Nov. 14, 1967 D. S. LONDAHL ET AL 3,352,234

ELECTROSTATIC PRINTER WITH POWDER FEED STRUCTURE INSIDE STENCIL DRUM

Filed Sept. 26, 1966

4 Sheets-Sheet 1

FIG_1

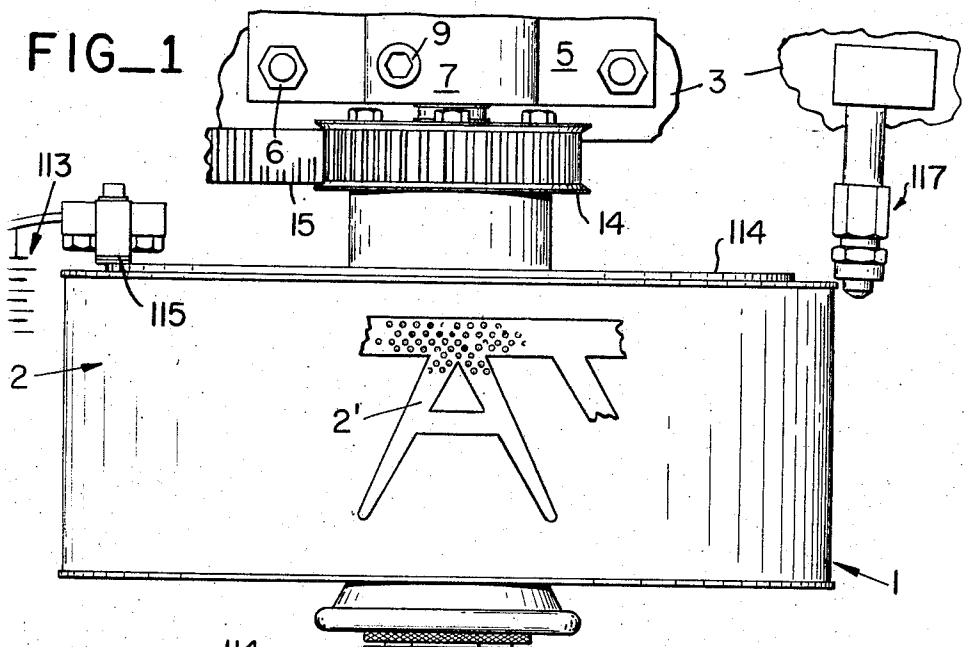
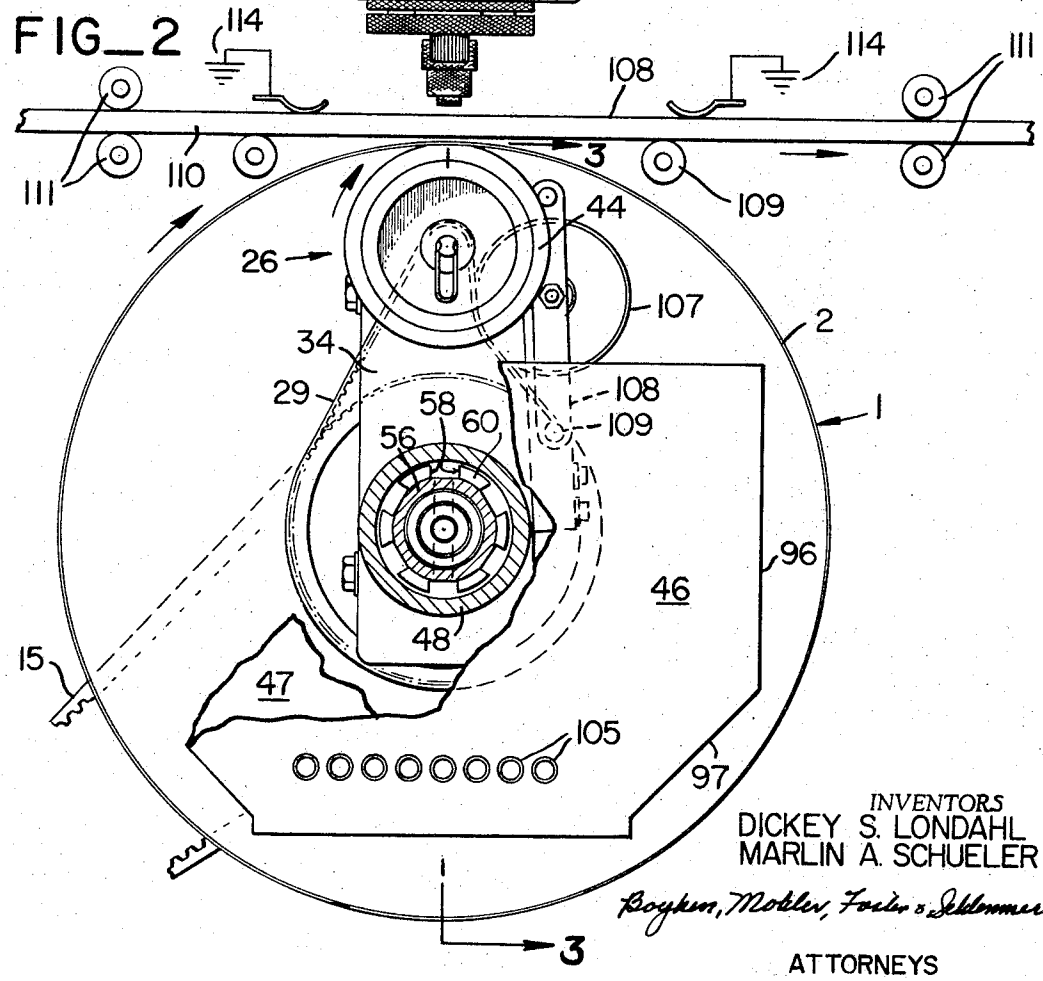


FIG_2



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4 Sheets-Sheet 2

FIG_3

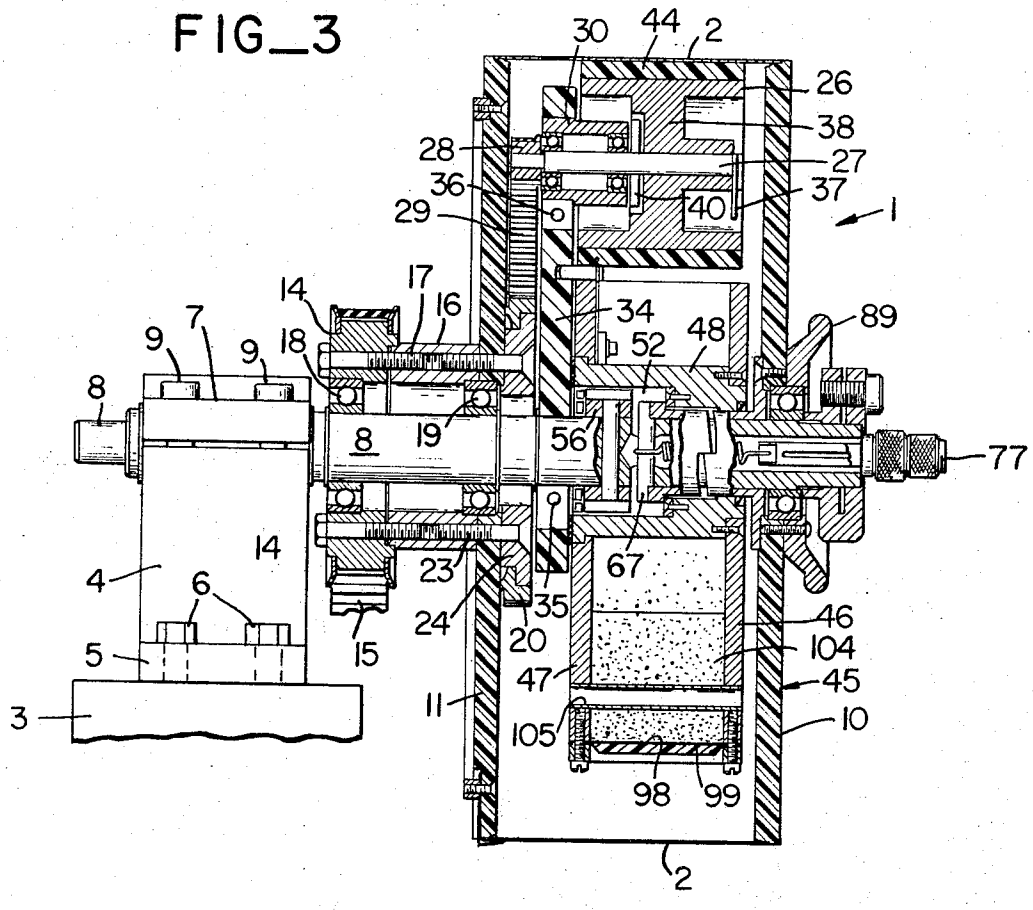
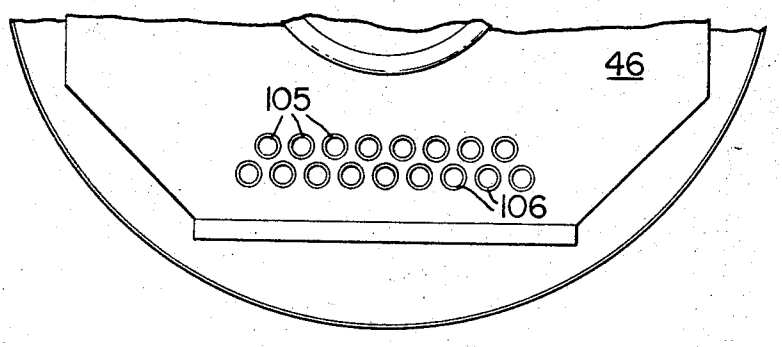


FIG_5



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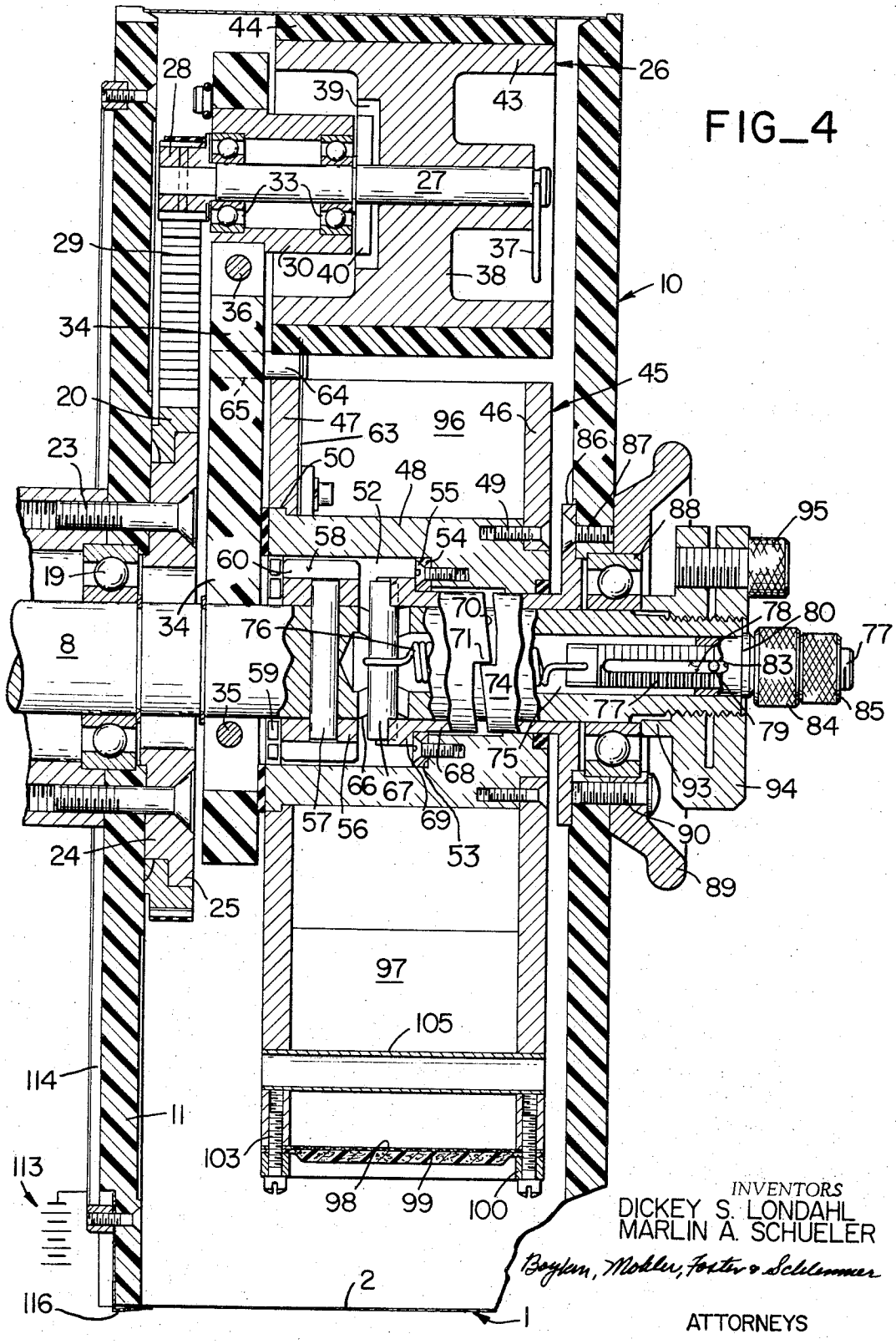
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Nov. 14, 1967 D. S. LONDAHL ET AL 3,352,234

ELECTROSTATIC PRINTER WITH POWDER FEED STRUCTURE INSIDE STENCIL DRUM

Filed Sept. 26, 1966 4 Sheets-Sheet 3

FIG_4



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ELECTROSTATIC PRINTER WITH POWDER FEED STRUCTURE INSIDE STENCIL DRUM

Filed Sept. 26, 1966

4 Sheets-Sheet 4

FIG_6

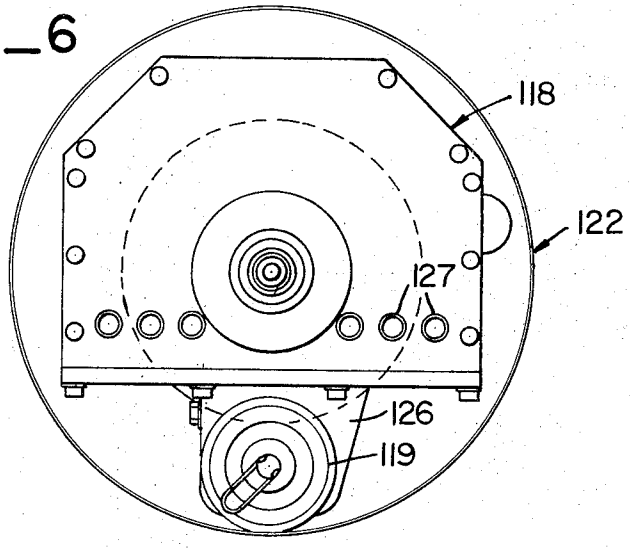
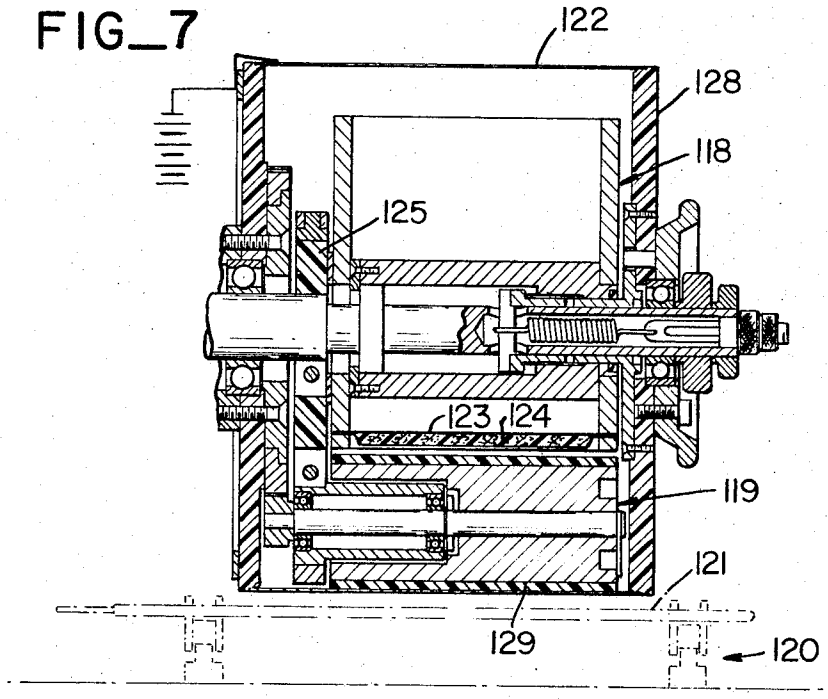


FIG_7



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United States Patent Office 3,352,234 Patented Nov. 14, 1967

3,352,234

ELECTROSTATIC PRINTER WITH POWDER FEED STRUCTURE INSIDE STENCIL DRUM

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Filed Sept. 26, 1966, Ser. No. 581,872
10 Claims. (Cl. 101—114)

ABSTRACT OF THE DISCLOSURE

Apparatus for electrostatic printing, in which a combined support and powder metering means is provided for supporting a bed of dry printing powder thereon and for causing the powder of said bed to move through said means and to be uniformly discharged from the underside of said means for deposit onto a stencil screen through which powder so deposited is moved into an electrostatic field established in an air gap between the screen and article for conduction onto the article to be printed.

This invention relates to an electrostatic printing machine and to an improved method of electrostatic printing, and has for one of its objects the provision of improved means providing for consistently uniform printing in an electrostatic printing system of the type described in United States Letters Patent No. 3,081,698, issued Mar. 19, 1963, to C. O. Childress et al., and in our copending application Ser. No. 494,326, filed Oct. 11, 1965.

Heretofore in a printing machine and method for electrostatic printing along the lines disclosed in the aforesaid patent, one of the principal problems has been the uniform feeding of the printing powder onto a stencilled screen, for passage of the powder through unobstructed mesh openings of the screen and into an electrostatic field established in the air gap between the screen and the article onto which the powder is to be finally deposited in a design corresponding to the design of the plurality of unobstructed mesh openings.

One object of the invention is the provision of improved powder feeding means in an electrostatic printing machine of the type in which the printing is effected by a dry powder being conducted across an air gap, and in an electrostatic field and deposited onto the article to receive the powder so conducted and in which the powder is uniformly fed onto the screen from a substantially stationary bed thereof.

A still further object of the invention is the provision of a structure in a printing machine of the general character described for upward feeding of the powder through the screen openings into an electrostatic field for overhead printing.

An added object is the provision of a structure that enables quick replenishment of printing powder and quick access to parts for maintenance and replacement of parts.

Other objects and advantages will appear in the description and drawings.

In the drawings,

FIG. 1 is a top plan view of the machine.

FIG. 2 is a part-sectional part elevational view of the wheel-like drum of the machine in which the front wall thereof is omitted and a portion of the powder container

is shown in elevation with the remainder thereof broken away to show structure.

FIG. 3 is a vertical sectional view through a fully assembled machine taken generally along line 3—3 of FIG. 2. Certain parts within the machine are shown in elevation for clarity.

FIG. 4 is an enlarged fragmentary cross sectional view of a portion of the machine shown in FIG. 3 to more clearly show the separate parts.

FIG. 5 is a fragmentary elevational view of a modification in the part of the powder container shown in elevation in FIG. 2.

FIG. 6 is a reduced size front elevational view of the wheel-like drum of the machine showing the structure and arrangement of FIGS. 2 and 3 modified and rearranged for printing on articles passing below the machine instead of above it.

FIG. 7 is a fragmentary vertical cross sectional view of the part shown in FIG. 6.

In detail the machine incorporating the invention comprises a cylindrical drum generally designated **1** that is supported for rotation about a horizontal axis, and the outer wall of which drum may comprise a cylindrical screen preferably in the form of a thin perforated sheet **2** having all of the perforations or mesh openings stopped out by any suitable stopping out medium except the portions designated **2'** (FIG. 1) that define the design to be printed. The design may be continuous around the drum or in separate parts either for repetition of the same design, or it may be any other printable matter.

The machine, as illustrated, including the drum is adapted to be supported on any suitable support **3** (FIG. 3) by a standard **4** or any other suitable support that may have a base **5** that, in turn, is adapted to be bolted by bolts **6** to said support, and which standard includes a clamp **7** at its upper end for gripping one end of a horizontally disposed shaft **8** for holding said shaft stationary, but permitting adjustment of the latter relative to the clamp. The shaft **8** projects laterally from the clamp **7** and the drum **1** is supported on the projecting end of shaft **8**, coaxial therewith. A stud bolt **9** may be provided on clamp **7** for tightening and loosening the grip of the clamp on shaft **8** for adjustment or replacement purposes.

Said cylindrical screen **2** is held between a pair of circular, horizontally spaced, opposed end walls **10, 11**, the former being at the front end of the drum **1** and wall **11** being at the rear end (FIG. 3) and which walls close the screen at its front and rear ends. Walls **10, 11** are coaxial with shaft **8** and the projecting end of the latter extends through the said walls.

Disposed between the clamp **7** and the rear wall **11** of the drum **1**, and adjacent to said clamp **7** is a pulley **14** over which a timing belt **15** extends to a driving pulley or to any suitable power means (not shown) for driving pulley **14**. A tubular sleeve **16**, coaxial with and around shaft **8** extends between pulley **14** and wall **11**, and bolts **17** extends through the pulley **14** and into threaded holes in the sleeve **16** rigidly but releasably secure the pulley to said sleeve, while a ball bearing **18** supports the pulley **14** on shaft **8** coaxial therewith and for rotation of the pulley **14** and sleeve **16** relative to shaft **8**.

A second ball bearing **19**, coaxial with bearing **18**, rotatably supports the end of sleeve **16** that is opposite to pulley **14** on shaft **8**, and said bearing also supports the inner wall **11** of drum **1** on said shaft.

A timing gear **20** (FIG. 4), coaxial with shaft **8**, is held against the inner side of end wall **11** by screws **23** that extend through registering holes in a clamping ring **24** and in inner wall **11** and into threaded engagement with threads within an axial extension of the openings in sleeve **16** for bolts **15**. The clamping ring is formed with an annular lip **25** that extends over a portion of the inner periphery of the gear **20** for clamping the pulley **14**, sleeve **16**, wall **11**, and gear **20** together as a unit and to permit rotary adjustment of gear **20** relative to wheel **1**. The heads of screws **23** are accessible from the side of ring **24** that faces toward the front end of the machine.

Supported within the upper portion of the drum **1** is a powder moving roller **26**, secured on a shaft **27** for rotation therewith. A timing gear **28** is secured on one end of said shaft **27** in a position spaced above, and in the same vertical plane as timing gear **20**, and a timing belt **29** connects gear **20** with the gear **28**.

A sleeve **30**, coaxial with shaft **27** is spaced around the latter and a pair of ball bearings **33** within the sleeve **30**, support shaft **27**, the latter being rotatable within sleeve **30**.

A vertically disposed plate **34** of electrical insulating material is releasably clamped at its lower end to stationary shaft **8** by a screw **35** and the upper end of the plate **34** is clamped to sleeve **30** by a screw **36** (FIG. 4). A conventional spring clip **37** on the end of shaft **27**, adjacent to wall **10**, releasably retains the roller **26** against axial movement off the adjacent end of shaft **27**.

The roller **26** includes a hub having an annular radially outwardly projecting web **38**. One side of said web faces sleeve **30**, and said side is formed with a recess **39** extending radially oppositely and outwardly of shaft **27**. A pin **40** extends through an opening in shaft **27** and projects from said shaft into the portions of recess **39** at opposite sides of said shaft to secure the roller **26** and shaft **27** for rotation together.

Said roller **26** has a relatively wide annular outer rim **43** that supports thereon a layer **44** of porous resilient filter material commonly known under the trade name of Scott Foam, and which layer substantially corresponds to the filter material shown and described in the copending application Serial No. 494,326 hereinbefore mentioned. The width of rim **43** and the layer **44** thereon are such that the layer will extend across and engage all of the inner surface of the cylinder **2** in which any design **2'** is formed by the screen openings.

From the description to this point, it is apparent that, upon removal of the front wall **10** of the drum **1**, the wheel **26** may be readily removed from the drum independently of any other elements, upon removal of the spring clip **37**.

A powder container or hopper generally designated **45**, comprises a vertical front wall **46** and a similar rear wall **47** in horizontally spaced opposed relation, and through which shaft **8** extends.

The use of the words "front," "rear," "forward," and "rearwardly" and words of similar connotation are used in the specification with respect to the standard **4** which is the rearmost element. Thus walls **10**, **11** are forwardly of standard **4** and wall **11** is rearwardly of wall **10**, with wall **10** being the front wall of the drum **1** and wall **11** being the rear wall.

The walls **46**, **47** of the powder containing hopper **45** are formed with coaxial central openings into which the ends of a central sleeve **48** extend, and to which the front wall **46** is removably secured by screws **49**. The rear end of sleeve **48** is formed with a radially outwardly projecting annular lip **50** (FIG. 4) that is seated in a complementarily formed rabbet around the rear corner of the opening into which the rear end of sleeve **48** extends.

The bore of sleeve **48** is greater in diameter than the external diameter of shaft **8**, and substantially the rear half of said bore is counterbored at **52**, to provide an axially rearwardly facing shoulder **53** at a point intermediate the ends of the bore in sleeve **48** and preferably approximately centrally between said ends. An annular strike plate **54** or anvil element is secured against said shoulder.

A lock member **56** (FIGS. 2, 4) is secured on shaft **8** by pin **57** at a point spaced rearwardly of the strike plate **54** and adjacent to, but spaced forwardly of the plate **34**, which lock member **56** is formed with an annular row of equally spaced outwardly opening recesses **58** (FIG. 2) around its outer periphery.

Sleeve **48**, in turn, is provided at its rear end with an annular row of radially inwardly extending projections **59** (FIG. 4) that are adapted to be moved through recesses **58**, axially of sleeve **48** into a space between the lock member **56**, rearwardly thereof, and the forward side of plate **34**. When the projections **59** are in the aforesaid space, a fractional rotation of the sleeve and hopper **45** will move the projections to positions behind the portions **60** that are between recesses **58** to retain the hopper against forward movement toward the front wall **10**. In this connection a vertically extending leaf spring **63** (FIG. 4) is pinned or otherwise suitably secured at its lower end to the front face of rear wall **47** of the hopper **45** and its upper end projects above said rear wall and is formed with an opening into which the forwardly projecting end of a pin **64** extends when said opening and pin **64** are in registration. Pin **64** is secured in a recess formed in the plate **34**. This pin releasably holds the hopper locked to stationary plate **34** against rotation relative thereto and when the pin **64** is in the opening in spring **63**, the radial projections **59** on sleeve **48** are behind portions **60** of the lock member **56**. Upon pulling the upper end of spring **63** forwardly, the spring is disengaged from the pin and the hopper and sleeve **48** may be rotated so that said projections **59** (FIG. 4) will register with the recesses **58** for withdrawal of the hopper axially thereof, assuming, of course, the front wall **10** is removed, as will later appear.

The shaft **8** is formed with an open ended slot **66** extending transversely through said shaft at a point adjacent to, but spaced forwardly of the locking member **56**, and a pin **67** extends through said slot, projecting at its opposite ends radially outwardly of the shaft. The forward sides of the projecting ends of pin **67** engage the rearwardly facing end of a tubular sleeve **68**, on the forward end of shaft **8**, which sleeve, in turn is reciprocable on shaft **1** forwardly of the slot **66**.

The rear end of sleeve **68** is formed with a radially outwardly projecting flange or striker **69**, which striker has an axially forwardly facing surface adapted to engage the rearwardly facing surface of the annular strike plate or anvil **54**. Said rear end of sleeve **68** is also formed with rearwardly opening recesses in which the opposite ends of pin **67** are positioned to prevent relative rotary movement of pin **67** and sleeve **68** about the axis of the latter.

The forward end of sleeve **68** is formed with a pair of circumferentially extending inclined cam surfaces **70** terminating in forwardly projecting risers **71**, each similar to a ratchet tooth.

Forwardly of the sleeve **68**, and on the forward end of shaft **8**, is a second sleeve **74** (FIG. 4) that is formed on its rear end with cam surfaces and risers that are complementary to the cam surfaces **70** and risers **71** on the forward end of sleeve **68**. The flange or striker **69** and anvil **54** are so positioned that when striker and anvil are in engagement, the risers on the sleeves **68**, **74** extend axially past each other (FIG. 4), with the inclined cam surfaces facing each other but spaced apart.

The forward end of shaft **8**, forwardly of slot **66** is hollow, providing a bore **75** that is open at the forward end of shaft **8**, and a coil spring **76** is within the rear end of bore **75**, which spring is connected at its rear end with pin **67**, while its forward end is connected to the rear end of an externally threaded rod **77**. Said rod **77**, in turn, is formed with a slot **78** extending longitudinally thereof, and a pin **79** secured at its ends in openings in the oppo-

site sides of the bore 75 extends through said slot to prevent rotation of the rod 77.

A collar 80 is around rod 77 at the forward end of bore 75, and partially extends into said bore. This collar also extends partially over the forward end of shaft 8 and is formed with a shoulder abutting the forward end of shaft 8, and rearwardly opening recesses 83 in collar 80 are adapted to receive the ends of pin 79.

The forward end of rod 77 is adapted to project from the forward end of bore 75, and a finger actuatable nut 84 threaded onto the projecting forward end of rod 77 enables adjusting the tension of spring 76. A lock nut 85 on said rod enables releasably locking the rod in adjusted position.

The forward end of shaft 8 projects a substantial distance forwardly of the front wall 10 of the drum 1, and sleeve 74 terminates at the forward end in a radially outwardly projecting flange 86 (FIG. 4) that abuts and is secured to the front wall 10 by screws 87. A ball bearing 88 rotatably supports the front wall 10 on the forwardly projecting end of shaft 8, and a disc 89 at the forward side of the front end wall 10 is secured to said end wall 10 by screws 90, which disc engages the outer race of ball bearing 88, the inner race being engaged by an axially rearwardly projecting annular flange 93 on a lock nut 94 that, in turn is threaded on the forward end of shaft 8 forwardly of disc 89, and is releasably clamped onto said outer end by a finger engageable head on a screw 95. The nut 94 is split transversely thereof with screw 95 extending across the split to clamp the nut to the threads upon tightening screw 95. The nuts 84 and screw 95, as well as nut 94, preferably have knurled heads permitting rapid and easy turning by the fingers of a hand.

Hopper 45 within the drum 1 has vertically extending side walls 96 (FIG. 2) equally spaced at opposite sides of sleeve 48, and convergently downwardly inclined lower portions 97. A thin horizontally disposed perforated screen or plate 98 provides a powder supporting bottom wall, below which is a layer 99 of resilient, porous, filter material of substantially the same character as that of layer 44 on the powder moving roller 26. The marginal portion of layer 99 is compressed and secured against the marginal portion of plate 98 by a collar 100 that, in turn, is secured against the compressed electrical insulating material of layer 99 by screws 103 that extend into the lower edges of the walls of the hopper.

Thep late 98 may be the equivalent of an approximately 20 mesh screen, while the layer 99 may have approximately sixty tortuous passageways to the inch therethrough while the openings in the area 2' in the screen 2 may be the equivalent of a three hundred mesh screen, the openings in the latter being larger than the discrete particles of powder held in the hopper 45, so as to freely pass therethrough.

A bed 104 of powder (FIG. 3) is within hopper 45 and a horizontal row of horizontally extending parallel, cylindrical bars 105 (FIGS. 2, 3) in spaced side-by-side relation are secured at their ends in walls 46, 47 adjacent to but spaced above the plate 98. These bars are preferably spaced apart a distance less than the diameter of a bar, and where the diameter of each bar is approximately 0.4 inch, the spacing may be 0.1 inch. In some instances it is desirable to provide a similar second row of bars or rods 106 (FIG. 5) below the single row of bars 105 with the bars 106 in staggered relation relative to the row of bars 105 to further contribute to support the weight of the portion of powder within hopper 45 above said rows of bars, and said bars also function to uniformly distribute the powder onto the inner side of the cylindrical screen 2. The adjacent convex sides of adjacent pairs of bars facilitate passage of the powder between each adjacent pair.

Tht portion 2' of the cylinder 2 may be acid etched to provide the openings, and the remainder of the cylinder may be imperforate, but partially etched to provide a roughness sufficient to carry powder passing through the

perforations in plate 98 and through layer 99 around with the cylinder 2 during rotation of the latter, as also occurs at the perforations, instead of any surplus powder tending to slide to the lowest point as the drum rotates. The etching is on the inner side of the cylinder.

A belt tightener 107 (FIG. 2) is on an arm 108 that, in turn, is pivotally supported at 109 on a bracket carried by plate 34 for engagement of the tightener with belt 29 to maintain the latter in taut relation to the timing gears 20, 28.

To load the hopper, it is merely necessary to remove the front wall 10 of the drum-like wheel 1 and the open upper end of the hopper is accessible for filling the hopper to the desired degree with the dry printing powder. The disc 89 is dished forwardly around its outer periphery for ready grasping by the finger of a hand to withdraw and to hold the wall 10. When clamping screw 95 is loosened and nut 94 is removed the front wall 10 may be removed for access to hopper 45 for filling the latter.

The hopper 45 may be readily withdrawn after removal of wall 10 by merely retracting spring 63 from pin 64 and then fractionally rotating the hopper until the projections 59 register with recesses 58 whereupon the hopper may be withdrawn to expose the plate 34. The roller 26 may be removed by removal of spring clip 37. However, for filling the hopper 45, it is only necessary to remove the wall 10.

After the hopper is filled and the front wall 10 replaced, the motor actuated timing belt 15 is actuated to rotate the drum 1 for moving the cylindrical screen 2 to carry the design or designs 2' past the rotary powder moving roller 26 and below the article to be printed upon. Such article is indicated as being a sheet of material 110, such as plywood, for example (FIG. 2), supported between drive rollers 111, actuatable for driving said material past drum 1 at a substantially uniform distance above the cylinder or screen 2 at the same rate of speed as the surface speed of the screen 2 and in the same direction as the direction in which the latter is moved.

Simultaneously with rotation of the drum 1, the powder moving roller 26 will be rotated at a substantially higher rate than screen 2, and the outer periphery of layer 44 where it contacts the inner surface of screen 2, will be moved in the same direction as the direction of rotation of the screen 2. This point of contact between the roller 44 and the inner surface of screen 2 is preferably at the point where the screen 2 is closest to the sheet 110. The roller 44 is electrically insulated from the rest of the printing machine by reason of the plate 34 that supports it, being of electrical insulating material, and the screen 2 may be connected with a D.C. source of power 113 while the sheet 108 may be grounded at 114, to establish an electrostatic field between the screen 2 and the plywood or material 110 for conducting powder moved by the layer 44 of roller 26 through the openings in screen 2 onto the lower surface of the material. Walls 10, 11 of the drum 1 are of electrical insulation material and wall 11 carries a conductor ring 114 contacted by a stationary wiper element 115. A conductor element 116 (FIG. 4) connects ring 114 with screen 2 (FIG. 4).

The rollers 111 may each be formed with annular ribs to span the design imprinted on the sheets 110 before such design is fixed by any suitable means (not shown) such as a spray, heat, etc. An air jet 117 (FIG. 1) directed across the outer surface of the screen 2 adjacent to but spaced from the point where the powder is conducted onto the sheet, may serve to clean the outer surface of the screen 2 of any powder that may tend to cling thereto, so that only a clear imprint of the design 2' will be deposited on the material 110.

Referring to FIGS. 6, 7, an arrangement is shown in which the powder hopper 45 and the powder moving roller 26 of FIGS. 2, 3, 4 are in inverted positions. The powder hopper in FIGS. 6, 7 is generally designated 118 and the roller 119.

A conventional conveyor **120**, indicated in dot-dash lines in FIG. 7, is adapted to carry rods **121** past the lowermost surface of the cylindrical screen indicated at **122** for being printed upon. Such conveyor and rods and their relation to a similar cylindrical screen are shown and described in copending application Ser. No. 494,326, filed Oct. 11, 1965, by us.

In the present invention, the lower side of the hopper **118** comprises a horizontal screen **123** and a layer of filter material **124** that corresponds structurally to the screen **98** and filter material **99** of FIGS. 3, 4.

Plate **125** performs the same function as plate **34** in FIG. 3, and has a downward extension **126** to support the roller **119** below the powder hopper, while the cylindrical bars **127** perform the function of rods **105** being in a horizontal row spaced above screen **121**.

The remaining elements, such as the central assembly for supporting the hopper and shock members are the same as in FIG. 3, and function in the same manner. In FIG. 7, it is apparent that the width of the outer drum **128** and its screen is wider than the outer drum **1** of FIG. 3 and the powder moving roller **119** of FIG. 7 is longer than roller **26**, but the structure is otherwise substantially the same.

The drums **1** and **128** may be called printing wheels and rollers **26**, **119** will be called powder moving rollers, since the latter perform the function of positively moving the powder deposited on the inner surface of the screens **2**, **122** through the unobstructed openings in said screens that form the designs to be printed. While the discrete powder particles are of a size to freely pass through the openings in the screen, it is essential that they be moved through the openings and into the electrostatic field established between the article to be printed upon and the screen **2** or **120** to be properly conducted onto said article.

The problem of providing a consistently uniform layer of powder onto the screen of the printing wheel is important in most instances, particularly over a constant and lengthy period of time.

Upon rotation of the printing wheel (FIG. 4), the flange **69** on the end of the hollow sleeve **68** performs the function of a striker, while the plate **55** comprises an anvil to receive the blow from the striker upon each revolution of the sleeve **74**, which sleeve is connected with the printing wheel **1**. The anvil is rigid with both ends of the powder hopper **45** and the force of each blow from the striker is transmitted to the sleeve **48** that in turn connects the end walls **46**, **47**. Since the point of impact is approximately centrally between walls **46** and **47**, the impact is substantially equally transmitted, and the intensity of each blow against the anvil **55** is regulated by the tension of spring **76**, which tension can be quickly regulated by rotation of nut **84**. The number of impacts or blows against the anvil during each revolution of the drum **1** is according to the number of risers **71** on the cam surfaces of sleeves **68**, **74**.

Each blow of striker **69** is transmitted substantially uniformly to the powder within the hopper **45** through the walls of the latter, including the screen **98** and filter layer **99** and bars **105**, resulting in an accurately metered amount of printing powder being uniformly deposited onto the inner surface of screen **2** (FIG. 2) or onto the outer layer of filter material **129** on roller **119** (FIG. 7).

The filter material **99** and **124** substantially provides a substantially uniform number of adjoining tortuous open ended passageways, many being in communication with each other at points intermediate their ends whereby the movement of the powder particles through the layers **99**, **124** will be checked, but will require vibration or shocks transmitted to the powder and layers for progressive passage through the passageways at a substantially uniform rate of speed. The powder will also be distributed uniformly through the layers **99**, **124**.

The provision of cylindrical bars **105**, **106** and **127** in relation to the screen **98** or **123** also materially contributes to the desired uniformity in the feed of the powder onto the screen **2** or **122**.

The use of the word "screen" is not intended to be restricted to a woven screen or to a perforated plate, although the latter is normally preferred.

It is to be understood that the detailed description is not to be considered as limiting the scope of the claims, it being obvious that modifications and changes may be made that come within said scope and within the spirit of the invention.

We claim:

1. In electrostatic printing apparatus that includes a printing screen having a perforated portion adapted to receive thereon printing powder for movement through the openings in said portion into an electrostatic field established in an air gap between said screen and an article to be printed upon for conduction of the powder so moved across said air gap, the combination of:

(a) a horizontally disposed, stationary layer of material over which a bed of printing powder is adapted to be supported, said material being formed with substantially uniformly distributed tortuous adjacent passageways extending therethrough from top to bottom of sufficient size to pass the particles of said powder downwardly therethrough from said bed for substantially uniform discharge from the underside of said layer upon administration of shocks to said layer and body;

(b) said layer having outer edges, and a rigid layer-support connected with said edges supporting said layer with the area thereof inwardly of its edges spaced over said portion of said screen for passage of said powder through said passageways and for discharge and deposit on said portion;

(c) a powder supporting screen disposed between said bed of printing powder and said layer supporting said bed of printing powder over said layer and through the openings of which screen powder passes from said bed to said layer, said screen being inelastic to stretching and held against distortion under the weight of said bed of powder;

(d) movable shock-administering means operatively connected with said layer for administering shocks thereto and to such bed for causing downward movement of powder of said bed through said passageways and said discharge therefrom under the combined influence of said shocks and gravity.

2. In the combination as defined in claim **1**,

(e) said layer including a relatively thick sheet of resilient, flexible material in which said passageways are formed, said powder supporting screen being a perforated sheet of material over said layer secured at its edges to said layer-support for transmission of said shocks from said shock administering means to the bed of powder adapted to be supported thereon, said sheet being quite thin compared to the thickness of said sheet of flexible material.

3. In the combination as defined in claim **1**,

(e) said rigid layer-support including spaced opposed pairs of stationary, rigid walls connected with and extending upwardly from the edges of said layer providing the sides of a hopper for said powder, with said layer defining the bottom of such hopper;

(f) said shock-administering means comprising a striker element and an anvil member and means supporting said striker element for intermittent movement into sharp impacting engagement with said anvil member, and means connected with said striker element for so moving it, said anvil member being rigidly connected with said walls of said hopper for intermittently transmitting a shock administered to the latter and to said layer upon movement of said

striker element into said impacting engagement with said anvil member.

4. In the combination as defined in claim 1,

(e) said printing screen being cylindrical, and having imperforate end walls;

(f) screen-supporting means supporting said printing screen for rotation about a horizontal axis;

(g) means supporting said layer-support stationary within said printing screen with said layer below said axis of rotation of said printing screen and said portion of said printing screen being the portion spaced below said layer when said printing screen is rotated;

(h) said rigid layer-support including a horizontally spaced opposed pair of walls extending upwardly from and rigidly connected with said layer at the edges of the latter, and rigidly connected with each other to provide two opposed sides of a stationary hopper having said layer as the bottom wall thereof;

(i) a horizontally extending row of parallel, horizontally spaced bars rigidly secured to and extending between said opposed pair of walls at a level spaced above said layer for distributing powder of said bed adapted to be positioned above said layer to opposite sides of the rods of adjacent pairs thereof as powder from said body is discharged from said printing screen.

5. In the combination as defined in claim 4,

(j) means supporting said shock-administering means within said hopper and between said pair of opposed walls, and connected with said pair of walls.

6. In the combination as defined in claim 1,

(e) said printing screen being cylindrical;

(f) screen-supporting means supporting said printing screen for rotation about a horizontal axis around said layer with said portion of said printing screen being the portion below said layer when said printing screen is rotated;

(g) said rigid layer-support including adjacent pairs of upstanding rigid walls rigidly connected with said layer at the edges of the latter, and rigidly connected with each other to provide a stationary hopper having said layer as the bottom wall thereof;

(h) the upper side of said hopper being open and facing the upper side of said printing screen;

(i) a roller of resilient material supported over said hopper for rotation in engagement with the inner surface of said printing screen for forcing powder discharged onto said lower portion from said layer and carried upwardly by said printing screen, through the openings in said printing screen;

(j) means for establishing an electrostatic field between the upper side of said printing screen and an article thereover for conducting the powder moved through the openings in said printing screen onto said article during rotation of said printing screen, and

(k) means for supporting such article over said printing screen and spaced thereabove for receiving said powder.

7. In the combination as defined in claim 6,

(l) the inner surface of said printing screen being roughened for carrying particles of powder deposited thereon to said roller.

8. In electrostatic printing apparatus that includes a drum-like printing wheel having a pair of horizontally spaced, opposed, imperforate vertically disposed end walls and an outer peripheral wall extending between said end walls at their outer peripheral edges and secured to the latter, which outer peripheral wall includes a perforated portion adapted to receive thereon printing powder for movement through the perforations of said portion into an electrostatic field to be established in an air gap between said portion and an article to be printed upon for conduction of the powder so moved,

(a) a stationary central shaft extending through said wheel having bearings supporting said wheel thereon for rotation about its horizontal axis;

(b) a powder holding hopper within said wheel for holding a supply of printing powder, said hopper having a pair of spaced opposed side walls through which said shaft extends;

(c) a horizontal bottom wall on the lower end of said hopper and side walls for supporting said supply of powder, said bottom wall including a layer of porous filter material having tortuous substantially uniformly distributed passageways therethrough for passage of said powder therethrough substantially only upon administering shocks to said layer, and said passageways being of a size to freely pass the discrete particles of said powder upon administration of said shocks;

(d) a tubular member coaxial with and around said shaft extending between and rigid with said pair of side walls of said hopper, said tubular member including an axially facing annular surface therewithin and coaxial with said shaft in a position intermediate said pair of opposed end walls of said housing for receiving impacts from a shock administering element;

(e) an annular shock administering element reciprocable on said shaft intermediate said opposed side walls of said hopper and within said tubular member having an axially facing annular surface facing adapted to intermittently engage said axially annular facing surface on said tubular member upon said reciprocation of said element for administering shocks to said tubular member for transmission to said pair of opposed side walls of said hopper and to said layer of porous material;

(f) means for reciprocating said shock administering element upon rotation of said wheel.

9. In a construction as defined in claim 8,

(g) said means for reciprocating said shock administering element including a spring enclosed within said shaft in engagement with said shock administering element for yieldably urging the latter toward said axially facing surface on said tubular member at all times and complementary cam surfaces on said shock administering element and on said tubular member engageable during rotation of said wheel for intermittently moving said shock administering element in a direction away from said tubular member against the resistance of said springs and for releasing said shock administering element at the end of each movement thereof away from said tubular member for said movement of said element toward and into engagement with said member under the force of said spring;

(h) means on said shaft outside said wheel connected with said spring manually actuatable for regulating the tension of said spring.

10. In a construction as defined in claim 8,

(g) one of the end walls of said wheel being removable from said outer peripheral wall for access to said hopper;

(h) finger engageable means on said shaft outside said wheel for releasably securing said one of said end walls in supporting relation to said outer peripheral wall and finger actuatable for release and removal of said one end wall from said wheel;

(i) a tubular member coaxial with and around said shaft extending between and rigid with said pair of side walls of said hopper;

(j) locking means respectively on said member and on said shaft in releasable locking relation for releasably locking said hopper to said shaft against movement of said hopper axially off said shaft when said one of said end walls is removed, said locking

means being releasable from each other for withdrawal of said hopper off said shaft when said one end wall is removed upon a predetermined rotation of said hopper in one direction about the axis of said wheel, and

(k) release means accessible from the open side of said wheel when said one wall is removed for releasably securing said hopper against said rotation thereof when said interlocking means are in locking relation, said release means being manually movable for releasing it to enable said rotation of said hopper.

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