ABSTRACT: An apparatus capable of dispensing particulate material and a method for accomplishing the dispensing of the material. The apparatus includes a fluid-activated means capable of causing particulate material to be withdrawn from a reservoir at a rate which is substantially proportional to the fluid flow rate in the fluid-activated means. A means for dispensing the particulate material toward an article to be coated is connected to the fluid-activated means through a conduit. A fluid divider has an inlet port connected to a source of compressed fluid. The fluid divider also includes a plurality of outlet ports. One of the outlet ports of the fluid divider is connected to the reservoir to thereby provide the fluid flow which activates the fluid-activated means. Another of the outlet ports of the fluid divider is connected to the conduit to provide a fluid flow in the conduit which assists in the movement of the particulate material in the conduit toward the means which dispenses the material. The fluid divider may be a device which includes a fluid-splitting member which divides the fluid flow at the inlet port among the several outlet ports. The sum of the fluid flows at the outlet ports of the fluid divider is substantially proportional to the fluid flow at the inlet port.
Fig. 1

Fig. 2

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APPARATUS AND METHOD FOR DISPENSING PARTICULATE MATERIAL

The present invention relates to a dispensing apparatus and, more particularly, to an apparatus capable of dispensing particulate material and to a fluid-dividing device which may be used as a component part of the apparatus. In addition, the present invention relates to a method for dispensing the particulate material.

Generally, a particulate material-dispensing apparatus is connected to a source of compressed air which serves as the means for activating a suitable air-activated pump. The pump generally includes an open-throated venturi tube seated in a reservoir containing particulate material. As the compressed air flows through the open-throated venturi tube, particulate material is caused to be drawn from the reservoir at a rate proportional to the rate of flow of the air through the venturi tube. The particulate material is entrained in the air and delivered by the flowing air to a dispensing device such as a handgun. The handgun causes the particulate material to be directed toward a surface of an article to be coated with the material.

The movement or rate of flow of the entraining air emitted at the nozzle of the dispensing device should be sufficiently high so as to achieve, among other things, the desired spray pattern, the desired distribution of the particulate material within the spray pattern and a uniform layer of the material on the article. Usually, satisfactory coating of the article with the particulate material is accomplished by using a hose having an internal diameter of about 1/8 of an inch and using an airflow thru the air-activated pump of from about 1.5 to about 2.5 standard cubic feet per minute (s.c.f.m.).

Generally, the hose has a substantially constant internal diameter so as to assist in providing the proper airflow rate necessary to transport the entrained material and to minimize the possibility of providing sites at which the particulate material may accumulate. The hose is generally satisfactory for its intended purpose as long as the airflow rate within the hose remains above a velocity which discourages accumulation of the particulate material along the sidewall of the hose. However, if the flow rate of the material through the hose drops below a minimum velocity due to any one of several factors such as a reduction in airflow below about 1.5 s.c.f.m. in a hose having a 1/8 inch internal diameter, the particulate material exhibits a tendency to accumulate along the sidewall of the hose connected between the reservoir and the dispensing device. During the interval of time the particulate material is accumulating along the sidewall of the hose, the amount of material being emitted per unit of time by the dispensing device may be below that which is necessary to coat the article within the required time interval with a uniform coating of material having a desired thickness.

When a sufficient amount of the particulate material has accumulated along the sidewall of the hose, the air pressure behind the accumulated material may build up sufficiently to provide a force adequate to cause the movement of the accumulated mass of particulate material through the hose and out of the nozzle of the dispensing means. Upon release of the accumulated mass of particulate material, the material again starts to accumulate along the sidewall of the hose until sufficient force is provided to move the mass of accumulated particulate material through and out of the hose. The release of the mass of accumulated material may be referred to as "puffing." The accumulation and release of accumulated particulate material is cyclical. As a result of substantially instantaneous release of the accumulated mass of particulate material from the dispensing means, undesirable amounts of the material may be deposited onto the article. In addition, "puffing" can cause localized heavy coating of material on the article and thus the coating tends to be undesirably nonuniform.

A reduction in the magnitude of the "puffing" problem may be realized by using a hose having a smaller internal diameter when the flow rate of the air is reduced. However, an operator may experience an inconvenience by "shutting down" the operation of the equipment in order to remove the hose and substitute for it a hose having a smaller internal diameter.

Therefore, it is an object of the present invention to provide a means and a method which overcome the above-stated problems.

Another object of the present invention is to provide an apparatus capable of dispensing particulate material entrained in a fluid which eliminates the necessity for changing from one hose diameter to a different hose diameter as the flow rate of the material through the hose is altered.

A further object of the present invention is to provide an apparatus capable of dispensing particulate material entrained in a fluid, the fluid having a substantially uniform flow rate at the point where the material is dispensed from the apparatus.

Another object of the present invention is to provide an apparatus capable of dispensing variable amounts of particulate material entrained in a gaseous medium, the gaseous medium having a substantially uniform flow rate at the point where the material is dispensed from the apparatus.

Yet another object of the present invention is to provide an apparatus capable of dispensing variable amounts of particulate material entrained in a gaseous medium having a substantially uniform flow rate at the point where the material is dispensed from the apparatus.

A further object of the present invention is to provide an apparatus capable of dispensing particulate material which is capable of depositing a substantially uniform layer of the material onto an article which may be passed by the dispensing device at a variable rate of speed.

Yet still another object of the present invention is to provide a particulate-dispensing apparatus including a fluid divider which assists in the movement of the material in a conduit towards a means for dispensing the material.

A further object of the present invention is to provide an apparatus capable of dispensing particulate material which is economical to manufacture.

Another object of the present invention is to provide means for dividing a fluid flow input into a plurality of fluid flow outputs, the sum of the fluid flow outputs of the means being substantially equal to the fluid flow input to the means.

A further object of the present invention is to provide a means having a fluid flow input and a plurality of fluid flow outputs, a fluid flow input to the means resulting in at least one fluid output.

A further object of the present invention is to provide a method for transporting particulate material to a particulate material-dispensing device wherein the fluid flow rate at the dispensing device is substantially constant with variable amounts of particulate material entrained in the fluid flow.

With the aforementioned objects enumerated, other objects will be apparent from reading the following description and the appended claims.

In the drawings:

FIG. 1 is a schematic view of the present invention;
FIG. 2 is a partial cross-sectional view of a means for dividing a fluid flow input into a plurality of fluid flow outputs;
FIG. 3 is a partial cross-sectional view of an embodiment of the means for dividing the fluid flow into a plurality of fluid flow outputs; and
FIG. 4 is a schematic view of an embodiment of the present invention.

Generally speaking, the present invention relates to a particulate material-dispensing apparatus and method which substantially eliminates "puffing" of the material and to a means used as a component part of the apparatus which divides a fluid flow input into a plurality of fluid flow outputs.

The apparatus is capable of dispensing variable amounts of particulate material entrained in a fluid medium wherein the fluid medium has a substantially uniform flow rate under substantially all conditions at the point in the apparatus where the material is dispensed. The apparatus includes a fluid-activated means capable of causing the particulate material to be drawn from a particulate material reservoir at a rate substantially proportional to the fluid flow rate in the fluid-activated means.

A conduit is used to connect the reservoir to a device which dispenses the particulate material. The fluid divider of the apparatus has an inlet port connected to a source of compressed air.
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The fluid divider includes at least one outlet port connected to the fluid-activated means so as to provide a fluid flow in the fluid-activated means and at least one other outlet port connected to the conduit so as to provide a fluid flow in the conduit which assists in the movement of the fluid-entained particulate material toward the means which dispenses the material. The sum of the fluid flows at the outputs of the fluid divider is substantially equal to the fluid flow at the input of the fluid divider thereby providing a fluid flow rate in the conduit between the fluid-activated means and the fluid flow means in which is substantially uniform and a fluid flow rate in the fluid-activated means which may be varied so as to vary and control the amounts of material from the reservoir without harmfully effecting the flow rate of the fluid through the conduit.

The method of the present invention generally relates to dividing a fluid flow input into a plurality of fluid flow outputs, which outputs are substantially equal in total to the input. The divided fluid is used to provide a fluid flow rate at the dispensing device which is substantially uniform and which is capable of providing variable but controlled amounts of particulate material entrained in the fluid flow.

Referring now to FIG. 1 of the drawing, the apparatus of the present invention, capable of dispensing a particulate material, is indicated by the reference numeral 10. The apparatus 10 includes means 11 which divides a fluid flow input into a plurality of fluid flow outputs, a fluidized bed 12 which includes a reservoir 27 for particulate material 13 and includes a suitable fluid activated pump 14 which draws the material 13 from the bed 12, and a dispensing device 15 which dispenses the material 13 toward an article (not shown) to be coated with the material 13.

The input port of fluid divider 11 may be connected to any suitable source 16 of compressed fluid through a suitable fluid conduit 19. The source 16 of compressed fluid may include suitable pressure-regulating devices 17 and 17' which are intended to compensate for variations in the fluid flow rate supplied by a suitable fluid compressor 18. The fluid supplied by the source 16 may be any suitable medium which is capable of being easily compressed and which is capable of entraining the particulate material 13. A suitable fluid is a gas such as air and the like.

The fluid divider 11 may include any suitable means which is capable of dividing the compressed fluid supplied thereto by the source 16 into at least two fluid outputs. The sum of the fluid flow rate at the outputs of the fluid divider 11 is substantially equal to the fluid flow rate at the input to the fluid divider. In addition, the fluid divider 11 may include a means (not shown in FIG. 1) which is capable of varying or adjusting the flow rate of compressed air from each of the output ports. The structure of the fluid divider 11 and its operation will be discussed herein later.

The fluid-activated pump 14 of the fluidized bed 12 is connected to one of the outlet ports of the fluid divider 11 by way of conduit 21. The fluidized bed 12 further includes a particulate material reservoir 27 having an air chamber 29 which may be equipped with an air-distributing device 24, an agitator 25 and a membrane 26 which permits fluidizing air to pass upwardly therethrough and prevents the particulate material 13 from passing downwardly therethrough. The air-distributing device 24 may be connected to the pressure-regulating device 17' of source 16 of compressed fluid by any suitable conduit such as hose 28. The air-distributing device 24, the membrane 26 and the agitator 25 cooperate to fluidize the particulate material 13. The membrane 26 supports the fluidized particulate material 13 and maintains the material separate from the air chamber 29. The fluid-activated pump 14 may traverse the length of the bed 12 above the air chamber 29 and in the fluid-activated means 14 may include an open-throat venturi tube (not shown). Although the opening 24 cooperatively associated with the venturi tube may be facing upwardly as illustrated in FIG. 1, it is understood that the opening cooperatively associated with the venturi tube may be faced to a side of the fluidized bed or faced down as desired. The movement of air from the source 16 through the open-throat venturi tube causes the fluidized particulate material 13 to be blown into the open-throat venturi tube. In lieu of the agitator 25, the fluidized bed 12 may be equipped with a vibrating member (not shown). The vibrating member tends to provide a uniform distribution of particulate material 13 to the open-throat venturi tube.

A suitable conduit such as a hose 22 may be used to carry the particulate material 13 from the open-throat venturi tube of the fluid pump 14 to a dispensing device 15. The dispensing device 15 may be any suitable electrostatic dispensing device such as a handgun capable of emitting and imparting an electrostatic charge to the particulate material 13. A suitable dispensing device 15 is an electrostatic powder dispensing handgun carrying the nomenclature Assembly No. 322/846 sold by the Ransburg Electro-Coating Corp. An electrical power supply 60 is connected to the electrostatic handgun and should be capable of supplying up to about 90,000 volts DC at a current of up to about 200 microamperes to the hand gun. A suitable power supply is Power Supply Assembly No. 231/8910 sold by the Ransburg Electro-Coating Corp.

Another outlet port of the fluid divider 11 is connected to the conduit 22 at a location downstream from the outlet orifice of the fluid-activated pump 14 by means of conduit 20. The flow rate of air through conduit 20 to the conduit 22 assists in the movement of particulate material 13 in conduit 22 toward the dispensing device 15. It is seen that a portion of compressed air emitted by source 16 is diverted from the fluid-activated pump 14 to a location which is between the dispensing device 15 and the pump 14. Generally, the airflow rate in the conduit 22 from the point where the conduit 20 is connected to the conduit 22 to the dispensing device 15 is substantially constant and equal to the sum of the airflow rates of the pump 14 and the conduit 20. However, it is to be understood that during the operation of the fluid-activated pump 14, the venturi tube may cause additional air to be drawn thereinto, thereby increasing the airflow rate in conduit 22 slightly above the sum of the airflow rates at the outlet ports of the fluid divider 11.

The present invention contemplates varying or adjusting the flow rate of air through the venturi tube as desired to thereby vary the amount of particulate material 13 withdrawn from bed 12 without materially altering the airflow in conduit 22. Therefore, large or small quantities of the particulate material 13 may be withdrawn per unit of time from bed 12 without materially altering the total fluid flow rate through conduit 22. It is seen that the airflow rate in conduit 22 is substantially constant under nearly all conditions thereby obviating the necessity for disconnecting conduit 22 from the fluid-activated pump 14 and the dispensing means 15 to alter the diameter of the conduit 22 in an attempt to minimize the possibility of particulate material 13 agglomerating or accumulating within conduit 22 to thereby reduce the possibility of "puffing" of the material 13.

The point at which the hose 20 joins the hose 22 should be as close to the outlet orifice of the fluid-activated means 14 as is physically possible. So locating the junction point minimizes the possibility of the particulate material 13 accumulating at a site between the outlet orifice of the fluid-activated means and the point at which hose 20 joins hose 22.

The particulate material 13 may be any dry, powdery substance which is capable of being fluidized, which is capable of being entrained in a fluid medium such as air and which is capable of accepting an electrostatic charge. Suitable powders are thermoplastic powders such as cellulose acetate butyrate, chlorinated polyether, polyester, polyethylene, polypropylene, polystyrene, hydroxyethylcellulose, and the like; setting agents such as epoxy and the like; and other powdery substances such as commercial talc, flour, glass, zinc stearate, starch, vitreous enamel and the like.
Referring now to FIG. 2 of the drawing, the fluid divider of the present invention is indicated by the reference number 11. As discussed hereinbefore, the fluid divider 11 provides a means for dividing the fluid supplied thereto by the source of compressed air. The fluid divider 11 includes a hollow, generally cylindrical housing 41 having at least one inlet port 51 and at least two outlet ports 52 and 53. The housing 41 may be fabricated from any suitable material which provides good wear and is available at reasonable cost. Suitable materials from which the housing 41 may be fabricated are brass, aluminum, stainless steel, reinforced plastic and the like. Of the several materials from which the housing 41 may be fabricated, aluminum is the preferred metallic material.

The diameter of the inlet port 51 of the housing 41 and the diameters of the outlet ports 52 and 53 are illustrated in the drawing as being substantially the same thereby providing substantially equal-area inlet and outlet ports. It is thought that the diameter of any one or all the ports need not be substantially the same. In addition, it is recognized that the housing may have a configuration other than the configuration illustrated in FIG. 2. For example, the housing 11 may have a “U” shaped configuration, “T” shaped configuration and the like.

As shown in FIG. 2, a displaceable, flow-splitting member 46 is adapted between the inlet port 51 and the outlet ports 52 and 53. The flow-splitting member 46 may include base-to-base coupled frustoconical shaped members 47 and 48. Each of the members 47 and 48 possess a section of a cone and a section of a cylinder having substantially the same diameter so as to engage or disengage with chambers 43 and 44 respectively thereby engaging, as the case may be, the airflow from the inlet port 51 to outlet port 52 or to outlet port 53. It has been noted that the fluid divider 11 allows fluid to flow from at least one of the outlet ports under all operating conditions. For example, substantially all of the compressed air present at inlet port 51 will flow through outlet port 52 if the frustoconical shaped member 48 is engaged with chamber 44 so as to discourage compressed airflow through outlet port 53. The flow-splitting member 46 should be fabricated from a material similar to the material from which the housing 41 is fabricated to minimize the occurrence of galvanic corrosion.

The housing of the fluid divider 11 may include seats 43 and 44 provided in the housing 41. The seats 43 and 44 may be chamfered at an angle greater than or less than the angle of the frustoconical member cooperatively associated therewith. It should be seen that it is not necessary for either of the frustoconical members 47 and 48 to tightly seal with their respective chambers 43 and 44. It is thought that it is only necessary that the frustoconical members and the chambers cooperate in such a manner so as to prevent a substantial flow of compressed air therethrough. However, it is recognized that if an airtight seal is desirable, a suitable seal may be provided between the frustoconical member and its cooperatively associated chamber, if desired.

Displacement of the frustoconical members 47 and 48 of the flow-splitting member 46 may be accomplished by any number of different techniques. One technique of displacing the member 46 is by rotating shaft 49 connected to the flow splitting member 46 by rotating knurled knob 50 so as to turn shaft 49 into or out of aperture 56 formed in the housing 41. It is seen that displacement of shaft 49 causes longitudinal displacement of the flow-splitting member 46. Longitudinal displacement of the flow-splitting member 46 causes the airflow at the inlet port 51 to be diverted to outlet ports 52 and 53 or only to outlet port 52 or only to outlet port 53 depending upon the position of the transverse axis of the fluid flow-splitting member 46 with respect to the axis of the inlet port 51. Positioning the frustoconical flow-splitting member 46 within the bore 55 of the housing 41 as shown in FIG. 2, causes a reduced amount of compressed air to flow out of outlet port 53 as compared with the amount of compressed air flowing out of outlet ports 52 and 53 or only to outlet port 52 or only to outlet port 53 depending upon the location of the transverse axis of the fluid flow-splitting member 46 with respect to the axis of the inlet port 51. Positioning the transverse axis of the fluid flow-splitting member 46 substantially coincides with the axis of the inlet orifice 51, results in a condition where the amount of airflow rate from both outlet ports 52 and 53 are substantially equal assuming that each of the outlet ports have substantially equal-area outlets. If the transverse axis of the flow-splitting member 46 is displaced slightly from the axis of the inlet port 51 toward the outlet port 52, the airflow rate at outlet port 52 will be greater than the airflow rate at outlet port 52 assuming, as shown in FIG. 2, that the outlet ports 52 and 53 are of equal area. The airflow through outlet port 53 is greater than the airflow through outlet port 52 since impedance to airflow through port 52 is greater than the impedance to airflow through port 53. If the flow-splitting member 46 is displaced in a position where the sidewall of the frustoconical member 47 engages with the chamfer 43 formed in the housing 41, the impedance to airflow through port 53 is nearly infinite and, therefore, substantially all of the compressed air will flow from inlet port 51 to outlet port 53.

Displacement of the transverse axis of the flow-splitting member 46 to the right of the axis of the inlet orifice 51 results in more compressed air flowing through outlet port 52 than through outlet port 53. Displacement of the frustoconical member 48 of the flow-splitting member 46 to a position of engagement with the chamfer 44 of the housing 41 encourages substantially all of the compressed air flowing from the source of compressed air 16 to flow from outlet port 52.

A further adjustment between the frustoconical members 47 and 48 with respect to its cooperatively associated chamfer may be desirable so that the cooperative relationship between the frustoconical member and its chamfer provides the desired restriction for any given position of the frustoconical member with respect to its cooperatively associated chamfer. To accomplish the adjustment, frustoconical member 48 may be rotated independently of member 47 to thereby longitudinally displace member 48 with respect to member 47 until the desired relationship between the member 48 and its cooperatively associated chamfer 44 is achieved. Member 47 and chamfer 43 would have its cooperative relationship established by turning shaft 49 into or out of the aperture 54 prior to the adjustment of member 48 with respect to its cooperatively associated chamfer. It is understood that the position of member 47 with respect to chamfer 43 should remain unaltered during the initial positioning of member 48 with respect to their cooperatively associated chambers, the members will move together by rotating shaft 49.

The configuration of one or each of the members 47 and 48 of the flow-splitting member 46 may be shaped different from the shape illustrated in FIG. 2. For example, the member 46 and/or the member 47 may have a convexed side configuration, a concaved side configuration and the like in lieu of the side configuration illustrated. The chamfers 43 and 44 provided in the housing 41 may be similarly altered so as to fit with the members 46 and 47 when the members engage therewith.

With the structural disclosure in mind and by continued reference to FIGS. 1 and 2 of the drawing, the following analysis of the operation of the present invention will further serve to amplify the novelty of the present invention.

Connecting the source 16 of compressed air to the inlet port 51 of the fluid divider 11 encourages compressed air to flow from the source 16 through the inlet port 51 to the outlet ports 52 and 53 of the fluid divider. Assuming that the flow-splitting member 46 has its transverse axis substantially coincident with the axis of the inlet orifice 51, the impedance presented to the airflow to each port is substantially equal, therefore, the airflow to outlet ports 52 and 53 is substantially equal. About one-half of the compressed air from source 16 flows to fluid-activated pump 14 so as to draw the particular material 13 through the open-throated venturi tube 29 and cause it to flow entrained in air into conduit 22. The rate at which the material 13 is drawn from the fluidized bed 12 by the fluid-activated pump 14 is proportional to the volume of the compressed air in the venturi tube of the fluid-activated pump. The remainder of the compressed air is caused to flow directly to hose 22. Hose 22 is downstream from the fluid-activated pump 14. It should be seen, however, that sub-

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stantially all of the compressed air supplied by the source 16 to the apparatus 10 is transferred to dispensing device 15 through hose 22.

The flow rate and may vary the amount of material 13 drawn from the fluidized bed 12 by directing greater or lesser amounts of airflow rates through the fluid-activated pump 14. The airflow rate delivered to the fluid-activated pump 14 may be varied by varying the position of the flow-splitting member 46 of flow divider 11 with respect to the outlet ports 52 and 53. For example, if a greater amount of particulate material 13 is to be drawn from the fluidized bed 12 and deposited onto an article, a greater portion of the compressed air is caused to flow to the pump 14, that is the airflow rate to the pump 14 is increased, and a lesser amount of compressed air is shunted to the hose 22, that is the airflow rate to the hose 22 through line 28 is decreased. If the amount of particulate material 13 to be deposited on the article is required to be less, the amount of compressed air caused to flow to the fluid-activated pump 14 is reduced thereby reducing the amount of particulate material 13 drawn from the fluidized bed 12; however, it is seen the flow rate of the compressed air in hose 22 remains substantially independent of variations in the flow rate at pump 14.

The present invention substantially reduces the possibility of accumulation of the particulate material 13 within the hose 22 since the airflow rate within hose 22 is above a minimum flow rate regardless of the amount of particulate material 13 drawn from the fluidized bed 12 by the fluid-activated pump 14. If a higher dispensing rate of particulate material 13 is desired, the flow-splitting member may be moved to a position whereby the outlet port 52 connected to the fluid-activated pump 14 is supplied with an increased flow rate of air. The increased flow rate of air through the venturi tube causes a greater amount of particulate material 13 to be drawn from the fluidized bed 12; however, the airflow rate within substantially the entire hose 22 remains substantially constant thereby significantly reducing the possibility of “puffing” of the particulate material 13 as it is emitted by the dispensing device 15. If a lesser amount of particulate material 13 is desired to be dispensed by device 15, the flow-splitting member is moved to a position so that the airflow rate through the venturi tube of the fluid activated pump 14 is reduced so as to draw less particulate material 13 from the fluidized bed 12 and so that the airflow rate through the hose 20 is increased. It should be noted, however, that the amount of airflow rate within hose 22, downstream from the fluid-activated pump 14, remains substantially constant thereby minimizing the possibility of “puffing” of the particulate material 13 as it is delivered to the article to be coated.

Referring now to FIG. 3 of the drawing, an embodiment of the fluid divider of the present invention is indicated by the reference number 81. As discussed hereinbefore, the fluid divider provides a means for dividing the fluid supplied thereto by the source of compressed air such as source 16. The fluid divider 81 includes a hollow, generally square housing 82 made up of housing half 101 and housing half 102 fixedly retained together by any suitable coupling means (not shown) such as bolts and the like. The housing 82 may be fabricated from any suitable material which provides good wear and is available at reasonable cost. Suitable materials from which the housing 82 may be fabricated are brass, aluminum, stainless steel, reinforced plastic and the like. Of the several materials from which the housing 41 may be fabricated aluminum is the preferred metallic material.

The housing half 102 includes at least one inlet port 83 and at least two outlet ports 84 and 85. The diameter of the inlet port 83 of the housing 82 and the diameters of the outlet ports 84 and 85 are illustrated in the drawing as being substantially the same thereby providing substantially equal-area inlet and outlet ports so that the diameter of particulate material 13 of any one or all of the ports need not be substantially the same.

A replaceable, flow-splitting member 86 is located adjacent the inlet port 83 and between the outlet ports 84 and 85. The flow-splitting member 86 may include base-to-base coupled frustoconical-shaped members 87 and 88. It should be recognized that members 87 and 88 may have a shape other than frustoconical such as conical and the like. Each of the members such as members 87 and 88 possess such as shape and size as to engage or disengage with chamfers 89 and 90 respectively thereby encouraging or discouraging, as the case may be, the airflow from the inlet port 83 to outlet port 84 or to outlet port 85. It is noted that the fluid divider 81 allows fluid to flow from at least one of the outlet ports under all operating conditions. For example, substantially all of the compressed air present at inlet port 83 will flow through outlet port 85 if the frustoconical-shaped member 87 is engaged with chamfer 89, as illustrated in FIG. 3, so as to discourage compressed airflow through outlet port 84. The flow-splitting member 86 should be fabricated from a material similar to the material from which the housing 82 is fabricated to minimize the occurrence of galvanic corrosion.

The housing 82 of the fluid divider 81 may include seats 89 and 90. The seats 89 and 90 may be chamfered at an angle greater than or less than the angle of the frustoconical member cooperatively associated therewith. It should be seen that it is not necessary for either of the frustoconical members 87 and 88 to tightly seal against their respective seats 89 and 90. It is thought that it is only necessary that the frustoconical members and the chamfers cooperate in such a manner so as to prevent a substantial flow of compressed air therebetween. However, it is recognized that if an artight seal is desirable, a suitable seat may be provided between the frustoconical member and its cooperatively associated chamfer, if desired.

Displacement of the frustoconical members 87 and 88 of the flow-splitting member 86 may be accomplished by any number of different techniques. One technique of displacing the member 86 may be accomplished by rotating shaft 91 connected to the flow-splitting member 86 through threaded block 92 and pin 93, carried by block 92 and rigidly connected to flow splitting member 86, by rotating knurled knob 94 and as to turn shaft 91 in recess 95 formed in the housing 82. Shaft 91 and block 92 are carried in housing half 101. It is seen that rotating shaft 91 causes longitudinal displacement of block 92 and displacement of pin 93 thereby causing longitudinal displacement of the flow-splitting member 86. Longitudinal displacement of the flow-splitting member 86 causes the flow in the inlet port 83 to be diverted to outlet ports 84 and 85 or only to outlet port 83 or only to outlet port 84 depending on the location of the transverse axis of the fluid flow splitting member 86 with respect to the axis of the inlet port 83. Positioning the frustoconical flow splitting member 86 within the bore 100 of the housing 82 as shown in FIG. 3, discourages compressed air from flowing out of the outlet ports 84 and 85 and encourages substantially all of the compressed air to flow out of outlet port 85. Displacement of the flow-splitting member 86 to a position where the transverse axis thereof substantially coincides with the axis of the input orifice 83, results in a condition where the amount of airflow rate from both outlet ports 84 and 85 are substantially equal assuming that each of the outlet ports have substantially equal-area outlets. If the transverse axis of the flow-splitting member 86 is displaced slightly from the axis of the input port 83 toward the outlet port 85, the airflow rate at outlet port 84 should be greater than the airflow rate at outlet port 85 assuming, as shown in FIG. 3, that the outlet port 84 and 85 are of equal-area. The airflow through outlet port 84 is greater than the airflow through outlet port 85 since impedance to airflow through port 84 is greater than the impedance to airflow through port 85. If the flow-splitting member 86 is displaced to a position where the sidewall of the frustoconical member 88 engages with the chamfer 90, the impedance to the airflow through port 85 is nearly infinite and, therefore, substantially all of the compressed air will flow from inlet port 83 to outlet port 85.

The threaded block 92 may be cylindrical in cross section. The recess 95 in which the threaded block 92 is slidably disposed should have the same general configuration as the peripheral contour of the block to thereby facilitate displace-
ment of the block therein. It is seen that the axial aperture 96 of the block 92 is threaded so as to mate with the threads formed on the shaft 91.

Rotational displacement of shaft 91 does not result in longitudinal displacement thereof but rotational displacement of the shaft does result in longitudinal displacement of the block 92 in the cylindrical recess 95. The amount of longitudinal displacement of the block 92 within recess 95 may be governed by, among other things, the number of threads per unit length of the shaft 91 and of the block 92.

A pin 93 may be carried by block 92 and fixedly attached to flow-splitting member 86 at an angle which is substantially perpendicular to the axis of rotation of the block 92. The extremity of the pin 93 may be threaded. A threaded aperture 98 may be formed in the flow-splitting member 86 which substantially coincides with the transverse axis of the flow-splitting member. The threaded extremity of the pin mates with the threaded aperture 98 of the flow-splitting member 86. It is seen that rotational displacement of shaft 91 causes longitudinal displacement of block 92 and displacement of the pin 93 and hence longitudinal displacement of the flow-splitting member 86. The pin 93 may be slidable displaced in guide slot 79 provided by the cooperative relationship of housing half 101 and housing half 102. One of the several functions of the slot is to substantially prevent the pin and the block 92 from rotating relative to one another. An image of the flow-splitting member 86 is indirectly driven by rotation of shaft 91 whereas in the embodiment shown in FIG. 2, rotation of shaft 49 directly drives flow-splitting member 46.

An initial adjustment of the chamfer 90 with respect to the flow-splitting member 86 may be desirable so that the cooperative relationship between the flow-splitting member 86 and its cooperatively associated chamfer provides the desired restriction for any given position of the flow-splitting member with respect to its cooperatively associated chamfer. To accomplish the adjustment, plug 99 sealing one end of bore 100 may be rotated to thereby longitudinally move plug 99 with respect to the flow-splitting member 86 until the desired relationship between the frustoconical member 88 and chamfer 90 is achieved. Frustoconical member 87 and chamfer 89 would have their cooperative relationship established by rotating shaft 91 prior to the adjustment of member 88 with respect to its cooperatively associated chamfer 90. It is understood that the position of member 87 with respect to chamfer 89 would remain unaltered during the initial positioning of member 88 with respect to chamfer 90.

The configuration of one or each of the members 87 and 88 of the flow-splitting member 86 may be shaped different from the shape illustrated in FIG. 3. For example, the member 86 and/or the member 87 may have a convexed side configuration, a concaved side configuration and the like in lieu of the side configuration illustrated. The chamfers 89 and 90 provided in the housing 81 may be similarly altered so as to fit with the members 89 and 90 when the members engage therewith.

Referring to FIG. 4 of the drawing, an embodiment of the present invention is illustrated which automatically regulates the airflow rate in a portion of the system. The embodiment is indicated by the reference numeral 10. The apparatus 10 includes means 34 which automatically divides a fluid flow input from source 16 of compressed air into a plurality of fluid flow outputs, a fluidized bed 12 which includes a reservoir 27 retaining particulate material 13 and includes a suitable fluid-activated pump 14 which draws the material 13 from the bed 12, and a dispensing device 15 which disperses the material 13 toward an article (not shown) to be coated with the material 13.

Several of the means which are used in FIG. 1 may also be adaptable for use with the embodiment illustrated in FIG. 4. Where the means illustrated in FIG. 1 have been used in FIG. 4, the same reference numerals have been used. For example, the fluidized bed 12 of FIG. 1 may be used in the embodiment of FIG. 4. The structure and function of each of the means illustrated in FIG. 4 which carries the same reference numeral as the means illustrated in FIG. 1 is identical to the means illustrated in FIG. 1.

The automatic fluid divider 34, connected to source 16 of compressed air by means of conduit 19, may include a means which is capable of automatically dividing the compressed fluid supplied thereto by the source 16 into at least two fluid outputs in response to a control signal. The control signal is supplied to the fluid divider by way of conduit 66. A particular pressure of the control signal may correspond to an event such as a particular rate of speed of a conveyor (not shown). The pressure of the control signal may be varied so as to correspond to the varying rate of speed of the conveyor.

In the embodiment shown in FIG. 4, the flow divider 34 includes at least a pair of pressure regulators 31 and 32. Regulator 31 includes a control port 60, an inlet port 64 and an outlet port 61. Regulator 32 includes a control port 62, an inlet port 65 and an outlet port 63. The sum of the fluid flow rates at the outlet ports 61 and 63 of the automatic fluid divider 34 is substantially equal to the fluid flow at the input port to the automatic fluid divider.

The operation of pressure regulators 31 and 32 is controlled by the magnitude of the pressure of the control signal present at control ports 60 and 62 of the regulators. The control signal is provided by control signal source 64 which is connected to control ports 60 and 62 of the gas tight conduit 66. The control signal appears at control port 60 of the pressure regulator 31, regulator 31 is biased to a "closed" position so that fluid from source 16 connected to the inlet port 64 of regulator 31 is not permitted to flow therethrough. When a control signal is caused to appear at control port 60 by the activation of source 64 the regulator 31 is biased to an "open" position. The amount of compressed air from source 16 which is permitted to flow through regulator 31 is proportional to the degree that regulator 31 is biased "open." The fluid flow rate through pressure regulator 31 from source 16 connected to regulator 31 is proportional to the magnitude of pressure of the control signal present at control port 60 of the regulator. Assuming that no control signal from source 64 appears at control port 62 of pressure regulator 32, the pressure regulator is biased to the "full open" position causing a fluid flow at outlet port 63 from the source 16 through inlet port 65 of the regulator. The appearance of a control signal at control port 62 causes the fluid flow at outlet port 63 to decrease in proportion to the magnitude of the pressure of the control signal provided by source 64.

As illustrated in FIG. 4 of the drawing, a suitable conduit 22 connects the output port 63 of the pressure regulator 32 to the conduit 22 at a junction just downstream from the fluid-activated pump 14. It is seen that regulator 32 and conduit 20 cooperate to shunt the air flowing therethrough from the source 16 around the fluidized bed to hose 22. A suitable conduit 21 connects the output of pressure regulator 31 to the inlet of the fluid-activated pump 14. The regulator 31 is used to regulate the airflow through the fluid-activated pump 14 and therefore regulate the rate at which the particulate material 13 is drawn from the reservoir 27 of the fluidized bed 12.

Hose 22 is used to carry the particulate material 13 from the open-throated venturi tube of the fluid pump 14 to dispensing device 15.

The control signal at control ports 60 and 62 of pressure regulator 31 and of pressure regulator 32 respectively are derived from any suitable source 64 capable of generating a control signal in response to the event 19. The source 64 may provide a control signal having a pressure magnitude which relates to an event such as a process function. For example, the control signal may be initiated by a suitable sensor (not shown) which is capable of acting on the source 64 so as to cause the source 64 to provide a control signal having a pressure magnitude of the event 19. The sensor 64 used to indicate the presence of a conveyor (not shown) carrying articles (not shown) to be coated past the dispensing device 15. The parameters of the
system may be established so that a stationary conveyor does not activate the source 64. A deactivated source 64 may be programmed so as not to provide a control signal thereby causing pressure regulator 31 to be biased to the “closed” position. A fluid-activated fluid flow therethrough from source 16 and causing pressure regulator 32 biased to an “open” position, that is permitting substantially all of the compressed air of the source 16 to flow therethrough thereby shunting the compressed air of source 16 around the pump 14 in fluidized bed 12. Since the compressed air of source 16 is shunted around the fluid-activated pump 14, no particulate material is caused to be delivered to spray gun 16. Causing an event to occur which activates the sensor (not shown) connected to source 64, such as activating the conveyor, source 64 is caused to generate a control signal which is proportional to the rate of displacement of the conveyor.

The control signal activates the pressure regulator 31 thereby causing compressed air from source 16 to flow therethrough. The control signal also causes the regulator to reduce the amount of compressed air which flows therethrough from source 16. The increase in airflow rate flows therethrough from source 16 through regulator 31 is proportional to the airflow rate through regulator 32 thereby dividing the flow from compressed air source 16 between conduits 21 and 22. It is seen that as the airflow rate through the fluid-activated pump 14 is increased, a greater amount of particulate material will be drawn from the fluidized bed 12 and delivered to the spray gun 15. Thus, the output of the gun may be varied according to the speed of the conveyor to maintain a constant coating thickness on the parts to be coated.

A suitable detachable hose union means (not shown) may be used to connect the hose 20 from the fluid divider and the hose of the fluidized bed to the hose 22 connected to the dispensing device.

The present invention is not intended to be limited by the disclosure therein, changes and modifications may be made by those skilled in the art without departing from the spirit and scope of the present invention. Such modifications are considered to be within the purview and scope of the invention.

1. An apparatus capable of dispensing particulate material comprising,
a bed containing particulate material,
a fluid-activated means capable of causing the particulate material to be drawn from the bed at a rate substantially proportional to the fluid flow rate in the fluid-activated means,
means for dispensing the particulate material drawn from the bed,
a conduit connecting the fluid-activated means to the means for dispensing the particulate material, and
a fluid divider having an inlet port connected to a source of fluid under an elevated pressure and having a plurality of outlet ports, one of the outlet ports connected to the fluid-activated means providing the fluid flow in the fluid-activated means, another of the outlet ports connected to the conduit to provide a fluid flow in the conduit which assists in the movement of the particulate material in the conduit toward the means for dispensing the particulate material, and the fluid divider including means activated by a fluid control signal thereby regulating the flow of fluid from at least one of the outlet ports of the fluid divider so that the sum of the fluid flows at the outlet ports of the fluid divider is substantially proportional to the fluid flow at the inlet port of the fluid divider.

2. The apparatus as claimed in claim 1 wherein the fluid divider includes a plurality of fluid regulators capable of adjustably regulating the fluid flow rate supplied to the fluid-activated means and to the other outlet.

3. The apparatus as claimed in claim 2 wherein at least one of the fluid regulators is activated by the control signal to thereby adjustably regulate the fluid flow rate.

4. The apparatus as claimed in claim 1, wherein the particulate material includes a powdery substance capable of being electrostatically charged and wherein the dispensing means includes an electrostatic spray gun capable of electrostatically charging the powdery substance.

5. The apparatus as claimed in claim 4, wherein the fluid-activated means includes a fluidized bed containing the powdery substance and a fluid-actuated pump which draws the powdery substances from the fluidized bed at a rate proportional to the fluid flow rate through the pump.

6. A method for dispensing particulate material comprising dividing a fluid flow into a plurality of fluid flow outputs by means of a fluid divider activated by a fluid control signal thereby regulating the flow of fluid from the fluid divider, supplying one of the fluid flow outputs to a fluid-activated means capable of drawing particulate material from a bed at a rate proportional to the fluid flow rate in the fluid-activated means, and combining the fluid flow rates from the fluid-activated means and from another of the fluid flow outputs in a conduit connected to a dispensing means whereby the fluid flow rate supplied to the dispensing means is substantially constant.

7. In an apparatus for dispensing particulate material, means for dividing a gaseous input into a plurality of gaseous outputs the sum of which is substantially equal to the gaseous input to the means, one of the gaseous outputs is connected to a particulate material-dispensing means and other of the gaseous outputs is connected to the dispensing means through a source of particulate material, the dispensing means having a substantially constant gaseous flow therethrough that is substantially independent of the particulate material dispensed whereby accumulation of particulate material in the apparatus is discouraged, the means for dividing the gaseous flow comprising a body including an inlet port and a plurality of outlet ports connected by a bore, the inlet port adapted to be connected to a gaseous medium source, the outlet ports connected to the particulate material dispensing means, and a displaceable gaseous flow-splitting member in the bore of the body adjacent the outlet ports, the gaseous flow-splitting member displaceable toward one of the outlet ports and away from the remaining outlet ports thereby providing gaseous outputs the sum of which is substantially equal to the gaseous input.

8. The means as claimed in claim 7, wherein the gaseous flow-splitting member includes surfaces which encourage fluid flow toward the outlet ports.

9. The means as claimed in claim 8, wherein the gaseous fluid-splitting member includes a plurality of frustoconical members having adjacent bases.

10. The means as claimed in claim 9, wherein each of the frustoconical members have substantially the same dimensions and substantially the same taper angle and each of the outlet ports have substantially equal area openings adjacent the frustoconical members.

11. The means as claimed in claim 10, wherein the outlet ports are two outlet ports spaced from each other and the openings thereof are substantially coaxial.

12. The means as claimed in claim 11, wherein the axis of the inlet port is substantially perpendicular to the axis of the outlet ports.

13. An apparatus for dispensing particulate material comprising a bed containing particulate material, a fluid-activated means in the bed for causing the particulate material to be drawn from the bed at a rate substantially proportional to the fluid flow rate in the fluid-activated means, means for dispensing the particulate material drawn from the bed, a conduit connecting the fluid-activated means to the means for dispensing the particulate material, and
a fluid divider including an inlet port adapted to be connected to a fluid under pressure, at least two outlet ports and a fluid impedance means adjacent the outlet ports, one of the outlet ports connected to the fluid-activated means so as to provide fluid flow to the fluid-activated means from the fluid source, another of the outlet ports connected to the conduit so as to provide a fluid flow in the conduit assisting in the movement of the particulate material in the conduit toward the means for dispensing the particulate material, the fluid impedance means displaceable toward one of the outlet ports and away from the other outlet port for predeterminately dividing the fluid flow at the inlet port between the outlet ports whereby the fluid flow rate to the fluid activated is adjustable so as to withdraw variable amounts of particulate material from the bed without effecting the flow rate of fluid in the conduit.

14. The apparatus as claimed in claim 13, wherein the fluid flow rate to the dispensing means is substantially constant and independent of the adjustment of the fluid divider.

15. The apparatus as claimed in claim 13 wherein the particulate material includes a powdery substance capable of being electrostatically charged and wherein the dispensing means includes an electrostatic spray gun capable of electrostatically charging the powdery substance.

16. The apparatus as claimed in claim 15, wherein the fluid-activated means includes a fluidized bed containing the powdery substance and a fluid-actuated pump which draws the powdery substance from the fluidized bed at a rate proportional to the fluid flow rate through the pump.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,625,404 Dated December 7, 1971

Inventor(s) Richard O. Probst

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 30, after "encouraging", insert -- or discouraging --. Column 6, line 5, "ate" should read -- rate --. Column 6, line 42, after "respect to", insert -- chamfer 44. After initial positioning and locking in place of the members with respect to --. Column 8, line 4, "as" should read -- a --. Column 8, line 63, "port" should read -- ports --. Column 9, line 46, "would" should read -- should --. Column 10, line 48, "2" should read -- 20 --.

Signed and sealed this 31st day of October 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents