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Probst et al.

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[54] **POWDER COATING APPARATUS**

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Related U.S. Application Data

[60] Division of Ser. No. 278,594, Aug. 7, 1972, which is a continuation of Ser. No. 126,621, March 22, 1971.

[52] **U.S. Cl.** **118/626;** 118/627; 118/630

[51] **Int. Cl.**^{2}... **B05B 5/02;** B05B 7/14; B05C 11/16

[58] **Field of Search** 118/620, 621, 626, 627, 118/630

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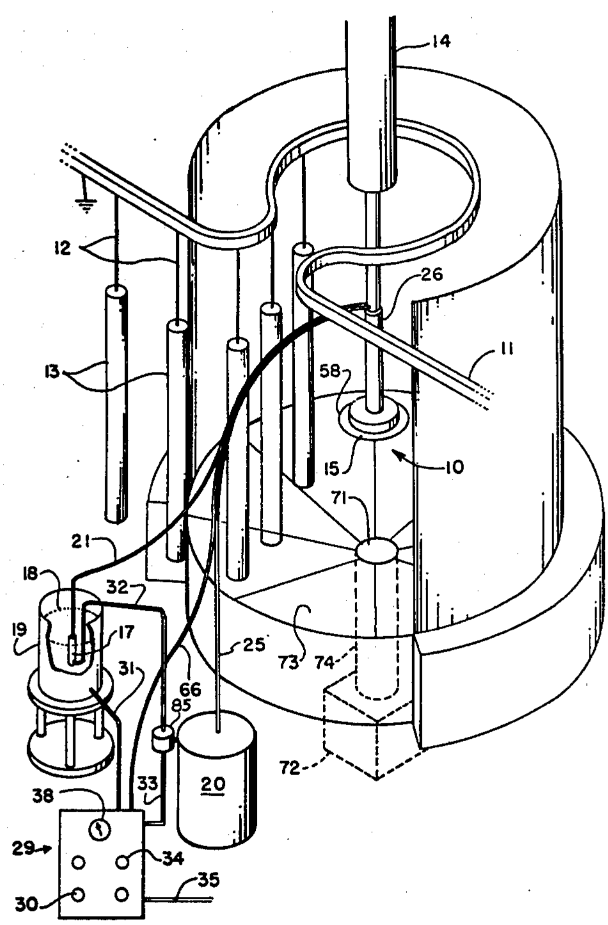
[57] **ABSTRACT**

An electrostatic powder spraying apparatus that includes a non-rotating disk-like member having an edge; the electrostatic field extends between the edge of disk and articles to be coated. A first means of the apparatus deflects powder radially outwardly into a chamber. The chamber is adjacent the first means and provides space in which tangential streams impart a spiral motion or whirling cyclone-type motion to the radially deflected powder. An apertured means is spaced from the non-rotating disk-like member. The spiral motion of entrained powder moves it outwardly along the surface of the non-rotating disk-like member and causes air to be aspirated through the aperture to mix with the powder moving radially outwardly along the surface of the disk-like member. By this means the powder is given sufficient momentum to be ejected from the edge of the disk to the vicinity of an article at a powder attracting potential where the electrostatic field forces can guide the charged powder to the article.

12 Claims, 4 Drawing Figures



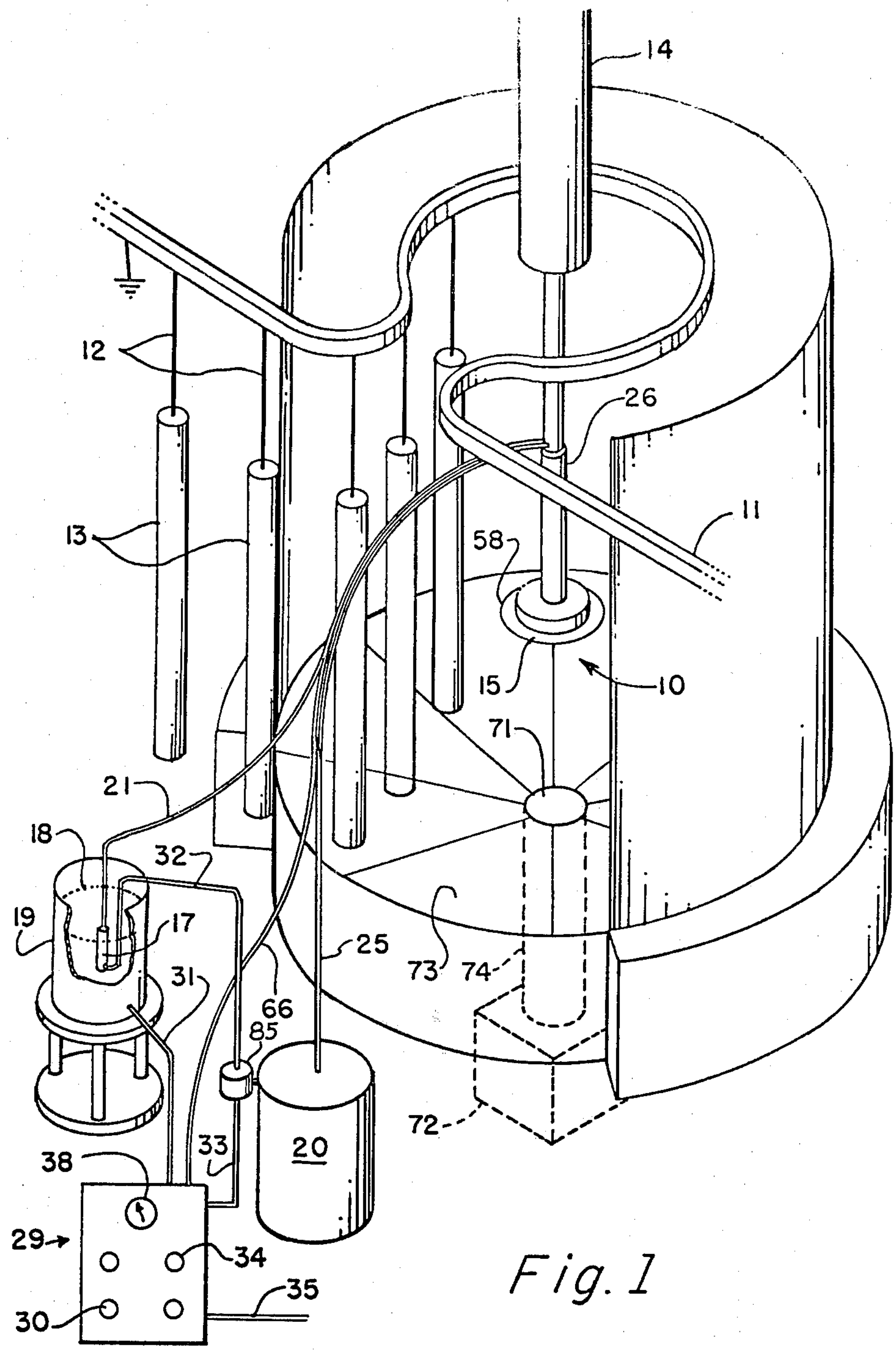

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Fig. 1

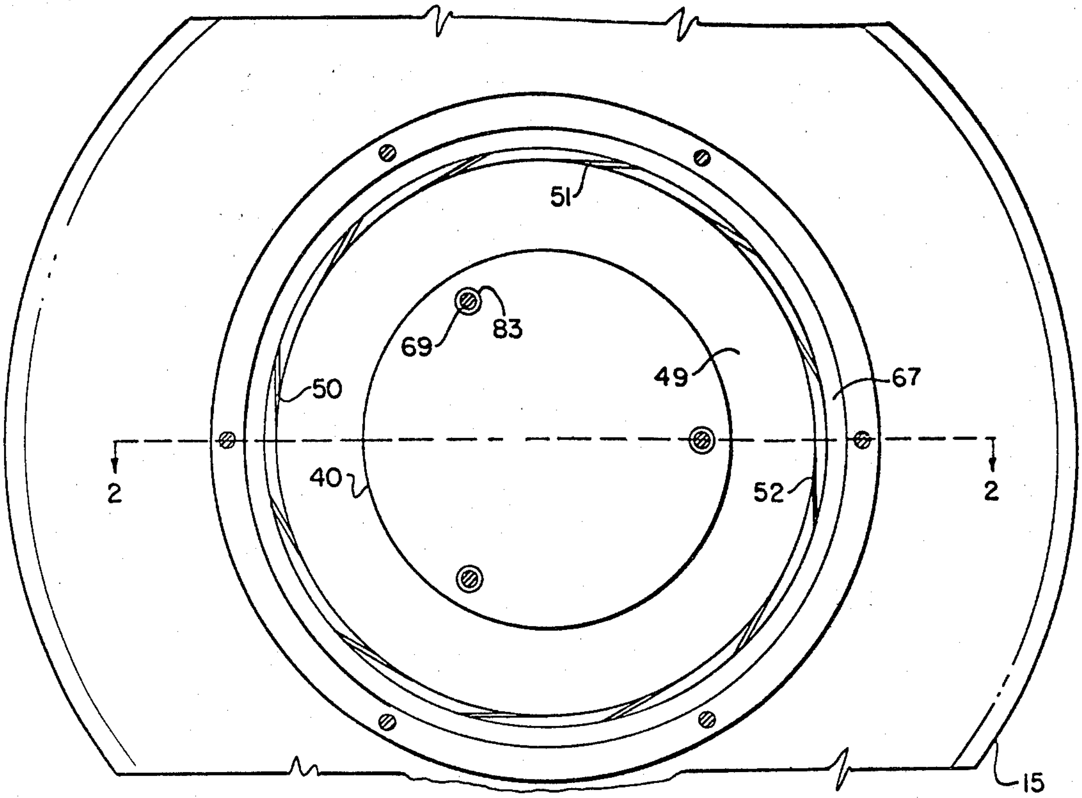

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Fig. 3

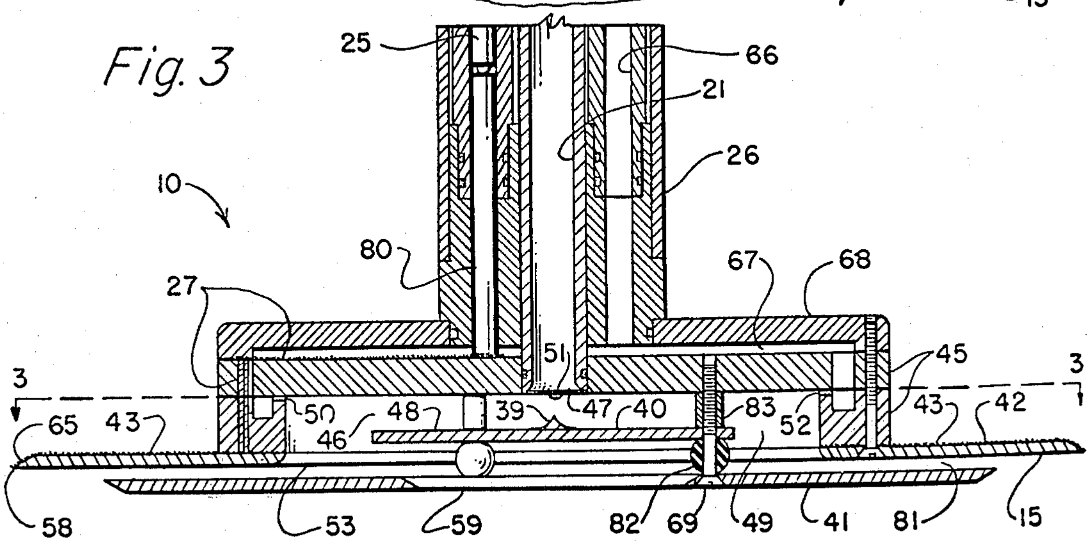

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Fig. 2

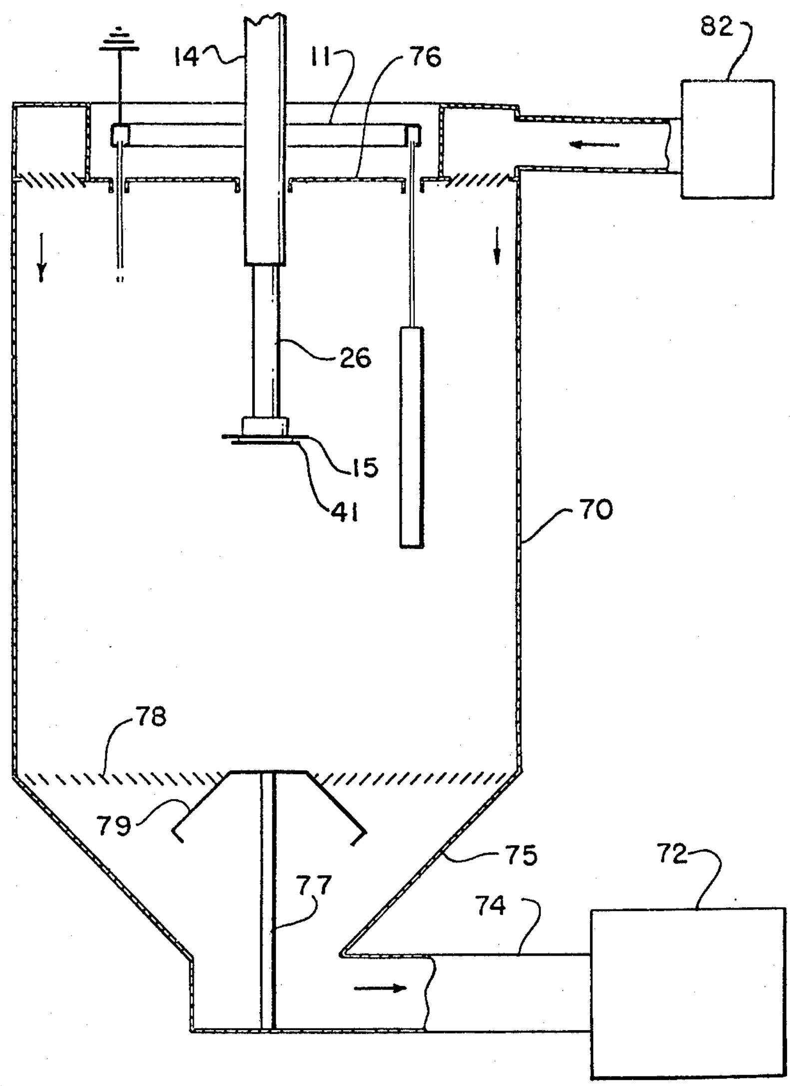

Fig. 4

POWDER COATING APPARATUS

This is a division of Application Ser. No. 278,594, filed Aug. 7, 1972, which is a continuation of Application Ser. No. 126,621, filed Mar. 22, 1971.

The present invention relates to coating articles with powder particles entrained in a gas, such as in air, and, more particularly, to an apparatus for and method of substantially uniformly distributing powder particles over the surface of a non-rotating member as a non-rotating disc-like member of the apparatus and ejecting the powder particles radially from the edge of the disk using aspirated air. An electrostatic field is used to electrostatically charge the powder particles. Preferably, the electrostatic field extends between the edge of the disk and articles to be coated.

It is highly desirable to have an apparatus which will form particles of powder into a radially expanding spray pattern having substantially uniform powder distribution therein so that the articles to be coated can be moved around the apparatus and through the pattern to receive a coating of powder particles. In this manner the powder deposition zone can be extended, as compared to the zone provided by several other previously suggested devices, and the powder is deposited on the article surface over a longer period of time. This latter feature is particularly desirable where the accumulation of heavier powder layers on the article is required to meet coating specifications.

Further, it is a desideratum to provide a non-rotating member which ejects the powder into an electrostatic field substantially uniformly and with sufficient momentum to carry the powder to the vicinity of the article to be coated, even though such article is 6 to 19 inches away from the edge of the non-rotating member, without establishing a flow of air in the direction of the articles being coated of such a character as to blow powder particles already deposited on the article away from the article. In addition, the powder should be conveyed across the surface of the non-rotating member in a manner to bring the powder as close as is possible to such surface of the member so that the powder, when ejected from the edge of the member, is brought in close proximity to the edge of the member. The field gradient is the greatest at the edge of the non-rotating member and by having the powder pass closely by this region, the powder particles are provided with a high charge-to-mass ratio and thus the tendency of the powder to deposit upon the article is greatly increased.

The present invention, directed to satisfying these desires, provides an apparatus for and a method of projecting or ejecting and charging powder from a non-rotating member. Powder entrained in air is conveyed to the non-rotating member in such a manner as to strike a first powder deflector means which reduces the forward velocity of the powder, deflects it about **90** degrees and causes it to essentially mushroom out in all directions. The powder travels in the deflected direction toward and into an annular chamber. In the chamber a swirl of air is provided by a plurality of jets of air entering the chamber approximately tangential to the side walls of the chamber. The deflected powder is picked up by and mixes with the swirl air in the chamber. Swirling the powder-air mixture in the chamber carries the mixture to an opening in the chamber. The powder particles and the carrier air composed of the entraining air and the swirl air escape from the chamber under the action of centrifugal force and are directed radially outwardly across the surface of the non-rotating member in a spiral fashion. The powder is propelled outwardly from the edge of the member as an expanding pattern having a relatively uniform distribution of powder therein.

A second deflector, spaced a short distance from the non-rotating member assists in "locking" the air-powder mixture to the surface of the member so that the powder does not leave that surface prematurely and so that substantially all of the powder passes in close proximity to the outer edge of the member. An aperture in the center of the second deflector allows air to be aspirated into the mixing chamber by the movement of the powder-air mixture from the chamber where it is added to the primary conveying air and the swirl air provided by tangential jets of air in the chamber. The aspirated air helps to maintain the required air velocity for conveying the powder particles and, therefore, the velocity necessary to move the powder particles outwardly to the edge of the member with sufficient momentum to carry the powder particles to the vicinity of the article to be coated. Electrostatic forces can then guide the powder particles to the article in the desired fashion. It should be understood that the effective flow area of a non-rotating member such as a non-rotating disk-like member increases as the powder particles move radially outward, and therefore, a greater volume of air is required to provide the powder velocity at the edge of the disk-like member necessary to maintain the powder air-entrained and to propel it outward toward the article to be coated with sufficient momentum to carry it to the vicinity of the article. If the aperture is not provided in the second deflector, an undesirable accumulation of powder particles occurs on the disk-like member and significant amounts of powder fail to reach the immediate vicinity of the article. The air aspirated into the chamber is essentially "free" air as opposed to the jets of air used to entrain and convey the powder initially or the jets or air used to provide the swirl air in the chamber and across the non-rotating disk-like member. An aperture in the second deflector significantly increases the air flow across the surface of the disk-like member over the air flow across the disk when an aperture is not provided in the second deflector.

The non-rotating disk-like member is fabricated from a non-conductive material. A coating having relatively high electrical resistance is applied to the uppermost surface of the disk-like member, that is, the surface opposite the surface across which the powder particles are propelled. This coating extends from about center of the disk-like member to its outer edge. A high voltage direct current potential is applied to the coating. The coating conducts the potential to the outer edge of the disk-like member and thus the edge becomes one terminus of a divergent electric field extending radially outwardly from the edge to the article. This field is concentrated at the edge of the disk-like member. As the powder particles are propelled through the high gradient field, they become electrically charged so each particle receives a high charge-to-mass ratio. Being projected to the vicinity of the article, the charged particles are attracted to the article surface and collect thereon by virtue of the charge carried by the powder particles. Because the non-rotating disk-like member is fabricated from a non-rotating conductive material and the coating is of relatively high electrical resistance, deleterious disruptive discharges are kept to a minimum when the edge of the disk-like member is contacted by the article being coated with particles of powder.

The present invention causes the powder particles to be ejected from the non-rotating disk-like member in a substantially flat plane and in a direction which is substantially parallel to the electrical forces of the field. The ports or apertures from which the jets of air are introduced into the mixing chamber are displaced further from the axis of the mixing chamber than the air ports associated with spray devices providing a conical spray. The present invention uses a first powder deflector to deflect the powder outwardly and into a chamber containing swirl air, and an apertured second deflector to assist in "locking" the powder onto the surface of the disk-like membere. The use of a non-rotating disk-like member has advantages over a rotating powder disk in that no bearings are required, no source of energy for rotating the disk is required, and no seals are required between the stationary powder feed hose and the rotating shaft necessary to rotate the disk. The present invention also does not depend upon any mechanical means for imparting circular motion to the powder to move it toward the article.

The appended drawings are intended to illustrate an apparatus embodying the concepts of the present invention constructed to function in the most advantageous mode presently devised for the practical application of the principles involved in the hereinafter described invention.

In the drawings:

FIG. 1 is a diagrammatic illustration of a system embodying a form of the present invention;

FIG. 2 is a partial cross sectional view of an apparatus including the non-rotating disk-like member taken across the line 2—2 of FIG. 3;

FIG. 3 is a partial cross sectional view of the apparatus taken across the line 3—3 of FIG. 2; and

FIG. 4 is a powder reclamation system that can be used with the invention.

"Powder," as that word is used herein, means and includes thermoplastic dry powders such as polyester, polyvinyl chloride, polypropylene, polyethylene, nylon, cellulose acetate butyrate; thermosetting dry powders such as epoxies, polyesters, acrylics; other dry powders such as starch, talc, vitreous enamel; and the like.

Many powders, and particularly synthetic thermosetting and thermoplasic powders, when fused, provide films which have characteristics, such as corrosion resistance, color and dielectric strength which make them desirable as coating materials. For example, epoxy resins may be applied and fused to pipe and fittings used in handling corrosive materials; and fused polyesters, butyrates and acrylics may be used as protective and decorative coatings for large flat surfaced articles such as automotive parts, appliance parts and the like, or tubular articles such as bicycle frames and the like. Still other powders such as powdered fluxes can be applied to a surface to be used ultimately in the powder form. Also powdered talc can be applied to prevent self-adhesion of the surfaces being coated. The particular powder used to coat the article will depend on, among other things, the purpose for which the coating is to be used, the nature of the finish required, the environmental conditions to which the article is to be subjected and the like.

Generally, powders are prepared by grinding bulk material, usually at a low temperature. Powder having a particle size in the order of 20 to 200 microns is preferred for electrostatic powder spraying, however, the powder may be coarser or finer, depending on the particular material and application thereof.

Referring to FIG. 1 of the drawing, a powder dispensing or spraying apparatus is indicated by the reference numeral **10**. The powder apparatus **10** is non-rotating. A conveyor **11** is provided with electrically conductive hook means **12** for carrying a plurality of articles to be coated with particles of powder such as tubular articles **13** in an arcuate path around the powder apparatus **10**. The powder apparatus **10** may be mounted for vertical reciprocation by hydraulically operated reciprocator **14**. The support housing **26**, attaching apparatus **10** to the reciprocator **14**, is fabricated from a dielectric material such as nylon or the like.

The lower end of reciprocator **14** carries the powder apparatus **10** which includes a non-rotating member as a substantially flat, non-rotating disk-like member **15** and a second deflector or baffle **41**, as shown in FIG. **2**, each fabricated from a suitable dielectric material such as phenolic or the like. The apparatus **10** is connected to a venturi pump **17** by hose **21**. The pump **17** draws powder particles **18** from fluidized powder container or bed **19** and delivers the powder particles to powder disk assembly **10**.

Conveyor **11** and hook means **12** maintain articles **13** at a powder particle attracting potential during the period of time the articles are in the powder coating zone. Preferably, conveyor **11** and hook means **12** are maintained at ground or earth potential. The sharp edge **58** of the non-rotating disk-like member **15** from which powder is ejected is maintained at a high electrical potential relative to ground by means of a suitable direct current power supply **20** connected to the disk-like member through cable **25**. The direct current power supply **20** is capable of supplying any desired voltage up to about 100,000 volts direct current to the apparatus **10**. Preferably, the polarity of the voltage applied to the apparatus **10** is negative although for some applications a positive voltage may be desired.

It should be noted that articles **13** are carried by conveyor **11** in an arcuate path (exceeding a semi-circle) around the apparatus **10**. The path may be characterized by the Greek letter "omega." It is also noted that the path over which articles **13** are carried is spaced radially outwardly from the apparatus **10**. The electrostatic force existing between edge **58** of the apparatus **10** and grounded articles **13** assists in directing the powder particles outwardly toward the articles along a path which is substantially parallel to the path dictated by the momentum of the particles. During movement around the apparatus **10**, the articles **13**, if adequately symmetric, may be rotated by suitable means (not shown) about an axis determined by hook means **12** so that all sides of the articles **13** are presented a number of times to the action of the apparatus **10**.

Powder particles **18** are entrained in air by means of venturi pump **17** immersed in the powder in bed **19** and delivered to the apparatus **10** through hose **21**. The powder bed **19** includes a foraminous sheet means (not shown) for assisting in fluidizing the powder particles **18**. The powder is fluidized by passing flowing air through the foraminous sheet located near the bottom of bed **19**. Air flowing through the powder causes the powder to expand so as to occupy a greater volume in the bed and to thus become "fluidized."

A control panel assembly **29** includes a suitable valve means **30** which controls the flow of air from a source (not shown) through hose **31** to the fluidizing bed **19**. A venturi pump **17** positioned in the powder bed **19** has associated therewith an air inlet hose **32**, an on-off solenoid valve **85**, an air hose **33**, pressure regulating valve **34** and air supply hose **35** connected to a suitable compressed air source (not shown). The outlet of pump **17** is connected through hose **21** with the rear end of the powder apparatus **10**. The rate of flow of air through venturi pump **17** is controlled by pressure regulating valve **34**. The air pressure, as indicated on gauge **38**, provides a reference which can be used to conveniently and readily duplicate desired powder flow rates.

A high voltage D.C. power supply **20**, capable of supplying any desired voltage up to 100,000 volts or more to the powder apparatus **10** is connected with the extended edge **58** of the non-rotating disk-like member **15** through cable **25** and a current limiting series resistor **80**, as shown in FIG. **2**, enclosed in the housing **26** which is of suitable dielectric material such as plastic. An electrostatic field is established from edge **58** of the non-rotating disk-like member **15** to articles **13** being coated. The powder ejected from the disk-like member **15** acquires an electrical charge and is projected into the electrostatic field between edge **58** of the disk-like member **15** and the articles **13** and attracted to and deposited on the articles thereby providing the articles with a coating of powder. The articles **13** are subsequently subjected to a suitable temperature so that the powder will be fused and flow in a substantially continuous film or coating.

Referring now to FIG. **2**, the apparatus **10** is mounted at the lowermost end of housing **26** which supports the apparatus on the reciprocator **14**. The venturi pump **17** and power supply **20** are connected to the apparatus **10** through conduits associated with the housing **26**. The apparatus **10** includes a first powder particle baffle or deflector **40**, an apertured second powder particle baffle or deflector **41**, a non-rotating disk-like member **15**, chamber **49**, cylindrical block **45** and a cup-shaped housing **68**. The deflectors **40** and **41**, disk **15**, cylindrical block **45** and housing **68** are fabricated from non-conductive or dielectric material such as phenolic or the like.

The rear face or upper surface **42** of disk **15** is provided with a substantially continuous conductive coating **43** having a high resistivity. A suitable material for coating **43** is described in U.S. Pat. No. 3,021,077. The disk end of high voltage cable **25** is connected to the rearward end of current limiting multimegohm resistor **80**, which in turn is connected to the conductive coating **43** by way of path **27** including a resistive portion and a wire portion. It is desirable to minimize the quantity of metallic conductive material associated with the apparatus **10** to minimize the effective electrical capacity of the powder spraying apparatus. The advantages of minimizing the effective capacity are disclosed in U.S. Pat. NO. 3,048,498. The safety features disclosed in that patent are desirably incorporated in apparatus **10**.

The first powder baffle or deflector **40** is carried by a plurality of fasteners **69** such as plastic bolts or the like which couple deflector **40** to block **45**. Powder deflector **40** and the block **45** cooperate so as to provide annular opening **46**. The configuration of the periphery of deflector **40** may be round, ellipsoidal, or the like so as to provide a substantially uniform distribution of powder particles in annular opening **46**. The radial extent of deflector **40** should be greater than the radial extent of orifice **47**. Orifice **47** is the powder outlet orifice of tube **21** at the disk and is connected to bed **19** through conduit **21**. The forward velocity of the powder ejected from orifice **47** is decreased when the powder strikes the rear surface **48** of deflector **40**. The powder is deflected about 90° in all directions. A substantially conically shaped means **39** may be located at the center of the deflector **40** to aid in the deflection of the powder into a 360° outwardly moving pattern. Preferably, the axes of the deflectors **40** and **41** and the orifice **47** are coincident.

Powder particles **18** are deflected toward chamber **49** at a reduced velocity. Chamber **49** is formed, in part, by the structural cooperation between deflector **40**, deflector **41** and block **45**. Jets of air are introduced into the chamber **49** substantially tangentially to the direction of the flow of powder particles ejected from orifice **47**. The jets of air are introduced through a plurality of apertures illustrated, in part, by apertures **50, 51** and **52** formed in the side walls of the chamber **49** to thereby assist in effecting a uniform distribution of the powder over surface **53** of disk **15** and in aspirating air through aperture **59**. As many apertures as are necessary to achieve the desired results may be formed in the walls of the chamber **49**. The jets of air intercept and swirl the powder over surface **53** in a substantially whirling cyclone-type fashion. The velocity of air entraining the powder and the velocity of the jets of air entering the chamber **49** are so interrelated that the powder moves substantially radially along the under surface **53** of disk **15** in restricted slot-like opening **81** provided by the cooperative relationship between disk **15** and deflector **41**.

As shown in FIG. **3**, the apertures **50, 51** and **52** extend from plenum **67** into chamber **49** so as to lie along a tangent to the circumference to chamber **49**. Air from a compressed source (not shown) is caused to flow to the apertures **50, 51** and **52** through air passage **66** and plenum **67**. Plenum **67** is formed by the structural cooperation between housing **68** and block **45**.

The deflector **41** functions to assist in "locking" the air-entrained powder to surface **53** so that the powder does not prematurely leave the disk **15**, and so that substantially all of the powder particles pass in close proximity to sharp edge **58** of the disk **15**.

Aperture **49** formed in the deflector **41** allows air to be aspirated into the mixing chamber **49** by the movement of the powder-air mixture from the chamber. The aspirated air is added to the primary entraining air used to entrain the powder drawn from powder bed **19** and to the swirl air provided through the various apertures in the side walls of chamber **49**. The aspirated air assists in maintaining the desired velocity of the air used to entrain and carry the powder particles as the particles move radially out toward edge **58** of disk **15** and toward the articles to be coated with the momentum necessary to carry the powder to the article to be coated. It should be understood that the cross-sectional flow area increases as the powder moves radially outwardly along surface **53** of disk **15**, and, therefore, a large volume of air is required to provide an air velocity at the edge **58** of the disk sufficiently high to maintain the powder entrained and to propel it to the vicinity of the article to be coated thereby. Forming the second deflector **41** without aperture **59** results in some powder particles accumulating on surface **53** of disk **15** and in significant amounts of powder failing to possess sufficient momentum to propel them to the vicinity of the articles to be coated. Upon being propelled to the vicinity of the article, the electrostatic forces guide the powder particles to the surface of the article. The electrostatic field for charging and depositing the powder ejected from the apparatus **10** extends from sharp edge **58** of disk **15** to articles **13** being coated. The charge on the particles is greatest when the powder particles are caused to pass in close proximity to the edge **58** of disk **15** since the field gradient is great at the edge of the disk.

Preferably, the major surfaces of disk **15** and the deflectors **40** and **41** are substantially flat. The radial, swirling flow of powder across surfaces of the deflectors **40** and **41** tends to prevent a build-up of powder particles on such surfaces and does not establish an air flow in the direction of articles **13** being coated which would blow from the articles, powder particles already deposited thereon. It is seen that apparatus **10** should not have any air flows associated with it that are likely to blow off powder that has heretofore been deposited and thereby decrease deposition efficiency.

Edge **58** of disk **15** is provided with a surface **65** having an angle in the order of 30° with the lower surface of the disk. This sharpens edge **58** so that the electrical field gradient at the edge is sufficiently high to provide the powder particles with a high charge-to-mass ratio. However, the angle of surface **65** can be varied considerably consistent with physical strength and maximum field gradient required.

During the coating operation, the grounded articles **13** are moved to a coating zone where charged particles of powder ejected from the apparatus **10** are attracted by the articles **13** to be coated and are retained on the articles by electrostatic attraction. As the coating becomes thicker, a surface charge is established on the articles because the particles tend to retain their electric charges. This charge tends to inhibit the accumulation of additional powder. The maximum thickness of the coating which can be applied varies with the electrical properties of the different powdered materials and with the voltage applied to sharp edge **58** of the disk **15**. The powder deposited on the articles being coated will tend to accumulate first in the area most closely aligned with edge **58** of the disk **15**. As the maximum coating thickness on this area is achieved, the deposition pattern expands and the particles are deposited on more distant portions of the article surfaces. The result is that the entire article **13** tends to acquire a substantially uniform coating with a minimum of relative movement between the apparatus **10** and the article **13**. If spraying is continued after the article is coated to maximum thickness, the powder particles will merely fail to be deposited on the article. Such excess powder will go past the articles **13** as oversprayed material, accumulate within the enclosure **70** and may be recovered in any suitable manner as by filter-separator **72**.

After a coating of the desired thickness is deposited on article **13**, it is removed from the coating zone, and the powder is cured in a suitable manner, as by heating to the melting temperature of the powder particles. In some cases additional applications of powder may be necessary to achieve at thicker coating. Preheating of the article to be coated increases the maximum thickness of the coating which can be achieved. The powder particles are heated upon the contact with the article and since the electrical properties of the hot material are different from those of the cold, the charge is dissipated rapidly permitting the application of additional powder particles.

The following examples are given to further illustrate the concepts of the present invention.

EXAMPLE 1

Unheated cylindrical metal articles **13** having a length of about 42 inches, a diameter of about 1 inch and arranged on about 3-inch centers are conveyed in an arc of about 270° in extent around the non-rotating disk-like member **15** of apparatus **10** at a rate of about 9 to 10 feet per minute. Powdered epoxy **202**, manufactured by Minnesota Mining and Manufacturing Company, having an average particle size of about 20 to 150 microns, is ejected from the apparatus **10** using air pressure at the pump of about 45 pounds per square inch and having an air flow rate of about 1.5 scfm with a delivery rate of about 240 grams of powder per minute. The spacing between the disk edge **58** and articles **13**, when the articles are adjacent the apparatus **10**, is about 14 to 19 inches. The articles are in the coating zone for about 45 to 60 seconds. The voltage applied to disk edge **58** from the power supply **20** through resistor **80** is approximately 100 kilovolts. The reciprocator **14** moves the apparatus **10** vertically over the length of the articles at about 10 times per minute. After spraying the articles with the epoxy powder, the coated articles are subjected to a fusing cycle of about 375°–450°F for about 2 minutes or more depending on the thickness of the metal wall of the cylindrical articles. An epoxy film of two to three mils thickness is formed on the articles. It is to be understood that the length of time required to fuse the epoxy powder can be reduced if the articles are appropriately pre-heated prior to depositing powder thereon.

EXAMPLE 2

The above example is repeated using a suitable vinyl powder such as vinyl powder 1315, manufactured by the Polymer Corp., having an average particle size of about 20 to 150 microns. The fusion cycle for the powder is about 450°–475°F for about 2 minutes or more depending on the thickness of the metal wall of the cylindrical article. A vinyl film of two to three mils thickness is formed on the articles.

The relationship between the diameters of deflector **41** and disk **15** and the spacing between deflector **41** and disk **15** should be such that the entrained powder does not leave the surface of the disk prior to passing in close proximity to edge **58** of the disk. Preferably, deflector **41** has a diameter substantially equal to or a few inches less than the diameter of disk **15**; a deflector **41** having a diameter 1 to 3 inches less than the diameter of the disk **15** is most preferred.

The spacing between disk **15** and deflector **41** should be such as to cause the powder to remain in close proximity with surface **53**. The distance between deflector **41** and surface **53** of disk **15** is adjusted by turning fasteners **69** into or out of cooperatively associated threaded apertures to thereby compress or release compressive pressure heretofore exerted upon resilient plastic spacers **82.** The distance separating deflector **41** and surface **53** should be substantially constant over the radial extent of both elements. Deflector **40** is predeterminately spaced from orifice **47** by plastic spacers **83.**

The radial extent of chamber **49** should be such so that the multiple of circumferentially directed air jets impart to the air entrained powder in the chamber a whirling cyclone-type motion which causes the entrained powder particles to escape from the chamber as an expanding powder-air mixture into the slot-like opening **81** provided by the structural cooperation between disk **15** and deflector **41.** The escape of the expanding powder-air mixture from the chamber is of such a nature as to aspirate air through aperture **59** into slot **81.**

Although substantially all of the powder ejected from apparatus **10** is attracted to and deposited on articles **13** by the action of the electrostatic forces, a small amount of the ejected powder will not be deposited. To reclaim the nondeposited powder particles, an air tube (not shown) connected to a source of air under pressure is suitably connected to floor **73** in the powder particle coating zone. Floor **73** is foraminous and directs streams of air upwardly so as to fluidize powder that has fallen to the floor. The nondeposited particles that have fallen upon the inclined floor **73** are fluidized by air forced upwardly through said floor so that the powder particles on the floor tend to flow downwardly along said floor to centrally located aperture **71.**

A collector **72** such as a filter-separator is connected to aperture **71** through conduit **74.** Preferably, collector **72** is maintained under at least a partial vacuum to assist in drawing the undeposited particles therein. In this manner, the nondeposited particles moving along the floor **73** will pass into conduit **74** and into collector **72** so that they can be collected for possible reuse.

An embodiment of a reclaiming means shown in FIG. **1** is shown in FIG. **4.** The enclosure **70,** essentially a cylinder body, has a height of about 8 feet with a conical bottom portion **75** and a substantially flat roof **76.** Preferably, the enclosure **70** includes appropriate entrance and exit silhouettes and tunnels for the articles to be coated with powder. Conveyor **11** is outside and above roof **76.** The enclosure is exhausted of undeposited powder particles through the lower part of the conical bottom **75.** Air input to the enclosure will be through the silhouettes, the conveyor slot in the roof and through such other openings as may be formed in roof **76.** Preferably, these openings are covered with a suitable plenum which receives some air from a recovery system exhaust **82.** These latter openings can be arranged with adjustable covers to permit air flow adjustment. preferably, enclosure **70** is maintained at a negative pressure.

At the bottom center of enclosure **70** is a column support **77** to retain in position the center of a foraminous floor grill **78** positioned in enclosure **70.** Immediately below grill **78** and retained by column support **77** is an inverted conical member **79** that extends downwardly at an angle so as to provide a powder-air exhaust exit having an annulus around the bottom center axis of enclosure **70.** It is apparent that other suitable means of recovering oversprayed powder can be used.

Although the present invention has particular application to electrostatic powder coating, it should be understood that the concepts are also applicable to non-electrostatic powder coating if the powder is projected to the surface of articles **13.** When apparatus **10** is used in non-electrostatic powder coating situations, the powder particles are entrained in air and projected by an air stream as described above onto heated articles. The articles must be heated to or above the softening point of the powder particles before the powder particles are applied, so that the particles are softened on contact with the article, adhere to the article and coalesce forming a substantially continuous coating. In this method, heat is required in order that the powder particles adhere to the article. It should be understood that the necessity of preheating the article and the problems involved in maintaining the entire article at a relatively uniform temperature during the coating operation, which is necessary in order to obtain a uniform coating, makes such a method less desirable than electrostatically charging and depositing powder particles.

As regards electrostatic coating, it appears that, in the alternative, articles **13** can be connected to high voltage power supply **20** and that disk edge **58** can be grounded. An electrostatic field exists between the grounded edge **58** of the disk and the articles **13;** such an electrostatic field appears to have substantially the same effect on the powder particles as does the electrostatic field provided when the article is grounded and the disk edge is connected to the power supply **20.** Preferably, however, disk edge **58** is connected to the high voltage power supply **20** and articles **13** are grounded. Also, in the event the surface of articles **13** is electrically non-conductive, the surface may be rendered sufficiently electrically conductive using a suitable pretreatment coating. For example, the insulative surfaces of wood, fiberboard, Masonite hardboard, polyethylene, nylon, glycol-terephthalate polyesters, and the like may be pretreated with the pretreatment coating described in U.S. Pat. No. 3,236,679 to thereby render such surfaces sufficiently electrically conductive for electrostatic powder coating.

While the invention is illustrated and described in its presently preferred embodiment, it will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of this invention and as set forth in the appended claims.

We claim:

1. A system for coating an article with powder coating material including an enclosure defining a coating zone, means for moving the article over a substantially omega-shaped path within the enclosure, and non-rotating means for distributing the powder located at the approximate center of the omega-shaped path of the article and including a chamber and an orifice for ejecting the powder from the chamber, first means to deliver a flow of powder entrained in gas to the chamber of the powder-distributing means, the powder-distributing means having a powder direction changing deflector adjacent the orifice, the side walls of the chamber including a plurality of apertures directing gas jets into the chamber to swirl the powder in the chamber and to direct it radially outward from the chamber and over the powder direction changing deflector in an expanding fashion and toward the omega-shaped path of the article, and an opening adjacent the deflector into which gas is aspirated by the movement of the gas entrained powder from the chamber, the deflector of the powder-distributing means cooperating to combine swirling gas and aspirated gas and to move the powder toward the article.

2. The system for coating an article with powder coating material as claimed in claim **1**, wherein the deflector of the powder-distributing means forms a slot and an edge of the powder-distributing means is connected to a voltage source so as to provide a high voltage gradient at the edge for charging powder leaving the slot.

3. A system for coating an article with powder coating material including an enclosure defining a coating zone, first means moving the article along an arcuate path within the coating zone, and an apparatus for coating an article with particles of powder entrained in gas located at the approximate center of the path, second means to deliver a flow of powder entrained in gas to the powder coating apparatus, the apparatus being adapted to receive and project the powder entrained in gas, and including third means spaced from the orifice moving the powder projected from the orifice radially outward from an orifice toward the article to be coated, a nonrotating surface adjacent the third means across which the powder moves radially outwardly, and fourth means adjacent the surface across which the powder is traveling allowing additional gas to be introduced to the powder to provide a further volume of gas to assist in conveying the powder outwardly from the surface to the article to be coated with sufficient momentum to carry substantially all the powder to the vicinity of the article.

4. The system for coating an article with powder coating material as claimed in claim **3**, including means for electrostatically charging powder prior to deposition on the article.

5. A system for coating an article with powder coating material including an enclosure defining a coating zone, first means moving the article along an arcuate path within the coating zone, and an apparatus for coating an article with particles of powder located at the approximate center of the path, second means to deliver a flow of powder entrained in gas to the powder coating apparatus, the apparatus being adapted to receive the powder entrained in gas and including third means to project the powder radially outwardly from an orifice toward the article to be coated, a nonrotating surface adjacent the third means across which the powder moves radially outwardly, fourth means adjacent the surface across which the powder is traveling allowing additional gas to be introduced to the powder to provide a further volume of gas to assist in conveying the powder outwardly from the surface to the article to be coated with sufficient momentum to carry substantially all the powder to the vicinity of the article, and fifth means for reclaiming powder coating material not deposted on the article.

6. The system for coating an article with powder coating material as claimed in claim **5**, wherein the enclosure is positioned generally about the article while the article is being coated, the enclosure confining the flow of gas and further volume of gas adjacent the first means to move undeposited powder coating material in the enclosure to the means for reclaiming powder coating material to thereby assist in removing the undeposited powder coating material from the enclosure and a powder collector means connected to the enclosure means for collecting undeposited powder moved from the enclosure means.

7. An apparatus for coating an article with particles of powder entrained in a gas, including means having an orifice adapted to receive and project powder entrained in a gas, a substantially flat and radially expanding non-rotating surface across which the powder travels allowing additional gas to be introduced to the entrained powder providing a further volume of gas to assist in conveying the powder outwardly from an extremity of the surface and to the article to be coated with sufficient momentum to carry substantially all of the powder to the vicinity of the article, means for electrostatically charging powder prior to deposition on the article, and means to move the articles along an arcuate path during coating by the charged powder.

8. A system for coating an article with powder coating material, including the coating apparatus set forth in claim **7** comprising an enclosure surrounding said coating apparatus to define a coating zone, means for moving the article to be coated around the coating apparatus within the coating zone between the enclosure and the coating apparatus, said enclosure including a foraminous floor to support the undeposited powder and means to direct air upwardly through said foraminous floor to fluidize undeposited powder falling to the floor, said foraminous floor being so formed that the fluidized powder flows downwardly through an opening, and collecting means to remove the undeposited powder from the enclosure through said opening.

9. The system of claim **8** wherein said coating apparatus and said enclosure are coaxially arranged and said means to move the article from an omega-shaped path with the coating apparatus at its center.

10. The system of claim **8** wherein the coating apparatus is stationary and uses a flow of compressed air and a flow or induced air within the enclosure and passing within the coating apparatus to form a radially expanding pattern of powder extending to adjacent the omega-shaped path.

11. A system for coating an article with powder coating material, including the coating apparatus set forth in claim **7**, an enclosure for said coating apparatus to define a coating zone, means for moving the article within the coating zone between the enclosure and the coating apparatus, said enclosure including a foraminous floor having openings to permit the powder to pass therethrough, a conically-shaped collecting means below said foraminous floor, an enclosure roof connected with means to provide air flow, said means to provide air flow and said collecting means providing air flow downwardly within the enclosure to remove undeposited powder from the enclosure at its bottom.

12. The system of claim **9** wherein the coating apparatus is located concentrically within the enclosure and the roof substantially and entirely closes the top of the enclosure, except an opening for said means to carry the articles which forms an omega-shaped path concentrically located around said coating apparatus.

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