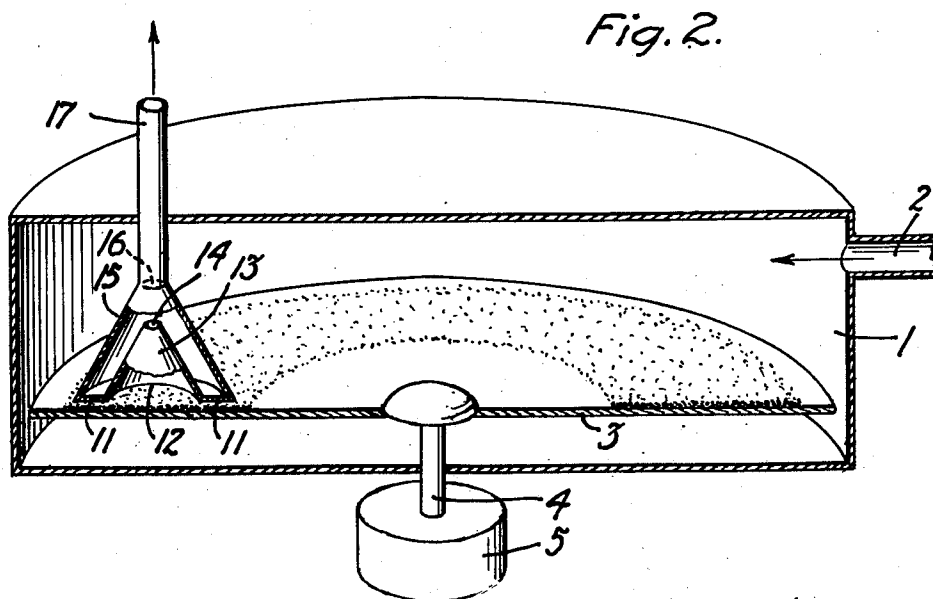
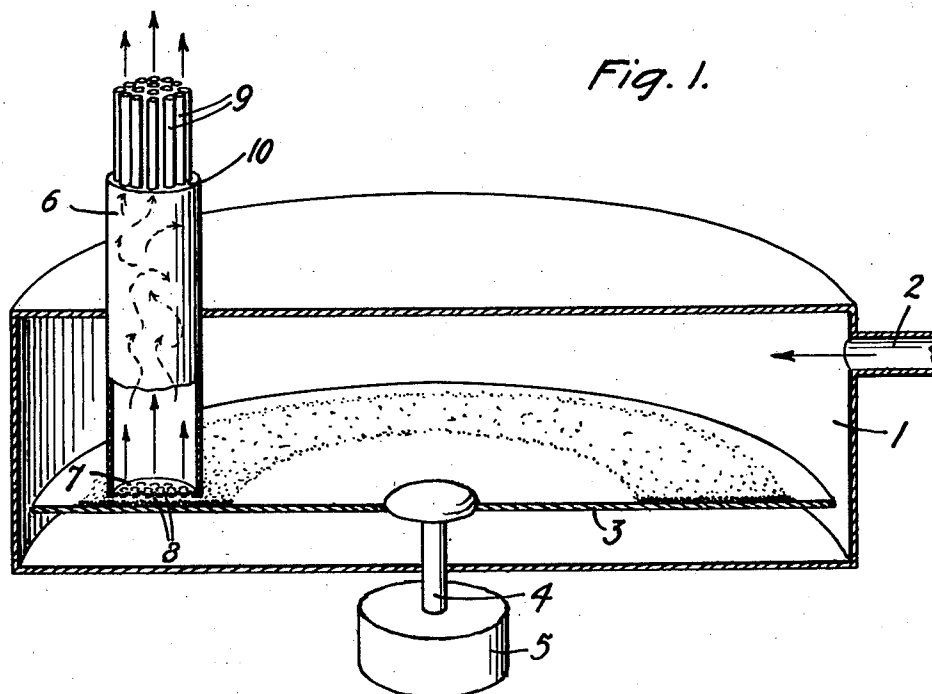


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ELECTROPHOTOGRAPHIC DEVELOPING POWDER CLOUD
GENERATING PROCESS AND APPARATUS
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ELECTROPHOTOGRAPHIC DEVELOPING POWDER CLOUD GENERATING PROC- ESS AND APPARATUS

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This invention relates to an electrophotographic developing powder cloud generating process and apparatus. In electrophotography the exposed electrophotographic image plate is developed by passing a flow of suitable developing powder over the exposed surface. The powder adheres to the surface inversely substantially in proportion to the degree of exposure to light thus producing a positive image.

The grain size of the developed image depends, of course, upon the particle size of the developing powder. As in photography generally a fine grain image is desirable. Electrophotographic developing powder may be made with a very small particle size, such as in the order of an average diameter of 1 micron, and if this particle size can be maintained during the necessary handling of the powder until the development is completed a fine grain image results.

One way for developing the image is to discharge or eject the powder over the latent electrophotographic image by means of a moving stream or flow of a gaseous carrier fluid, such as air, in which the powder is dispersed in the form of a cloud. This practice requires the generation of the cloud from the powder and this should be done in such a manner as to disperse the individual powder particles uniformly throughout the moving air flow. If the particles tend to agglomerate and form large sized particles, representing a number of the powder particles, the use of this powder cloud cannot produce a developed image that is as fine grain throughout as is potentially possible. Prior art powder cloud generating processes and equipment have sometimes tended to produce this agglomerating effect with its attendant effect on the developed image and although it may be possible to deagglomerate the flowing particles it obviously is more desirable to eliminate completely or materially retard agglomeration in the first place.

With the foregoing in mind, one of the objects of the present invention is to provide a powder cloud generating process and equipment which is more successful than usual in producing a powder cloud free from agglomerations of individual particles and which represents more truly a complete dispersion of the developing powder. Another object is to provide a practical and inexpensive powder cloud generating process and equipment which produces a dispersion of the developing powder particles in a substantially uniform pattern of individually free particles. Other objects may be inferred from the following.

Referring now to the accompanying drawings, which are mainly schematic in character:

Fig. 1 schematically showing in vertical cross section one example of the invention, and Fig. 2 being a similar kind of view but showing a second example of the invention.

Having reference first to Fig. 1, certain elements shown are the same as one form of the prior art electrophotographic developing cloud generator. Thus, there is an

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enclosure 1 provided with an inlet 2 which is supplied with a compressed carrier gas, for the cloud, under super-atmospheric pressure such as in the order of 60 p. s. i. This carrier gas customarily is compressed air and will be referred to hereinafter as air with the understanding that any compressible gaseous medium may be used which is of such a physical and chemical character as not to interfere with the desired development and which can carry the developing powder in the form of a cloud.

A suitable support 3 for the developing powder is located inside of the enclosure 1. Any prior art support of the travelling type is suitable, such as a travelling web of fabric impregnated with the developing powder or, as is illustrated, a rotating disk which supports the powder either by impregnation or otherwise. In Fig. 1 the disk 3 is connected by a shaft 4 with a source of rotary motion 5 so that the disk 3 rotates continuously within the enclosure 1 and, of course, while bathed in the compressed air or other carrier gas. As is known to those skilled in the electrophotographic art, a travelling support, such as the disk 3, may be kept continuously impregnated with electrophotographic developing powder, such as powdered charcoal or other material capable of accepting an electrical charge, in various ways. Although not illustrated, one way is to maintain a pile of the powder on the support 3 at a localized location where the powder is maintained by a scraper or the like so that as the disk turns away from the powder a uniform amount of the latter is distributed over the disk.

The prior art powder cloud generator includes the above elements. In this generator it is necessary that the travelling support 3 be pervious to the air or other carrier gas. The powder cloud is produced by locating a powder cloud outlet directly on the support 3 so that the compressed air, existing like a bath within the enclosure 1, drives through the pervious support, picks up the powder particles and carries these particles through the outlet in cloud form for transmission to the developing location. In one particular form of prior art device the cloud outlet is in the form of a plurality of turbulence tubes arranged with their inner ends pressing on the travelling powder support so that the powder is driven through the turbulence tubes. Such tubes actually are tubes having a sufficiently small diameter so that the fluid flow produces turbulent conditions within the tube causing the powder cloud travelling through the tubes to be tribo-electrically charged.

Now with the above prior art kind of generator and cloud creating practice there are various connected disadvantages. For example, the developing powder, which may have an average particle size in the neighborhood of 1 micron in diameter, is driven into cloud formation by the compressed air driving the lowermost particles against the uppermost particles and so on up through the particles forming the mass conveyed by the support 3, the particle size and physical characteristics of the powder tending to cause agglomeration of the particles thus driven together so that the resulting powder cloud contains a certain percentage of relatively large particles. Obviously the developed image, resulting from the use of this powder, is not as fine grain in character as is possible potentially. Another disadvantage is that it is necessary to use a pervious material for the travelling support 3, the small particle size of the powder more or less demanding that such a support be in the form of cloth or other fabric made from threads spun from fibrous material. This, in turn, introduces the problem that lint may be driven up through the turbulence tubes along with the powder cloud being generated, which is naturally undesirable.

According to the present invention the powder cloud

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outlet conduit for the enclosure 1, it being possible that this outlet may comprise either a single tube or a plurality of tubes such as the turbulence tubes, has its opening or openings located in the enclosure 1 so that this opening is adjacent but is spaced an appreciable distance from the support 3. With this arrangement there is established a zone of pressure, between the powder cloud outlet opening or openings and the support 3, which is relatively low in pressure as compared to the average pressure existing throughout the enclosure 1 due to the introduction of the compressed air or other gas through the inlet 2. With such an arrangement the powder particles are literally sucked from the support 3. Since the powder particles are bathed with the compressed air or other fluid and since this gaseous medium must exist in at least some small amount between the particles, the reduction in pressure effected by the described arrangement results in floating off, picking up, or otherwise carrying away the uppermost particles first followed progressively by the lower particles on down through the layer of powder on the support 3 or impregnated therein. With this new concept the support 3 need no longer be pervious to the carrier gas, it being possible to use a solid metal support, for example, over which the powder is spread in a relatively thin layer. Due to the particle size of the powder such a layer would ordinarily be many particles deep in any event. The same result is achieved if the support is in the form of the prior art pervious cloth type, for example.

With the above in mind, reference to Fig. 1 shows that the powder cloud outlet is illustrated as comprising a vertically arranged, elongated, cylinder 6 having a bottom wall 7 in which a relatively large number of orifices or openings 8 are formed. The arrangement is somewhat like that of the top of a saltcellar, for example. The bottom wall 7 is spaced slightly above the support 3 so that the above described effect is obtained. The turbulence tubes 9, required to tribo-electrically charge the powder or desirable for other reasons, connects with the inside of the cylinder 6 by being connected through the top wall 10 of this cylinder.

Now with this illustrated new generator the described action is secured. The electrophotographic developing powder carried on or impregnated in the support 3 is moved continuously below but spaced from the orifices 8. Compressed air or other gas is continuously supplied to the enclosure 1 through the inlet 2. The turbulence tubes 9 lead to the development location and hence to atmospheric pressure, so there is a flow through the orifices 8 developing a localized zone of low pressure between these orifices and the support 3. As the latter continuously moves a fresh supply or layer of the developing powder into this zone, the powder particles are sucked or floated upwardly through the holes 8. The former tendency to agglomerate is eliminated or reduced.

The cylinder 6 functions as an expansion chamber for the cloud jets which enter this cylinder by way of the orifices 8. Thus there is considerable turbulence inside of the chamber 6 and a tendency, of considerable practical effect, for the powder cloud to homogenize or become uniform without agglomeration of the powder particles. This is of importance because, among other reasons, those orifices which are closest to the axis of the rotating disk 3 naturally receive less powder. In the case of a belt, it may be that the belt is not uniformly impregnated with the powder so, again, some of the orifices 8 will receive more powder than others or, in other words, a powder cloud of greater density. The expansion chamber 6 functions to consolidate the powder cloud and produce a single powder cloud of substantially uniform density.

It now becomes obvious that the turbulence tubes 9, regardless of their relative positions with respect to the disk 3, and regardless of uneven powder impregnation or distribution, all receive or are charged with a powder

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cloud which is in each tube of substantially the same density as in all other tubes.

Due to the fact that the powder particles are picked up, lifted from, or sucked from the support 3, there is less tendency for lint to be carried along in the event this support is of the impregnated cloth type such as might be used particularly if a belt type of powder support or conveyor is used.

It can be seen that in all instances the effect is that of moving a layer of the powder particles, while they are bathed in the carrier gas, into a zone which is of lower relative fluid pressure, this causing the powder particles to be sucked or lifted off by the expansion of the air or other gas in which they are bathed. The prior art effect of one particle driving against another is avoided and, therefore, the generated powder cloud is less liable to represent agglomerated particles to any great extent such as might be sufficient to be visible in the development image.

In the example shown by Fig. 2, the wall portion 7, shown by the example of Fig. 1, is now in the form of a large diameter annular wall 11 forming a central hole 12 of large diameter in the sense that it is large as compared to any of the orifices 8 of the Fig. 1 example. As in the case of the first example this wall 11 is, of course, within the enclosure 1 and the opening 12 connects with a conduit which carries the resulting powder cloud to the location where development is desired. This Fig. 2 example serves to emphasize the fact that the powder particles are continuously introduced to a zone of relatively low pressure which causes a flow of the compressed air or other carrier gas so as to effect the described sucking or floating action. It is to be appreciated that assuming that the powder particles are of adequately small size to permit a powder cloud of aerosol-like character, that with this invention such aerosol-like cloud becomes a realistic possibility. This invention eliminates the prior art tendency toward agglomeration and, of course, reduces the problem of lint, when this is present, and various other troubles.

Referring more specifically to Fig. 2, an inner conical wall 13 extends upwardly from the inside of the annular wall 12 and terminates with an opening or orifice 14 formed in the apex of the wall 13, and an outer conical wall 15 extends upwardly from the outer periphery of the wall 11, this outer wall having an opening 16 formed in its apex which connects with a conduit 17 which carries the powder cloud to wherever it may be required for use. If turbulence tubes are used they may be substituted for this single relatively large tube 17 which is illustrated.

In the case of this second example, the expansion chamber is formed by the relatively large space between the walls 13 and 15, the action otherwise being somewhat as previously described.

In the operation of both devices the powder cloud carrier gas is flowed over this support carrying the powder and is flowed to and through the opening in the generator enclosure through which the powder cloud is driven. The expansion chamber, provided by both examples, gives the powder cloud an opportunity to become more uniform. In both examples the entrance to the expansion chamber, represented by the total cross sectional area of the holes 8 or the cross sectional area of the hole 14, as the case may be, is relatively small as compared to the volume of the expansion chamber; the volume of this expansion chamber both laterally and longitudinally, with respect to the inlet opening thereto whereby the cloud is introduced, is in both instances many times greater than the dimensions or cross sectional area of this inlet.

In the handling of a powder cloud it is customary to experience a settling or drifting of the particles when an enlargement in the flow path of the cloud is encountered. However, with the present invention, involving the sucking principle described, no trouble has been experienced with such settling or drifting of powder par-

ticles. Apparently as the carrier gas is sucked from above the powder layer so as to carry the powder particles therewith, the various particles are individually separated or floated in such a manner as to remain, in effect, airborne at all times, the effect of the expansion chamber being largely to smooth out or make uniform the density of the powder cloud.

It is to be appreciated that the inlet 2 might be opened to the atmosphere and a suction applied to either the turbulence tubes 9 or the tubes 17, whereby to effect the previously described action. However, in addition to technical problems such a procedure does limit the available pressure differential to atmospheric pressure. In the actual practice of the present invention it has been customary, for example, to introduce air through the inlet 2 of the enclosure 1 at a pressure in the neighborhood of 60 p. s. i., the exhausting ends of the turbulence tubes 9 or the tubes 17 going to atmospheric pressure for all practical purposes.

I claim:

1. A powder particle dispersion process including forming a layer of superimposed powder particles bathed in a gaseous fluid, forming a zone of fluid pressure that is less than that of said gaseous fluid, and causing said layer to travel so that one side thereof passes through said zone and so that said gaseous fluid flows away from said layer carrying said particles therewith in a dispersed state for xerographic development purposes, the improvement comprising homogenizing the mixture of particles in the gaseous fluid while maintaining the particles in a substantially deagglomerated state prior to conveying the particles for xerographic development purposes.

2. An electrophotographic developing powder cloud generator including an enclosure having an inlet for a compressed carrier gas for the cloud, a support for the powder and which is located within said enclosure, and a powder cloud outlet conduit for said enclosure and which has at least one opening located in said enclosure adjacent to but spaced from said support so as to establish a zone of pressure therebetween which is less than the average pressure throughout said enclosure when said inlet is supplied with compressed carrier gas, whereby to generate the powder cloud by sucking the powder from said support, said outlet conduit including an expansion chamber to homogenize the mixture of powder in carrier gas while maintaining the powder in a deagglomerated state.

3. An electrophotographic developing powder cloud generator including an enclosure having an inlet for a compressed carrier gas for the cloud, a support for the powder and which is located within said enclosure, and a powder cloud outlet conduit for said enclosure and which has at least one opening located in said enclosure adjacent to but spaced from said support so as to establish a zone of pressure therebetween which is less than the average pressure throughout said enclosure when said inlet is supplied with compressed carrier gas, whereby to generate the powder cloud by sucking the powder from said support, said conduit including an expansion chamber in which the powder cloud expands after leaving said opening.

4. An electrophotographic developing powder cloud generator including an enclosure having an inlet for a compressed carrier gas for the cloud, a support for the powder and which is located within said enclosure, an expansion chamber having a wall portion located within said enclosure and adjacent to but spaced from said support and said portion having a plurality of orifices formed therethrough so as to establish a zone of pressure between said orifices and said support which is less than the average pressure throughout said enclosure when said inlet is supplied with compressed carrier gas, whereby to generate the powder cloud by sucking the powder from said support, and conduit means connected to said chamber to conduct the powder cloud therefrom.

5. An electrophotographic developing powder cloud generator including an enclosure having an inlet for a compressed carrier gas for the cloud, a support for the powder and which is located within said enclosure, an expansion chamber having a wall portion located within said enclosure and adjacent to but spaced from said support, said wall portion being annular and having inner and outer conical walls extending therefrom away from said support, said outer wall terminating with an outlet passage formed through its apex and said inner wall terminating with an inlet passage formed through its apex, said inner wall being shorter axially than is said outer wall and the space therebetween defining said expansion chamber.

6. An electrophotographic developing powder cloud generator including a support for said powder, conduit means for receiving said cloud and having, therefore, at least one receiving opening spaced adjacent to said support, and means for flowing a cloud carrier gas over said support and to and through said opening, said conduit means including an expansion chamber for the cloud.

7. In an electrophotographic developing powder cloud generator having an enclosure supplied with compressed gas and containing a travelling support charged with the powder and a plurality of turbulence tubes through which the generated cloud is forced, the combination therewith of a cloud expansion chamber interposed between said tubes and said support and having at least one opening adjacent to said support and which is located within said enclosure so that the compressed gas flows there-through so as to create a pressure drop sucking the powder from said support into said expansion chamber of driving on through said chamber and into said tubes, said chamber having an expansion space volume many times greater than that of all of said tubes combined and also many times greater than that of said opening.

References Cited in the file of this patent

UNITED STATES PATENTS

1,371,412	Davis	Mar. 15, 1921
1,673,087	Morse	June 12, 1928
2,360,464	Arveson	Oct. 17, 1944
2,533,331	Skinner	Dec. 12, 1950
2,624,652	Carlson	Jan. 6, 1953