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(11) **EP 0 693 973 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
21.11.2001 Bulletin 2001/47

(51) Int Cl.7: **B05B 5/00**, B05C 11/00,
B05C 13/00, B05C 19/06,
B05D 1/02, B05D 1/12

(21) Application number: **94914073.5**

(86) International application number:
PCT/US94/03828

(22) Date of filing: **07.04.1994**

(87) International publication number:
WO 94/22589 (13.10.1994 Gazette 1994/23)

(54) **METHOD AND APPARATUS FOR COATING THREE DIMENSIONAL ARTICLES**

VERFAHREN UND GERÄT ZUM BESCHICHTEN DREIDIMENSIONALER ARTIKEL

PROCEDE ET APPAREIL DE REVETEMENT D'ARTICLES TRIDIMENSIONNELS

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DE FR GB IT

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(30) Priority: **07.04.1993 JP 10516893**

(43) Date of publication of application:
31.01.1996 Bulletin 1996/05

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Description

[0001] This invention relates to an improved method and apparatus for powder coating three dimensional articles having surface irregularities which vary in angle, curvature, and/or surface area.

[0002] SU-A-1087191 discloses an automatic paint spraying unit. It comprises a paint feed line and an air feed line, each having pressure regulators therein. In addition, it includes workpiece sensors, workpiece surface sensors and a control system.

[0003] One common method and apparatus for coating three dimensional articles involves spray coating powder particles onto the external surface of the articles as they are conveyed by a conveyor pasta spray gun. Typically, a sensor detects when an article carried by the conveyor moves into the spray pattern of the gun and signals the apparatus to spray a preset uniform quantity of powder particles to coat the article. Thus, to coat a plurality of articles, the apparatus intermittently sprays a preset, uniform quantity of coating material onto each article as the articles pass the gun.

[0004] This manner of coating three dimensional articles is generally acceptable if all of the articles have a flat coating surface, or a surface which is parallel to the conveyor and perpendicular to the orientation of the gun.

[0005] However, with three dimensional articles which have surface irregularities such as cut-out regions, angled or curved surfaces, protrusions, indentations, or bent edges, etc., these surface irregularities make it difficult to uniformly coat the entire external surface of the article. One reason for this difficulty relates to the angular orientation of the surface irregularities with respect to the direction of the gun. The more the surface varies from an orientation perpendicular to the spray direction, the more difficult it becomes to adequately coat the surface. For curved or angled surfaces difficulty in coating occurs in part because an angled or curved surface has a greater density of surface area than a flat surface. This means that as the conveyor moves the three dimensional articles past the spray gun, the surface area per unit time which passes the gun is greater for angled or curved surfaces than for flat surfaces. Additionally, some surface irregularities are actually cut-out regions, which require no coating at all. Continued operation of a spray gun as a cut-out region passes by represents a waste of coating material.

[0006] Thus, as the topography of the three dimensional article varies, it becomes more difficult to uniformly coat the entire surface area, particularly for conveyors commonly used in the industry which convey such articles past the spray gun at a relatively constant speed.

[0007] One way to assure that the entire surface is coated is to operate the spray gun at a sufficiently high pressure to discharge a quantity of coating material which is greater than that which is actually necessary to coat the surface, with the pressure being determined by

the portion of the surface which is most difficult to coat. This assures some coating on the most steeply angled or curved surfaces. However, a coating applied in this manner is generally not uniform due to the surface irregularities. This manner of coating also results in a tremendous amount of wasted energy and coating material.

[0008] It is an objective of this invention to improve uniformity in coating three dimensional articles with surface irregularities.

[0009] It is another objective of this invention to adequately coat the irregular surface areas of a three dimensional article while minimizing the amount of wasted coating material.

[0010] The above-stated objectives are achieved by a method and apparatus which control the discharge rate of coating material according to the irregularity and/or area of the surface of a three dimensional article as it is conveyed past a spray gun.

[0011] The invention is therefore directed at apparatus for applying coating material to an article comprising means for conveying a three-dimensional article along a conveying path, the article having an external surface with a plurality of surface portions of different topography and/or surface area, wherein at least one of said portions is not parallel to the conveying path, a first gun aimed along a first discharge path which intersects the conveying path, and a controller. According to the invention, the apparatus is for powder coating and further comprises means for flowing powder particles to the gun in a pressurized condition and for discharging the particles therefrom to powder coat the surface portions as the article is moved through the first discharge path via the conveying means, the means for flowing including means for supplying pressurized air to the gun, thereby to combine the pressurized air and the powder particles in a mixed stream for subsequent discharge from the gun and toward the surface portions, and the controller is operatively connected to the means for supplying pressurized air and adapted to vary the flow of the pressurized air therefrom, thereby to variably control the rate of discharging of the powder particles in the mixed stream according to a predetermined discharge sequence so that the rate of discharging for each surface portion is commensurate with the surface area thereof and/or a different rate of discharging is used for each of the plurality of different topographies of the surface portions, thereby to uniformly powder coat the surface portions and to minimize waste of the powder particles.

[0012] Furthermore, the invention is directed at a method of applying coating material to an article, comprising the steps of moving a three-dimensional article to be coated along a conveying path relative to a spray gun, the gun aimed along a discharge path generally perpendicular to and intersecting the conveying path, the article having an external surface to be coated, the external surface having a plurality of surface portions of different surface topography and surface area. In ac-

cordance with the invention the method is for powder coating, and further comprises the steps of mixing powder particles and pressurized air in the gun to form a mixed stream, the powder particles supplied by a powder source and the pressurized air supplied by a pressurized air source, discharging the mixed stream from the gun along the discharge path to successively powder coat the surface portions as the article moves into the discharge path, and controlling the rate of discharging of the mixed stream according to the predetermined coating sequence by varying the flow of pressurized air from the pressurized air source, to provide a corresponding plurality of different rates of discharging the mixed stream, the rate of discharging being dependent upon the surface topography and the surface area of the surface portion located in the discharge path, thereby to uniformly powder coat the surface portions with optimized efficiency in use of powder.

[0013] For powder spray coating applications, the discharge rate is controlled by regulating the air pressure input to the powder pump. This controls the volume of powder mixed into the conveying air stream moving through the pump and the rate at which the mixed powder-air stream is discharged from a spray gun toward the three dimensional article. For flat surfaces, a standard reference discharge rate is used. For steeply curved surface portions, the discharge rate increases commensurately to assure adequate coating of the increased surface density which moves past the gun per unit time. For cut-out regions, discharge of the powder is temporarily stopped to reduce waste.

[0014] Depending upon the dimensions of the articles to be coated, more than one spray gun may be necessary. Each spray gun is adapted to coat along a topographical strip, or channel, of the external surface of the article. The discharge rate for a gun dedicated to a particular channel is predetermined to correspond to the particular irregularities of the surface portions of that channel. Each gun is controlled independently, so that each channel of the three dimensional article is coated according to a predetermined discharge sequence which corresponds uniquely to the configuration of the surface portions thereof.

[0015] By varying the discharge rate in accordance with curvature and/or surface area of the surface portions as they pass in front of a gun along a conveying path, this invention assures uniform coating of all surface portions of the article, regardless of surface irregularities. Additionally, because the discharge rate is lowered for flat surfaces, and discharge is discontinued entirely for cut-out regions, this invention reduces the amount of coating material which is wasted during the coating of three dimensional articles.

[0016] According to a preferred embodiment of the invention, a method and apparatus for coating three dimensional articles includes a conveyor, a spray gun, a powder pump, a powder hopper, a pressurized air source, a master controller, and electro-pneumatic air

regulator, a position sensor for articles on the conveyor and a speed sensor for the conveyor. The conveyor carries three dimensional articles in spaced relation along the conveying path, which is oriented perpendicular to the discharge path of the spray gun. Stated another way, the discharge path of the spray gun intersects the conveying path at a 90° angle. The powder pump conveys a mixed stream of pressurized air and powder particles to the gun via a transport hose. The powder hopper, preferably a fluidized bed, supplies powder particles to the powder pump. The pressurized air source supplies pressurized air via a supply tube to the powder pump. The electro-pneumatic air regulator is connected in the supply tube between the pressurized air source and the powder pump, and the electro-pneumatic air regulator regulates the flow rate of pressurized air supplied to the powder pump. Because the amount of powder particles drawn into the powder pump is directly proportional to the flow rate therethrough, this also controls the discharge rate from the gun.

[0017] The controller operatively connects to the electro-pneumatic air regulator and controls operation thereof according to a predetermined discharge sequence, the sequence initially determined by an operator to uniformly coat a topographical channel of the three dimensional article as the various surface portions thereof pass in front of the gun. A position sensor senses movement of an article by the conveyor into the discharge path of the gun, and thereby activates the controller to initiate the predetermined coating sequence. The conveyor speed sensor operatively connects to the controller and signals to the controller the speed of the conveyor, thereby to correlate the predetermined discharge sequence with the actual speed of the conveyor. Stated another way, the speed sensor serves as a feedback device to the controller to assure that the predetermined coating sequence actually matches the topography of the surface portions of the channel as the article is transported in front of the gun.

[0018] An air pressure sensor may be located in the supply line between the electro-pneumatic air regulator and the pump, thereby to sense and provide an indication of the air pressure in the line. If desired, this air pressure can be calculated to determine, and provide a display of, the discharge rate from the gun.

[0019] Depending upon the transverse dimension of the articles to be coated and/or the variations in surface topography for the articles to be coated, one or more additional surface channels may be designated. This will necessitate the use of one or more additional guns, along with the corresponding additional powder supply apparatus. This additional powder supply apparatus functions in the same manner as described above, and discharge from each gun is independently controlled by the master controller. However, only a single air supply source is necessary, with a control valve located downstream thereof and operatively connected to the master controller, thereby to turn "off" or "on" all pressurized air

flowing into the apparatus.

[0020] An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings wherein:

Fig. 1 is a schematic of a powder coating apparatus for coating three dimensional articles, in accordance with a preferred embodiment of the invention.

Fig. 2 is an enlarged perspective view of a portion of the apparatus shown in Fig. 1, showing the orientation of the spray guns with respect to a three dimensional article during coating thereof.

Fig. 3A is a plan view of one spray coating gun during coating of a first channel of the three dimensional article shown in Fig. 2.

Fig. 3B is a graph which illustrates the surface area to be coated for the surface portions of the first channel shown in Fig. 3A.

Fig. 3C is a graph which illustrates the quantity of coating material discharged as successive surface portions of the first channel move past the gun.

Fig. 4A is a plan view of a second spray coating gun during coating of a second channel of three dimensional article shown in Fig. 2.

Fig. 4B is a graph which illustrates the surface area to be coated for the surface portions of the second channel shown in Fig. 4A.

Fig. 4C is a graph which illustrates the quantity of coating material discharged as successive surface portions of the second channel move past the gun.

[0021] Fig. 1 schematically shows an improved spray coating apparatus 10 for powder coating a three dimensional article 12 in accordance with a preferred embodiment of the invention. While the figures show an apparatus 10 particularly suitable for powder coating, the invention is not limited thereby and is also applicable to other types of coating and coating materials. More specifically, the apparatus 10 coats a first external surface 13 of three dimensional articles 12 carried by a conveyor 14. The conveyor 14 moves the articles 12 along a conveying path and past a spray coating gun 16. The gun 16 is adapted to spray coating material along a discharge path which intersects the conveying path of the conveyor 14 at 90°. This discharge path is defined by a conical-shaped pattern 18 which is formed during operation of the gun 16 under high pressure discharge conditions.

[0022] As shown in Fig. 1, the first external surface 13 of article 12 includes first and second widths, or topographic channels 19 and 21, respectively. As shown in Fig. 1, channel 19 is located above channel 21, though this invention is not limited to the use of a horizontal conveying path and a horizontal discharge path, and the channels may reside next to each other in the X, Y or Z planes. The number of channels depends upon the transverse dimension of the first external surface 13 with respect to the direction of the conveyor 14. As shown in

Fig. 1, the conveyor 14 moves the articles 12 along a conveying path which comes out of the page, and thus the transverse dimension of external surface 13 is along the vertical, or y-axis. Another factor which plays a role in determining the number of channels, in addition to the transverse dimension, is the surface variation of the first external surface 13. For instance, channel 21 has a cut-out region while channel 19 does not..

[0023] In addition to the gun 16 for discharging coating material in a conical-shaped pattern 18 toward the first channel 19 of surface 13, Fig. 1 also shows a second gun 16a for discharging coating material in a conical-shaped pattern 18a toward the second channel 21. As described above, depending upon the number of channels and the surface configuration of first external surface 13, one or more additional guns may be added as necessary. The structural elements which supply coating material to second gun 16a are identical to the structural elements which supply first gun 16, and reference numerals for these elements are identical, but have an "a" appended thereto. To simplify the explanation of Fig. 1, only the elements associated with first gun 16 will be described.

[0024] A supply hose 22 conveys a mixed stream of pressurized air and powder paint coating material to the gun 16. A powder pump 24 creates this mixture of pressurized air and coating material. The pump 24 is mounted to the top of a powder hopper 26 which maintains a fluidized bed of powder coating material. Pump 24 includes a venturi pumping chamber under negative pressure which is connected by suction tube 28 to the fluidized bed of powder in hopper 26 to draw powder into pump 24.

[0025] A pressurized air supply tube 30 defines a flow path for conveying pressurized air from a pressurized air source 32 to the pump 24. This pressurized air creates the negative pressure condition in the venturi pumping chamber of pump 24 which draws powder from hopper 26 into the pump. The supply of pressurized air from pressurized air source 32 is turned "off" and "on" via a solenoid valve 34 which is controlled by a master controller 36. The master controller 36 is preferably programmable and includes a central processing unit.

[0026] An electro-pneumatic air regulator 38 is installed in the flow path defined by supply tube 30, between the pressurized air source 32 and the pump 24. Regulator 38 is preferably a voltage to pressure regulator manufactured by Nordson Corporation of Amherst, Ohio under Part No. 113,626. An electrical signal is provided to regulator 38 via a line 40 from controller 36 indicating the air pressure to be provided at the output of regulator 38.

[0027] Operation of this electropneumatic air regulator 38 regulates the flow of pressurized air along the tube 30, which in turn regulates the amount of negative pressure in the venturi pumping chamber of pump 24 and the flow rate of the mixed powder-air stream from hopper 26 along supply tube 22, and the discharge rate of

powder coating material from gun 16. Supply tube 30 also includes an air pressure sensor 42 which is operatively connected to the master controller 36, and the master controller 36 includes or is operatively connected to a display 41, such as an LED or LCD, for displaying the air pressure in the tube 30.

[0028] The master controller 36 also connects to position sensors 46a and 46b, which may be a light beam detector, to sense movement of the article 12 into the discharge path of the gun 16. The signal generated by the sensors 46a and 46b may then be used to actuate the master controller 36 to initiate coating.

[0029] The master controller 36 is programmed to control the operation of the regulator 38 (and regulator 38a) according to a predetermined coating sequence. This coating sequence may involve increasing or decreasing the supply of pressurized air to the pump 24 from regulator 38, thereby to increase or decrease the discharge rate of coating material from the gun 16 in accordance with the particular surface configuration or topography of the channel 19 (and channel 21). For instance, if the surface channel 19 includes flat portions and angled portions or curved portions, i.e. portions not parallel to the conveying path, the surface area of the non-parallel portions which pass by the gun 16 per unit time will be greater than the surface area of the flat portions which pass by the gun 16 per unit time, assuming the conveyor 14 moves at a constant speed. As described in more detail below with respect to Fig. 2, these uneven or non-parallel portions therefore require a higher discharge rate, with the discharge rate being commensurate with the slope of a tangent line to the surface.

[0030] If desired, the speed of the conveyor 14 may be fed back to the master controller 36. This may be done by fixing a rotatable spool 48 in contact with the conveyor 14 so that the spool 48 rotates upon movement of the conveyor 14. An axle 50 connects to the spool 48 and supports a disc 52 which rotates therewith. The disc 52 is coded via punched out regions at a diameter which corresponds to a location of light beam sensors 54a and 54b. As the disc 52 rotates, the passage or obstruction of the light beam between sensors 54a and 54b indicates to the master controller 36 the speed of the conveyor 14. In its simplest form, with uniformly spaced punch-out regions in the disc 52, this structure may be used simply to indicate to the master controller 36 the speed of the conveyor 14 and whether the conveyor 14 has stopped or started, via sensing at the controller 36 the rate of receipt of the "obstructed" and "unobstructed" signals. If the conveyor 14 always runs at the same speed to coat the same articles 12, this speed sensing structure may not be necessary, because the predetermined coating sequences can be correlated to the channel or channels of the article 12 in relation to that constant speed. However, this added degree of control is preferable because of possible fluctuations in the speed of the conveyor 14 and/or the desire to operate the conveyor 14 at different speeds for coating dif-

ferent articles 12.

[0031] If desired, the coding on the disc 52 may be specific to a particular article 12, and arranged such that one complete rotation of disc 52 corresponds to movement of the conveyor 14 from the leading edge of one article 12 to the leading edge of the next succeeding article 12. Each surface portion to be coated can then be correlated to an arcuate section of the disc 52. The spacing of the cut out regions could then dictate the discharge rate. Thus, the invention contemplates added levels of feedback control, if desired.

[0032] Fig. 2 shows the first external surface 13 of article 12 in greater detail. More particularly, Fig. 2 shows the topographic surface details of first upper channel 19 and second lower channel 21. The surfaces of channels 19 and 21 are coated by material discharged from gun 16 and 16a, respectively, as the article 12 moves along the conveying path in a direction designated by reference numeral 56. Channel 19 includes multiple surface portions, designated 19a, 19b, 19c, 19d and 19e. Surface portion 19a is oriented parallel to the discharge path of the gun 16 and perpendicular to the conveying path of the conveyor 14. Surface portion 19b is parallel to the conveying path and perpendicular to the discharge path. Surface portion 19c is curved, and a tangent line to this curve is almost parallel with the discharge path adjacent portion 19b, but becomes almost perpendicular to the discharge path as the surface portion 19c flattens, adjacent the flat or parallel surface portion 19d. Surface portion 19e is oriented parallel with the discharge path and perpendicular to the conveying path. Surface portions 21a, 21b, 21c and 21d are similar to surface portions 19a, 19b, 19c and 19d, respectively. However, channel 21 also includes a cut-out region 21e which does not require discharge of any coating material, followed by a flat surface portion 21f and a perpendicular surface portion 21g.

[0033] As shown in Fig. 2, if article 12 is moved past guns 16 and 16a at a constant rate of speed, a greater surface area of the article 12 passes the guns 16 and 16a per unit time during passage of those portions which are non-parallel to the conveying path i.e. such as portions 19c and 21c. Also, the greater the curvature, or angle of the surface portions with respect to the conveying path, the greater the amount of surface area which passes the guns 16 and 16a per unit time. Thus, to uniformly coat surface portions 19b and 19c with a layer of coating material of uniform thickness, and to minimize waste of coating material, more coating material must be discharged as portion 19c passes gun 16 than when portion 19b passes gun 16, assuming the conveyor 14 operates at constant speed. Subsequently, as surface portion 19c levels off toward surface portion 19d, the needed volume of coating material decreases. The effect is similar for channel 21, but channel 21 also includes cut-out 21e, which requires no coating material to be discharged.

[0034] To accomplish the desired increases and de-

creases in quantity of coating material discharged, as dictated by the surface configuration of the channels 19 and 21, the master controller 36 controls the flow rate of pressurized air along tube 30 by means of regulator 38. For a portion which is flat, such as 19b and 21b, the standard reference for surface area passing gun 16 per unit time is 1.0 and the standard reference for quantity discharged is also 1.0. When a curved portion such as 19c moves in front of the gun 16, (adjacent portion 19b) the initial surface area which passes gun 16 per unit time is about 4.4 times the reference value region. As the angle of surface portion 19c decreases to about 30°, (adjacent portion 19d) the region which passes gun 16 per unit time is about 1.15 times the standard reference value.

[0035] Thus, the apparatus 10 opens up or closes down the flow passage in regulator 38, under the control of controller 36, to increase or decrease, respectively, the discharge rate from guns 16 and 16a relative to the surface area of the respective channel 19 or 21. Thus, for example, the flow passage through regulator 38 would be opened wider during the coating of portion 19c, than during the coating of portion 19b. This results in the most efficient use of the coating material, since excess coating material is not discharged onto flat portions, and additional material is discharged on curved portions to accommodate the additional surface area defined by the surface topography. Additionally, coating material is saved because the apparatus 10 does not discharge coating material toward cut-out regions, such as portion 21e.

[0036] For portions which are substantially parallel to the discharge path, such as portions 19a, 21a, 19e, and 21g, it is extremely difficult to uniformly coat the exposed surface area, due to the angular orientation of the surface with respect to the guns 16 and 16a. Therefore, it is desirable to electrostatically charge the powder particles to promote attraction toward these surfaces and uniform coverage thereof. As shown in Fig. 1, electrostatic charging of the powder particles may occur via use of corona charging electrodes 37 and 37a external to the guns 16 and 16a, respectively, though it is preferable to electrostatically charge the powder particles while in the apparatus 10, either via an internal corona electrode or an internal charging system such as a triboelectric friction charging system. Moreover, this type of electrostatic powder coating gun is preferably also used for coating the other portions of the article 12 as well.

[0037] Fig. 3A shows topographic channel 19 in plan view, and particularly surface portions 19a, 19b, 19c, 19d and 19e. Fig. 3B includes a curve 58 which graphically illustrates the surface area of channel 19 which passes in front of gun 16 during movement of the conveyor 14. For instance, the surface area represented for portions 19a and 19d are equal to the standard reference value 1.0. The surface area represented for the slightly inclined region of portion 19c is 1.15 times the reference value, while the surface area for the steeper

region of portion 19c increases from 1.15 to 4.4 of the reference value. For curved portions such as 19c, Fig. 3B also reflects the slope of a tangent line to the surface.

[0038] Fig. 3C graphically illustrates the quantity of coating material which should be discharged according to the invention as surface portions 19a, 19b, 19c, 19d and 19e pass in front of gun 16. This quantity is represented by curve 60. The shaded region located above curve 60, and designated by reference numeral 62, represents the amount of coating material that is saved by using this invention, since without this invention it would otherwise be necessary to discharge at a rate sufficient to cover the steepest region of surface portion 19c. The other option of course, though equally undesirable, would be to discharge at a rate insufficient to adequately coat the steepest region of surface portion 19c.

[0039] Figs. 4A, 4B and 4C correspond to Figs. 3A, 3B and 3C, respectively, but relate to coverage of second topographic channel 21. Curve 64 in Fig. 4B shows the surface area for portions 21a, 21b, 21c, 21d, 21e, 21f and 21g of channel 21, and curve 66 in Fig. 4C graphically shows the quantity of coating material discharged as these surface portions pass the gun 16a. Also, the reference numeral 68 designates the amount of coating material saved with this invention by varying the discharge rate.

[0040] Compared to Figs. 3A, 3B and 3C, Figs. 4A, 4B and 4C differ only in respect to the cut-out portion 21e, which does not require any coating material. The second discharge path 18a and the second gun 16a are necessary for coating article 12 because of the different surface configurations, or surface topography, represented by the cut-out region 21e. In some cases, as explained previously, additional or fewer guns may be needed, but the number of guns necessary will be determined by the transverse dimension of the article 12 and the number of topographic variations in the surface orientation of the article 12. The invention requires one gun, and therefore one topographic channel, for each variation and surface orientation across the transverse dimension of the article 12.

Claims

1. Apparatus (10) for applying coating material to an article comprising means (14) for conveying a three-dimensional article (12) along a conveying path, the article (12) having an external surface (13) with a plurality of surface portions (19a-e, 21a-g) of different topography and/or surface area, wherein at least one of said portions is not parallel to the conveying path, a first gun (16) aimed along a first discharge path which intersects the conveying path, and a controller (36), **characterised in that** the apparatus is for powder coating and further comprises means for flowing powder particles to the gun (16) in a pressurized condition and for discharging the

particles therefrom to powder coat the surface portions (19a-e, 21a-g) as the article (12) is moved through the first discharge path via the conveying means (14), the means for flowing including means (32, 34, 38) for supplying pressurized air to the gun, thereby to combine the pressurized air and the powder particles in a mixed stream for subsequent discharge from the gun (16) and toward the surface portions (19a-e, 21a-g), and the controller (36) is operatively connected to the means (32, 34, 38) for supplying pressurized air and adapted to vary the flow of the pressurized air therefrom, thereby to variably control the rate of discharging of the powder particles in the mixed stream according to a predetermined discharge sequence so that the rate of discharging for each surface portion (19a-e, 21a-g) is commensurate with the surface area thereof and/or a different rate of discharging is used for each of the plurality of different topographies of the surface portions, thereby to uniformly powder coat the surface portions and to minimize waste of the powder particles.

2. Apparatus as claimed in Claim 1 further comprising air pressure sensing means (42) operatively connected to the powder flowing means and adapted to sense the display a parameter proportional to the rate of discharging.
3. Apparatus as claimed in either Claim 1 or Claim 2 further comprising a second gun (16a) adapted to discharge coating material along a second discharge path (18a) which intersects the conveying path as the article (12) moves along the conveying path, the second gun (16a) and the first gun (16) arranged along a line perpendicular to the conveying path and the first and second discharge paths.
4. Apparatus as claimed in Claim 1 or Claim 2 wherein the powder flowing means includes a powder pump (24) operatively connected to the gun (16), and means (26) for supplying fluidized powder particles to the pump, the air supplying means (32, 34, 38) supplies air to the pump (24) via a flow path (30), the pump (24) being adapted to combine the pressurized air and powder particles in a mixed stream and to convey the mixed stream along a transport path to the gun (16) for discharge therefrom toward the surface portions (19a-e, 21a-g), and the air supplying means includes flow control means (38) located in the flow path (30) and adapted to regulate the flow of pressurized air therethrough, thereby to regulate the flow rate of the mixed stream conveyed to the gun (16) and discharged therefrom, the controller (36) being operatively connected to the flow control means (38) and adapted to control the flow control means to vary the discharge rate of the mixed stream from the gun (16) according to the

predetermined discharge sequence.

5. Apparatus as claimed in Claim 4 as appendant to Claim 1 further comprising an air pressure sensor (42) located in the flow path (30) between the flow control means (38) and the pump (24), and display means operatively connected to the air pressure sensor (42) for indicating the air pressure in the flow path (30).
6. Apparatus as claimed in either Claim 4 or Claim 5 wherein the flow control means (38) comprises an electropneumatic regulator which receives an electrical signal from the controller (36) and in response varies the flow rate of pressurized air therethrough.
7. Apparatus as claimed in any of Claims 4 to 6 further comprising a second gun (16a) adapted to discharge pressurized air and powder particles in a second stream (18a) toward successively conveyed surface portions (21a-g) of the article, the second gun (18a) and the first gun (18) arranged along a line perpendicular to the conveying path and the discharge direction.
8. Apparatus as claimed in any preceding claim further comprising a sensor (46a, 46b) operatively connected to the controller (36) and adapted to sense the article (12) as it moves in front of the gun (18, 18a) and to signal the controller (36) to initiate the predetermined discharge sequence.
9. Apparatus as claimed in any preceding claim further comprising speed sensing means (54a, 54b) connected to the controller and adapted to determine the rate of speed of the conveying means (14), thereby to correlate the predetermined discharge sequence with the rate at which the surface portions (19a-e, 21a-g) pass in front of the gun (18, 18a).
10. Apparatus as claimed in any preceding claim further comprising means or electrostatically charging the particles in the mixed stream.
11. Apparatus as claimed in Claim 10 wherein the electrostatic charging means is located in the transport path.
12. Apparatus as claimed in any preceding claim wherein the gun (18, 18a) remains in a fixed position and the conveying means (14) carries the article (12) past the gun (18, 18a).
13. A method of applying coating material to an article, comprising the steps of moving a three-dimensional article (12) to be coated along a conveying path relative to a spray gun (18, 18a), the gun aimed along a discharge path generally perpendicular to and in-

intersecting the conveying path, the article (12) having an external surface (13) to be coated, the external surface having a plurality of surface portions (19a-e, 21a-g) of different surface topography and surface area, **characterised in that** the method is for powder coating, and further comprises the steps of mixing powder particles and pressurized air in the gun (18, 18a) to form a mixed stream, the powder particles supplied by a powder source (26, 26a) and the pressurized air supplied by a pressurized air source (32), discharging the mixed stream from the gun (18, 18a) along the discharge path to successively powder coat the surface portions (19a-e, 21a-g) as the article (12) moves into the discharge path, and controlling the rate of discharging of the mixed stream according to the predetermined coating sequence by varying the flow of pressurized air from the pressurized air source (32), to provide a corresponding plurality of different rates of discharging the mixed stream, the rate of discharging being dependent upon the surface topography and the surface area of the surface portion located in the discharge path, thereby to uniformly powder coat the surface portions with optimized efficiency in use of powder.

14. A method as claimed in Claim 13 further comprising the steps of electrostatically charging the discharged particles.
15. A method as claimed in Claim 14 wherein the charging occurs inside the gun (18, 18a).
16. A method as claimed in any one of Claims 13 to 15 further comprising the step of sensing the article (12) as it moves into the discharge path, thereby to actuate a controller (36) to initiate the predetermined coating sequence.
17. A method as claimed in any one of Claims 13 to 16 further comprising the step of measuring the speed at which the article (12) is moved through the discharge path and along the conveying path, and, inputting the measured speed to a or the controller (36) to control the predetermined coating sequence.

Patentansprüche

1. Vorrichtung zum Aufbringen von Beschichtungsmaterial auf einen Gegenstand, enthaltend Mittel (14) zum Transportieren eines dreidimensionalen Gegenstandes (12) entlang eines Transportweges, wobei der Gegenstand (12) eine Außenoberfläche (13) aufweist, die mehrere Flächenabschnitte (19a-e, 21a-g) mit unterschiedlicher Topographie und/oder Oberflächenbereich besitzt, wobei zumindest

einer der Abschnitte nicht parallel zu dem Transportweg verläuft, eine erste Pistole (16), die auf einem ersten Abgabebeweg ausgerichtet ist, welcher den Transportweg schneidet, sowie eine Steuereinrichtung (36),

dadurch gekennzeichnet, dass die Vorrichtung zum Pulverbeschichten vorgesehen ist und weiterhin Mittel enthält, um zum Beschichten der Oberflächenabschnitte (19a-e, 21a-g) mit Pulver Pulverpartikel unter Druck zu der Pistole (16) strömen zu lassen und die Partikel aus der Pistole abzugeben, wenn der Gegenstand (12) mittels dem Transportmittel (14) durch den ersten Abgabebeweg hindurchbewegt wird, wobei die Strömungsmittel ein Mittel (32, 34, 38) enthalten, um Druckluft zu der Pistole zuzuführen, um dadurch die Druckluft und die Pulverpartikel in einem Mischstrahl für die nachfolgende Abgabe aus der Pistole (16) in Richtung der Oberflächeabschnitte (19a-e, 21a-g) zu vereinen, und dass die Steuereinrichtung (36) mit dem Mittel (32, 34, 38) zum Zuführen der Druckluft verbunden und in der Lage ist, die Strömung der Druckluft zu verändern, um dadurch die Abgabeleistung der Pulverpartikel in dem Mischstrahl gemäß einer vorbestimmten Abgabesequenz variabel so zu steuern, dass die Abgabeleistung für jeden Oberflächenabschnitt (19a-e, 21a-g) dem Oberflächenbereich hiervon angepasst ist und/oder eine unterschiedliche Abgabeleistung für jeden der mehreren unterschiedlichen Topographien der Oberflächeabschnitte verwendet wird, um die Oberflächeabschnitte gleichförmig mit Pulver zu beschichten und den Abfall der Pulverpartikel zu minimieren.

2. Vorrichtung nach Anspruch 1, weiterhin enthaltend Luftdruck-Erfassungsmittel (42), die mit dem Pulverströmungsmittel verbunden und in der Lage sind, einen Parameter, der proportional der Abgabeleistung ist, für die Anzeige zu erfassen.
3. Vorrichtung nach Anspruch 1 oder 2, weiterhin enthaltend eine zweite Pistole (16a), die in der Lage ist, Beschichtungsmaterial entlang eines zweiten den Transportweg schneidenden Abgabeweges (18a) abzugeben, wenn sich der Gegenstand (12) entlang des Transportweges bewegt, wobei die zweite Pistole (16a) und die erste Pistole (16) entlang einer Linie angeordnet sind, die senkrecht zu dem Transportweg sowie dem ersten und dem zweiten Abgabebeweg verläuft.
4. Vorrichtung nach Anspruch 1 oder 2, bei der das Pulverströmungsmittel eine Pulverpumpe (24), die mit der Pistole (16) verbunden ist, sowie Mittel (26) zum Zuführen fluidisierter Pulverpartikel zu der Pumpe enthält, wobei das Luftzuführungsmittel (32, 34, 38) über einen Strömungsweg (30) der

- Pumpe (24) Luft zuführt, wobei die Pumpe (24) in der Lage ist, die Druckluft und die Pulverpartikel in einen Mischstrom zu vereinen und den Mischstrom entlang eines Transportweges zu der Pistole (16) für die Abgabe hieraus in Richtung der Oberflächenabschnitte (19a-e, 21a-g) zu transportieren, und bei der das Luftzufuhrmittel ein Strömungssteueremittel (38) enthält, das in dem Strömungsweg (30) angeordnet und in der Lage ist, die Druckluftströmung dort hindurch zu regeln, um die Strömungsgeschwindigkeit des Mischstromes, der zu der Pistole (16) transportiert und von dort abgegeben wird, zu regeln, wobei die Steuereinrichtung (36) mit dem Strömungssteueremittel (38) verbunden und in der Lage ist, das Strömungssteueremittel zu steuern, wodurch die Abgabeleistung des Mischstromes aus der Pistole (16) gemäß der vorbestimmten Abgabesequenz veränderbar ist.
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- bunden und in der Lage sind, die Geschwindigkeitsrate des Transportmittels (14) zu bestimmen, um die vorbestimmte Abgabesequenz mit der Geschwindigkeit, bei der die Oberflächenabschnitte (19a-e, 21a-g) vor der Pistole (18, 18a) vorbeigeführt werden, zu korrelieren.
- Vorrichtung nach einem der vorstehenden Ansprüche, weiterhin enthaltend ein Mittel zum elektrostatischen Aufladen der Partikel in dem Mischstrom.
- Vorrichtung nach Anspruch 10, bei der das elektrostatische Auflademittel in dem Transportweg angeordnet ist.
- Vorrichtung nach einem der vorstehenden Ansprüche, bei der die Pistole (18, 18a) in einer ortsfesten Position bleibt und das Transportmittel (14) den Gegenstand (12) an der Pistole (18, 18a) vorbeiführt.
- Verfahren zum Aufbringen von Beschichtungsmaterial auf einen Artikel, enthaltend die Schritte des Bewegens eines dreidimensionalen, zu beschichtenden Artikels (12) entlang eines Transportweges relativ zu einer Sprühpistole (18, 18a), wobei die Pistole entlang eines Abgabeweges ausgerichtet ist, der im wesentlichen senkrecht zu dem Transportweg verläuft und den Transportweg schneidet, wobei der Gegenstand (12) eine zu beschichtende Außenoberfläche (13) aufweist, wobei die Außenoberfläche mehrere Oberflächenabschnitte (19a-e, 21a-g) mit unterschiedlicher Oberflächentopographie und Oberflächenbereich besitzt, **dadurch gekennzeichnet, dass** das Verfahren für das Pulverbeschichten vorgesehen ist und weiterhin die folgenden Schritte enthält: Mischen von Pulverpartikeln und Druckluft in der Pistole (18, 18a), um einen Mischstrahl zu bilden, wobei die Pulverpartikel durch eine Pulverquelle (26, 26a) und die Druckluft durch eine Druckluftquelle (32) zugeführt werden, Abgeben des Mischstrahles aus der Pistole (18, 18a) entlang des Abgabeweges, um die Oberflächenabschnitte (19a-e, 21a-g) aufeinanderfolgend mit Pulver zu beschichten, wenn sich der Gegenstand (12) in den Abgabeweg bewegt, und Steuern der Abgabeleistung des Mischstromes gemäß der vorbestimmten Beschichtungssequenz durch Verändern der Strömung der Druckluft aus der Druckluftquelle (32), um eine Reihe von unterschiedlichen Leistungen der Abgabe des Mischstromes bereitzustellen, wobei die Abgabeleistung abhängig von der Oberflächentopographie und dem Oberflächenbereich des Oberflächenabschnittes ist, der in dem Abgabeweg angeordnet ist, wodurch die Oberflächeabschnitte mit optimierter Effizienz hinsichtlich der Verwendung des Pulvers

gleichförmig beschichtbar sind.

14. Verfahren nach Anspruch 13, weiterhin enthaltend die Schritte des elektrostatischen Aufladens der abgegebenen Partikel. 5
15. Verfahren nach Anspruch 14, bei dem das Aufladen innerhalb der Pistole (18, 18a) erfolgt. 10
16. Verfahren nach einem der Ansprüche 13 bis 15, weiterhin enthaltend die Schritte des Erfassens des Gegenstands (12), wenn er sich in den Abgabeweg bewegt, um dadurch eine Steuereinrichtung (36) zum Beginn der vorbestimmten Beschichtungssequenz zu betätigen. 15
17. Verfahren nach einem der Ansprüche 13 bis 16, weiterhin enthaltend den Schritt des Messens der Geschwindigkeit, mit dem der Gegenstand (12) durch den Abgabeweg und entlang des Transportweges bewegt wird, und Eingeben der gemessenen Geschwindigkeit in eine oder die Steuereinrichtung (36), um die vorbestimmte Beschichtungssequenz zu steuern. 20 25

Revendications

1. Appareil (10) pour appliquer un matériau de revêtement à un article, comprenant des moyens (14) pour transporter un article tridimensionnel (12) le long d'une trajectoire de transport l'article (12) présentant une surface externe (13) avec une pluralité de parties de surface (19a-e, 21a-g) de topographie et/ou d'aire de surface différentes, selon lequel au moins une desdites parties n'est pas parallèle à la trajectoire de transport, un premier pistolet (16) orienté le long d'une première trajectoire de projection qui coupe la trajectoire de transport, et un contrôleur (36), **caractérisé en ce que** l'appareil est prévu pour déposer un revêtement de poudre et comprend, en outre, des moyens pour acheminer des particules de poudre sous pression jusqu'au pistolet (16) et pour projeter les particules à partir de ce dernier pour recouvrir de poudre les parties de surface (19a-e, 21a-g) lorsque l'article (12) se déplace dans la première trajectoire de projection via le moyen de transport (14), les moyens d'acheminement comprenant des moyens (32, 34, 38) pour fournir de l'air sous pression au pistolet, et pour combiner ensemble l'air sous pression et les particules de poudre dans un courant mélangé en vue de leur projection ultérieure à partir du pistolet (16) et en direction des parties de surface (19a-e, 21a-g), et le contrôleur (36) est relié de manière opérationnelle aux moyens (32, 34, 38) pour fournir de l'air sous pression et adapté pour faire varier l'écou-

lement d'air sous pression à partir de ces derniers, et pour commander ainsi de manière variable la vitesse de projection des particules de poudre dans le courant combiné, selon une séquence de projection prédéterminée de telle sorte que la vitesse de projection pour chaque partie de surface (19a-e, 21a-g) correspond à l'aire de surface de cette dernière et/ou une vitesse de projection différente est utilisée pour chacune des topographies différentes des parties de surface, pour déposer un revêtement de poudre uniforme sur les parties de surface et minimiser la perte de particules de poudre.

2. Appareil selon la revendication 1, comprenant en outre des moyens de détection de la pression d'air (42) reliés de manière opérationnelle aux moyens d'acheminement de poudre et adaptés pour détecter et afficher un paramètre proportionnel à la vitesse de projection.
3. Appareil selon la revendication 1 ou la revendication 2 comprenant, en outre, un deuxième pistolet (16a) adapté pour projeter un matériau de revêtement le long d'une deuxième trajectoire de projection (18a) qui coupe la trajectoire de transport lorsque l'article (12) se déplace le long de la trajectoire de transport, le deuxième pistolet (16a) et le premier pistolet (16) étant placés le long d'une ligne perpendiculaire à la trajectoire de transport et aux première et deuxième trajectoires de projection.
4. Appareil selon la revendication 1 ou la revendication 2, selon lequel le moyen d'acheminement de poudre comprend une pompe à poudre (24) reliée de manière opérationnelle au pistolet (16) et des moyens (26) pour fournir des particules de poudre fluidisées à la pompe, le moyen d'alimentation en air (32, 34, 38) fournit de l'air à la pompe (24) via une trajectoire d'écoulement (30), la pompe (24) étant adaptée pour combiner l'air sous pression et les particules de poudre dans un courant mélangé et pour transporter le courant mélangé le long d'une trajectoire de transport jusqu'au pistolet (16) en vue de leur projection à partir de ce dernier vers les parties de surface (19a-e, 21a-g), et le moyen d'alimentation en air comprend un moyen de commande d'écoulement (38) placés dans la trajectoire d'écoulement (30) et adaptés pour réguler l'écoulement d'air sous pression dans cette dernière, pour réguler ainsi le débit du courant mélangé transporté jusqu'au pistolet (16) et projeté à partir de ce dernier, le contrôleur (36) étant relié de manière opérationnelle au moyen de commande d'écoulement (38) et étant adapté pour commander le moyen de commande d'écoulement pour faire varier la vitesse de projection du courant mélangé à partir du pistolet (16) selon la séquence de projection prédéterminée.

5. Appareil selon la revendication 4 conformément à la revendication 1, comprenant, en outre, un capteur de pression d'air (42) placé dans la trajectoire d'écoulement (3C) entre le moyen de commande d'écoulement (38) et la pompe (24) et des moyens d'affichage reliés de manière opérationnelle au capteur de pression d'air (42) pour indiquer la pression d'air dans la trajectoire d'écoulement (30). 5
6. Appareil selon la revendication 4 ou la revendication 5 selon lequel le moyen de commande d'écoulement (38) comprend un régulateur électro-pneumatique qui reçoit un signal électrique à partir du contrôleur (36) et en réponse fait varier le débit de l'air sous pression dans ce dernier. 10
7. Appareil selon l'une quelconque des revendications 4 à 6 comprenant, en outre, un deuxième pistolet (16a) adapté pour projeter de l'air sous pression et des particules de poudre dans un deuxième courant (18a) en direction successivement des parties de surface transportées (21a-g) de l'article, le deuxième pistolet (18a) et le premier pistolet (18) étant placés le long d'une ligne perpendiculaire à la trajectoire de déplacement et au sens de projection. 20
8. Appareil selon l'une quelconque des revendications précédentes comprenant, en outre, un capteur (46a, 46b) relié de manière opérationnelle au contrôleur (36) et adapté pour détecter l'article (12) lors de son passage devant le pistolet (18, 18a) et envoyer un signal au contrôleur (36) pour initier la séquence de projection prédéterminée. 25
9. Appareil selon l'une quelconque des revendications précédentes, comprenant en outre un moyen de détection de la vitesse (54a, 54b) relié au contrôleur et adapté pour déterminer la vitesse du moyen de transport (14), pour corrélérer ainsi la séquence de projection prédéterminée à la vitesse à laquelle les parties de surface (19a-e, 21a-g) passent devant le pistolet (18, 18a). 30
10. Appareil selon l'une quelconque des revendications précédentes, comprenant, en outre, des moyens pour conférer une charge électrostatique aux particules dans le courant mélangé. 35
11. Appareil selon la revendication 10, selon lequel le moyen pour conférer une charge électrostatique est placé dans la trajectoire de transport 40
12. Appareil selon l'une quelconque des revendications précédentes, selon lequel le pistolet (18, 18a) reste dans une position fixe et le moyen de transport (14) transporte l'article (12) en passant devant le pistolet (18, 18a). 45
13. Procédé d'application d'un matériau de revêtement à un article, comprenant des étapes pour transporter un article tridimensionnel (12) à recouvrir le long d'une trajectoire de transport par rapport à un pistolet pulvérisateur (18, 18a), le pistolet étant orienté le long d'une trajectoire de projection généralement perpendiculaire à la trajectoire de transport et recoupant cette dernière, l'article (12) présentant une surface externe (13) à recouvrir, la surface externe comportant une pluralité de parties de surface (19a-e, 21a-g) de topographie et/ou d'aire de surface différentes, **caractérisé en ce que** le procédé est prévu pour déposer un revêtement en poudre, et comprend, en outre, les étapes consistant à mélanger les particules de poudre et de l'air sous pression dans le pistolet (18, 18a) pour former un courant mélangé, les particules de poudre fournies par une source de poudre (26, 26a) et l'air sous pression fourni par une source d'air sous pression (32), à projeter le courant mélangé à partir du pistolet (18, 18a) le long d'une trajectoire de projection pour recouvrir de poudre successivement les parties de surface (19a-e, 21a-g) lorsque l'article (12) se déplace dans la trajectoire de projection, et contrôler la vitesse de projection du courant mélangé selon la séquence de revêtement prédéterminée en faisant varier l'écoulement d'air sous pression à partir de la source d'air sous pression (32) pour fournir une pluralité correspondante de vitesses de déchargement du courant mélangé, la vitesse de projection étant fonction de la topographie de la surface et de l'aire de surface de la partie de surface placée dans la trajectoire de projection, pour déposer un revêtement de poudre uniforme sur les parties de surface avec une efficacité d'utilisation de poudre optimisée. 50
14. Procédé selon la revendication 13, comprenant en outre les étapes consistant à conférer une charge électrostatique aux particules projetées. 55
15. Procédé selon la revendication 14 selon lequel la charge électrostatique est transmise à l'intérieur du pistolet (18, 18a).
16. Procédé selon l'une quelconque des revendications 13 à 15, comprenant, en outre, l'étape consistant à détecter l'article (12) lors de son passage dans la trajectoire de projection, pour actionner ainsi un contrôleur (36) pour initier la séquence de dépôt de revêtement prédéterminée.
17. Procédé selon l'une quelconque des revendications 13 à 16, comprenant, en outre, l'étape consistant à mesurer la vitesse à laquelle l'article (12) se déplace dans la trajectoire de projection et le long de la trajectoire de transport, et à entrer la vitesse mesurée dans un contrôleur (36) pour contrôler la sé-

quence de dépôt de revêtement prédéterminée.

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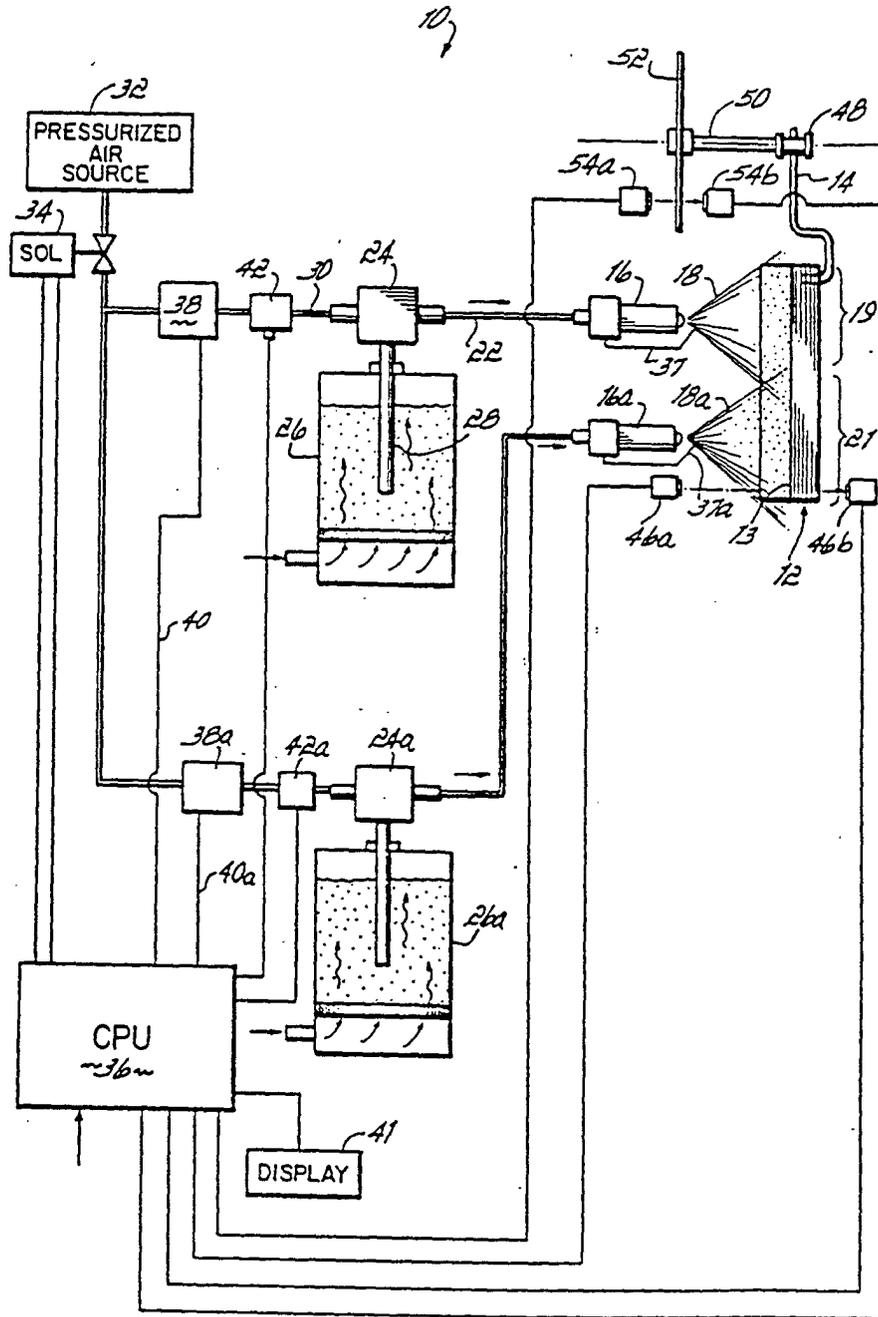


FIG. 1

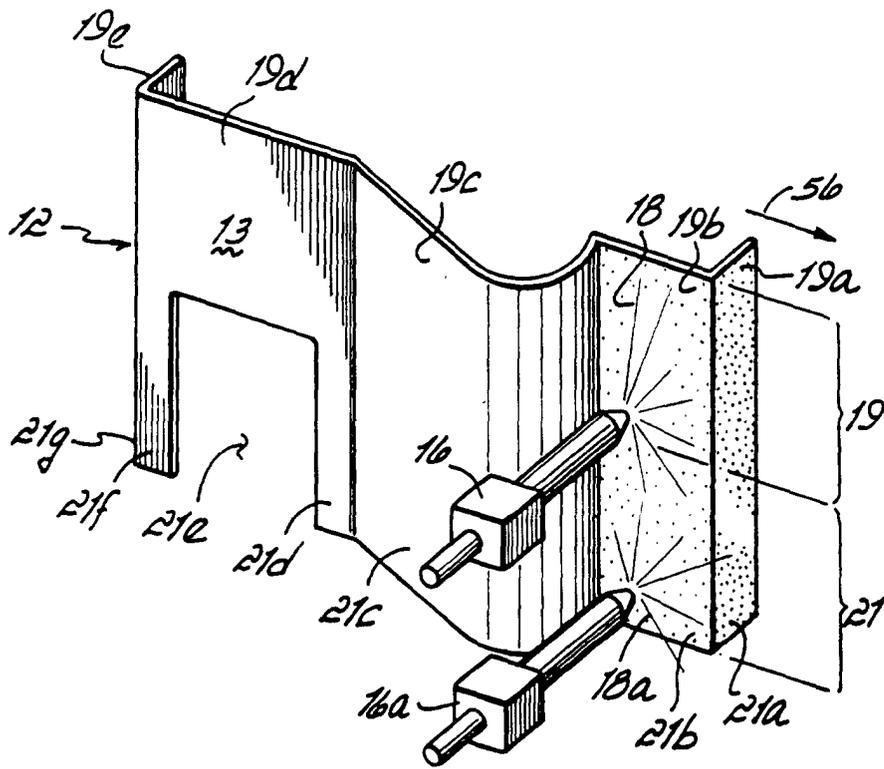


FIG. 2

