May 21, 1957 C. W. JACOB 2,792,780

PRINTING METHODS AND APPARATUS

Filed Oct. 3, 1952 3 Sheets-Sheet 1

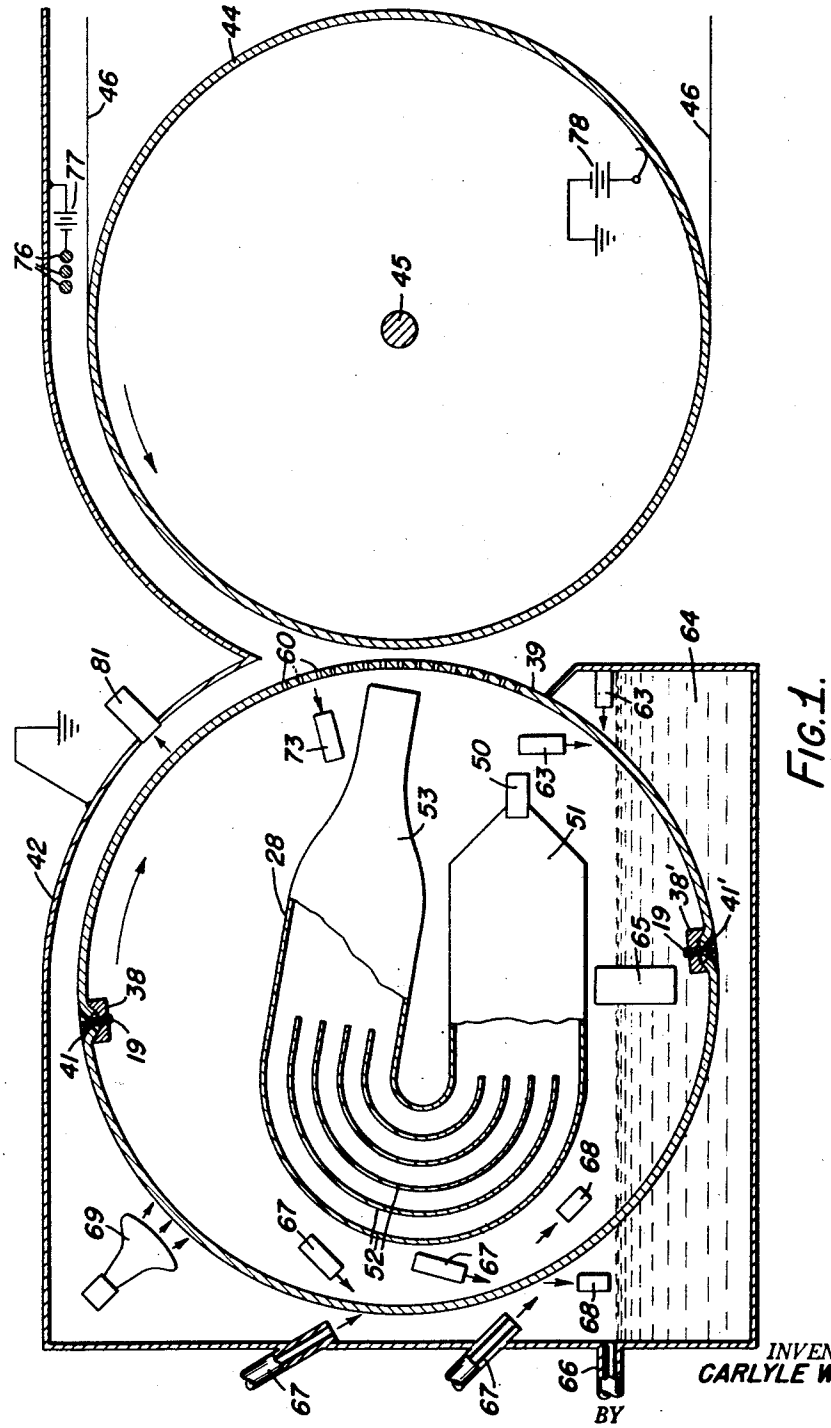

FIG. 1.

INVENTOR.
CARLYLE W. JACOB

BY

Harold C. Bayer

ATTORNEY

May 21, 1957 C. W. JACOB 2,792,780

PRINTING METHODS AND APPARATUS

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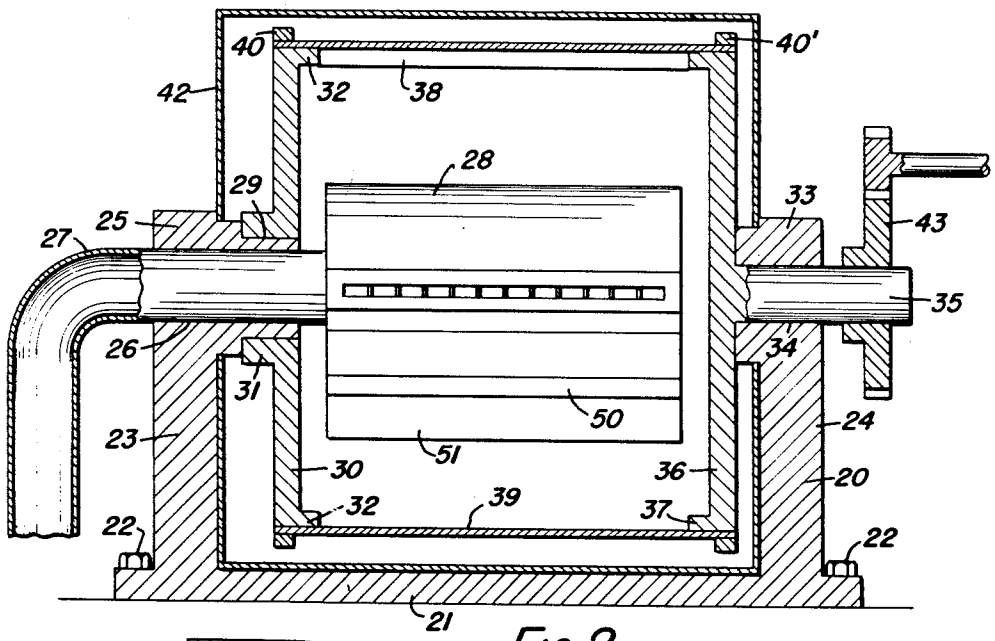

FIG. 2.

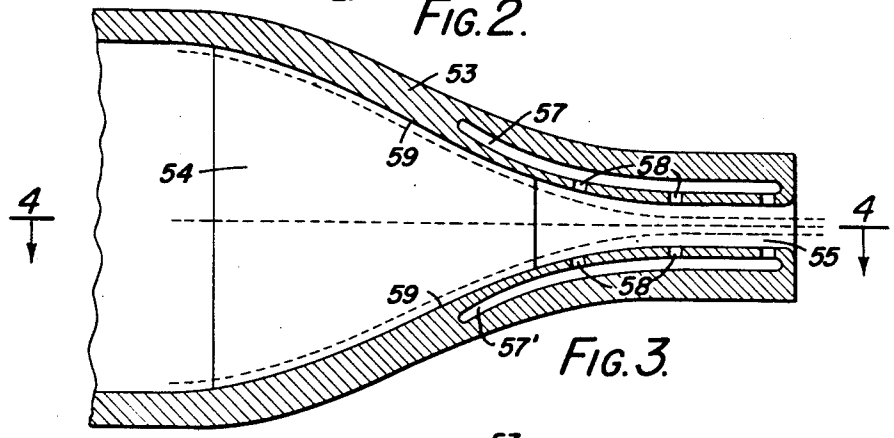

FIG. 3.

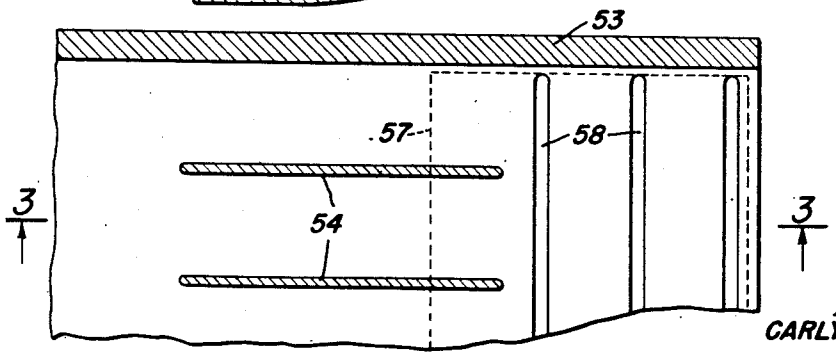

FIG. 4.

INVENTOR.
CARLYLE W. JACOB

BY Harold C. Bayer

ATTORNEY

May 21, 1957 C. W. JACOB 2,792,780

PRINTING METHODS AND APPARATUS

Filed Oct. 3, 1952 3 Sheets-Sheet 3

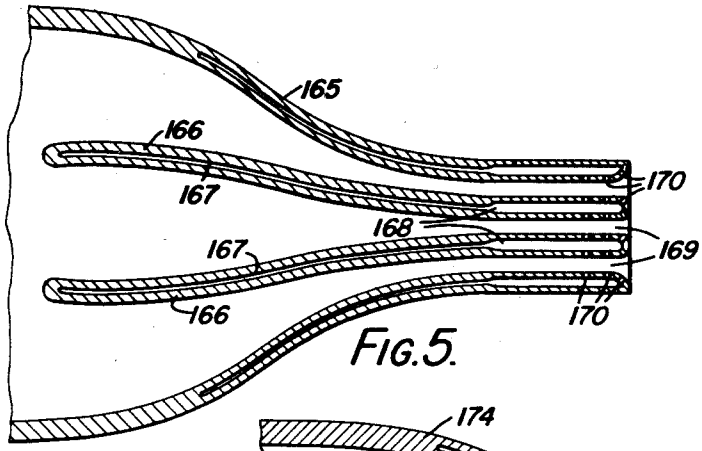

FIG. 5.

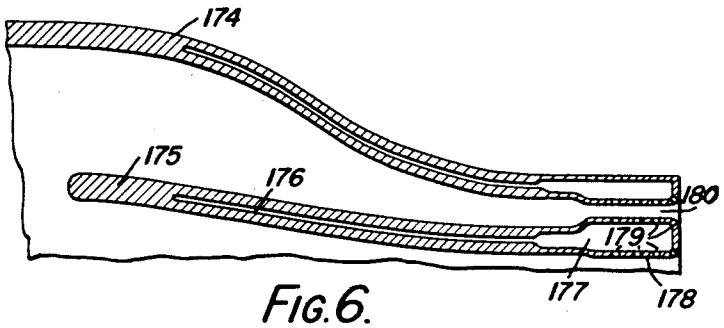

FIG. 6.

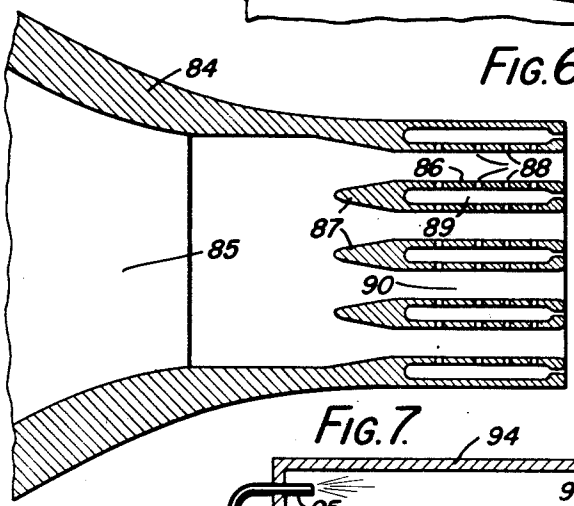

FIG. 7.

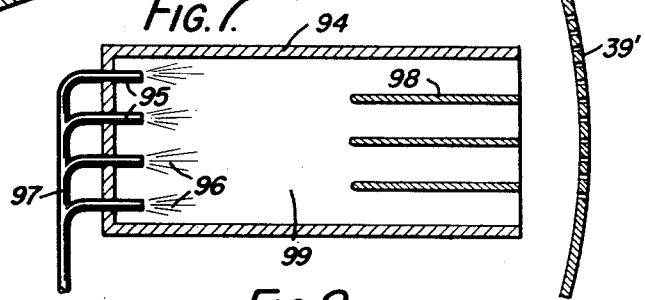

FIG. 8.

INVENTOR.
CARLYLE W. JACOB

BY

Harold C. Bayer

ATTORNEY

United States Patent Office 2,792,780 Patented May 21, 1957

2,792,780

PRINTING METHODS AND APPARATUS

Carlyle W. Jacob, Rochester, N. Y.

Application October 3, 1952, Serial No. 313,019
9 Claims. (Cl. 101—119)

This invention relates to a method and apparatus for printing, and more particularly to a method and apparatus, wherein the printing operation is accomplished without the printing plate contacting the print receiving medium.

Heretofore, material has been printed generally by such conventional methods as letterpress, lithography, or gravure. In each of these methods a plate, or an equivalent element containing a symbol to be printed, comes into physical contact, with the material to be printed. As a result of this direct contact, it has been found necessary to carefully select only papers having the required fiber strength, porosity, and degree of smoothness. Such papers are frequently expensive and not easily procureable. Further, the speed of such printing operations is limited by the time required for the inks to dry. This is especially the case in multi-color operations. Also, where half-tone dot structures are employed, it has not been uncommon to experience the undesirable irregular spreading out of the half-tone dots. This problem has been alleviated to some extent only, by the use of expensive inks and papers.

It is the primary object of this invention to provide a method and an apparatus for printing, wherein the printing plate does not come into direct physical contact with the material to be printed.

Another object of this invention is to provide a method and an apparatus wherein material may be printed by means of passing a stream of marking particles through a printing plate which is located adjacent but spaced from the material.

Another object of this invention is to provide a method and an apparatus for priting wherein a flow of ink particles is given a high velocity and collimated and then passed through a printing plate into contact with a print receiving medium.

A still further object of this invention is to provide an apparatus, of the character described, wherein the pattern to be printed is located on a rotatable hollow cylinder which is disposed adjacent to, but spaced from, a cylindrical drum rotating synchronously therewith and having mounted thereon the material to be printed.

A still further object of this invention is to provide a method and apparatus, of the character described, wherein a flow of gas containing therein a suspension of ink particles is produced, and wherein the gas is removed from the flow to leave a collimated beam of ink particles to be passed through a printing plate into contact with a print receiving medium.

Another object of this invention is to provide a method and an apparatus for printing wherein relatively cheap and porous papers may be employed as print receiving mediums.

Still another object of this invention is the provision of a method and an apparatus for printing wherein heavy deposits of inks may be applied at relatively high printing speeds without the necessity of time consuming drying operations.

A still further object of this invention is to provide a method and apparatus for printing wherein continuous tones of various densities may be applied to a print receiving medium and wherein exceptionally fine definition is possible.

With the foregoing and other objects in view which will appear as the description proceeds, the invention resides

in the combination and arrangement of parts and in the details of construction hereinafter described and claimed, it being understood that changes in the precise embodiment of the invention herein disclosed can be made within the scope of what is claimed without departing from the spirit of the invention.

The invention is illustrated in the accompanying drawing, wherein:

Figure 1 is a side elevational view partly in section and showing somewhat diagrammatically one form of the apparatus constituting this invention.

Figure 2 is a front elevational view of the device of Figure 1 and shown partly in section to thereby expose a part of the interior structure, hereinafter referred to as the collimating section and the droplet chamber.

Figure 3 is a vertical section of a portion of a preferred embodiment of the collimating structure constituting part of the invention herein and taken along lines 3—3 of Figure 4.

Figure 4 is a horizontal section taken along the lines 4—4 of Figure 3.

Figure 5 is a vertical section of a portion of a modified form of collimating structure forming a part of this invention.

Figure 6 is a vertical section of a portion of another form of a collimating structure forming a part of this invention.

Figure 7 is a vertical section of a portion of another form of collimating structure forming a part of this invention.

Figure 8 is a vertical section of a modified form of an ink supplying means and collimating structure forming a part of this invention, shown disposed adjacent to a fragment of a printing plate.

Referring in particular to Figures 1 and 2 of the drawing, a frame **20** is provided having a base portion **21** which is secured to a supporting surface by means of bolts **22**. A pair of parallel upright portions **23** and **24** are carried by the base portion **21**. The upper end **25** of the upright **23** is provided with an opening **26** through which extends a hollow shaft **27**. The hollow shaft **27** supports at its end a substantially U-shaped duct **28**. The upper end **25** of the upright **23** is provided with a bearing surface **29**, which in turn supports a rotatable wheel **30** having a hub portion **31** and a peripheral flange portion **32**.

The upright **24** has an upper end **33** which is provided with an opening **34** in which is suitably supported a rotatable shaft **35**. The rotatable shaft **35** has secured to its inner end a wheel **36** having a peripheral flange portion **37**. Transverse, substantially V-notched bars **38**, **38'** are suitably connected to the peripheral flange portions **32** and **37** of the wheels **30** and **36** respectively, so that the latter rotate in synchronism.

A thin printing plate is mounted around the peripheral flange portions **32** and **37** to thereby define a hollow printing cylinder **39**. The printing cylinder **39** is held in position thereon by means of clamping rings **40**, **40'** and transverse triangular bars **41**, **41'** secured to bars **38**, **38'** by screws **19**.

The outer end of the shaft **35** is suitably connected to a drive mechanism through a system of gears **43**. A cover **42** is provided to cover the printing plate **39** to thereby minimize the deposits thereon of lint, dirt, or other foreign particles.

A drum **44** rotated about a shaft **45** and having paper **46**, to be printed and mounted thereon, is positioned adjacent the printing plate **39**. The drum **44** is preferably spaced about 1/16 of an inch from the printing cylinder **39**. The shafts **45** and **35** are preferably rotated by means of a common power source, so that one is rotated in a clockwise direction and the other in counterclockwise

direction. The circumferential velocity of the printing plate 39 is equivalent to that of the drum 44.

The U-shaped duct 28 has mounted on one leg thereof an ink injector system 50 similar to the system shown in my Patent No. 2,577,894 issued on December 11, 1951. The ink injector 50 produces a fine mist of atomized particles of ink which are transported in suspension in a flow of a suitable gas such as air. The ink injector 50 discharges a mixture of atomized ink particles and air at high velocity into a droplet chamber section 51 which has a relatively large area, so that the ink particles lose some of their high blast momentum. The ink droplets are carried along smoothly by their air vehicle from the droplet chamber 51 to the guiding vanes 52. The vanes 52 also function in the capacity of a particle size selector, in that excessively large droplets are caught on the walls of the vanes due to the high inertia of such droplets. Although vanes of the type in Figure 1 are shown, it is obvious that other types of particle selectors could be expediently utilized, such as electronic selectors. The vanes 52 could in fact be eliminated, and yet a substantial amount of particle selection would result, in that the excessively large particles would, due to their relatively high inertia be caught against the inside wall of the bight portion of the U-shaped duct 28. It should also be mentioned, that although the droplet chamber 51 is illustrated inside the printing cylinder 39, it could just as well be outside in which instance suitable ducts would transport the atomized ink particles to the inside of the printing cylinder 39.

As particularly shown in Figures 3 and 4, the U-shaped duct 28 is provided with a collimating section 53 in which is located a plurality of vertical vanes 54. The collimating section 53 converges so as to produce a narrow passageway 55. The interior wall 59 of the collimating section 53, defining the narrow passageway 55, is provided with a plurality of apertures 58 suitably spaced which communicate with suction chambers 57, 57'.

The mixture of air and atomized ink particles having traveled through the vanes 52, passes into the collimating section 53. The vertical vanes aid in producing a vertical collimation of the flow. The flow continues, and the ink particle paths are caused to speed up and to converge due to the converging configuration of the collimating section 53. When the flow reaches the narrow passageway 55, the air vehicle is substantially removed due to the action of the suction chambers 57 and 57', the latter being connected to a suitable suction producing source. The air vehicle is removed not only through the apertures 58, but also through the interior wall 59, which is constructed of a porous material. The remaining flow, which consists almost exclusively of ink particles traveling at high speeds in relatively still air, is discharged from the narrow passageway 55 toward the printing cylinder 39. Where holes 60 are present the ink particles pass in a collimated beam through into contact with the paper 46 to be printed.

It should be mentioned that the vertical vanes 54 should preferably be located some distance from the discharge end of the narrow passageway 55, so as to eliminate the possibility of there being a shadow cast on the printing plate 39. The ink particles suspended in the air stream travel in paths which converge toward the center of the narrow passageway 55. The lateral flow of air through the porous wall 59 and through the apertures 58 imparts a force on the ink particles which tend to cause their flow paths to diverge. The tendency of the ink particle paths to diverge in the narrow passageway 55 is substantially equal to their tendency to converge in this area. Therefore, the converging and diverging forces acting on the ink particles counterbalance each other with the result that a substantially parallel or collimated beam of ink particles is produced. The deviation of the beam from parallelism should preferably be less than one part in ten to twenty-five.

The interior wall 59 of the collimating section 53, due to its porous surface, has the characteristic of soaking up the ink particles that come in contact with it. The soaked up ink travels through the wall 59 into the suction chambers 57 and 57'. The absorbent action of the wall 59 tends to prevent large accumulations or large droplets of ink particles on the wall 59, which might be blown off into contact with the printing plate, thereby tending to plug the openings 60 in the latter. The action of the suction chambers 57 and 57' not only cause the removal of the air vehicle from the flow, but also tends to remove excessively small droplets from the flow. Just as excessive large droplets tend to plug the openings or the half-tones holes 60, excessively small particles are undesirable in that they do not possess sufficient momentum to move in relatively straight lines toward the printing cylinder 39 and the paper 46. Thus, excessively large particles and excessively small particles, together with the air vehicle are removed by the time the flow is discharged from the narrow passageway 55, leaving a collimated beam of relatively small atomized particles of ink traveling in a relatively still medium of air.

It should be mentioned that it is undesirable that the beam of ink droplets striking the printing cylinder 39 be encumbered by an air flow, due to the fact that such air flow would tend to distort the straight line motion of the ink droplets. Also, if there is excessive air flow in the vicinity of the portion of the printing plate 39 adjacent the exit of the passageway 55, some of this air flow is apt to pass through some of the openings or half-tone holes 60, thereby causing an undesirable deflection of the flow of ink droplets before the latter strikes the paper 46.

It should be mentioned that absolutely perfect collimation of the ink particle paths is not generally desired, due to the fact that a slight divergence of the beam is necessary in order to cause one half-tone dot to spread toward the adjacent half-tone dot to thereby produce a continuous tone. Normally it is desirable that each half-tone dot be enlarged sufficiently to meet its neighboring or adjacent dots so as to produce a continuous tonal effect.

The spreading of the half-tone dots is controlled by several factors, such as spacing of the printing cylinder 39 from the paper 46, the degree of particle size selection, and the extent of the collimation. It is preferable that the collimating section 53 be directed at a downward angle with respect to a horizontal diametrical axis of the printing cylinder 39.

This angle should be such that the downward vertical component of velocity of the ink particles is approximately equal to the circumferential velocity of the drum 44. Therefore, the ink particles will travel through the openings 60 in a manner so that they will strike the paper 46 at a point directly across from the particular opening 60 from which they were discharged. Thus, excessively fine registration is made possible.

Referring now in particular to Figure 1, a suitable number of fluid jets 63 eject a cleaning fluid 64 onto the printing cylinder 39. An agitator 65 is located beneath the U-shaped duct 28 and produces an agitating action in the cleaning fluid 64, thereby tending to cleanse the printing cylinder 39, washing the remaining ink from the same. An exhaust tube 66 is located adjacent the bottom of the cover 42 to thereby control the level of the cleaning fluid 64 inside the bottom of the cover or the enclosure 42. Suitable air jets 67 impart streams of high velocity air against the printing cylinder 39 to thereby remove the cleaning fluid and any remaining foreign particles from the latter. Suction lines 68 are provided to remove the air from within the enclosure 42, as well as, from inside the cylindrical printing cylinder 39. By means of the suction line 68 located inside the cylinder 39, the pressure inside the latter can be conveniently maintained slightly positive to thereby prevent foreign particles from entering through the openings 60.

A heat lamp **69** tends to dry the printing cylinder **39** and is suitably located for this purpose. It should be pointed out that in addition to or in substitution for the air jet **67**, a plurality of absorbent rollers or brushes could be used for the purpose of cleaning the printing plate **39**. A suction line **73** is located in the vicinity of the discharge end of the collimating section **53** to thereby stop any unwarranted circulation of air, which would tend to distort the collimated beam of ink particles striking the printing cylinder **39**.

A wire corona screen **76**, connected to a high pressure voltage source **77**, imparts negative ions on to the paper **46**. A voltage source **78** of positive potential is connected to the drum **44**. Thus, any lint or foreign particles resting on the surface of the paper **46**, being negatively charged, are caused to be securely held in position on the paper. Therefore, these foreign particles are prevented from falling off the paper and entering and clogging the openings **60** of the printing cylinder **39**. The printing cylinder **39** is preferably grounded, although, it could be connected to a suitable voltage potential source to thereby aid in keeping off foreign particles or dust. The cover **42** is also provided with a suction line **81** which removes the uncleaned air circulating in the vicinity of the printing cylinder **39** and the paper **46**.

The printing cylinder or plate **39** is composed of any suitable material which is adapted to etching such as is customary in conventional photographic processes. The plates are fabricated with a thickness in the order of approximately $\frac{1}{1000}$ of an inch, but may be either thicker or thinner depending upon the particular application involved. The plates are produced in a manner similar to conventional plates employed in connection with methods of printing such as lithography, letterpress, or gravure. Customary screening methods may be employed to produce the half-tone dots. However, instead of etching only the surface of the printing plate, the plate used in connection with this invention is etched until a hole is produced extending through the plate. Even glass plates could be used, provided they are of a photographic variety such that after exposure to light, the plates could be etched in a manner to produce holes extending through the plates. Plates having as many as 50,000 half-tone holes per square inch may be used.

It is preferable that the surface of the printing cylinder **39**, and preferably the inside surface, be serrated. When ink particles are ejected from the collimating section **53** on to the cylinder **39**, some particles will not go through the openings **60**, but rather will remain or adhere to the inside surface of the cylinder **39**. If the inside surface of the cylinder **39** is serrated, the ink particles will tend to adhere more readily to the serrated surface and will be less inclined to drip down over the openings **60**, thereby tending to clog the latter.

A modified form of collimating section **165** is shown in Figure 5. The collimating section **165** converges toward its discharge end similar to the embodiment shown in Figure 2. However, the collimating section **165** is provided with a plurality of hollow elongated guide vanes **166** having interior spaces **167** therein. The interior spaces **167**, commencing at the interior end of the vanes **166**, communicate with enlarged suction chambers **168**, which are located adjacent the exterior ends of the vanes **166**. The guide vanes **166** converge toward their exterior ends to define a plurality of narrow parallel passageways **169**. A plurality of apertures **170** are located in the walls of the vanes **166** adjacent their exterior ends and communicate with the enlarged suction chamber **168**. The operation of the modified collimating section **165** is similar to the form shown in Figure 2, in that, the air vehicle transporting the mist of ink particles is removed through the apertures **170**, and to some extent, by the walls of the hollow vanes **166** which are constructed of porous material. The air so removed is conveyed into the suction chambers **168** which is connected to a suitable vacuum producing source. In the narrow parallel passageways **169** the trajectories of the ink particles become generally parallel, and since the particles have already gained considerable velocity due to the funneling action of the guide vanes **166**, they continue their generally parallel direction after leaving the passageways **169**. Thus, a plurality of narrow collimated beams of ink particles are produced and strike the printing cylinder **39**.

It should be pointed out that a plurality of relatively small parallel beams of ink particles has the characteristic of being better collimated than a single relatively large beam of ink particles. A large beam possesses a great quantity of air vehicle which must necessarily be removed, and the removal of which has a greater distorting effect on the motion of the ink particles. Therefore, more accurate collimation can be effected by a collimating section composed of a plurality of narrow passageways.

Another form of collimating section, designated as **174**, is shown in Figure 6. This modification contains a plurality of hollow elongated vanes **175** having interior spaces **176** therein communicating with enlarged suction chambers **177**. The vanes **175** have thickened end portions **178** having apertures **179** therein which communicate with the suction chamber **177**. The vanes **175** converge, in a manner similar to the vanes shown in the modification of Figure 5, thereby defining a plurality of narrow parallel passageways **180**. In this form, a greater focusing action of the flow paths of the ink particles is effected due to the tapering configuration of the vanes adjacent the thickened portion **178**.

In Figure 7, a modified form of collimating section **84** is illustrated. This form comprises a plurality of vertical vanes **85** and a plurality of relatively short parallel vanes **86**. The vanes **86** are provided with tapered entrance portions **87** and apertures **88** which communicate with suction chambers **89**. The tapered entrance portions **87** have a converging action on the ink particles in the same manner as the structures shown in Figure 3 and Figure 6. This converging action aids in the subsequent collimation of the particles. The walls of the vanes **86** define a plurality of narrow parallel passageways **90**, spaced preferably less than $\frac{1}{16}$ of an inch apart. The tapered entrance portions **87** may be extended to include the complete length of the vane, but preferably are confined, as shown to only the initial portions of the vanes. In this particular form, the flow paths of the ink particles are collimated not only by the action of the vanes **86**, but, also, by means of the vertical vanes **85**.

In Figure 8, a modified form of fluid ejection system and collimating system is shown. In this form, an enclosure **94** is provided, having mounted at one end thereof a plurality of high pressure ejection nozzles **95**. The nozzles **95**, which eject a marking fluid, such as ink **96**, are connected to a trunk line **97** which is connected to a suitable high pressure ink source. The high pressure nozzles **95** eject the ink **96** in a finely atomized form and cause the ink particles to travel toward a plurality of spaced parallel vanes **98** which define a plurality of parallel narrow passageways **99**. In this modification, no air or other gas vehicle is used to transport the ink particles. The flow of ink particles is, therefore, collimated, and a plurality of collimated beams of ink particles is directed against a print cylinder **39'** and against paper to be printed, in a manner as aforesaid. The walls of the enclosure and the vanes **98** may be provided with suction chambers similar to the construction illustrated in the previously mentioned modifications.

Although, the invention herein disclosed has been discussed in connection with various forms of collimating sections through which ink particles are discharged and which particles come into contact with a rotating printing plate and a rotating print receiving medium, it is obvious that other applications of the novel principles, herein disclosed, can be employed. For example, the print receiving medium and the printing plate could be

disposed in superimposed stationary positions, and the collimating section could be oscillated back and forth across the printing plate in linear movements. Also, it shall be stated that although the device herein has been discussed in connection with a printing plate or stencil, the application of the invention is not to be confined in this respect. As is obvious to those skilled in the art, the invention disclosed herein is adapted to numerous applications wherein a stencil is not employed.

Having thus described my invention, I claim:

1. In an apparatus for marking a surface by passing a flow of marking particles through a stencil, a source of flow of marking particles suspended in a gas, a conduit for said flow having its discharge end arranged to be positioned adjacent to the stencil, means associated with the interior of said conduit adjacent the discharge end thereof to aid in collimating the movement of the marking particles in said flow, and means including porous interior surfaces of said conduit, adjacent the discharge end thereof for removing some of the surface flows of said marking particles from the interior surfaces of said conduit to prevent the discharge thereof with the flow of marking particles.

2. In a device of the type described for producing a fine stream of coating particles, a source of a mixture of coating particles suspended in a gas under pressure, a duct for conveying a flow of said mixture, said duct converging toward the discharge end thereof and including means located therein adjacent the discharge end thereof to aid in collimating said flow of coating particles, and means including a series of holes in the interior walls of said duct adjacent the discharge end thereof of a large enough size for removing from said flow some of the coating particles smaller than a predetermined minimum size and a part of the gas contained in said flow.

3. In an apparatus for producing a relatively small concentrated stream of coating particles, a source of flow of finely divided coating particles suspended in a gas, a duct for conveying said flow from said source to a discharge area, said duct having at least one pair of opposite walls converging toward the discharge end thereof, the interior walls of said duct adjacent the discharge end thereof being provided with apertures in communication with a sump having a pressure lower than the pressure existing in the gaseous portion of said flow, whereby some of the coating particles smaller than a predetermined minimum size and a part of the gas contained in said flow are removed from said flow prior to the discharge of said flow from said duct.

4. In an apparatus for marking a surface by passing a flow of marking particles through a stencil, a source of flow of marking particles suspended in a gas, a conduit for said flow having its discharge end arranged to be positioned adjacent to the stencil, means associated with said conduit to aid in collimating the movement of the marking particles in said flow, said last-mentioned means including a series of apertures arranged in the interior walls of said conduit adjacent the discharge end thereof in communication with a sump having a pressure lower than the pressure existing in the gaseous portion of said flow, whereby a part of the gas contained in said flow is removed from said flow prior to the discharge of said flow from said conduit.

5. In an apparatus for producing relatively fine streams of coating particles for depositing on a surface, a source of a mixture of coating particles suspended in a gas under pressure, a duct for conveying a flow of said mixture, said duct converging toward the discharge end thereof, a series of hollow vanes in said duct for collimating and directing the flow of said mixture, said vanes dividing the mixture into a plurality of streams, a series of openings in the sides of said vanes to the interior thereof, the interiors of said vanes being connected to a sump of lower pressure than the pressure of the gaseous portion of said flow whereby a part of the gas in said mixture is removed from said streams prior to the discharge thereof from said duct.

6. In an apparatus for producing relatively small highly concentrated streams of coating particles, a source of a mixture of coating particles suspended in a gas under pressure, a duct for conveying a flow of said mixture from said source to a discharge end thereof, means including converging sides of said duct toward said discharge end to increase the velocity of said flow, means for dividing said flow into a plurality of individual flows, means positioned within said duct adjacent to the discharge end thereof tending to collimate the movement of said coating particles in individual flows, a sump of lower pressure than the pressure of the gaseous portion of said flow in communication with the interior of said duct adjacent the discharge end thereof and means including said sump for withdrawing from said flow prior to the discharge thereof from said duct a part of the gas contained in said flow.

7. The method of depositing a coating on a surface in accordance with the openings in a stencil which comprises the steps of placing the stencil in front of the surface to be coated, producing a flow of gas containing a suspension of coating particles, passing said flow through a duct, removing a part of the gas from said flow prior to the discharge of the flow from said duct, applying collimating forces to the flow of coating particles prior to the discharge of said flow from said duct, and directing the resultant flow of coating particles toward the stencil and surface to be coated.

8. In an apparatus for marking a surface by passing a flow of marking particles through a stencil, a source of flow of marking particles suspended in a gas, a duct for said flow having its discharge end arranged to be positioned adjacent to the stencil, said duct having at least one pair of opposite sides converging toward the discharge end thereof, a plurality of vanes secured within said duct adjacent the discharge end thereof to aid in collimating the flow of marking particles, and means connected to each of said vanes and in communication with the interior of said duct adjacent the discharge end thereof for removing a part of the gas in said flow and some of the surface flows of said marking particles from the interior surfaces of said duct to prevent the discharge thereof with the flow of marking particles.

9. The method of claim 7, and further including the step of removing some of the surface flows of said marking particles from the interior surfaces of said duct to prevent the discharge thereof with the flow of marking particles.

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