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METHODS AND APPARATUS FOR ELECTRICAL PRINTING

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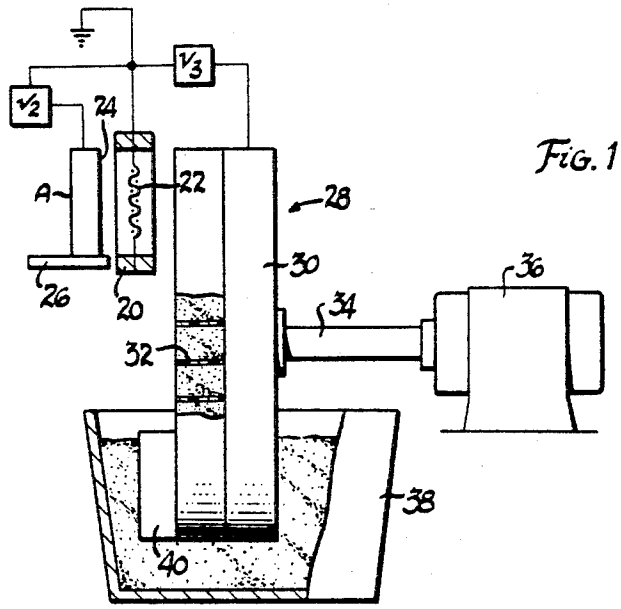


FIG. 1

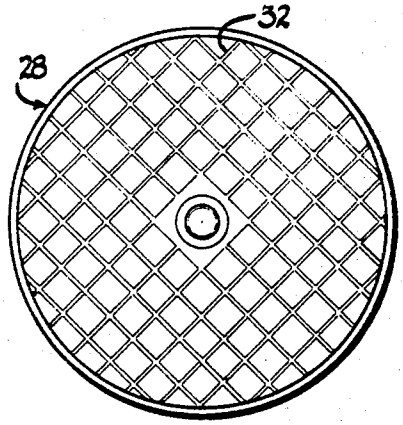
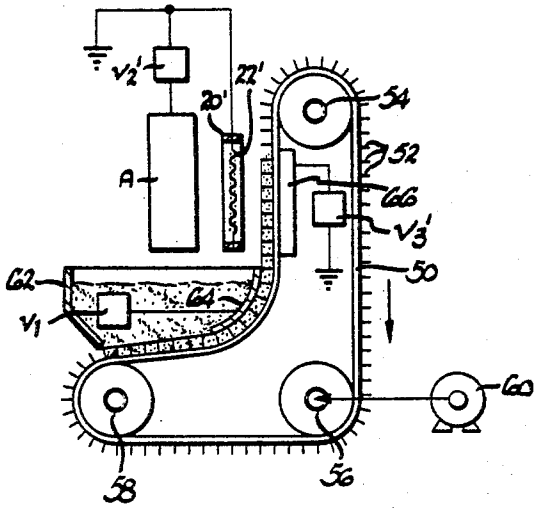


FIG. 2

FIG. 3



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METHODS AND APPARATUS FOR ELECTRICAL PRINTING

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U.S. Cl. 101—114 10 Claims

ABSTRACT OF THE DISCLOSURE

Methods and apparatus for electrostatic printing of articles' surfaces while the surfaces are disposed in an upright position. A stencil screen is located in spaced generally parallel relationship to an upright article surface and a powder supply is supported with an exposed side surface located on the opposite side of the screen from the article surface and in generally parallel relationship with the stencil screen. The area encompassed by the exposed surface of the powder bed is somewhat larger than the area encompassed by the image-defining aperture of the stencil screen. The bed is supported by ledges or shelves, and during the electrostatic transfer of the powder from the bed, relative motion is established so that the entire image aperture of the stencil is uniformly exposed to powder from the bed.

In a co-pending application of William E. Johnson, Ser. No. 393,817, filed Aug. 31, 1964, and assigned to the assignee of the present application, there is disclosed various methods for applying an image-shaped layer of printing powder particles to an article surface. In essence, in such methods a layer of loosely packed printing powder particles is supported upon a flat plate and a wire mesh stencil screen having an image-shaped aperture is supported in spaced relationship above the surface of the powder bed. An article to be decorated is brought into overlying registry with the aperture of the screen, and upon the application of an electric field, the printing powder particles become electrically charged and are impelled upwardly through the aperture of the stencil screen to the article surface. This method has several advantages, one advantage being that a minimum amount of preparation of the powder bed is required. However, the methods as disclosed in the above Johnson application are substantially limited to the printing of an article surface while the surface is in a horizontal position because of the horizontal supporting of the powder bed.

In many instances, it is desirable to apply an image to an article surface while the surface is in an upright position. This may be done by an offset plate process or, in some instances by a so-called cloud chamber in which a cloud of particles is maintained at one side of a vertically disposed stencil screen by air currents. In an offset plate process, the powder image is first applied to a flat plate either by the Johnson process described generally above or by brushing the powder particles through a stencil screen onto the surface of the plate. The offset plate with the applied powder image is then moved into registry with the upright article surface and the powder particles may be transferred from the plate to the article surface by the application of an electric field. While this process achieves satisfactory results, its drawback is that it requires two separate powder transferring operations with an intermediate step of physically manipulating the offset plate between registry with the stencil and registry with the article.

The cloud chamber process has the potential drawback of the cloud of particles being inherently less dense

than a powder bed, thus lengthening the period of time for the application of the electric field to transfer the particles as compared with the period of time to achieve a corresponding image density in transferring the particles from a powder bed. Further, in the cloud chamber process, the particles in the cloud are subject to random motion, which may create problems of scattering, and air currents which either or both may effect sharpness of image definition.

Accordingly, it is an object of the present invention to provide methods and apparatus for applying an image-shaped layer of printing powder particles to an article surface in an upright position by transferring the particles directly to the article surface from a powder bed.

It is another object of the invention to provide methods and apparatus for applying an image-shaped layer of printing powder particles to an article surface in an upright position by supporting a bed of powder particles with a side surface exposed to the article surface over the entire image area.

The foregoing, and other objects are achieved by subdividing the exposed area of a powder bed in to a plurality of relatively small powder beds. In one embodiment of the invention, the flat surface of a disc is provided with a honeycomb-like arrangement of relatively thin webs which provide a large number of relatively small recesses opening outwardly from the face of the disc. The recesses are filled with powder particles and doctored so that when filled, the face of the disc presents a smooth surface of powder particles interrupted only by the edges of the web of the honeycomb. By employing recesses of relatively small dimensions, and lightly packing the powder into the recesses, the disc face can be supported in a vertical position, while maintaining the smooth powder surface. By rotating the disc slowly during the transfer of powder particles from the recesses through astencil screen to a vertically positioned article surface, the superimposed pattern of the web edges on the resultant image is eliminated.

Other objects and features of the invention will become apparent by reference to the following specification and the drawings.

In the drawings:

FIGURE 1 is a schematic view, partially in section of one form of the invention;

FIGURE 2 is a detail view of the front face of the disc of FIGURE 1; and

FIGURE 3 is a schematic view of another form of the invention.

Referring first to FIGURES 1 and 2, in one form of the invention an article A to be decorated is supported in spaced horizontal registry to a stencil screen designated generally **20** having an image aperture **22** shaped in accordance with the design to be applied to the upright side surface **24** of article A. Stencil screen **20** is preferably constructed from a relatively fine wire mesh screen in which the openings in all areas other than aperture **22** are masked by a coating, see for example Patent No. 3,100,150. Article A is supported upon a suitable support schematically shown at **26** which, in the usual case, will take the form of a conveyor operable to advance articles to be decorated into registry with screen **20**.

At the opposite side of screen **20** from article A, a powder bed support assembly designated generally **28** is located and includes a metallic disc **30** having a honeycomb grid **32** of electrically non-conductive material fixedly mounted upon the front face of the disc. As best seen in FIGURE 2, grid **32** may have a gridiron like pattern of thin webs intersecting each other at right angles to define a series of square recesses open at the front or left hand side as viewed in FIGURE 1, with the opposite ends of the recesses being closed by the front face of

electrically conductive disc **30**. Powder bed support **28** is mounted upon the shaft **34** of a drive motor **36** for rotation with the shaft. The axis of shaft **34** is horizontal, and thus the powder bed support **28** rotates in a vertical general plane which is parallel to the general plane of screen **20**.

As is apparent from FIGURE 1, the area of the front face of powder bed support **28** is substantially greater than that of screen **20**. The lower portion of powder bed support **28** is positioned in a powder supply which takes the form of an open topped box or container **38** which is substantially filled with printing powder particles.

In the case of printing with highly resistive powders, i.e. those of 10^{10} ohm-cm. or greater bulk resistivity, precharging may be necessary. Examples of suitable precharging techniques are corona charging, triboelectrification, inductive charging, or the like.

In the case of printing with powders having a lower resistivity, i.e. less than 10^{10} ohm-cm. bulk resistivity, no precharging is required. This is illustrated on FIGURE 1 in connection with the apparatus embodiment wherein no precharging device is shown. FIGURE 3 shows an apparatus embodiment of the invention wherein an inductive precharging device VI is included.

Either embodiment may be operated under present invention with or without precharging devices.

A metallic plate **40** is fixedly mounted within the interior of box **38** with one edge in sliding engagement with the face of grid **32**. Plate **40** may perform a dual function of: (1) acting as a doctor blade, and (2) as an electrically conductive element to charge powder particles in the supply. In the latter case, plate **40** is at a selected electric potential by connection to a voltage source (not shown). Voltage sources V2 and V3 are, respectively, electrically connected between the article A and screen **20** and between screen **20** and metallic disc **30** of powder support **28**. Voltage sources V2 and V3 are operable to establish an electric field which extends between plate **30** and surface **24** of article A, the lines of force of the field being horizontal, or substantially so.

The electric field established by voltage source V3 is operable to electrically charge and impel powder particles from the recesses in grid **32** through image aperture **22** to the surface **24** of the article A. The voltage source V2 establishes an electric field between the image bearing screen **22** and the article being printed to aid this transfer. Details as to desired field strength and electrical characteristics of the printing powder particles are described in a co-pending application of William E. Johnson filed Aug. 31, 1964, Ser No. 393,817, which application is assigned to the assignee of the present application.

In operation, motor **36** of the FIGURE 1 embodiment is energized to drive powder support assembly **28** in rotation. As support **28** is rotated through the supply of particles in container **38**, the particles flow into the recesses defined by grid **32** and upon further rotation of supply **28**, the particles are carried upwardly by grid **32** and eventually move into horizontal alignment or registry with screen **20**. As the particles move into this position, the electric field developed between plate **28** and surface **24** of article A is operable to carry the particles from the recesses of grid **32** to the right hand side of screen **20**. Those particles which move along paths which pass through image aperture **22** continue to move to the left as viewed in FIGURE 1 until they reach the surface **24** of article A. All other particles are intercepted by the imperforate masked portion of stencil screen **20**. Powder supply **28** is rotated continuously throughout the particle transferring operation so that the entire area of the image aperture of screen **20** is uniformly exposed to particles supported on support **28**, thereby achieving a uniform distribution of particles over the entire area of the image formed on surface **24** of the article. It is believed apparent that if powder support **28** were stationary, the resulting image would have a grid-like pattern of bare spots due to the presence of the webs which define grid **32**.

The pattern of grid **32** has been shown as a square grid-iron pattern, but may be of other configurations, such as hexagonal or triangular. The shape of the recesses must be one in which upon rotation of the disc there is no fixed point in registry with the image aperture which is not traversed by a recess during rotation of the disc. The dimensions of the openings or recesses is preferably made relatively small, taking into consideration the normal angle of repose of the particular powder being employed so that with a relatively loose degree of compaction such as achieved by doctor blade **40**, the recesses are completely filled and a smooth vertical side surface of powder particles exists at the opening of each grid recess. A too firm degree of compaction of the powder particles is undesirable because this increases the difficulty of transferring the particles from the bed. Because a completely continuous and uninterrupted vertical side surface of the powder bed cannot be easily achieved in practice, the closest approach is achieved by making the webs of grid **32** as thin as possible so that the web edges occupy a minimum percentage of the area exposed to the screen. Because of the fact that at least some edges of the web which defines grid **32** will be in registry with the image aperture at all times, the entire area of image aperture **22** is never directly exposed to the side surface of a bed at any given instant. However, by virtue of a relative movement of powder support **28** to the screen aperture during the time the electric field is applied, all areas of the image aperture are directly exposed to the side surface of the bed, thus effectively achieving substantially the same result as if a continuous vertical surface of a powder bed were exposed to the image aperture.

In one specific example, a powder support similar to that disclosed in FIGURE 1 having a radius of 4½ inches with recesses approximately one-eighth of an inch square was rotated at 2½ revolutions per minute while an electric field was applied for a time period of 140 milliseconds. Under these conditions, a substantially uniform density was achieved over the surface area of the image applied to the article.

The volume of powder supported in the grid registry with aperture **22** during the transfer operation is chosen to at least equal or exceed the volume of powder which is actually transferred to the article.

A second form of the invention is disclosed in FIGURE 3 in which the powder bed support takes the form of an endless conveyor belt **50** having a series of powder support webs such as **52** extending transversely across the belt. Belt **40** is operatively trained about a series of guide rolls **54**, **56** and **58** which are supported in a suitable frame, not shown, for rotation. One of the guide rolls, such as **56**, is coupled to a suitable drive motor schematically illustrated at **60** to drive the belt in a clockwise direction as viewed in FIGURE 3. The article A to be printed and a stencil screen **20'** having an image aperture **22'** are supported in the same fashion as in the previously described embodiment in registry with a vertically extending run of belt **50**.

As belt **50** passes beyond roll **58**, it passes beneath an opened bottomed powder supply bin **62** and powder from the bin falls onto the belt into the spaces between adjacent webs **52**. At the right hand end of bin **62** as viewed in FIGURE 3, a curved plate **64** is located to perform the doctoring of powder from bin **62** into the recesses of belt **50**. In the use of non-conductive powders in bin **62**, the plate **64**, as shown, may be connected to a voltage source V1 to perform a powder charging function. In addition, plate **64** acts as a guide surface for the transition of the belt between the substantially horizontal position in which the belt leaves roll **58** to the vertical orientation along which the belt passes upwardly into registry with stencil screen **20'**.

Belt **50** and webs **52** are formed from a relatively elec-

trically conductive material, such as a thin neoprene. Webs **52** may be in the form of a simple shelf-like arrangement or may take the form of a honeycomb or inclined gridiron-like pattern. A metal plate **66** is mounted behind belt **50** in registery with stencil screen **20'** and, as in the previous case, is electrically connected to a suitable voltage source V3', while a second source V2' is electrically connected between the article A and stencil screen **20'**.

In case of a conductive powder, the metal plate **66** of FIGURE 3 should be in contact with the belt **50** (as shown in phantom outline, FIGURE 3).

Operation of the FIGURE 3 embodiment is believed to be apparent. The spaces between webs **52** are filled with powder during the transit of belt **50** beneath powder supply **62**. The recesses between webs **52** are of relatively small dimensions and, as in the previous case, a powder bed having a smooth and substantially continuous vertical side surface is exposed to registry with stencil screen **20'** so that upon application of the electric field between plate **66** and the surface of article A, powder particles are electrically transferred through the aperture **22'** of stencil screen **20** to the surface of article A. Movement of belt **50** during the transfer of powder particles provides the uniform complete exposure of the image aperture to the vertical side surface of a powder bed during the transfer. In actual printing use, the powder stored in the recesses of the belt **50** will not or need not be exhausted. In fact, it is preferable that a limited number of image patterns be drawn from an area or group of recesses of the belt as it is advanced endlessly in the process.

While two embodiments of the invention have been described, it will be apparent to those skilled in the art that the disclosed embodiments may be modified. Therefore, the foregoing description is to be considered exemplary rather than limiting, and the true scope of our invention is that defined in the following claims.

We claim:

1. The method of applying an image-shaped layer of printing powder particles capable of being electrically charged to an article surface while the surface is in a substantially vertical position comprising the steps of interposing a stencil screen having an image shaped aperture therethrough in spaced parallel relationship to and between a substantially vertical article surface and an electrically conductive element, the conductive element and article surface defining a particle transfer region therebetween, supporting a plurality of individual beds of printing powder particles in said transfer region with the beds having side surfaces disposed in a common plane parallel to said article surface and encompassing an area at least equal to the area encompassed by said aperture, applying an electric field between the conductive element and the article surface extending through said transfer region and operable to electrically impel printing powder particles from said beds across said transfer region through the aperture of said screen to the article surface, and directly exposing said side surfaces of said beds to said screen throughout the entire area of said region in registry with the aperture of said screen by moving the surfaces of said beds in said common plane while said field is applied.

2. The method of claim **1** further comprising the step of forming said beds by moving a member having a plurality of webs projecting from one surface thereof through a body of printing powder particles to completely fill the spaces between said webs with powder particles.

3. The method of applying an image-shaped layer of printing powder particles capable of being electrically charged to an article surface while the surface is in a vertical position comprising the steps of interposing a flat stencil screen having an image shaped aperture therethrough in a vertical position between an upright article surface and a vertically disposed electrically conductive plate with the screen in spaced opposed relationship to the plate to define a particle transfer region between said conductive element and said article surface, supporting a plurality of individual beds of printing powder particles in said transfer region with one side of said beds directly exposed to said screen in substantially uniformly spaced relationship thereto, applying an electric field between the conductive element and the article surface extending through said transfer region and operable to electrically impel printing powder particles from said transfer region horizontally through the aperture of said screen to the article surface, and moving said beds while maintaining said uniformly spaced relationship to uniformly expose the sides of said beds over the entire area of said screen aperture during the application of said electric field.

4. A method of applying an image-shaped layer of printing powder particles capable of being electrically charged to an upright article surface comprising the steps of positioning a stencil screen having an image-defining aperture therethrough in an upright position in spaced relation to and between an upright article surface and a plate-like electrically conductive element extending in generally parallel relationship to said screen, interposing a plurality of individual beds of printing powder particles between said screen and said conductive element, said beds having side surfaces directly exposed to said screen and uniformly spaced therefrom, and simultaneously (1) applying an electric field between said conductive element and said article surface operable to electrically impel printing powder particles from said beds through the image aperture of said stencil to said article surface and (2) relatively moving said beds with respect to said stencil and article surface to distribute particles transferred from said beds uniformly over the entire area of said article surface in registry with said image aperture.

5. A method of applying an image-shaped layer of printing powder particles capable of being electrically charged to an upright article surface comprising the steps of positioning a flat stencil screen having an image-defining aperture therethrough in vertical position in spaced relation to and between a vertical article surface and a flat electrically conductive plate extending in spaced parallel relationship to said screen, interposing a plurality of individual separated beds of printing powder particles in the space between said screen and said conductive plate, said beds having side surfaces horizontally opposed to said screen and uniformly spaced therefrom, and simultaneously (1) applying an electric field between said conductive plate and said article surface operable to electrically impel printing powder particles from said beds horizontally through the image aperture of said stencil to said particle surface and (2) relatively moving said beds in a vertical general plane with respect to said stencil and article surface to move the side surfaces of said beds to uniformly distribute particles over the entire area of said article surface in registry with the image aperture of said screen.

6. The method of applying an image-shaped layer of printing powder particles capable of being electrically charged to an article surface while the surface is in an upright position comprising the steps of interposing a stencil screen having an image-defining aperture therethrough in an upright position between an upright article surface and an electrically conductive element with the screen in spaced opposed relationship to the electrically conductive element to define a particle transfer region between said conductive element and said article surface, moving a powder support member having a plurality of adjacent recesses of uniform depth in one surface thereof through a supply of printing powder particles to completely fill said recesses with particles and subsequently doctoring said one surface to smooth the exposed surfaces of the individual beds of powder in said

recesses flush with said one surface, applying an electric field between the conductive element and the article surface extending through said transfer region and operable to electrically impel printing powder particles from said beds across said transfer region through the aperture of said screen to the article surface, and subsequently moving said support member through said transfer region with said exposed surfaces of said beds facing said screen and said one surface of said support maintained in uniformly spaced relationship to said screen while said field is applied.

7. Apparatus for applying an image-shaped layer of printing powder particles capable of being electrically charged to an article surface while the surface is in an upright position comprising a stencil screen having an image-defining aperture therethrough, means for supporting said stencil screen in an upright position in adjacent spaced relationship to an upright article surface, an electrically conductive plate mounted in an upright position in uniformly spaced relationship to the side of said screen remote from said article, powder bed support means for supporting a bed of printing powder particles in the space between said plate and said screen with a side surface of said bed exposed to said screen in uniformly spaced relationship thereto, means for applying an electric field between the conductive plate and the article surface operable to electrically impel printing powder particles from said bed through the aperture of said screen to the article surface, and means for moving said powder bed support means relative to said screen while maintaining said uniformly spaced relationship between said side surface of said bed and said screen.

8. Apparatus for applying an image-shaped layer of printing powder particles capable of being electrically charged to an article surface while the surface is in an upright position comprising a stencil screen having an image-defining aperture therethrough, means for supporting said stencil screen in an upright position in adjacent spaced relationship to an upright article surface, a powder support member having at least a portion thereof located in spaced parallel registry with said screen at the side of said screen remote from said article, means defining a plurality of relatively small recesses in the side of said support member facing said screen, means for filling said recesses with printing powder particles, means for applying an electric field between the conductive plate and the article surface operable to electrically impel printing powder particles from said recesses through the aperture of said screen to the article surface, and means for moving said powder bed support member relative to said screen while said field is applied to uniformly distribute impelled particles over the entire area of said image aperture.

9. Apparatus for applying an image-shaped layer of printing powder particles capable of being electrically charged to an article surface while the surface is an in upright position comprising a stencil screen having an image-defining aperture therethrough, means for supporting said stencil screen in an upright position in adjacent

spaced relationship to an upright article surface, an electrically conductive disc mounted for rotation about a horizontal axis in parallel spaced relationship to the side of said screen remote from said article with one portion of said disc in registry with said image aperture, a honeycomb-like web of electrically non-conductive material mounted on the face of said disc facing said screen to define a series of recesses for supporting printing powder particles, means for filling said recesses with printing powder particles to define a smooth surfaced bed of particles interrupted by the edges of said web exposed to said screen in uniformly spaced relationship thereto, means for applying an electric field between the conductive disc and the article surface operable to electrically impel printing powder particles from said bed through the aperture of said screen to the article surface, and means for rotating said disc during application of said fluid.

10. Apparatus for applying an image-shaped layer of printing powder particles capable of being electrically charged to an article surface while the surface is in an upright position comprising a stencil screen having an image-defining aperture therethrough, means for supporting said stencil screen in an upright position in adjacent spaced relationship to an upright article surface, an electrically relatively conductive conveyor belt having a run extending in spaced parallel relationship to said screen at the side of said screen remote from said article, a plurality of webs projecting outwardly from said belt to define a plurality of printing powder particle receiving recesses, means for filling said recesses with printing powder particles to form a bed of particles having a side surface exposed to said screen in uniformly spaced relationship thereto, a conductive plate mounted at the side of said belt remote from said screen in opposed relationship thereto, means for applying an electric field between the conductive plate and the article surface operable to electrically impel printing powder particles from said bed through the aperture of said screen to the article surface, and means for moving said belt relative to said screen during application of said electric field.

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EDGAR S. BURR, Primary Examiner

U.S. Cl. X.R.

101—129

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,473,467 Dated October 21, 1969

Inventor(s) William E. Johnson and Douglas F. St. John

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 9, column 8, line 17:

"fluid" should read --field--

SIGNED AND
SEALED
FEB 17 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents