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2,792,971

PARTICLE AEROSOL GENERATION

Filed March 3, 1955

2 Sheets-Sheet 1

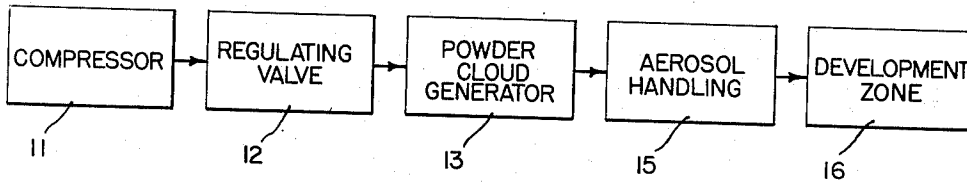


FIG. 1

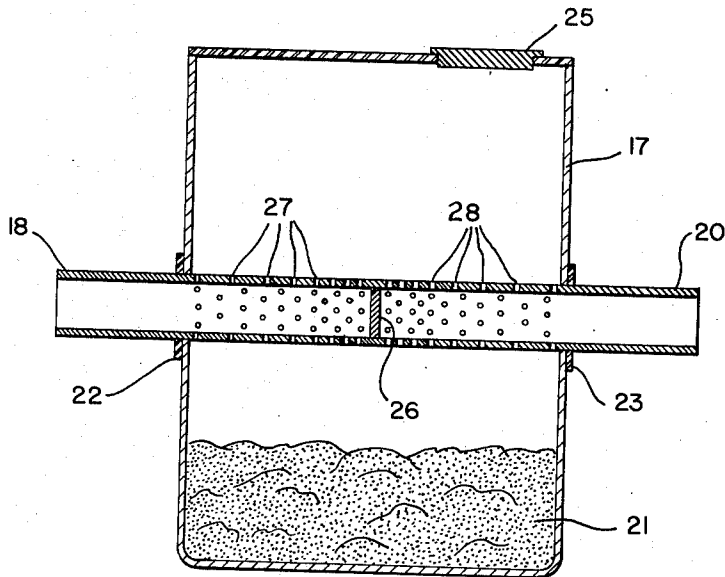


FIG. 2

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2 Sheets-Sheet 2

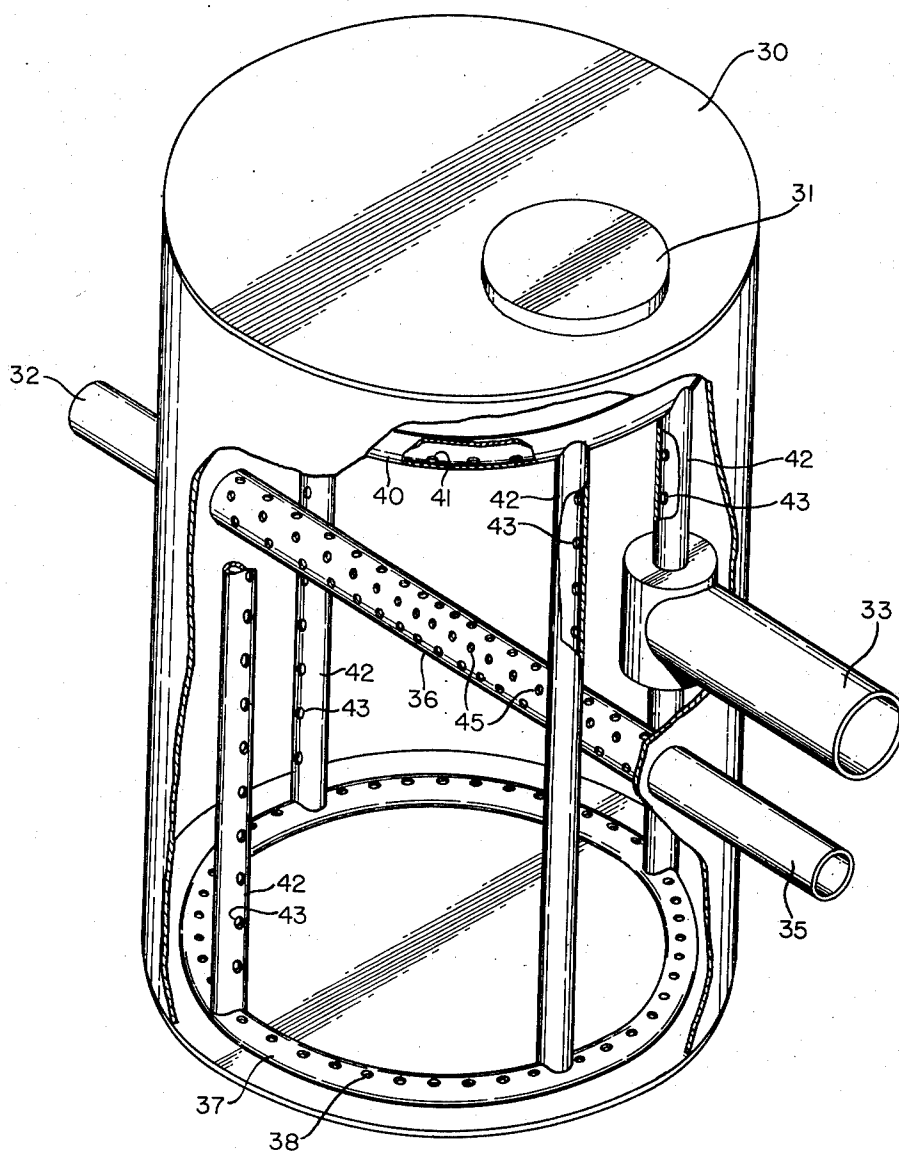


FIG. 3

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2,792,971

PARTICLE AEROSOL GENERATION

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2 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. A substance suitable for the photoconductive insulating material 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. Photoconductive amorphous selenium is an example of such a material.

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. The most highly charged areas of the electrostatic image correspond to the areas of least brightness in the light image to which the sensitive plate was exposed. The areas of least charge of the electrostatic image correspond to the brightest portions of the light image to which the sensitive plate was exposed. Areas of intermediate charge in the electrostatic image correspond to areas of intermediate brightness of the light image to which the sensitive plate was exposed. This electrostatic image which may be allowed to remain on the plate or may be transferred is generally developed by allowing it to attract 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.

One method of development is generally known as "powder cloud development." In this technique of development, a dispersion 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 development 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

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means and methods for creating aerosols of powder in gas.

Generally, in powder cloud creating apparatus there is included in 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 the 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."

The powder cloud generator of this invention includes a housing or an enclosure in which is positioned a supply of developer powder particles. Also positioned within the housing or enclosure are a number of tubes having many fine holes. At least two tubes extend out from the housing. One is used as an input tube and the other as an output tube. These tubes both connect to the tubes within the housing or enclosure. The principle of operation of this powder cloud generator is that of supplying gas through the input tube to the housing or enclosure.

The gas leaves the tubes within the enclosure by contracting and passing through the fine holes. Within the enclosure the gas combines with the powder particles and swirls about. The output aerosol of powder particles is created by contraction of the gas carrying particles to pass through the fine holes connected to the output tube and then expansion in the output tube as it passes along to the output end. This type of powder cloud generator has been found capable of producing very dense aerosols of powder particles rapidly. Also, the output aerosol of powder particles from this type of generator is composed of particles deagglomerated to a sufficient degree to allow the production of high quality xerographic prints. The powder cloud generator of this invention is also simple, efficient, and inexpensive.

And, it is therefore an object of this invention to improve upon powder cloud generators by devising apparatus able to produce aerosols of deagglomerated powder particles rapidly and efficiently.

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

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 a transverse section view of an embodiment of a powder cloud generator according to this invention.

Fig. 3 is a perspective view partially cutaway of another embodiment of a powder-cloud generator according to this invention.

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 image.

The source of compressed or pressurized gas may be any suitable source, such as for example, an air pump or

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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-chloro-alkanes 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 alone 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 and optionally this may be done by leading the air from tubes or the like to a larger area creating the expanded 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, when particles are made 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 forces other than the electric 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

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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 power 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 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 a simple embodiment of a powder cloud generator according to this invention. As shown in this figure, a housing 17 is fed by an input tube 18 and the aerosol created by this apparatus is led from housing 17 out an output tube 20. The housing is otherwise air-tight and air seals 22 and 23 surrounding the input and output tubes prevent leakage around the edges of tubes 18 and 20, thereby assuring as the only means of ingress into housing 17 means provided in input tube 18 and as the only means of egress means provided in output tube 20. Positioned somewhere along a section of the housing is a removable lid 25. This lid may be opened to insert developer powder particles into housing 17. When lid 25 is closed, its edges are sealed against gas leakage. A supply of developer powder particles 21 is shown in this figure at the base of housing 17. In this embodiment, input tube 18 and output tube 20 comprise one tube having a blocking wall 26 positioned centrally within housing 17; however, it is to be realized that two individual tubes may be used to accomplish the same objectives. Many fine holes 27 are formed in that portion of input tube 18 located within the walls of housing 17 and similar fine holes 28 are formed in that portion of output tube 20 positioned within the walls of housing 17.

To operate the device shown in Fig. 2, powder particles are loaded to the inside of housing 17 by opening lid 25 and pouring in a supply of particles. The particles will settle to the base of the device. Tube 18, the input tube, is connected to a supply of compressed gas. The gas feeds along the tube length and then into the housing through fine holes 27. The holes 27 in tube 18 are formed through all areas of that portion of the tube within housing 17. There is no particular regularity in the position of the holes and in fact, it is presently believed a degree of irregularity is preferred. The block 26 prevents the passage of compressed gas directly through to the output tube 20 and compels its movements through fine holes 27. The gas contracts when passing through holes 27 and then expands as it travels into housing 17. The expanding gas in housing 17 follows flow patterns which are believed to be irregular and without specific direction. If only one hole existed, it is believed that the flow of gas from the hole would tend to be shaped like a cone, having its apex at the hole. However, many holes are irregularly placed throughout that portion of input tube 18 which is within housing 17, and the many cones formed by the compressed gas flowing from holes 27 tend to extend within one another, and thereby distort the air flow from any particular hole. Also, the holes direct the gas in all directions within the housing. Whatever the particular paths taken by the gas escaping through holes 27, the objective obtained by the embodiment shown in this figure is that of agitating the particles of supply 21 to create an interspersed mixture of particles in gas swirling about within housing 17. The gas pressure created within housing 17 forces the mixture of particles in gas through holes 28 of output tube 20. As the gas flow carrying particles moves through fine holes 28, the gas is again compressed. It is expanded again

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when it reaches the inner area of tube 20. The negative pressure at the output end of tube 20 causes the compressed gas moving through holes 28 of output tube 20 to be directed to the output end. Thus, the output of an aerosol of powder particles is created at the output end of output tube 20. This output aerosol is created within a fraction of a second following the supply of compressed gas to the input tube.

Reference is now had to Fig. 3 wherein is shown another embodiment of a powder cloud generator according to this invention. A housing 30 surrounds the internal elements of this generator. Lid 31 which may be positioned at any point along the housing is a removable member which when in place seals that area of housing 30 against gas leakage. The housing should be air-tight in all areas with gas ingress and egress means being provided by the tubes projected into or extending out of housing 30. In this embodiment, three tubes are shown extending through housing 30. The ends of the tubes are numbered 32, 33 and 35. Tube ends 32 and 35 are actually the ends of the same tube, which is generally designated 36. Positioned within housing 30 at the base is a circular, tubular ring 37 having formed therein many fine holes 38. Positioned at the top of the device is a similar tube member 40 having many fine holes 41 formed therein. Extending between circular ring 37 and circular ring 40 are tubular posts 42, having formed therein many fine holes 43. That portion of tube 36 positioned within housing 30 has formed in it many fine holes 45.

The device of the embodiment shown in Fig. 3 may be operated in a fashion similar to the device shown in Fig. 2. Slightly different operation is also possible. To operate this device in a fashion similar to the device of Fig. 2, one end of tube 36 is sealed, as for example, end 32, and compressed gas is supplied to tube 33. The gas fed to tube 33 is led through to tubes connected therewith, which comprise tubes 42 and rings 37 and 40. The gas fed through tubes 42 and rings 40 and 37 escapes into the housing through fine holes 43, 38 and 41. In this embodiment, fine holes 38 are shown directed upward and fine holes 41 are shown directed downward, whereas fine holes 43 are positioned to create a clockwise swirl of air in housing 30 by being formed at points which are tangential to the circle, the circumference of which they create. The gas on passing through the fine holes is compressed and when leaving forms into the conical shape discussed in connection with Fig. 2. The different cones tend to react on one another and create air flows to agitate the powder particles. Powder particles in this device are loaded through lid 31 into housing 30. The mixture of particles swirling in compressed gas within the housing are forced with the gas through holes 45 in tube 36, thereby creating an output aerosol at end 35 of tube 36.

Operation of the device shown in Fig. 3 may also be modified by adding additional gas to the aerosol being created by unsealing end 32 of tube 36 and attaching therat a compressed gas source. It is to be realized, of course, that end 32 of tube 36 could be used for the output end and compressed gas could be fed to end 35 of tube 36. It is to be realized also that end 32 could be used for the output end when compressed gas is not being added to the output aerosol by sealing end 35 of tube 36 instead of end 32.

The device shown in Fig. 3 may also be used by sealing one end of tube 36, as for example, end 32, and feeding the input supply of compressed gas through end 35 of tube 36. This will create the swirling and agitation desired within housing 30 and the output aerosol of particles will be created at the output end of tube 33. The particles and gas in this instance will be carried through the same cycle of compression and expansion as they are when tube 36 is being used as the output tube. Generally, however, it is preferred to use tube 36 as the output tube rather than tube 33, in that tubes 40, 37

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and 42 are narrower and might more easily clog with powder particles when used to create the output aerosol, whereas tube 36 is substantially wider and tends not to clog.

Although it is not intended in any way to limit this invention, the following specific information is included herein for purposes of illustrating respective tube sizes, holes, pressures, and the like. A device constructed according to the embodiment shown in Fig. 3 has tubes having a $\frac{1}{8}$ inch inside diameter as tubes 42, 37 and 40. The fine holes 38, 41 and 43 have an inside diameter of 0.018 inch. The fine holes 45 have an inside diameter of 0.015 inch and the exit tube 36 has an inside diameter of $\frac{3}{16}$ inch. The input tube 33 has an inside diameter approximately twice the diameter of ring 37 or ring 40 or tubes 42.

It is to be realized that although a specific arrangement has been shown and described having holes directed upward and downward and to produce a clockwise swirl, there is no intention to limit this invention to such an embodiment. The intent and purpose is to agitate the particles within the housing and to keep the particles suspended and in a state of agitation while gas is being supplied. This is accomplished with the embodiment shown and would be accomplished with rings and vertical tubes carrying holes in all directions. The holes in the rings and vertical tubes are positioned to force the gas out all holes to bring about efficient agitation.

It is also to be realized that it is not intended to limit this invention to the particular arrangement of tubes shown. The tubes may be positioned in any manner which will accomplish the objectives of agitating and swirling the particles in gas.

The compressed gas supplied to the input tube may vary from 0.25 p. s. i. to 100 p. s. i. Using the device of Fig. 3 good prints may be made in from 2 to 3 seconds using about a 10 p. s. i. supply of compressed gas. Increasing the compressed gas supply to about 30 or 40 p. s. i. would result in development in approximately one-half second. When using 10 p. s. i. the gas flow measured through the system was 1.9 C. F. M. and when using 60 p. s. i. the gas flow measured at 6.5 C. F. M. When using 10 p. s. i. and a 1.9 C. F. M. gas flow, a cloud density of .8 gram of powder per cubic foot of gas is produced. These data have been included herein for illustrative purposes and it is not intended to limit this invention thereto.

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. For highest quality work the presently preferred material is milled wood charcoal.

It is presently believed that operation of the devices being described is dependent on the patterns of the gas flow. It is desired that the powder within the housing remain in a state of agitation during operation of the apparatus. Compression of the gas in traveling through the fine holes and then expansion of the gas on leaving the fine holes causes a state of particle agitation in gas to exist within the housing. Agitation within the housing creates a turbulent flow of powder particles in gas within the housing which aids in deagglomerating particles. Also there is created a mixture of particles in gas to be fed through the fine holes of the output tube. The compressed

sion of the gas of the mixture of particles in gas on passing through the fine holes of the output tube and the subsequent expansion of the gas of the mixture on leaving the fine holes also, it is believed, creates a form of turbulent flow which further aids in deagglomerating particles fed out the output end of the output tube. Although the principles discussed herein disclose one possible theory of operation of this invention, there is no intention to limit this invention in any way to such a theory. Instead, the desire is to create an aerosol of deagglomerated powder particles through the use of gas flows. In this invention such an aerosol is attained through the compression and expansion of gas fed through the input tube to bring about a state of agitating particles in gas within the housing and through the compression and expansion of the mixture of particles in gas fed out the output tube.

Powder particles used in xerography to develop electrophotographs tend to some extent to cake or agglomerate. Constant use with steady gas flows of the device of this invention will tend to produce a decreasing output of powder particles in the mixture of particles in gas. A constant output, however, may be attained by spurring the gas fed through the input tube or by agitating or rotating the housing enclosing a supply of developer particles and the other elements of the device. Agitation or rotation of the housing stirs the mass of particles within the housing and tends to prevent caking of the particles. Spurring the gas rhythmically at the input end also tends to keep the particles in a state of agitation and will produce a consistent and uniform output of particles in gas. When gas is spurted at the input end, the use of additional gas on an output similar to the output tube of Fig. 3 has been found quite valuable in producing a smooth and consistent aerosol of powder particles output. When such measures to produce a continuing and consistent output are not taken, the device of this invention has particular applicability for the development of single pictures or xerographic prints. A dense output is created very rapidly and consistency in output is present. It is presently believed that consistency in output is attained in that using the device of this invention to develop single pictures is similar to spurring the input to produce consistent, continuous outputs.

While the invention has been described as carried out in specific embodiments, it 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 for xerographic development comprising an air-tight housing, a section in said housing adapted to be removed to allow the insertion of powder particles into said housing, an input tube extending into said housing, a tubular ring positioned within the housing near the base thereof, another tubular ring positioned within the housing near the top thereof, a plurality of tubes vertically positioned within said housing extending between said ring near the base and said ring near the top, said input tube being connected to said tubes positioned within said housing and adapted to supply compressed gas to said tubes within said housing, a multiplicity of fine holes in said vertical tubes adapted to produce a circular swirl of gas within said housing, a multiplicity of fine holes in said tubular ring near the top to direct gas flow downward into said housing, a multiplicity of fine holes in said tubular ring near the bottom to direct gas flow upward in said housing, and an output tube extending into and out of said housing adapted to supply an output aerosol of powder particles out one end thereof, the other end thereof adapted to have connected thereto a supply of compressed gas and that portion of said output tube positioned within housing having a multiplicity of fine holes therein.

2. The method of generating an aerosol of powder particles for use in making visible electrostatic images comprising positioning a supply of xerographic developer powder particles within a housing, flowing compressed gas into the housing through a plurality of fine holes positioned within the housing to agitate and swirl the particles in the gas within the housing, flowing the agitating and swirling mixture of particles in gas from within the housing into the output tube through a plurality of fine holes in a section of an output tube within the housing, and, without changing the feed of gas to the housing, adding additional gas to the mixture of particles in gas within the output tube and flowing the composite mixture out the output tube.

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