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(54) **Powder delivery system.**

(57) A method and apparatus for pumping air entrained solid particulate powder material from a hopper to a dispenser so as to maintain a steady rate of flow of powder to the dispenser. The apparatus comprises a primary fluidized bed hopper from which powder is pumped to an auxiliary and much smaller capacity auxiliary fluidized bed hopper. The powder is then supplied from the auxiliary hopper to the dispenser.

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This invention relates to systems for supplying air entrained solid particulate powder material to powder spray guns or dispensers. More particularly, it is concerned with supplying an even flow of powder from a fluidized powder source to a powder spray gun or dispenser.

Characteristically, powder is supplied to a powder spray gun through a pneumatic conveyor line within which there is a powder pump containing a low pressure venturi pumping chamber. This chamber is intersected by a powder supply passage through which powder is supplied to the pump from a fluidized bed hopper. In order to meter or control the rate of flow of powder from the fluidized bed into the venturi pumping charber, such pumps conventionally include a metering air flow passage operable to inject a controlled flow of air into the powder supply passage. The pressure of this metering air flow controls the amount of air which is mixed with the powder entering the pump, and consequently the rate of flow of powder from the pump.

One of the shortcomings of all powder spray systems, including systems incorporating powder pumps of the type described hereinabove, is that the powder ejected from the spray gun of the system commonly flows unevenly from the gun. There are periodic puffs or clouds of powder ejected from the gun and periodic reductions in the density of powder ejected from the gun. Such periodic increases or decreases in powder density sprayed from the gun result in uneven application of powder to a target substrate to which the powder is applied. Consequently, such random changes in powder density are very undesirable.

There have been numerous attempts to minimize or reduce these random changes of powder density sprayed from a powder spray gun. Such attempts have taken the form of changes in the design of the powder spray gun, changes in the design and configuration of the powder pump, etc. Most of these changes have improved the situation somewhat, but have not cured the problem.

It has been an objective of this invention to provide an improved powder spray system wherein inadvertent or random changes in the flow rate of powder dispensed from a powder spray gun or dispenser of the system are minimized or eliminated.

This invention is in part predicated upon the discovery that one source of uneven flow of powder from a powder spray gun or dispenser of a powder spray system is the configuration of the system between the fluidized bed source of powder and the dispensing gun. That portion of the system has heretofore simply consisted of a siphon tube for supplying powder from the fluidized bed to a powder pump, the pump, and a long supply hose connecting the pump to the gun. It has therefore been an objective of this invention to eliminate powder flow variances which have heretofore been attributable to the configuration of this portion of the system.

These objectives are achieved, in accordance with the invention by supplying powder from the powder pump through a hose to an auxiliary fluidized bed of powder located near the dispensing gun, and then supplying the powder to the gun from the auxiliary fluidized bed through an auxiliary powder pump and a relatively short hose. By utilizing an auxiliary

fluidized bed and an auxiliary powder pump located near the dispensing gun outlet, erratic powder flow heretofore atributable to the relatively long length of hose between the pump and the gun, and to a varying level of powder within the fluidized bed source of powder, has been reduced or completely eliminated.

A substantial portion of the flow variances within a conventional prior art powder spray system are, we have found, attributable to two sources. These sources are the relatively long hose between the pump and the gun and the varying level of powder in the fluidized bed source of powder to the system. A long hose between the pump and the gun creates flow variances as a result of loops and curves which inevitably occur in such long hoses. Powder collects in these loops or curves and eventually restricts flow through the hose until a pressure build-up behind the powder restriction breaks the restriction away and causes a resulting puff of powder to be dispensed from the gun while simultaneously causing a pressure increase in the hose and a resulting increase in the flow of powder to the gun. Thereafter, the powder again begins to collect in the curve or loop of the hose from which it had just broken away, until it forms a restriction in the hose, breaks free, causes another puff of powder, etc.

The other primary source of varying flow from a conventionally configurated prior art powder flow system, the varying level of powder contained in the fluidized bed source of powder, causes flow variances as a result of differing pressures being required to draw powder into the powder pump as the powder level changes in the fluidized bed. In fact though, the

vacuum within the pump tending to draw powder into the pump does not change with the differing level of powder in the fluidized bed hopper. Instead, the vacuum pressure remains the same but the quantity of powder drawn into the pump changes as the level of powder in the hopper changes.

A powder spray system in accordance with this invention comprises a primary fluidized bed hopper source of powder and a smaller capacity auxiliary fluidized bed hopper located adjacent or near the powder dispensing guns, a venturi style pump and a connecting hose to transport powder from the primary hopper to the auxiliary hopper and an auxiliary venturi style powder pump and connecting hose to transport the powder from the auxiliary hopper to a dispensing gun. There is preferably also an overflow pipe which extends between the auxiliary hopper and the primary hopper and which functions to maintain a fixed level of powder in the auxiliary hopper.

The practice of this invention with its use of an auxiliary fluidized bed hopper and an auxiliary venturi pump located closely adjacent the powder spray gun of a powder spray system enables both of the above identified sources of powder flow variances to be eliminated. Any flow variances which occur in the long hose between the primary hopper and the auxiliary hopper do not affect the flow rate between the auxiliary powder pump and the spray gun. Furthermore, the use of an overflow pipe between the auxiliary fluidized bed hopper and the primary fluidized bed hopper enables the level of powder in the auxiliary hopper to be maintained at a fixed level so long as an excess amount of powder is supplied to the auxiliary

fluidized bed. Thereby, flow variances attributable to the changing level of powder in the supply hopper are eliminated.

The invention will now be further described by way of example with reference to the accompanying drawings, which is a schematic view of a powder spray apparatus incorporating an auxiliary powder hopper and auxiliary powder pump.

Referring to the drawing, a powder spray system 10 is shown for dispensing solid particulate powder material from a plurality of spray guns 12. Three guns 12 are illustrated but the system is equally applicable to the spraying of powder from a single gun or from a substantially greater number of guns 12. The guns 12 per se form no part of the invention of this application and are well known in the prior art. One such gun which is suitable for use in this application is illustrated and described in our U.S. Patent No. 4,380,320.

The apparatus, in addition to the guns 12, comprises a primary or supply hopper 14, an auxiliary hopper 16, as well as a primary pneumatic pump 18 for pumping powder from the primary hopper 14 to the auxiliary 16, and a plurality of auxiliary pneumatic pumps 20 for pumping powder from the auxiliary hopper 16 to the guns 12. The pneumatic pumps 18 and 20 are conventional powder pumps which per se form no part of the invention of this application. One such pump which is suitable for use in this application is illustrated and described in our U.S. Patent No. 3,746,254, and a preferred pump, useful in this system is illustrated and described in our co-pending patent application Serial No. 85307054.8, filed 2nd October, 1985 and

entitled "Improved Venturi Powder Pump", also assigned to the assignee of this application.

The hoppers 14 and 16 are also conventional fluidizing bed hoppers and per se form no part of the invention of this application. Both of these hoppers 14, 16 have an enclosed chamber 24 in the base of the hopper and an air pervious ceiling 26 in the chamber. When high pressure air is admitted into the inlet 28 of the chambers 24, such air passes through the ceiling 26 of the closed chamber 24 and is operative to fluidize powder 30 contained in the hopper above the closed chamber 24.

The two hoppers differ only in that the auxiliary hopper is much smaller in size and capacity than is the supply hopper 14. In one preferred embodiment wherein the auxiliary hopper 16 supplies powder to eight guns 12, the auxiliary hopper 16 has a volume equal to approximately 1/16th the volume of the supply hopper 14.

The two hoppers 14 and 16 also differ in that the supply hopper 14 has a vent 34 in its top wall while the auxiliary hopper has no such vent. Instead, the auxiliary hopper 16 is vented via an overflow tube 36 which extends from the interior of the auxiliary hopper 16 downwardly through the closed chamber 24 of the hopper 16 and through the top wall 38 of the supply hopper 14. As explained more fully hereinafter, this overflow tube 36 functions to vent the auxiliary hopper 16 as well as to transport all excess powder from the auxiliary hopper 16 back to the supply hopper. This overflow tube also functions to maintain a fixed level of fluidized powder within the auxiliary hopper 16.

The powder pumps 18 and 20 are all identical

except that the powder pumps 20 of the auxiliary hopper may be of smaller capacity than the pump 18 of the supply hopper 14. Each of these powder pumps has an inlet port 40, an outlet port 42, and an atomizing air inlet port 44. Additionally, each of these pumps has a powder flow passage 46 therein through which powder is drawn into a venturi pumping chamber 48 of the pump via a siphon tube 50 which connects the inlet 52 of the powder flow passage 46 to the fluidized bed 30 of powder from which the pump draws powder. The supply hopper pump 18 draws powder from the hopper 14 and pumps it into the auxiliary hopper 16 via a transfer conduit 54 while the auxiliary hopper pumps 20 draw powder from the auxiliary hopper 16 and pump it to the dispensing guns 12 via short transfer hoses 56.

The inlet ports 40 of the pumps 18, 20 are connected via air lines 58 to a source of high pressure air 60 while the atomizing air inlet ports 44 of the pumps are connected to the same high pressure air source via air lines 62. Internally of each pump there is a small air orifice through which the high pressure air from the source 60 flows into the venturi pumping chamber 48 so as to create a low pressure within that venturi pumping chamber. That low pressure is operative to draw powder via the siphon tubes 50 upwardly into the venturi pumping chambers 48 of the pumps such that the powder can then be transported via the hose 54 from the pump 18 to the hopper 16, or in the case of the pumps 20, via the hoses 56 to the dispensing guns 12.

As is explained more fully in the above identified U.S. Patent No. 3,746,254, or in our co-pending application Serial No. 85307054.8, the pressure of air supplied to the port 40 controls the

quantity of powder drawn upwardly through the siphon tube into the venturi pumping chamber 48 of the pump, and the pressure of air supplied to port 44 controls the ratio of air to powder mix within the the pump. Typically, each of the air lines 58, 62 contains a pressure regulator (not shown) through which the air pressure supplied to the inlet ports 44 may be adjusted so as to control the amount of vacuum drawn within the venturi pumping chamber 48 of the pump and the relative air to powder mix supplied to the venturi chamber through the powder flow passage 46 of the pump.

In operation of the powder dispensing system 10, high pressure air is supplied from the source 60 to the inlet ports 40, 44 of the powder pumps 18, 20, and to the inlet ports 28 of the air chambers 24 of the hoppers 14 and 16. The high pressure air supplied to the inlet port 28 of the hoppers 14, 16 is operative to fluidize all of the powder 30 contained in the supply hopper 14 and the auxiliary hopper 16. The fluidized powder 30 in the supply hopper 14 is drawn via the siphon tube 50 upwardly into the venturi pumping chamber 48 of the pump 18. This powder is then transported from the supply hopper pump 18 via the relatively long transfer hose 54 to the powder inlet 68 of the auxiliary hopper 16. The fluidized powder in the auxiliary hopper 16 is in turn pumped by the auxiliary pump 20 to the dispenser guns 12 via the relatively short hoses 56. In practice, an excess quantity of powder is pumped from the primary or supply hopper 14 to the auxiliary hopper 16, which excess is greater than the capacity of all of the pumps 20. As a result, excess fluidized powder flows through the inlet 70 of the over-flow tube 36 back to the supply hopper

14. The level of powder within the auxiliary hopper 16 is thus always maintained at a fixed level, that of the top edge of the inlet 70 of the overflow tube.

A powder pump 72 may be associated with the overflow line 36 in the event that gravity is insufficient to carry the overflow powder to the primary hopper. Such a pump may be required in installation where there is substantial distance between the two hoppers or where the primary hopper is not located beneath the auxiliary hopper. In the event that a powder pump 72 is associated with the overflow line 36, a vent (not shown) would be provided in the top of the auxiliary hopper in order to maintain ambient pressure in the auxiliary hopper.

Prior to this invention, it has been the practice to pump powder directly from the supply or primary hopper 14 to the guns 12. There was no intermediate or auxiliary hopper 16 in the system. We have found that the long hoses which hereto extended from the supply hopper 18 to the guns, as well as the constantly changing level of powder within the supply hopper 14, both contributed to and created a problem of varying powder flow from the guns. Specifically, we have found that a long hose extending from the pump of the supply hopper to the gun had numerous curved or looped sections wherein powder collected and tended to restrict flow through the long hose. This restricted flow in turn caused a pressure drop in the hose to the gun with a resultant drop in the quantity of powder being pumped from the supply hopper to the gun. Periodically through, the pressure behind the powder created restriction built up to the point that it caused the restriction to break, thereby causing a high

density puff of powder to be dispensed from the gun. This in turn resulted in a temporary increase in the flow of air and powder from the pump to the gun because of the sudden increase in air flow through the hose. Then the restriction would again build up in the hose at the same point at which it had just broken free and the process was repeated.

We have found that by utilizing the auxiliary hopper 16 between the supply hopper and the guns, and preferably close to the guns, the erratic powder flow from the guns created by these powder created restrictions in the hose are minimized or substantially eliminated. We have also found that the use of the auxiliary hopper 16 assists in maintaining an even flow of powder from the guns 20 by maintaining a fixed level of powder in the hopper from which powder is supplied to the guns 20. The level of powder in the supply hopper is subject to change, and that change, prior to this invention, causes changes in the powder from the guns 20. These changing powder flows were the result of the changing air pressure required to draw powder from the fluidized bed of powder into the venturi pumping chamber 48 of the pump. As the level of powder in the fluidized bed is lowered a greater vacuum is required to pull powder from that bed into the venturi chamber or as the level is raised a lesser vacuum is required. But, the vacuum in the venturi pumping chamber of the pump does not change with changing levels of powder in the fluidized bed. Instead, the powder flow from the pump varies. By utilizing the invention of this application, with the fixed level of powder in the auxiliary hopper, this source of varying powder from the gun is eliminated.

CLAIMS:

1. Apparatus for dispensing solid particulate powder comprising, a primary fluidized bed hopper having an interior chamber adapted to receive and fluidize solid particulate powder material, a primary pneumatic powder pump having a low pressure venturi pumping chamber contained therein and a powder flow passage intersecting said venturi pumping chamber, the powder flow passage having an inlet connected via a siphon tube to the interior chamber of the primary hopper, means connecting the inlet port of the primary powder pump to a source of high pressure air, characterised in that an auxiliary fluidized bed hopper (16) having an interior chamber of substantially less capacity than the interior chamber of the primary hopper, is provided, the outlet port of the primary powder pump being connected to the interior chamber (24) of the auxiliary hopper, and in that at least one auxiliary pneumatic powder pump is also provided having a low pressure venturi pumping chamber (48) contained therein and a powder flow passage intersecting the venturi pumping chamber, the powder flow passage (46) of the auxiliary powder pump having an inlet (52) connected via a siphon tube (50) to the interior chamber (24) of the auxiliary hopper (16), the outlet port of the auxiliary powder pump being connected to a powder dispenser.

2. Apparatus as claimed in Claim 1 including a plurality of auxiliary powder pumps and a plurality of powder dispensers, each of the auxiliary powder pumps having a powder flow passage connected via a siphon tube to the interior chamber of the auxiliary hopper, and each of the auxiliary powder pumps having an outlet

port connected via conduit means to one of the powder dispensers.

3. Apparatus as claimed in Claim 1 or 2 including means for maintaining a constant level of fluidized powder in the auxiliary hopper.

4. Apparatus as claimed in Claim 3 wherein the means for maintaining a constant level of fluidized powder in the auxiliary hopper comprises an overflow tube extending between the auxiliary hopper and the primary hopper, the overflow tube having an inlet spaced upwardly from the bottom of the interior chamber of the auxiliary hopper.

5. Apparatus for dispensing a relatively constant flow of solid particulate powder material from a powder dispenser, which apparatus comprises, means including a relatively large capacity primary hopper for fluidizing said solid particulate material, a substantially smaller capacity auxiliary hopper, means for pumping said solid particulate material from said primary hopper into said auxiliary hopper, means for fluidizing said solid particulate material from said primary hopper into said auxiliary hopper, means for fluidizing said solid particulate material in said auxiliary hopper, and means for pumping said solid particulate material from said auxiliary hopper to said powder dispenser.

6. Apparatus as claimed in Claim 5 wherein the means for pumping said solid particulate material from said primary hopper to said auxiliary hopper is operable to pump a greater quantity of solid particulate powder material to said auxiliary hopper than is pumped from said auxiliary hopper to said dispenser, and means for transporting excess solid

particulate material from said auxiliary hopper to said primary hopper so as to maintain a substantially constant level of fluidized powder in said auxiliary hopper.

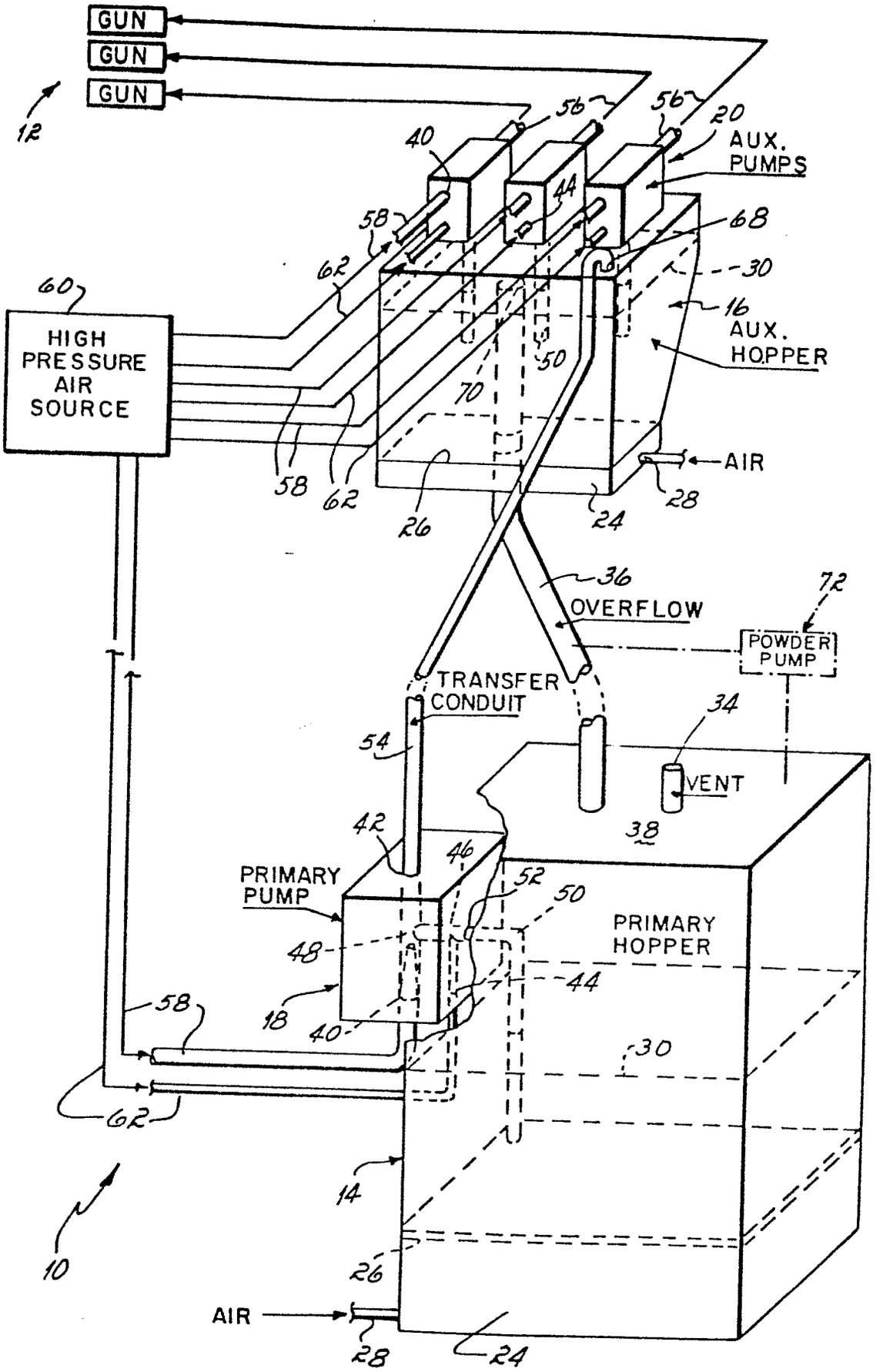
7. Apparatus as claimed in claim 5 wherein said means for pumping said solid particulate powder from said primary hopper to said auxiliary hopper is a first relatively long hose and said means for pumping said solid particulate powder from said auxiliary hopper to said dispenser is a second substantially shorter hose.

8. Apparatus for dispensing a relatively constant flow of solid particulate powder material from a plurality of powder dispensers, which apparatus comprises, means including a relatively large capacity primary hopper for fluidizing said solid particulate material, a substantially smaller capacity auxiliary hopper, means for pumping said solid particulate material from said primary hopper into said auxiliary hopper, means for fluidizing said solid particulate material in said auxiliary hopper, and means including a plurality of powder pumps, each of said powder pumps being operable to pump said solid particulate material from said auxiliary hopper to one of said powder dispensers.

9. A method of maintaining a relatively constant flow of solid particulate powder material from a powder dispenser, which method comprises fluidizing solid particulate material within a relatively large capacity primary hopper, pumping said solid particulate material from said hopper into a substantially smaller capacity auxiliary hopper, fluiding said solid particulate material in said auxiliary hopper, and pumping said solid particulate material from said auxiliary hopper

to a powder dispenser.

10. A method as claimed in Claim 9 which comprises pumping a greater quantity of solid particulate material from said primary hopper to said auxiliary hopper than is pumped from said auxiliary hopper to said dispenser, and transporting excess solid particulate material from said auxiliary hopper to said primary hopper so as to maintain a substantially constant level of fluidized powder in said auxiliary hopper.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