Dec. 2, 1958 R. E. HAYFORD ET AL 2,862,646

POWDER PARTICLE AEROSOL GENERATOR

Filed Feb. 18, 1955 3 Sheets-Sheet 1

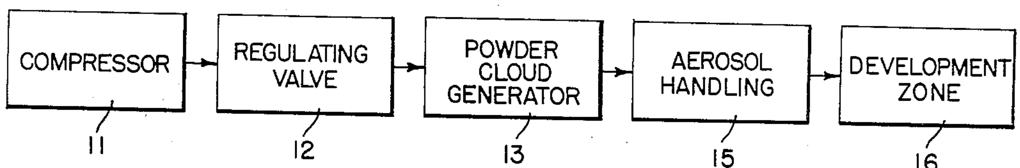

FIG. 1

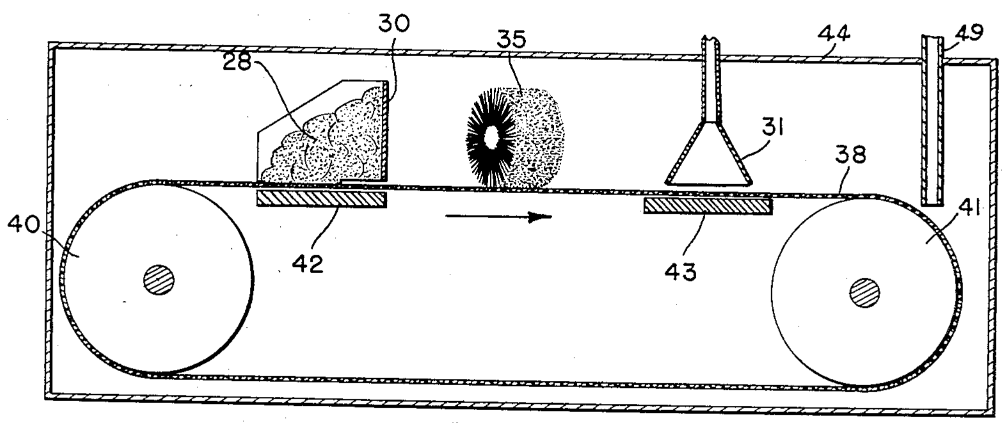

FIG. 4

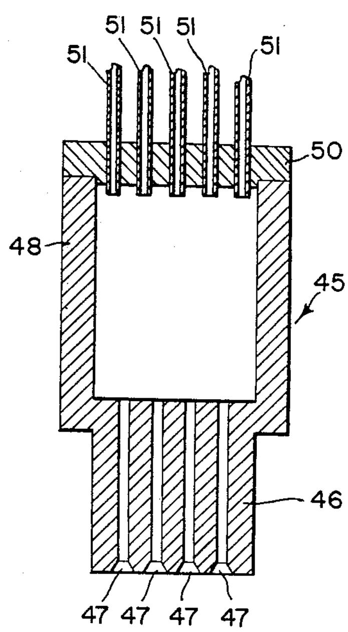

FIG. 6

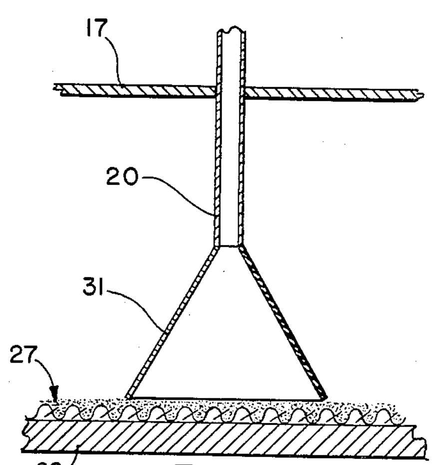

FIG. 5

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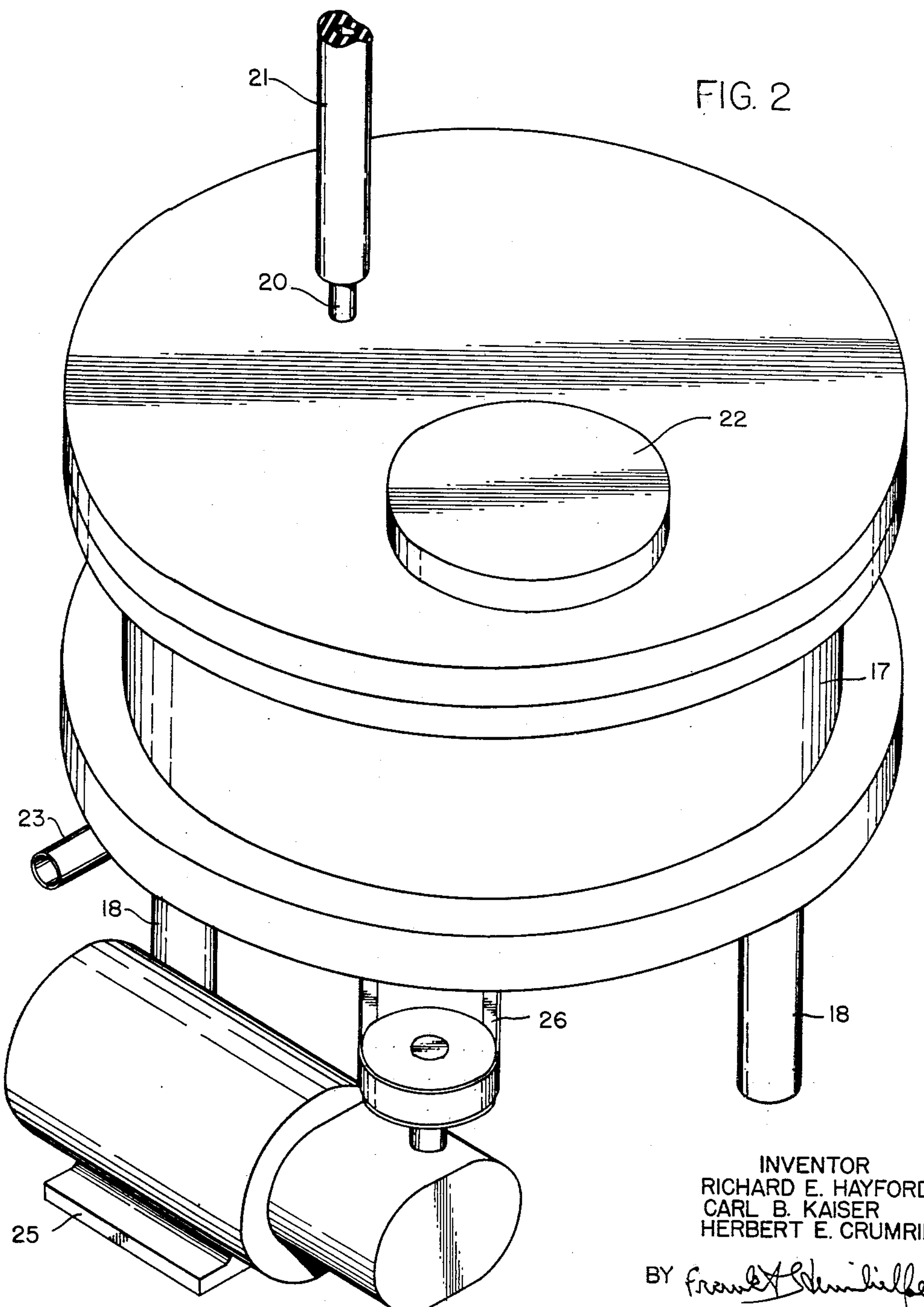
FIG. 2



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Filed Feb. 18, 1955 3 Sheets-Sheet 3

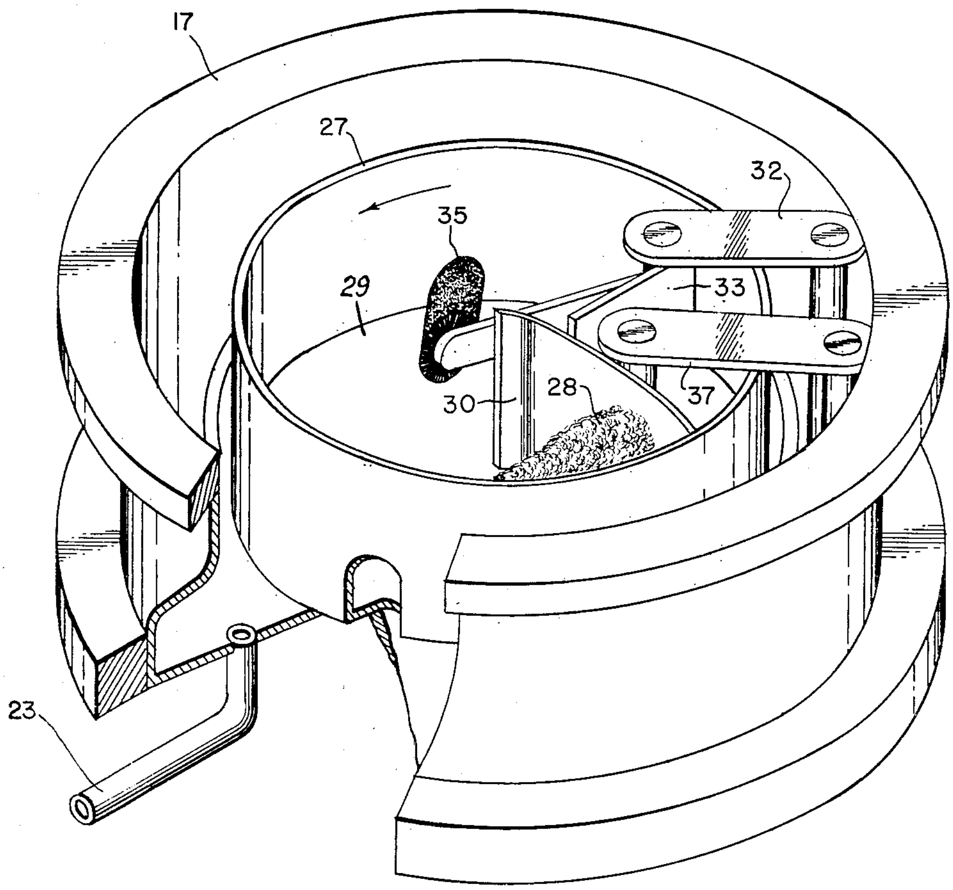

FIG. 3

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POWDER PARTICLE AEROSOL GENERATOR

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Application February 18, 1955, Serial No. 489,257

6 Claims. (Cl. 222—193)

This invention relates in general to xerography and in particular to development of electrostatic charge patterns.

Xerography uses the physical phenomena of photoconductivity and electrostatic attraction of electrostatically charged bodies to convert a light image into a physical image consisting of, for instance, black powder on white paper. The xerographic plate consists of a film of a photoconductive insulating material on a conductive backing member. In use, the plate is given an electrostatic surface charge and then exposed to a light image, which results in an electrostatic image on the plate surface. This electrostatic image, which may be allowed to remain on the plate or may be transferred, is developed by allowing it to attract and collect electrically charged particles of powder. The powder image may then be transferred and fixed to another surface, such as a sheet of paper, and the plate may be cleaned for reuse or the powder image may be allowed to remain on the plate for photographing, viewing, or the like.

The xerographic plate may consist of a sheet of metal on which a film of selenium has been deposited uniformly by a vacuum evaporation process. Materials other than selenium may be used; sulfur and anthracene are examples, though both are much slower photographically than selenium. Other materials may be added to the selenium to modify its characteristics; some materials added under the proper conditions, increase the plate sensitivity and spectral response. A material suitable for the film on a xerographic plate must be a good enough insulator in darkness to retain an electrical charge on its surface for sufficient time to permit exposure and development of the plate before much of the charge has leaked away. The material also must dissipate its charge rapidly when the plate is exposed to light.

The ions are deposited on the surface of the plate by the action of the electric field. Two arrangements have been found practical for sensitizing plates: (1) a corona discharge to provide both the ions and the electrical field, and (2) a radioactive, alpha-particle source to ionize the air, used in conjunction with an electrical field to move ions to the plate.

The xerographic plate, once sensitized, may be exposed in any of the ways ordinarily used for exposing silver halide photographic materials. After exposure to a light image, the plate bears an electrical image in which the most highly charged areas correspond to the areas of least brightness in the light image, the areas of least charge correspond to the brightest part of the light image, and those of intermediate charge correspond to areas of intermediate brightness. This electrical image is developed by bringing in contact with it particles of powder charged to the opposite polarity of the electrical image.

Two methods of image development are in use. One is described in Walkup U. S. Patent 2,618,551 and is known as cascade development. In this technique, the powder is mixed with a granular material, and this two component "developer" is poured or cascaded over the plate surface. The function of the granular material is to improve the flow characteristics of the powder and

to produce, on the powder, by triboelectrification, the proper electrical charge so that the powder will be attracted to the image. The other form of development is known as powder cloud development. In this technique of development, a disperson of electrically charged powder particles in gas is passed to the surface bearing the electrical image and particles are drawn from the gas dispersion to form a powder image on the plate. This form of development is disclosed and described in Carlson U. S. Patent 2,221,776 wherein a rotating vane wheel or propeller is used to stir up powder in a chamber, thereby creating a cloud of particles for presentation to the electrostatic image. The vane or propeller in that patent may be connected to a terminal of a battery to impart charge to the powder particles.

It is an object of this invention to improve upon means and methods for the development of electrostatic images.

It is also an object of this invention to improve upon apparatus for the develoment of electrostatic images.

It is a further object of this invention to improve the art of xerography by improving powder cloud generators for powder cloud development.

It is a still further object of this invention to provide new means and methods for creating aerosols of powder in gas.

Generally in powder cloud creating apparatus there is included a powder source, means to create a cloud of powder in gas, means to convey the cloud to a surface carrying an electrostatic image, and means to electrostatically charge the powder in the cloud before it reaches the surface. Such devices, which include one or a number of the above elements, and which are used to take powder from a source whether it be a mound of powder or whether it be in other shapes or forms and convert the powder to an aerosol of powder in gas is herein, and generally in the art, referred to as a "powder cloud generator" or as a "cloud generator."

An object in the art of xerography, as in any art concerned with image reproduction, is that of uniformly developing high quality copy. Means of obtaining this objective, while using powder cloud development, is through the uniform and constant presentation to the electrostatic latent image on a surface of a powder cloud of fine developer powder particles uniformly and densely dispersed throughout.

This invention is concerned with uniformly loading a membrane and uniformly dispensing the powder particles loaded onto the membrane in the form of a powder cloud. The membrane of this invention is capable of delivering uniform dispersions and great quantities of powder in gas. Further, the device of this invention is able to operate over long periods of time and can produce outputs which are sufficient for rapid processing in xerography.

The surface is enclosed in a housing and rotated or moved in a substantially horizontal plane. At one point on the surface is positioned raw or bulk developer powder particles. These particles are held in position by a retaining arm or meter blade, which also acts to meter out a layer of powder to the surface as it moves or rotates beneath the powder supply and retaining arm. The particular surface is one which loads uniformly as it passes beneath the powder supply. Gas is flowed into the housing at one point and powder in gas flows out of an output tube. An output orifice is connected within the housing to the output tube and is positioned at a distance above the surface. Particles on the surface are entrained in the flow of gas traveling from the housing out the output orifice and through the output tube, thereby creating at the output end of the output ube an aerosol of powder particles.

It is, therefore, an object of this invention to improve upon powder cloud generators so that a uniform and dense dispersion of powder particles in gas is created.

It is another object of this invention to improve upon means and methods of creating uniform and dense dispersions of particles of powder in gas.

It is yet a further object of this invention to provide a new powder cloud generator in which powder is uniformly loaded to a surface and then entrained in the flow of gas out an output tube.

A still further object of this invention is to provide new means and methods for generating a powder cloud in which powder is loaded onto a surface and then entrained in a flow of gas out an output tube.

For a better understanding of this invention, together with other further objects thereof, reference is now had to the following description taken in connection with the accompanying drawings, and the scope of the invention will be pointed out in the appended claims.

Fig. 1 is a block diagram of elements which would generally appear in xerographic cloud creating apparatus for use in developing electrostatic images.

Fig. 2 is an isometric view of an embodiment of a powder cloud generator according to this invention.

Fig. 3 is an isometric view of the internal elements of the embodiment of the powder cloud generator shown in Fig. 2.

Fig. 4 is a transverse sectional view of the interior elements of another embodiment of a powder cloud generator according to this invention.

Fig. 5 is a detailed cross section of an output fitting of a powder cloud generator.

Fig. 6 is a detailed view in section of another embodiment of an output fitting of a powder cloud generator.

Referring now with more particularity to the drawings, in Fig. 1 is shown a block diagram of elements which compose cloud creating apparatus for development of electrostatic images. As is indicated in this diagram, compressed gas is fed from compressor **11** to a powder cloud generator **13** through a regulating valve **12**, and the output of the powder cloud generator is fed through aerosol handling means **15** and then to the development zone **16** whereat developer particles are passed for development purposes to a surface carrying an electrostatic latent image.

The source of compressed or pressurized gas may be any suitable source, such as for example, an air pump or like pressure generating member or a suitable pressurized gas container. Such containers are readily available on the commercial market in the form of gas capsules of carbon dioxide or the like under pressure, in the form of bombs or the like of gas such as fluoro-chloroalkanes, which are available under the general family name of "Freon." Similarly, a suitable system may comprise a pump or generating means optionally in combination with a pressure chamber whereby fluctuations in pressure may be limited or avoided.

Regulating valve **12** is used to control the rate of flow of gas from compressor **11** to powder cloud generator **13** and also to control the pressure of gas supplied to the powder cloud generator. The powder cloud generator, which is the next block in this diagram following regulating valve **12**, is used to create an aerosol of powder in gas. It may be supplied with powder in what may be termed the raw or bulk form, that is powder taken directly from a container and directly supplied in that form without treatment. It may also be supplied with powder which is first treated and then placed in position in the generator. The particular powder used is dependent on a number of factors such as other elements used in the cloud creating apparatus, the form of xerographic development, the desired quality of final copy, and the like. A more detailed discussion of powders will appear below.

The aerosol handling block **15** of the diagram appearing in Fig. 1 may represent any number of means and apparatus for imparting an electrostatic charge or deagglomerating the individual powder particles in the aerosol supplied from the powder cloud generator. Charging and deagglomeration of particles may be accomplished by turbulently flowing them through fine capillary tubes. Charging may be accomplished by passing the aerosol of powder in air through a corona discharge zone, or the like.

The aerosol composed of charged particles in gas is next supplied, as indicated by the block diagram, to development zone **16**. Generally, this zone includes a means for expanding the aerosol to a cloud, and optionally this may be done by leading the air from tubes or the like to a larger area where the aerosol expands, creating the cloud of charged developer particles in gas. It is also feasible and sometimes desirable to use the particles in aerosol form without expansion.

In xerography in order to develop a true copy of the original image, it is generally desirable to develop against gravitational pull in that the electrostatic charges on the plate surface truly represent the pattern of the image projected to the plate surface, and allowing gravitational forces to operate in causing deposition of powder particles may result in a distorted reproduction. Also in causing the particles to deposit against the pull of gravity, deposition on the image bearing surface of agglomerates is reduced. This may be accomplished by positioning the plate with the image bearing surface facing downward and creating a cloud beneath it. In some instances particles deposited because of other forces may be removed during the development process through the use of such techniques as directing slight air currents or winds to the plate surface. Such winds or currents should be sufficient to remove particles not held in place due to electrostatic forces, but should be limited so that particles electrostatically held in place are not affected.

It is to be understood that many modifications may be made in the apparatus described in connection with the block diagram shown in Fig. 1. For example, a device may be inserted between the powder cloud generator and the aerosol handling block for purposes of further deagglomerating clumps of particles fed in the aerosol fed from the powder cloud generator. A device may also be inserted between the powder cloud generator and the aerosol handling block for purposes of dehumidifying the developer powder particles. These modifications have been included herein for purposes of demonstrating that the powder cloud creating device shown and described in relation to Fig. 1 is for illustrative purposes and is intended to include within its scope modifications and equivalents able to accomplish the purpose of generating a charged powder cloud for deposition on electric charge patterns.

It is also to be understood that the elements shown in Fig. 1 to create the aerosol of powder in gas, that is the elements omitting the development zone block, may be used for purposes other than developing. As for example, the aerosol may be fed to a belt loader or belt impregnator wherein a tape or belt of material is passed over an opening fed by the aerosol thereby loading powder particles into the belt. The belt is moved over the opening while covering substantially the entire opening at a uniform rate and the aerosol is fed to and through the opening at a substantially uniform rate. The aerosol passes to, into and, to some extent, through the belt material. Those particles which remain in the belt material become loaded or impregnated particles producing a loaded or impregnated belt. The belt may then be used for the development of electrostatic latent images and the like by blowing the particles from the belt to a development zone.

Reference is now had to Fig. 2, wherein is shown an external view of an embodiment of a powder cloud generator according to this invention. A housing generally designated **17** surrounds and encompasses the internal elements. The housing is an air-tight enclosure and should be able to withstand a pressure of 100 p. s. i. It may be formed in sections, allowing for removal of the base and top members. The housing material may be any material such as metals or the like, and it is to be understood, of course, that any material which may be formed into the necessary shape and which is able to withstand the pressures used is intended to be encompassed within this invention. Projecting from the base of the housing 17 are legs 18 intended to support the cloud generator. As will appear more clearly in connection with the discussion of the internal elements of the cloud generator, as for example in connection with Fig. 3, it is desirable to maintain one of these elements substantially in a horizontal plane, and legs 18 should be fitted and positioned and optionally adjustable to maintain such positioning of the internal elements. It is to be understood, of course, that the legs 18 may be dispensed with or may be substituted for, depending on positioning of the powder cloud generator shown in Fig. 2 as it relates to other equipment. Extending externally from the lid or top of housing 17 is output tube 20, which may be fitted with a hose 21 or the like connecting the powder cloud generator to other apparatus. Other means of conveying the aerosol from the cloud generator itself, other than output tube 20, may be used, such as capillary tubes or a capillary tube or the like. These varying and different output fittings will be discussed more fully below; however, they are mentioned here for illustrative purposes to indicate that it is not intended to limit the powder cloud generator shown in this embodiment only to an output fitting similar to output tube 20. Other possible means for conveying the aerosol from the powder cloud generator are intended to be encompassed within this invention. Positioned also within the lid or top of the powder cloud generator shown in Fig. 2 is a removable disc 22. This disc is positioned above the area at which powder particles are positioned within the powder cloud generator and should be easily removable so that new powder may be added when desired without removing the entire top or lid of housing 17.

An input tube 23 is provided in this embodiment entering the base of the generator near one wall of housing 17, but optionally it may enter housing 17 anywhere. Preferably, however, it is desirable to avoid directing the flow of input gas directly, without deflection, at the supply or reserve of powder particles within housing 17.

The driving mechanism shown in this embodiment comprises a motor 25 causing rotation of endless belt 26. The belt is connected to an axle (not visible in this figure) extending out of housing 17. This axle is connected within housing 17 to a cup-like element, not visible in Fig. 2 but shown and discussed in connection with Fig. 3. Motor 25 is preferably a variable speed drive motor.

The top or lid of housing 17 may optionally be formed of a transparent material. This will allow examination of the internal elements and of operation of the powder cloud generator.

In Fig. 3 is shown one possible internal structure of the embodiment of a powder cloud generator shown in Fig. 2. In this figure the top or lid of the device has been removed and the driving mechanism and legs are not shown. As in Fig. 2, the housing is designated 17 and the input tube is designated 23. In this embodiment a cup-like element 27 positioned within housing 17 comprises a cylinder having a length of about 4 inches and a diameter of about 6 inches and having one end sealed with a flat surface. The sealed flat end is positioned toward the base of the powder cloud generator and the walls of the cylinder are positioned to extend upward. Desirably this flat sealed end is kept substantially in a horizontal plane. Cup-like element 27 may be formed of any solid material such as metals, plastic, fibrous compositions, glass, and the like. The particular apparatus which has been constructed and operated according to the embodiment of the invention being described had a cup-like element 27 formed of brass, but it is presently believed that this material is not critical to efficient and proper

operation of the powder cloud generator being discussed. Extending downward from the center area of the base of cup-like element 27 is an axle which is connected to the driving means discussed in connection with Fig. 2, and the rotation of motor 25 causing movement of belt 26 causes rotation of cup-like element 27. Cup-like element 27 is positioned within housing 17, and is spaced above the base of housing 17 at a slight distance from the walls of housing 17. This form of positioning is simply to facilitate rotation of cup-like element 27 and the positioning of other elements which are now to be described and discussed.

A reserve or a supply of developer powder particles 28 is positioned on cup-like element 27 against a scraper, retaining, or meter blade or arm 30. This supply of powder particles 28 is retained in position on the cup-like element 27, whether cup-like element 27 is standing still or rotating, by meter arm or blade or retaining arm or blade 30. This arm or blade 30 is positioned by support 37, which is fixedly attached to housing 17. At the point of connection between retaining arm 30 and support 37, it is desirable to provide means to adjust the position of retaining arm 30 and means for the connection of different retaining arms. Generally the retaining arm or meter blade is curved to best retain powder; that is, it is desirable to form this blade to avoid movement of powder past the edges of the blade on the cup-like member. It is also desirable to form the blade curved in shape so that the larger mass of powder in developer supply 28 congregates at that area over the flat surface of the cup-like member 27, which will pass under an output orifice where powder will be removed in the output aerosol. The lower edge of retaining arm or meter blade 30 is preferably straight, that is, it is not indented, and it is preferably spaced apart from the flat bottom surface of cup-like member 27. It is desirable also that the spacing between the bottom edge of retaining arm or meter blade 30 and the top surface of the flat bottom surface of cup-like member 27 is variable within limits. Means may, for example, be provided at the connecting point between retaining arm 30 and support 37 to allow adjustment of retaining arms as well as to allow changing of retaining arms to thereby enable one to vary spacing. It is to be understood, of course, that other provisions may be made so that the spacing may be varied such as for example, means to move support 37 upward and downward, and the like. Blade 30 should be positioned to extend at least from the center of the cylinder to the wall of the cylinder or as close as possible to the wall so that a good seal between the blade edge and the wall exists. This is to prevent the escape of powder around the edge of the blade.

A support arm 32 similar to support 37 is fixedly mounted to housing 17. Support arm 32 is used to position a second blade 33 and a brush 35. The second blade adds additional and fine control to the amount of powder metered to the flat bottom surface of member 27. This blade 33 is angularly positioned with the radii of the enclosed end of the cylinder, and powder particles which are removed by scraper blade 33 are desirably carried to an area of the flat surface at the base of cup-like member 27 out of the path over which the output orifice is effective. Optionally, this blade may or may not be used, and means may be provided to move this blade in and out of contact with the powder layer passing under retaining arm 30. Brush 35 is spring mounted on support arm 32 so that a slight tension exists between the brush fibers and the top surface of the flat portion of cup-like member 27 beneath it. The rotation of cup-like member 27 causes rotation of brush 35. Rotation of brush 35 causes the brush bristles to rotate against and flick away from the flat surface of member 27. Movement by brush 35 causes agitation of powder particles deposited on the flat surface of member 27 which have passed by scraper blade or fine control blade 33. The brush should be so positioned and should be of such size so as to stir up any particles on that portion of the disc which is to pass beneath the output orifice. The output orifice is positioned above the flat sealed end at a point along the direction of rotation of cup-like member 27 following passage beneath brush 35. Although not shown in this figure, it is noted that optionally it may be desirable to provide a cleaning device positioned next in the direction of rotation of the cup-like member 27 following the area 36 over which the output orifice is effective. Whether or not such a device is provided is dependent basically on whether the particular base material of member 27 tends to clog. Clogging will depend generally on the particular powder being used and the particular surface material the base is provided with. Clogging presents a real problem, in that once an area becomes clogged with powder, in effect the powder becomes a portion of that particular part of the base, and when that area is presented to the powder supply for replenishment, it will pick up less powder than an area which is not clogged. Uniformity, then, in loading will not be present and it follows that non-uniformity in output will result. It is believed generally, however, that the use of brush 35 or other similar means will agitate the powder sufficiently before it gets to output orifice area to prevent caking of powder particles and to bring about complete removal of powder to the output orifice.

It is to be understood that the top surface of the flat bottom surface of wall 29 of cup-like member 27 in this embodiment may be any material either solid or porous, such as plastic, fibrous materials, glass and the like. When cloth or similar materials are being used, it is desirable to hold the material taut and also to support such material on a solid surface. In such instances, the cloth may be glued or otherwise permanently affixed to the plate closing off the lower end of the cylinder making up cup-like member 27. In each instance, the characteristic desired in this particular member is its ability to uniformly load with developer powder as it rotates beneath the supply of developer powder and its ability to uniformly load the gas rushing out the output orifice with the particles from this surface.

It is to be understood, of course, that although this embodiment has been described in terms of particular features and particular elements, this invention is intended to encompass these elements broadly. As for example, the particular cup-like member 27 of the embodiment shown in Fig. 2 has rather high walls. These walls are intended to mesh with the retainer blade 30 as an aid in keeping the powder supply 28 in place and as a further aid in allowing a large supply of powder to be stored as powder supply 28. It is to be realized, of course, that modifications may be made in the retaining arm which retains the powder supply so that the seal and supply aid of the wall is no longer needed. In such an instance, the wall may be spaced from the retaining arm edge. With such a modified retaining arm, there is also no need to use a circular cup-like member. The edges of the cup-like member no longer are needed to aid in retaining the powder particles, and, therefore, any shape or structure carrying a flat surface which uniformly loads with powder particles when passed beneath a supply of powder particles and which delivers this loaded powder to an output area is intended to be encompassed within this invention. Also, other means of supporting or holding in position blades such as blade 30 and blade 33 are intended to be encompassed within this invention. Also, it is to be realized that the principle of this invention is one of loading a uniform amount of material onto a surface and delivering this uniform load of material to an output tube. It is to be realized that relative motion is what is desired and necessary rather than motion only of the surface being loaded. Therefore, a device similar to the device shown in Fig. 2, in which the cup-like member is held stationary while the scraper blade 30 carrying a supply of developer particles 28 and the brush 35 and the scraper blade or the fine control blade 33 and the output orifice are moved relative to the stationary cup-like member will produce an aerosol of powder in air and is intended to be encompassed within this invention. The suggested modifications intended to be encompassed within this invention have been included herein for illustrative purposes, and it is to be understood that other modifications which are obvious to those skilled in the art are also intended to be included herein.

In Fig. 4 is shown another embodiment of a powder cloud generator according to this invention. In this figure endless belt 38 is rotated around cylinders 40 and 41. Cylinder 41 is driven by a motor (not shown) and is coated with a friction drive surface such as a layer of sandpaper or any similar rough material to cause movement of the belt. Cylinder 40 is positioned in the apparatus to provide free movement and tautness to belt 38 while guiding the belt as it moves. Positioned on the belt is a retaining arm designated 30, as in the case of the retaining arm shown in Figs. 2 and 3. The retaining arm 30 acts to retain powder particles 28 in position as the belt moves therebeneath over a portion of the belt moving substantially in a horizontal plane. Brush 35 is mounted next in direction of movement of belt 38 following movement of the belt under powder supply 28 and retaining arm 30. Brush 35 acts similar to the brush which was discussed in connection with Fig. 3 to brush up and agitate and loosen powder particles passed from powder supply 28 to belt 38 under retaining arm or meter arm 30. Next in direction of movement of belt 38 still in an area substantially in a horizontal plane, is positioned output orifice 31. Output orifice 31 acts to supply to the output tube the gas and powder particles entrained by the gas rushing out of the device. The apparatus of this figure is enclosed in a housing 44 which should be formed to withstand pressures up to 100 p. s. i. and an input tube 49 supplies gas to the housing. The retaining arm 30 is either positioned against the walls of the housing so as to prevent loss of powder and to act with the walls to retain powder in position on belt 38, or has trailing edges within the width of the belt to accomplish the same purpose. It is desirable also to have a support floor 42 positioned beneath the powder supply 28 and the meter blade 30 so that the belt is held in place as it passes beneath and is loaded with the powder from supply 28 metered by arm 30. A similar support arm is positioned beneath the area over which output orifice 31 is effective. Support arm 43 acts to maintain spacing between belt 38 and the output orifice 31.

Belt 38 may be composed of any flexible material. It is desirable that the particular material used be able to uniformly load with powder particles as it passes beneath supply 28 and retaining arm 30 and also able to uniformly supply powder particles to the gas flowing out output orifice 31. If a cloth material is used, it is sometimes desirable to provide a metallic backing member, such as aluminum foil, or the like, so that developer powder will not leak through or be brushed through belt 38, but instead will remain in place in and on the belt material. When plastic materials are used, it is desirable to present a somewhat roughened surface to the supply of developer particles 28. This form of roughened surface tends to increase the ability of the particular material to carry with it a load of powder particles. Uniformity in loading of such materials is substantially aided by the brushing and agitating action of brush 35.

Reference is now had to Fig. 5, wherein is shown in detail one embodiment of an output orifice. In a sense, output orifice 31, the numeral used to designate the output orifice in Figs. 2, 3 and 4 and so used here, is in appearance like an inverted funnel. At its base it has a circular opening having a diameter of one inch, which narrows and terminates in ¼ inch tubing. The tubing may be designated as output tube 20 and as shown in this figure, extends externally from generator housing 17.

The plane of the lower and open edge of output orifice 31 is desirably in a plane parallel to the top of the flat surface of cup-like member here generally designated 27. It is pointed out that in this embodiment, the flat surface of wall 29 of member 27 is shown as two layers of material. This has been done for illustrative purposes, to indicate a cloth material glued to a solid base. The solidness in the base of member 27 is desired and preferred so as to maintain an equal distance between the top of member 27 and the plane of the edge of output orifice 31. It is to be understood that the desired spacing will vary depending upon the particular developer powder material being used, the particular material being used for the top surface of member 27, the particular use the aerosol of powder in gas is being put to and the like. The use in many instances determines the rate of flow of gas through the powder cloud generator and rate of flow of gas and pressures within the housing which are also factors governing this distance. It is to be understood, of course, that output orifices in other forms or shapes are also intended to be included within the scope of this invention, and when different shapes are used, different spacings may be required. The shape of the output orifice shown in Fig. 5 has been found to work well for most applications of powder cloud generators according to this invention in the art of xerography and particularly well for line copy xerography and for belt or tape loading, a topic which will be discussed in greater detail hereinafter.

Reference is now had to Fig. 6 in which an enlarged view of another embodiment of an output orifice generally designated 45 is shown. At its base 46 or the area which is closely spaced and in a plane parallel to the loaded flat surface, a number of fine holes 47 are present. The base area is solid other than where holes 47 appear. Essentially area 48 is a hollow tube. The top 50 of output orifice 45 is another solid area having holes. In this figure extended through the holes in top 50 are capillary tubes 51. Capillary tubes 51 project through the holes in top 50 and extend slightly into the central area 48 which is, as indicated, a hollow tube. This type of orifice and others having a central zone such as central area 48 have been found particularly valuable in the art of xerography. For fine grain development, it is presently believed that carrying the particles through fine holes such as holes 47 at the base of output orifice 45 and then into a larger area such as central area 48, effects deagglomeration of clumps of powder particles carried into the gas stream rushing through holes 47. The deagglomeration of the particles aids in the presentation to the electrostatic charge pattern of very fine and individual particles for developing the electrostatic latent image. The passage of particles to capillary tubes such as tubes 51 has been found valuable in xerography to cause electrostatic charging of the particles and also deagglomeration. Turbulently flowing particles through capillary tubes is a valuable aid in reducing elements in a xerographic development unit in that the capillary tubes may act as the conveying means to the development zone, also as the electrostatic charging means and also as deagglomerating means. It is to be understood, of course, that although the capillary tubes are shown in this figure extending into central zone 48, they may be positioned to extend to holes 47 or they may be positioned only extending to the top of the holes in section 50 or the like of an output orifice.

It has been found that with turbulent flow of particles, extending the capillary tubes into the central zone 48 as shown in this figure, results in an orifice which is self cleaning. That is, capillary tubes themselves are quite fine, and in some instances tend to clog with powder particles. Also, central zone 48 and holes 47 could easily clog with powder particles. The form of structure shown in Fig. 6 tends to remain clean although continuously used over long periods with normal xerographic developer

powder turbulently flowing therethrough. It is to be realized, of course, that an infinite variety of shapes and forms of output orifices are possible, and the few herein discussed are mentioned only for illustrative purposes, and it is not intended to limit this invention thereto.

As has been previously pointed out, an object of this invention is to meter controlled amounts of developer powder particles to a surface and to pass this powder from the surface in an aerosol of powder in air to create a uniformly dense and constant powder cloud output. The powder is metered to the surface by placing powder on the surface and moving the powder and surface relative one to another. The surface is one that tends to draw powder with it and thereby becomes coated with powder material when it moves beneath the powder supply or powder reserve. A meter arm is positioned next to the powder reservoir to hold powder in position and also to remove that powder which the surface draws onto itself which is more than the quantity of loaded powder desired. Allowing too little powder to pass beneath the meter blade creates too thin an aerosol of powder particles, whereas allowing too much powder to pass under the meter blade will create too dense an aerosol of powder particles. Denseness is a desirable feature of an aerosol; yet, when an aerosol of powder in gas is too dense, fine grain development is detrimentally affected in that the aerosol tends to be a presentation of bulk powder including agglomerated powder to the output zone rather than a compressed cloud of powder particles in gas. The density of powder in gas or of the aerosol is a factor which relates to the particular use the aerosol is to be put to. For example, in the development of line copy or normal printed pages, it is quite proper and not unpleasing to the eye to develop with larger sized particles or particles of smaller sizes which are less deagglomerated than in the case of the development of continuous tone images wherein it is desirable to develop with deagglomerated and individual particles and smaller sized particles. In line copy work, then, the retaining or metering arm may be adjusted to allow passage of a greater quantity of particles to the surface being loaded, whereas when developing fine grain continuous tones, it is desirable to pass a lesser quantity of powder particles beneath the meter arm. Spacing of the meter arm from the surface being loaded relates to the particular surface material and to the particular powder particles being used. Yet, similarly, it may be said that spacing from just about contacting the top of the surface being loaded to 50/1000 of an inch will work quite well with the powder cloud generators herein being described. For continuous tone xerography using normal continuous tone developer powders and using the preferred loading surface as will be discussed more fully hereinafter, it has been found that spacing the bottom edge of the meter arm 30/1000 of an inch from the top of the surface being loaded is preferred and produces optimum quality reproductions.

Spacing of the output orifice is also an important consideration in the denseness of the cloud created. If the output orifice is spaced too close to the loaded surface, the tendency is to develop a very dense cloud, whereas if the output orifice is spaced at too great a distance from the surface, the tendency is to develop too thin a cloud. The general range of spacing, which is again dependent on a number of factors such as the particular output orifice being used, the particular developer powder, the particular surface material being loaded, the particular use the aerosol is to be put to, pressure within the housing, speed of movement of the loaded surface beneath the output orifice, the spacing between the lower edge of the meter arm and the surface being loaded, and the like, may be said to vary between slightly out of contact with the loaded surface to a distance of 50/1000 of an inch from the loaded surface. Also, it is pointed out that generally it is desirable to maintain turbulent flow at the point of entrance to the output orifice and in the output orifice generally so that the walls of the output orifice will remain clean due to the scouring action of the gas currents and particles turbulently flowing therein. Spacing, in some instances, may affect turbulent flow in the output orifice, and for the sake of keeping the output orifice clean, it is sometimes desirable to allow this factor to control the distance the output orifice is spaced from the loaded surface. It is to be realized, of course, that turbulent flow in the output orifice is only one of the factors controlling spacing and that the other factors must be taken into account. Preferred spacing of the output orifice from the loaded surface for continuous tone development using usual continuous tone, developer powders, and with the retaining arm or meter arm properly spaced from the surface being loaded and using an output fitting similar to the one shown in Fig. 6 to feed the particles to capillary tubes and using proper air flows and pressures through and within the housing of the powder cloud generator, has been found to be about 35/1000 of an inch.

For line copy or printed material or for using the powder cloud generator disclosed herein for purposes of impregnating belts, it is desirable to attain a slightly denser output than in the case of continuous tone usage. The retaining arm in such an instance is preferably spaced at from 30/1000 to 35/1000 of an inch and the output orifice is preferably spaced in such an instance at from 30/1000 to 35/1000 of an inch. Positioning the retaining arm at a greater distance than is preferred in the case of continuous tone xerography will allow a greater amount of particles to pass to the surface being loaded, and the output orifice being closer will draw more particles into the gas stream moving out of the device, thereby creating a denser aerosol.

In order to assure constant spacing between the retaining arm and the surface to be loaded and the output orifice and the surface to be loaded, it is desirable to position this surface on a solid base or to form the surface to be loaded as the top surface of a solid material. In the apparatus shown in Figs. 2 and 3, if materials are being used as the surface to be loaded, it is desirable to fasten or glue or attach such a material to the top surface of the base of the cup-like member. In an embodiment similar to that shown in Fig. 4, it is possible to assure spacing by raising the support blades beneath the retaining arm and powder supply beneath the output orifice slightly above the normal path of movement of the endless belt.

At present it is believed that the surface to be loaded may be almost any material. As has been indicated, when solid materials are used, it is desirable to present a roughened upper surface to the powder so that powder will be drawn both into and onto the surface. The roughness in a solid material should be rather uniform so that powder particles tend to be uniformly drawn along with the surface as it moves beneath the powder supply and meter arm. Also as has been indicated, it is often desirable to glue cloth-like materials or cloth to the solid surface to provide a cloth surface to be loaded. A study has been made of various cloth and cloth-like materials which can be used as the surface to be loaded. In this study a number of samples were tested for each of the eleven different types of materials listed. The data appear in Table I.

Table I

Material	Amount of powder held, gm./sq. in.	Material	Amount of powder held, gm./sq. in.
Velveteen	0.062	Wool jersey	0.013
Woolen coating	0.042	Filter paper, Whatman No. 1	0.011
Napped rayon lining	0.040	Mercerized cotton	0.016
Cotton flannel	0.030	Novelty weave wool	0.007
Cotton terry cloth	0.025	Cotton broadcloth	0.006
Miracloth	0.015		

The technique used in arriving at the data in Table I was that of tumbling powder over the cloth and scraping off excess powder with a blade. This data are an indication of the amount of powder particular samples gathered within and on themselves from tumbling of the powder over the samples. Table I indicates that materials having considerable nap are most effective in holding powder. It is to be understood, of course, that the materials listed in Table I are only a sample of materials which can be used to act as the surface to be loaded. Any material capable of drawing powder with it as it moves beneath the powder supply and the meter arm is intended to be encompassed within the scope of this invention.

Napped cotton flannel has been found the preferred surface to be loaded. Although cotton flannel does not appear at the top of Table I, it has been found through usage that the output produced when cotton flannel is being used is more constant and more uniform in density in the production of powder in gas directed from an output tube or into capillary tubes than the other materials appearing in Table I, and also it has been found that a cotton flannel surface produces consistent and better outputs than roughened solid surfaces.

Cloth materials or porous materials in general have been found valuable as the surface to be loaded, in that generally powder cloud generators using such materials tend to produce a finer and more deagglomerated cloud than when solid surfaces with roughened tops are used. It is presently believed that this better aerosol of particles in gas may be attributed to the partial impregnation of the powder particles into the porous membrane surface, thereby partially breaking down and deagglomerating agglomerates of particles in the powder supply. These particles, when removed at the output orifice, tend to remain in their deagglomerated state, creating a valuable cloud of individual particles in gas.

The housing of the powder cloud generator, according to this invention, should be able to withstand pressures of up to 100 p. s. i. Operation of powder cloud generators depending on their particular use, should be somewhere between 0 and 100 p. s. i. The preferred range of pressure for belt loading has been found to be .4 to 5 p. s. i. with best results being obtained at .8 p. s. i., and operation of powder cloud generators for continuous tone work is within the preferred range of 50 to 70 p. s. i., with optimum results being produced at 60 p. s. i. The preferred range of pressure when using the generator for line copy work is from 5 to 50 p. s. i. with optimum results being attained at about 30 p. s. i.

The air flow through powder cloud generators is dependent upon a number of factors such as the use of the aerosol, the pressures being used, and the like. Generally the air flow through the powder cloud generator is controlled by the desired free air flow of aerosol output. For example, in using the powder cloud generator embodiment shown in Figs. 2 and 3 and using an output orifice similar to the one shown in Fig. 6 having thereon ten capillary tubes extending from the top, it has been found that using the output from the capillary tubes to develop continuous tone images, a free air flow of from 3.5 to 4.5 C. F. M. at the development zone is desired and a preferred air flow of 4.1 C. F. M. gives optimum results. The range of air flow through the powder cloud generator in such an instance is from .7 to .9 C. F. M. It is to be understood, of course, that the figures being given for air flow and air pressure as preferred figures for the powder cloud generator as shown in Figs. 2 and 3 are specific figures which develop a continuous tone image in a reasonably short period. Continuous tone images may also be developed with low pressures such as 15 to 25 p. s. i. or even lower, and lower rates of air flow. The copy produced in such an instance will equal the quality of copy produced using higher pressures and greater air flow rates. The time required to develop the image will be longer. Modification of the output orifice and tubes may be necessary with low air pressure. It is to be understood the pressures may also be reduced for other uses of the equipment with a resulting increase in time to accomplish the purpose. The preferred air flow rates when using the embodiment of a powder cloud generator as shown in Figs. 2 and 3 to impregnate a belt within a reasonable time, range from .5 C. F. M. to 2.5 C. F. M. with best results and good speed being attained using .9 C. F. M., these figures being the desired free air flow at the output or belt loading zone. The air flows stated in this paragraph have been found using the preferred pressures stated in the last paragraph.

The speed of movement of a loaded surface beneath the output orifice is dependent upon a number of factors such as the particular surface material being loaded, the particular developer powders being used, the gas flow and gas pressure supplied to the device, the use desired of the output, and the like. For a generator constructed along lines of the embodiment shown in Figs. 2 and 3, it has been found that revolving the cup-like member at a rate of 1 to 5 revolutions per minute and preferably at 3 revolutions per minute tends to give optimum outputs. It is to be understood, of course, that the output of powder in gas tends to increase as the revolutions per minute of the cup-like member increase. If it is, therefore, desired to continue receiving a dense cloud with more gas pressures and lower gas flows, a dense cloud may be obtained with more revolutions per minute.

The principle of operation of the powder cloud generators being described herein is one of flowing gas into an enclosure having an output tube. Since the output tube is the only exit for the gas flow, the gas being flowed into the device leaves through the output tube. The output orifice attached to the output tube is closely spaced to the loaded surface and the gas rushing out the output orifice entrains into its stream the powder particles carried by the loaded surface positioned beneath or substantially beneath the output orifice. The operation of the device when operating properly removes completely all loaded powder from the loaded surface. As an aid to the complete removal, the brush stirs up the powder particles so that they may more easily become entrained in the gas flow rushing out the output orifice. Thus it is clear that increasing the speed of rotation of the cup-like member or increasing the speed of movement of the endless belt, will increase the powder particles passed beneath or substantially beneath the output orifice, and thereby create a denser cloud. Increasing gas flow in the device of this invention will tend to decrease denseness of cloud, in that all particles are entrained in lower gas flow rates and the same amount of particles for a larger flow of gas will create a thinner aerosol of powder particles.

Certain features relating to the developer material are pertinent in operating the powder cloud generator and pertinent in developing electrostatic images. In general, particles should be grossly smaller than the output tube diameter, and it may be stated that finer sized particles in the absence of undue agglomeration may reveal a print or picture more pleasing to the eye than larger sized particles. Thus, a convenient particle size which results in extremely high quality copy contemplates particles having average diameters in the order of 1 micron. Yet particles in a size range of about 5 to 10 microns are substantially undetectable as fine particles with the aid of a magnifying glass and would result in high quality reproductions. From the point of view of composition of the developer particles, prints or pictures may be produced with charcoal, carbon blacks, or carbonaceous pigments. Under proper conditions, any of a number of various carbon or lamp black materials may be employed, including such material as furnace blacks, channel blacks and the like. In addition, there may be used such material as milled charcoals and similar materials, or, if desired, finely divided materials having added pigment matter. In the latter category are materials such as finely divided resins containing pigments or dyes such as carbonaceous pigments or various coloring pigments and the like, compositions of this type being preferred where the print or picture ultimately is to be made permanent by a fusing process including heat or vapor fusing. Milled wood charcoal is the preferred developer material where the print or picture is not to be fused with heat or vapor.

The amount of developer particles placed behind the retaining arm or scraper blade is dependent on the amount of continuous use desired of the powder cloud generator and also on the shape and size of the retaining arm, which determines how much this arm will retain. Using a retaining arm 2½" in height and 3" in length, it is usual and proper to load the generator with from 150 to 400 gms. of raw powder particles.

Although this invention has been described in terms of a single retaining arm and a single output tube, it is to be understood and it is intended to include within the scope of this invention the use of more than one retaining arm followed by a flicking brush and an output tube in each instance. When more than one output tube is used to carry powder in air from the loaded surface, these tubes may be combined at one point to combine their output of powder in air or they may be used individually for similar or different purposes.

The uses this powder cloud generator may be put to include, but are in no way limited to, the development of electrostatic images and belt loading or impregnation. In belt loading, particles are carried to a belt of material and blown into the belt. The belt may then be used by blowing the particles impregnated into the belt out of the belt for the development of electrostatic images. Belts have their value as storage areas of developer particles for the development of electrophotographic images and also supply additional beneficial features which aid in the production of uniform and dense clouds. It is to be understood, of course, that other valuable uses exist for powder cloud generators as described herein.

While the present invention as to its objects and advantages, as has been described herein, has been carried out in specific embodiments thereof, it is not desired to be limited thereby, but is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. A generator of an aerosol of powder particles comprising a housing, a support layer positioned in said housing and having thereon a substantially flat surface, drive means to rotate said layer in a predetermined path including at all times positioning at least a portion of said surface substantially in a horizontal plane while facing in an upward direction, meter means within said housing positioned along the path of movement of said surface through which said surface moves substantially in a horizontal plane adapted to meter a uniform amount of powder particles to said surface and adapted to retain on said surface against said meter means a supply of powder particles, said surface being characterized by its ability to uniformly load with powder particles as it moves beneath a supply of powder particles, said meter means being positioned at a slight distance above said surface, brushing means positioned along the path of movement of said surface through which said surface moves substantially in a horizontal plane adapted to agitate powder particles metered to said surface, input means adapted to supply a flow of gas into said housing, and ouput means positioned at a slight distance above said surface along the path of movement of said surface through which said surface moves in a horizontal plane, said output means beings adapted to carry off a gaseous suspension of powder particles out of said housing.

2. A generator of an aerosol of particles comprising a housing, means positioned within said housing mounted for rotation and having an upper substantially flat surface, said means being positioned in said housing to maintain said surface facing upward while substantially in a horizontal plane, means to rotate said surface around its central area, meter means positioned within said housing at a slight distance above said surface adapted to meter a uniform amount of powder particles to said surface as it rotates therebeneath and adapted to retain a supply of powder particles in position on said surface against said meter means, said surface being characterized by its ability to uniformly load with powder particles as it moves beneath a supply of powder particles, brushing means positioned within said housing to impinge on said surface next in the path of movement of said surface following movement beneath said meter means and adapted to agitate by brushing powder particles loaded to said surface, input means adapted to supply a flow of gas into said housing, and output means positioned slightly above said surface next in the path of movement of said surface following movement beneath said brushing means adapted to carry out of said housing a gaseous suspension of powder particles.

3. A generator of an aerosol of powder particles comprising an airtight housing, an input tube adapted to supply a flow of gas into said housing, an output tube adapted to carry off a gaseous suspension of powder particles from said housing, powder conveying means including a substantially flat upper surface positioned substantially in a horizontal plane facing upward in said housing characterized by its ability to uniformly load with powder particles as a supply of powder particles and said surface are moved in contact and relative to one another, a retaining blade comprising a radial element positioned in said housing extending upward from said surface spaced at a slight distance therefrom adapted to retain on said surface against said blade a supply of powder particles, an output orifice attached to said output tube within said housing positioned above said surface at a slight distance therefrom, a brush within said housing to impinge on said surface and adapted to agitate powder particles loaded to said surface, and means to bring about relative movement between said surface and said retaining blade and relative movement between said surface and said agitating means and relative movement between said surface and said output orifice, said movement causing areas of said surface to first pass beneath said retaining blade and then beneath said agitating means and then beneath said output orifice.

4. A generator of an aerosol of powder particles for use in developing xerographic images comprising an airtight housing, a cylinder having an end thereof sealed positioned within said housing, said sealed end of said cylinder being positioned toward the base of said housing with the cylinder walls extending upward, the upper surface of said sealed end being positioned substantially in a horizontal plane, a retaining arm comprising a radial element fixedly mounted to said housing and positioned at a slight distance from said upper surface of said sealed end extending upward in said cylinder, said arm being positioned to extend at least from the center of said cylinder outward to the walls of said cylinder, an input tube adapted to supply a flow of air to said housing, an output tube adapted to carry a gaseous suspension of powder particles formed in said housing out of said housing, an output orifice at the end of said output tube within said housing positioned with its lower edge slightly above and in a plane parallel with the plane of said upper surface of said sealed end, a brush positioned to contact the upper surface of said sealed end, and a motor connected to said cylinder to cause rotation of said sealed end around its center, said retaining arm being adapted to hold in position a supply of developer powder particles on said surface of said sealed end against said arm as said surface rotates, said surface of said sealed end characterized by its ability to uniformly load with powder particles as said surface rotates beneath a supply of powder particles, said arm being adapted to meter a uniform amount of particulate material to said surface as said surface rotates therebeneath, said brush being adapted and positioned to agitate powder particles loaded to said surface and said output orifice being positioned and adapted to remove particles once agitated from said surface in an air flow and to feed the gaseous suspension of particles to the output tube.

5. A generator of an aerosol of powder particles for use in developing xerographic images comprising an airtight housing adapted to withstand pressures of less than 100 p. s. i., a cylinder having an end thereof sealed positioned within said housing, said sealed end of said cylinder being positioned toward the base of said housing with the cylinder walls extending upward, the upper surface of said sealed end being positioned substantially in a horizontal plane, a layer of cotton flannel material overlying said upper surface of said sealed end of said cylinder, a retaining arm comprising a radial element fixedly mounted to said housing and adjustably positioned out of contact and at a distance of less than 50/1000 of an inch above said layer of cotton flannel material, said arm being positioned to extend at least from the center of said cylinder outward to the walls of said cylinder, an input tube adapted to supply a flow of air to said housing, an output tube adapted to carry a gaseous suspension of powder particles formed in said housing out of said housing, an output orifice at the end of said output tube within said housing positioned with its lower edge out of contact and at a distance of less than 50/1000 of an inch above and in a plane parallel with the plane of said layer of cotton flannel material, a rotatable brush positioned to contact said layer of cotton flannel material, and a variable speed motor connected to said cylinder to cause rotation of said sealed end around its center, said retaining arm being adapted to hold in position a supply of developer powder particles on said layer of cotton flannel material against said arm as said layer rotates, said arm being adapted to meter a uniform amount of particulate material to said layer as said layer rotates therebeneath, said brush being adapted and positioned to rotate against said layer next in position in the direction of rotation of said layer following movement beneath said retaining arm to thereby agitate powder particles loaded to said layer and said output orifice being positioned and adapted next in the direction of rotation of said layer following movement of said layer beneath said rotatable brush to remove particles once agitated from said surface in an air flow, the feed of air through said generator being first into said housing from said input tube and then out said output orifice and into said output tube.

6. Apparatus according to claim 1 in which said support layer comprises an endless belt.

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