected to coupling 84. Valve 90 serves to depressurize pilot port 86 of pilot valve 34 when desired.

The pilot port 86 of the pilot valve 34 is pressurized in the following manner: High pressure air from the source passes through line 72, coupling 74 and control line 78 to inlet port 82 of the remote control valve 36. The remote control valve 36 is arranged such that the inlet and outlet ports thereof are normally disconnected from one another. As will be considered in detail later, upon the depression of lever 92 of the remote valve 36, the inlet and outlet ports thereof are connected together, whereupon high pressure air from line 78 is enabled to pass through inlet port 82, valve 36, control line 80 and coupling 84 to pressurize pilot air-port 86. The pressurization of the pilot air port 86 results in the depressurization of line 68, thereby opening valves 26 and 28 to commence the blasting operation.

Control lines 78 and 80 are preferably flexible and extend along flexible hose 30.

In FIG. 2 there is shown a portion of the flexible hose 30 adjacent nozzle 32 and the remote control valve 36 which is connected to said portion of the hose. As can be seen therein, remote control valve 36 includes a base portion 94 including a concave surface 96 abutting a portion of the periphery of hose 30. The remote control valve 36 is connected to hose 30 via a pair of bands 98 surrounding base 94 and hose 30. A generally

U-shaped member 100 projects from base portion 94. U-shaped portion 100 serves to preclude the lever 92 from being accidentally depressed. The lever 92 includes a pair of ears 102 (see FIG. 4) which are connected via bolt 104 (see FIG. 4) to U-shaped member 100. As connected, lever 92 is adapted for pivotal motion about bolt 104.

The remote control valve 36 includes a valve housing 106 abutting the U-shaped member 100. Both the inlet port 82 and the outlet port 88 of the valve 36 are disposed within the housing 106. The structural details of the operation of the remote control valve 36 will best be understood by reference to FIG. 3.

As can be seen therein, housing 106 includes a valve chamber 108 having a large diameter bore 110 and a small diameter bore 112 contiguous with one another. A passageway 114 serves to connect inlet port 82 with the large bore 110 of chamber 108. Passageway 116 serves to connect the outlet port 88 with the small bore 112 of the chamber 108. A movable piston 118 is disposed within valve chamber 108 and includes a cylindrical shank portion 120 extending through small bore 112 and an axially aligned hole 122 in U-shaped member 100. A portion of the shank 120 extends out of the U-shaped member 100 and abuts a camming surface 124 on lever 92. An O-ring 126 is provided within a groove 128 in the periphery of the shank 120 and serves to seal the interior of the valve chamber 108 from the ambient atmosphere surrounding valve 36. A piston head 130 is connected to the other end of shank 120 and is disposed within the large diameter bore 110 of chamber 108. A resilient sealing gasket 132 is disposed on a ledge 134 on shank 120 and within a recess 136 in piston head 130. A portion 138 of shaft 120 projects from piston head 130. A threaded sealing screw 140 serves to seal the interior of chamber 108. A stop member 142 projects from the interior surface of screw 140 towards portion 138 of piston 118. A helical spring 144 is interposed between piston head 130 and the sealing screw 140 and is disposed about portion 138 of the piston and stop member 142. The helical spring is operative to bias the piston to the position wherein the sealing ring 32 firmly abuts the periphery of the valve chamber contiguous with the small bore portion 112 of the chamber 108, thereby isolating portion 110 from portion 112. In so doing, inlet port 82 is isolated from outlet port 88.

Upon depression of lever 92 towards base portion 92 by an operator utilizing the sand blasting system 20, the camming surface 124 of the lever 92 forces the piston 118 towards sealing screw 140 and against the urging of spring 144, thereby effecting the communication between the large and small bore portions of valve chamber 108. This action enables high pressure air entering inlet port 82 to pass through passageway 114 into the large bore 110 of chamber 108, around piston head 130 and sealing gasket 132 into the small bore 112 of the chamber, through passageway 116 and to outlet port 88. The stop member 142 serves to preclude the piston 118 from moving too close to sealing screw 140 when lever 92 is depressed, which action would result in the closing of passageway 114.

The structural details and operation of the pilot valve 34 will be considered with reference to FIG. 5. As can be seen therein, valve 34 includes a housing 146. Housing 146 includes a poppet chamber 148 in which a movable poppet 150 is disposed. Poppet chamber 148

is made up of three portions, an upper portion 152, a mid-portion 154 and a lower portion 156. A ledge 158 divides the upper portion of the poppet chamber from the mid-portion of the poppet chamber. A ledge 160 divides the mid-portion of the poppet chamber from the lower portion of the poppet chamber. An inlet port 162 is provided in housing 146 and communicates with the interior of the lower portion 156 of the poppet chamber, an outlet port 164 is provided in the housing and communicates with the mid-portion 154 of the poppet chamber and an exhaust port 166 is provided in the housing and communicates with the upper portion 152 of the poppet chamber.

As can be seen, housing 146 also includes top plate 168 through which plate the pilot air-port 86 passes to communicate with a pilot chamber 170 within the housing.

The inlet port 162 is threadedly connected to air-line 72, the outlet port 164 is threadedly connected to control line 68, the pilot air-port 86 is threadedly connected to control air-line 80 and exhaust port 166 communicates with the ambient atmosphere surrounding the valve 34.

The poppet 150 includes a piston head 172 disposed within a bore 174 in the upper portion of the poppet chamber. An O-ring 176 is provided within a peripheral groove 178 in the piston and serves to seal the poppet chamber 148 from the pilot chamber 170. A small diameter orifice 180 is provided within piston head 172 and enables air in the pilot chamber 170 to pass there-through and into the upper portion of the poppet chamber from whence said air can exhaust to the atmosphere, for reasons to be considered later.

Poppet 150 includes a shank 182 having a flange 184 thereon. The flange 184 passes through an opening 186 in ledge 158. Shaft 182 includes a second flange 188 and a third flange 190. A sealing gasket 192 is disposed about shaft 182 and is interposed between flanges 184 and 188. A similar sealing gasket 194 is disposed about shaft 182 and is interposed between flanges 188 and 190. The sealing gasket 192 is adapted for isolating the upper portion 152 of the poppet chamber 148 from the mid-portion 154 thereof when said gasket abuts the contiguous surface of a recess 196 in ledge 158. In a similar manner, sealing gasket 194 is adapted to isolate the mid-portion 154 of poppet chamber 148 from the lower portion 156 thereof when said gasket abuts the contiguous surface of ledge 160.

A resilient spring 198 is disposed within the lower portion 156 of the poppet chamber and is interposed between a lower wall 200 thereof and flange 190 of the poppet 150. The spring serves to bias the poppet into the position shown in FIG. 5. In such a position, the sealing gasket 192 abuts the contiguous surfaces of recess 196 of ledge 158 to effectuate the isolation of the upper portion 152 of the poppet chamber from the mid-portion 154 thereof, while sealing gasket 194 is moved off of ledge 160 such that mid-portion 154 of poppet chamber 148 is in communication with lower portion 156 thereof. Accordingly, the inlet port 162 is in communication with the outlet port, whereupon high pressure air entering line 72 is enabled to pass through inlet port 162 through the communicating mid and lower portions of the poppet chamber 148 and through outlet port 164 into control line 68.

When high pressure air is introduced via line 80 and connected pilot air-port 86 into the pilot chamber 170,

the resulting pressurization of chamber 170 effectuates the downward displacement of poppet 150, whereupon sealing gasket 192 moves out of abutting engagement with recess 196 and sealing gasket 194 moves into abutting relationship with ledge 160. In such a condition, the lower portion 156 of the poppet chamber 148 is isolated from the mid-portion 154 thereof and the mid-portion 154 is connected to the upper portion 152. This action enables the control line 68 to be depressurized via the path composed of the outlet port 164, the mid-portion 154 of the poppet chamber 148, the upper portion 152 of the poppet chamber 148 and the exhaust port 166. The orifice 180 is provided to enable the pilot chamber to be depressurized in the event that pilot air-line 80 becomes pinched. This action automatically results in the cessation of the blasting operation.

As will be appreciated by those skilled in the art, absent orifice 180, should control line 80 become pinched during a blasting operation, i.e., when control line 80 is pressurized, chamber 170 would remain pressurized and thus blasting would continue irrespective of whether or not the operator thereafter released handle 92.

The diameter of orifice 180 is relatively small, e.g., one sixth, in comparison to the diameter of pilot port 86 such that the air from line 80 that bleeds there-through exits through the vent port 166 is not of sufficient volume to prevent the piston 172 from being displaced downward upon the pressurization of air-line 80 via the closure of remote control valve 36.

Operation of abrasive blasting system 20 is as follows: Manual valves 64 and 66 are opened and valves 60 and 90 are closed. High pressure air from the air source (not shown) passes through open manual valve 66 and into air-line 24 and at the same time high pressure air passes via coupling 70 into branch 50 where it causes piston 56 to seal and pressurize tank 22. The high pressure air from the air source also passes via line 72 into inlet port 162 of pilot valve 34. At the same time, high pressure air is provided from line 72 via coupling 74 into control line 78 and from there through inlet port 82 of valve 36 and its associated passage 114 to the large bore portion 110 of the remote control valve chamber 108. In the OFF or non-blasting state, the spring 144 biases piston 118 to the position shown in FIG. 3, whereupon gasket 132 effectuates the isolation of the small bore portion 112 of chamber 108 from the large bore portion 110 thereof and the concomitant isolation of inlet port 82 from outlet port 88. Any pre-existing high pressure air within control line 80 is enabled to pass through orifice 180 to vent through exhaust port 166 to the atmosphere. Accordingly, poppet 150 of valve 34 is in the position shown in FIG. 5 whereupon the high pressure air appearing at its inlet port 162 is enabled to pass in the direction of the arrows shown to its outlet port 164 and connected control line 68 to result in the pressurization of the diaphragm chambers of valves 26 and 28. This action holds the valves in their closed state; whereupon blasting is precluded.

When the operator desires to begin blasting, he depresses lever 92, whereupon piston 118 of valve 36 is moved against the action of its spring 144 towards sealing screw 140, thereby coupling the inlet port 82 to the outlet port 88. The high pressure air appearing at the inlet port 78 is thus enabled to pass through the valve

36 and into control line 80. High pressure air appearing on line 80 effectuates the downward motion of piston 172 notwithstanding the small volume of air which is enabled to bleed through orifice 180 and associated vent port 166 to the atmosphere. The downward displacement of poppet 150 results in the isolation of lower portion 156 of the poppet chamber from the mid-portion thereof and the connection of the mid-portion to the upper portion 152 thereof. Accordingly, any high pressure air appearing on line 68 is enabled to pass through the mid-portion 154 and communicating upper portion 152 of poppet chamber 148 to vent to the atmosphere via exhaust port 166. The depressurization of line 68 results in the opening of diaphragm valves 26 and 28, whereupon blasting commences.

In order to cease the blasting operation, the operator releases lever 92, whereupon the spring 144 biases piston 118 of valve 36 to the position shown in FIG. 3. This action results in the isolation of the outlet port 88 from the inlet port 82. Once the outlet port 88 is isolated from the inlet port, the high pressure air then existing in line 80 is enabled to pass through the pilot port 86, the pilot chamber 170, the orifice 180 and the exhaust port 166 to vent to the atmosphere. Once line 80 has vented sufficiently such that the upper force exerted by spring 198 overcomes the downward force exerted by the pressure in pilot chamber 170, poppet 150 moves to the position shown in FIG. 5 whereupon high pressure air on line 72 is enabled to pass to line 68 to pressurize the diaphragm chambers of valves 26 and 28 and render those valves closed. In accordance with this invention, the diameter of the orifice is selected such that the above described cessation of the blasting operation occurs within a very short time after the release of lever 92, the shorter the control lines 78 and 80, the shorter of period of time between the release of the lever 92 and the cessation of the blasting operation. In accordance with the preferred embodiment of the system 20, valve 34 is a "Norgren" valve Model E10T2B-UUA1, having a 3/8 inch pilot air-port 86 and having a 1/16 inch orifice 180 through piston head 172.

By venting the control line 80, via the pilot valve 36, a distinct safety advantage is realized, i.e., the automatic cessation of blasting in the event that the pilot air-line becomes pinched. For example, should the pilot air-line 80 become pinched during the blasting operation, when said line is pressurized, the high pressure air then existing on the line is enabled to pass through the line, through pilot chamber 170, the orifice 180, the upper portion 152 of the poppet chamber 148 and the exhaust port 166 to vent to the atmosphere. Accordingly, the pressure within pilot chamber 170 decreases. When the pressure within the pilot chamber has decreased to the point wherein the upward force exerted by spring 198 overcomes the downward force exerted by the pressure within the pilot chamber, the poppet 150 moves to the position shown in FIG. 5 and such action results in the pressurization of control line 68 thereby resulting in the closure of valves 26 and 28 and the cessation of the blasting operation.

In FIG. 6 there is shown another embodiment of a sand blasting system in accordance with this invention. That system denoted as 202 is somewhat similar in construction to system 20 in that it includes a tank 22 for holding abrasive particles 42 therein, a high pressure air-line 24 for carrying particles inserted therein through a flexible hose 30 to a nozzle 32 from whence

the abrasive stream may be directed at an article to be surface treated and a remote control valve 36 on the hose adjacent its nozzle 32 and connected to a pair of control air-lines 78 and 80 for controlling the operation of the system.

The tank 22 in system 202, unlike tank 22 and system 20, is arranged to be pressurized only during the blasting operation. To that end, a branch 50 of the high pressure air line 24 extends within tank 22. Branch 50 terminates in an end portion 52 extending vertically upwards within the tank. A movable piston 54 including a shank portion (not shown) is disposed within the branch end portion 52. The piston includes a cap 56. Upon high pressure air entering line 24, which only occurs during the blasting operation as will be described hereinafter, line 50 is pressurized, whereupon piston 54 moves vertically upward such that its cap 56 seals the opening 46 of tank 22 by tightly abutting its gasket 48. Once the tank is sealed, the continued flow of air into the tank results in its pressurization.

As can be seen in FIG. 6, the system 202 includes an exhaust valve 204 which is connected to tank 22 adjacent its top. Valve 204 is a diaphragm valve including a diaphragm chamber. The valve 204 serves to depressurize tank 22, i.e., let the pressurized air existing within the tank during the blasting operation bleed off to the atmosphere when blasting ceases. The valve also includes a control port 205 connected to the control air-line 80 via a coupling 212. Valve 204 is arranged such that when control port 205 is pressurized, the valve is closed and does not permit the tank 22 to depressurize, but when port 205 is depressurized, the valve opens and the tank depressurizes.

System 202 includes a manually operable valve 206 which, when opened, enables abrasive particles from the tank 22 to pass into the air-line 24. A manual valve 64 is connected in the air-line 24 between branch 50 and valve 206 to preclude air from carrying any abrasive particles through the hose if blasting is not desired. When the blasting system shown in FIG. 6 is to be used, valve 64 is opened.

A controlled, fluid pressure operated valve 208 is connected between a source of high pressure air (not shown) and the high pressure air-line 24. The valve is operative, when opened, to enable high pressure air to pressurize tank 22, as described above, and to enable high pressure air to flow through line 24 to carry any abrasive particles provided therein by valve 206 through the hose 30 and out of nozzle 32. The valve 208 is of the "diaphragm" type including master fluid pressure operated means, i.e., a diaphragm chamber, which controls the opening or closing of the valve. The diaphragm chamber includes inlet control port 210 which is connected to the control line 80 from the remote control valve 36 via coupling 212 and an exhaust port 214 which communicates with the atmosphere. The remaining portion of the valve includes an inlet port 216, an outlet port 218 and an outlet control port 220. The inlet port 216 is connected to the source of high pressure air, the outlet control port 220 is connected between the inlet port 216 and the control line 78 and the outlet port 218 is connected to the high pressure air-line 24.

In FIG. 7, the structural details of the valve 208 are shown. As can be seen therein, valve 208 includes housing 222 including a top cover 224. Housing 222 includes the inlet port 216, the outlet port 218, and the

outlet control port 220. The cover 224 includes the inlet control port 210 and the exhaust port 214. A flexible diaphragm 226 is provided between the cover 224 and housing 222. The diaphragm defines a diaphragm chamber 228 between itself and the interior wall of the cover 224. Both of the ports 210 and 214 communicate with chamber 228.

The diaphragm 226 also serves to define a two part valve chamber within housing 222. One part of the valve chamber communicates with inlet port 216 and is denoted as the valve chamber portion 230 and the other portion of the valve chamber communicates with port 218 and is denoted as valve chamber portion 232. A pair of ledges 234 and 236 serve to provide means for separating portions 230 and 232 of the valve chamber. A valve seat 238 is threadedly engaged with ledges 234 and 236 and includes an opening 240 therein. A movable stem 242 is connected to the diaphragm 226 by a stem nut 244 and an upper diaphragm washer 246. The stem extends through an opening in the diaphragm but is sealed thereto by O-ring 248 disposed within a groove in a lower diaphragm washer 250. The stem 242 extends through opening 240 in valve seat 238 and terminates at its lower end in a seal retainer member 252. The seal retainer 252 supports thereon a resilient gasket or seal 254. The seal 254 is held between the seal retainer 252 and a seal flange 256. A spacing tube 258 is disposed about the shank of stem 242 and within opening 240. The helical spring 260 is interposed between lower diaphragm washer 250 and seat 238 and serves to bias the diaphragm 226, stem 242 and seal 254 in the position shown in FIG. 7. In this position, the seal 254 firmly abuts the valve seat 238 contiguous therewith so that the valve chamber portion 230 is isolated from valve chamber portion 232, thereby isolating the inlet port 216 from the outlet port 218.

As will be appreciated by those skilled in the art, should high pressure air enter through line 80 and control inlet port 210, diaphragm chamber 228 becomes pressurized, whereupon the diaphragm is displaced downward thereby moving the associated stem and seal 54. This action results in the connection of valve chamber portion 230 to valve chamber portion 232 and thereby enables high pressure air at port 216 to pass through the valve through the outlet port 218 and into high pressure air-line 24.

In FIG. 8 there is shown the details of the exhaust valve 204. As can be seen therein, exhaust valve 204 includes a housing 260 including a threaded connector 262 connected to the wall of tank 22 and a housing cap 264 connected to the housing 260. The housing cap 264 includes the control inlet port 205 which is connected to control line 80. A first flexible diaphragm 268 abuts a flange 270 on the cap 264. A spacing ring 272 abuts a portion of diaphragm 268 contiguous with flange 270. A second diaphragm 274 is provided within housing 260 and abuts spacing ring 274. A bleed off ring 276 abuts the portion of diaphragm 274 contiguous with ring 272. The bleed off ring 276 includes a plurality of apertures 278 therein which connect the interior of housing 260 to the atmosphere surrounding the valve. The bleed off ring 276 is connected to a flange 280 on the housing 260.

The space within housing cap 264 between its inner surface and diaphragm 268 defines a diaphragm chamber 282. Port 205 communicates with diaphragm chamber 282. The space defined within the housing

260 between its interior wall and diaphragm 274 defines a valve chamber 284. A valve ball 286 is connected to the diaphragm 274 and is disposed within the valve chamber 284. The valve ball is connected to the diaphragm via a valve nut 288 abutting the diaphragm 268. A spacing ring 290 is interposed between both diaphragms.

Valve 204 operates in the following manner: Upon high pressure air passing through line 80 and into inlet port 205 the diaphragm chamber 282 is pressurized, thereby displacing diaphragms 268 and 274 laterally towards the valve coupling 262, whereupon the valve ball 286 abuts the inner surface of the housing 260 contiguous with the coupling thereby isolating the valve chamber 284 from the interior of tank 22. Accordingly, high pressure air within tank 22 is precluded from exiting through the exhaust ports 278 in the valve 204. When the control line 80 is depressurized, diaphragms 270 and 274 move to the position shown in FIG. 8 thereby unseating valve ball 386 from the coupling 264. This action thereby enables the interior of tank 22 to vent to the atmosphere via coupling 262, valve chamber 284 and exhaust ports 278.

The operation of the abrasive blasting system 202 shown in FIG. 6 is as follows: The manual valves 64 and 206 are opened, thereby enabling the system to commence blasting when the operator desires. Prior to the commencement of blasting, high pressure air from the air source not shown enters through port 216 of valve 208. The valve 208 is at this time in the position shown in FIG. 7, whereupon chamber 230 is isolated from chamber 232. Accordingly, the high pressure air entering port 216 exits port 220 and into air-line 78. The air-line 78 is connected to the input port 82 of the remote control valve 36. Since at this time the handle 92 of the remote control valve 36 is not depressed, the control valve is closed, whereupon its outlet port 88 is isolated from its inlet port 82. Accordingly, any air existing in line 80 will be at atmospheric pressure, it having vented through exhaust port 214 in the valve 208. Due to the atmospheric pressure existing on air-line 80, the exhaust valve 204 is in the position shown in FIG. 8 whereupon the interior of the tank 22 communicates with the atmosphere via its exhaust ports 278.

When the operator desires to commence blasting, he depresses lever 92, thereby connecting control air-line 78 to control air-line 80 via valve 36. This action pressurizes line 80 notwithstanding the slight bleed off therefrom via exhaust port 214 in valve 208. In this regard, port 214 is configured to be smaller in diameter, e.g., one sixth, than inlet port 210.

Upon the pressurization of line 80, the diaphragm chamber 228 becomes pressurized, whereupon the diaphragm is displaced downward, thereby carrying the stem 242 and the seal 254 downward. This action results in the unseating of the seal 254 from seat 238. Once seal 254 is unseated from seat 238, the valve chamber portion 230 is in communication with valve chamber portion 232, whereupon high pressure air entering port 216 exists through port 218 into air-line 24. The high pressure air entering air-line 24 carries abrasive particles which are disposed therein from open valve 206, into hose 30 and through nozzle 32 to effectuate blasting. At the same time, the high pressure air existing on line 80 pressurizes the diaphragm chamber 282 in valve 204 thereby causing the valve ball 286 to seal the opening in coupling 262 and thereby isolate the

interior of tank 22 from the atmosphere. Furthermore, the high pressure air appearing on line 24 passes through branch 50 and termination 52 thereby causing piston 54 to move upward whereupon its cap 56 closes opening 46 by abutting gasket 48. The high pressure air from line 24 thus pressurizes tank 22.

The cessation of the blasting operation occurs in the following manner: The operator releases lever 92, whereupon line 78 is disconnected from line 80 via valve 36. Line 80 thereby vents through exhaust port 214 in valve 208. When the pressure within diaphragm chamber 228 of valve 208 has decreased at the point wherein the upward force exerted by the spring 260 overcomes the downward force exerted by the pressure in the diaphragm chamber, the diaphragm moves to the position shown in FIG. 7 thereby seating seal 254 on valve seat 238, whereupon inlet port 216 is isolated from outlet port 218 such that high pressure air ceases flowing through air-line 24. This action effectively terminates blasting and depressurizes diaphragm chamber 282 of valve 204 such that the valve opens, thereby enabling the tank 22 to exhaust via exhaust ports 278.

Like the abrasive blasting system 20, abrasive blasting system 202 automatically turns off should control 80 become pinched during the blasting operation. That operation is as follows: When heretofore pressurized line 80 becomes pinched, the high pressure air then existing in the line is enabled to pass through port 210, diaphragm chamber 228 and exhaust port 214 of valve 208. This action results in the depressurization of line 80. When the pressure within diaphragm chamber 228 has decreased to the point wherein the force exerted thereby is less than the upward force exerted by spring 260, the stem 242 and seal 254 carried thereby are moved to the position shown in FIG. 7, whereupon the inlet port is isolated from the outlet port. This action ceases the blasting operation. Furthermore, at the same time the depressurization of air-line 80 causes the depressurization of diaphragm chamber 282 in valve 204 whereupon valve 204 opens to enable the tank to exhaust through its exhaust ports 278.

In accordance with the preferred embodiment of the system 202, valve 208 is a "Clayton" valve Model 105A, having a $\frac{3}{8}$ inch control inlet port 210 and having a 1/16 inch exhaust port 214.

Without further elaboration, the foregoing will so fully illustrate my invention, that others may, by applying current or future knowledge, readily adapt the same for use under various conditions of service.

What is claimed as the invention is:

1. An abrasive blasting system comprising a high pressure air-line having a downstream end, an abrasive tank having an abrasive outlet, a first valve connected between said outlet and said air-line, a second controlled, fluid pressure operated valve connected in said air-line upstream of said first valve and operative when opened to enable high pressure air to flow through the high pressure air-line, master fluid pressure operating means located adjacent said tank and operative when pressurized for causing said second controlled valve to open and a remote control valve for controlling fluid flow to said master fluid pressure operated means, said remote control valve being located adjacent the downstream end of said air-line and including a first port connected via a first control air-line to a source of high pressure air, a second port connected via a second control air-line to said master fluid pressure-operated

means and manually operable means for connecting said first port to said second port, whereupon said master fluid pressure operated means is pressurized via said first and second control air-lines, said master fluid pressure operated means including bleed off means for venting the air in said second control air-line to the atmosphere at all times, with the rate of venting being small enough that when the first and the second ports are connected together the master fluid pressure-operated means remains pressurized to cause the second control valve to be opened and when said first and said second ports are disconnected from one another said master fluid pressure means depressurizes and thereby effects the closing of the second control valve.

2. The system as specified in claim 1 wherein said master fluid pressure operated means is a pilot valve, and wherein said first valve is a controlled fluid pressure operated valve which is opened in response to the pressurization of said pilot valve.

3. The system as specified in claim 2 wherein the interior of said tank is connected to said air-line upstream of said second controlled valve to result in the pressurization of said tank irrespective of whether or not said first and said second valves are opened.

4. The system as specified in claim 3 wherein said pilot valve comprises an inlet port which is connected to said high pressure air-line, an outlet port which is connected via a third control air-line to said first and said second valves, and exhaust port, a pilot port which is connected to said second control air-line and movable poppet, said poppet being arranged to move to a position to isolate said outlet port from said inlet port when said pilot valve is pressurized and to move to a position to connect said outlet port to said exhaust port when said pilot line is depressurized, said poppet including an orifice enabling said pilot port to communicate with said exhaust port at all times.

5. The system as specified in claim 4 wherein said orifice is of smaller diameter than the said pilot air-port.

6. The system as specified in claim 5 wherein said first and said second valves are diaphragm valves which are closed when pressurized.

7. An abrasive blasting system comprising a high pressure air-line having a downstream end, an abrasive tank having an abrasive outlet, a first valve connected between said outlet and said air-line, a second controlled, fluid pressure operated valve connected in said air-line upstream of said first valve and operative when opened to enable high pressure air to flow through the high pressure air-line, master fluid pressure operated means located adjacent said tank and operative when pressurized for causing said second controlled valve to open and a remote control valve for controlling fluid flow through said master fluid pressure operated means, said remote control valve being located adjacent the downstream end of said air-line and including a first port connected via a first control air-line to a source of high pressure air, a second port connected via a second control air-line to said master fluid pressure operated means and manually operable means for connecting said first port to said second port, whereupon said master fluid pressure operated means is pressurized via said first and second control air-lines, said master fluid pressure operated means including means for venting said second control air-line to the atmosphere,

15

said master fluid control means being a diaphragm chamber of a diaphragm valve, said second controlled fluid pressure means comprising the remaining portion of said diaphragm valve and wherein said first valve is a manually operable valve.

8. The system as specified in claim 7 wherein the interior of said tank is connected to said air-line downstream of said diaphragm valve to result in the pressurization of said tank only when said diaphragm valve is opened.

9. The system as specified in claim 8 wherein said diaphragm valve includes an inlet port connected to said air-line at an upstream point, an outlet port connected to said air-line downstream of said upstream point, a control outlet port connected to said inlet port and said first control air-line, a control inlet port connected to said second control air-line and said diaphragm cham-

16

ber, an exhaust port connected to said diaphragm chamber and a movable diaphragm separating said diaphragm chamber from the remaining portion of said diaphragm valve, said diaphragm being moved to a position to connect said outlet port to said inlet port when said controlled inlet port is pressurized and to move to a position to disconnect said inlet port from said outlet port when said controlled inlet port is depressurized.

10. The system as specified in claim 9 wherein said exhaust port is of smaller diameter than said inlet control port.

11. The system as specified in claim 10 additionally comprising a venting diaphragm valve which is connected to said tank and to said control inlet port to vent said tank when said control inlet port is depressurized.

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