Nov. 1, 1966 C. E. PLYMALE 3,282,207

SCREEN PRINTING IN WHICH SCREEN MEMBERS ARE GIVEN RELATIVE MOVEMENT TO CONTROL INK FLOW

Filed May 12, 1964 3 Sheets-Sheet 1

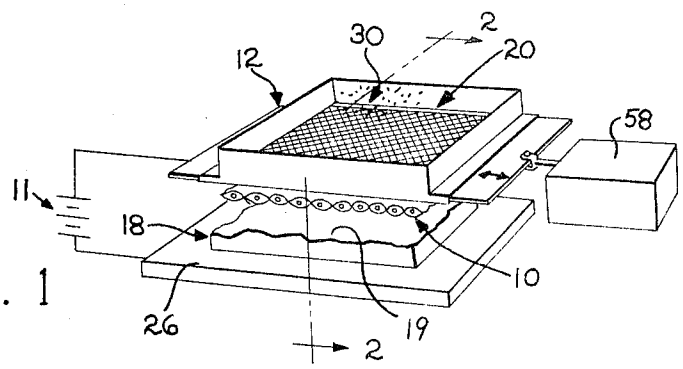


FIG. 1

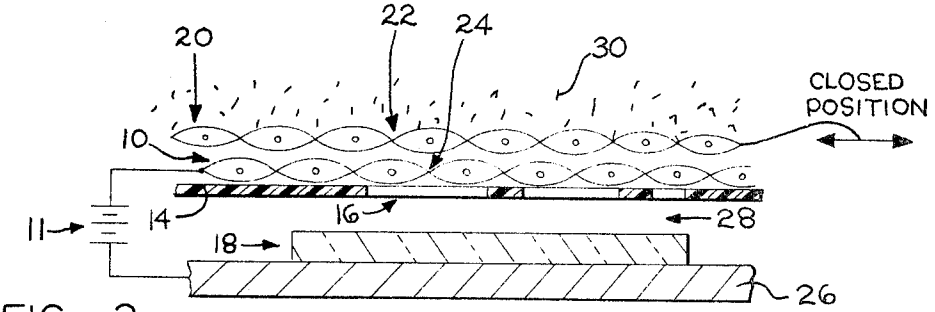


FIG. 2

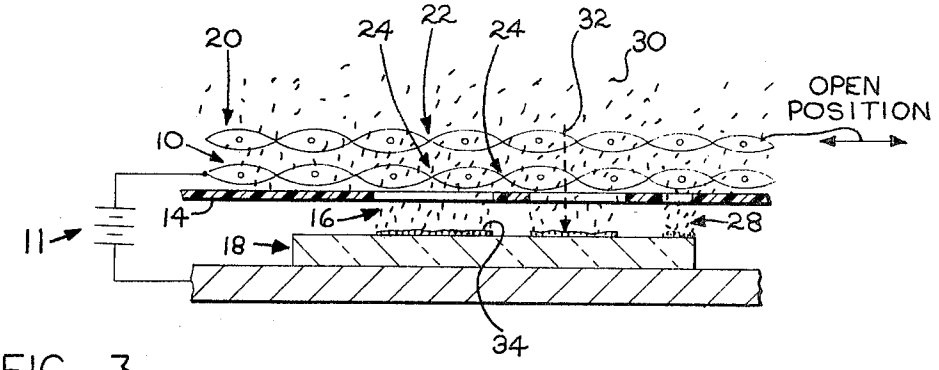


FIG. 3

INVENTOR.
CHARLES E PLYMALE
BY C. M. White and L. L. Blair
ATTORNEYS

Nov. 1, 1966 C. E. PLYMALE 3,282,207

SCREEN PRINTING IN WHICH SCREEN MEMBERS ARE GIVEN RELATIVE MOVEMENT TO CONTROL INK FLOW

Filed May 12, 1964 3 Sheets-Sheet 2

FIG. 4

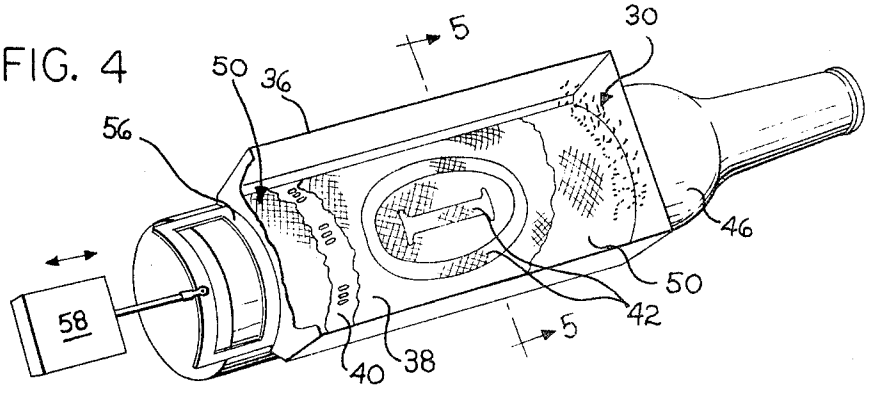


FIG. 5

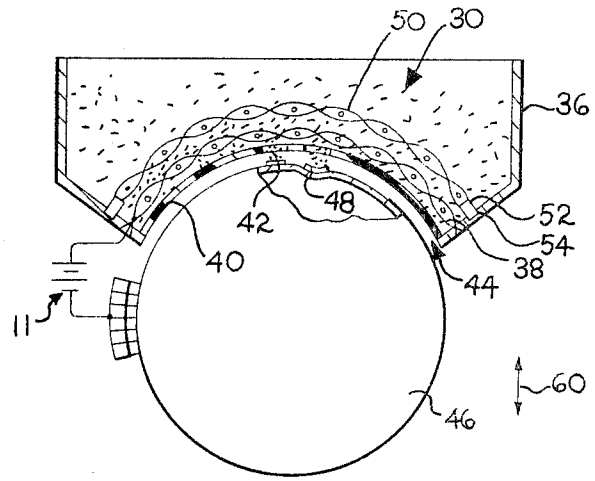
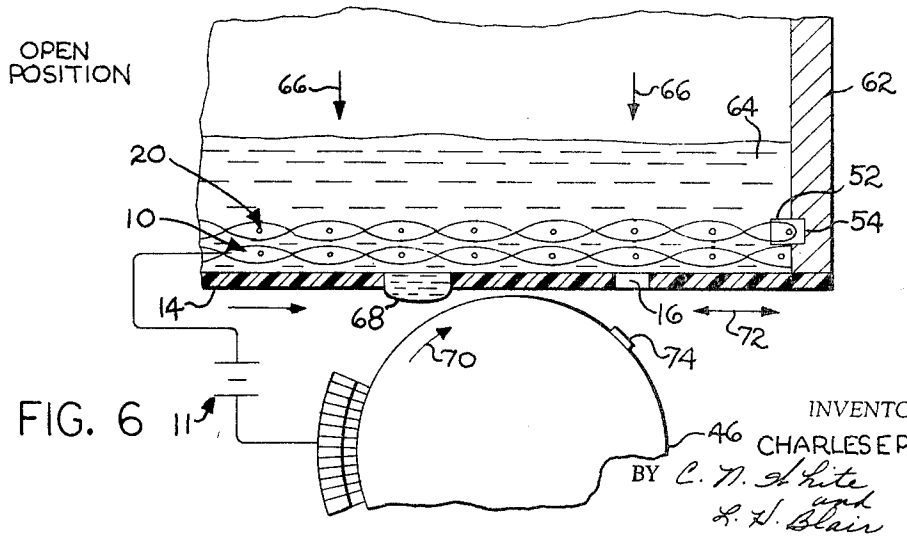


FIG. 6



INVENTOR.
CHARLES E PLYMALE
BY C. M. White and L. N. Blair
ATTORNEYS

Nov. 1, 1966 C. E. PLYMALE 3,282,207

SCREEN PRINTING IN WHICH SCREEN MEMBERS ARE GIVEN RELATIVE MOVEMENT TO CONTROL INK FLOW

Filed May 12, 1964 3 Sheets-Sheet 3

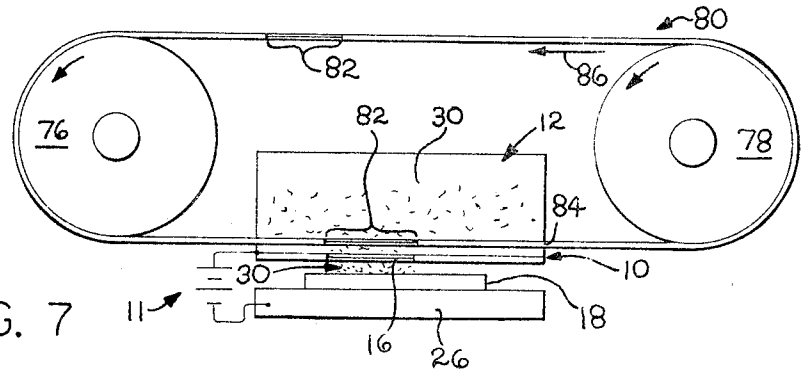


FIG. 7

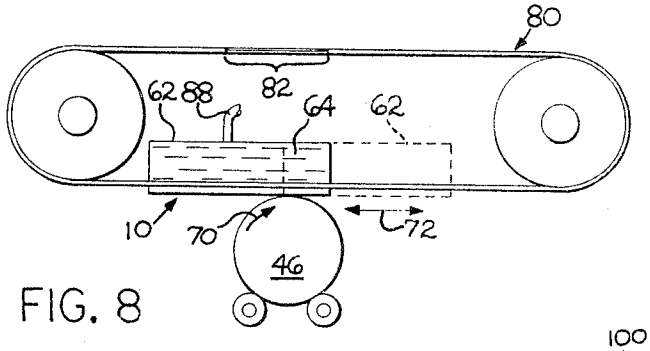


FIG. 8

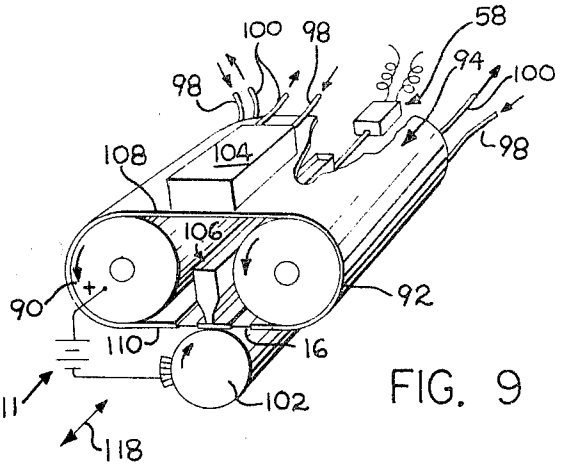


FIG. 9

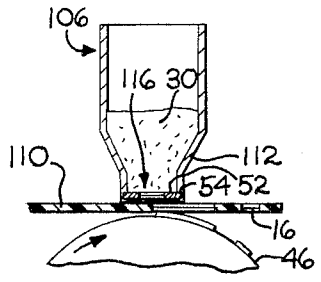


FIG. 10

INVENTOR.
CHARLES E PLYMALE
BY C. N. White and L. N. Blair
ATTORNEYS

United States Patent Office 3,282,207
Patented Nov. 1, 1966

3,282,207

SCREEN PRINTING IN WHICH SCREEN MEMBERS ARE GIVEN RELATIVE MOVEMENT TO CONTROL INK FLOW

Charles E. Plymale, Toledo, Ohio, assignor to Owens-Illinois, Inc., a corporation of Ohio

Filed May 12, 1964, Ser. No. 366,701
8 Claims. (Cl. 101—114)

This invention relates to the art of printing, and more particularly to printing apparatus and method utilizing a decorating or transfer screen; the invention being more generally concerned with the art of transferring or feeding pulverulent decorating materials through an image-containing transfer screen and onto an article being printed. In the present invention, printing apparatus and method both are contemplated, wherein printing may be effected without either pressure or contact between the printing element and the article being printed.

The problem

The conventional silk screen printing processes of the present art utilize a blade or squeegee that is moved back and forth over the silk screen to force a gob of ink through the openings of the image area of the screen.

One form of powdered ink feeding mechanism for electrostatic printing, utilizing a silk screen, relies upon a brush to force the powdered ink through the openings in the image area of the screen. Another system, contemplated by U.S. Patent 3,081,698 dated March 19, 1963, includes a cloud chamber and also a roller to supply powdered ink through the openings of the transfer or decorating screen. In the cloud chamber aspect disclosed, it has been necessary to provide complex and quick acting controls, whereby when a printing surface is properly exposed before the screen, both electrical and gas pressure energies are actuated to develop the cloud in the chamber to be passed through the image area of the screen and onto the article being printed. It will be well understood by those skilled in the art that such a process involves complexities, involved in making allowances for the time lag in developing the cloud and stopping the cloud, in order that accurate amounts of materials can be fed by the decorating screen. These complexities become particularly acute when high speed printing is attempted by these methods. Of course, the use of either a brush or roller will also mitigate against extremely high speed processing in this manner.

Accordingly, a substantial contribution to the art would be provided by apparatus and method for decorative screen printing adapted to produce highly critical control, accurate metering of printing ink media, and high speed processing on the order of 100 to 150 articles per minute or faster.

It is therefore, an important object of the present invention to provide a novel apparatus for feeding powdered inks.

A further object is to provide a novel apparatus for feeding powdered inks in an electrostatic printing operation.

A further object is to provide a novel method of accurately metering selected amounts of powdered ink materials through a decorating screen and onto an article being printed, with provision for absolute stoppage of flow in the intervals between printing, as distinguished from the cloud chamber methods of the prior art.

A further object is to provide apparatus for electrostatic printing, utilizing powdered or otherwise flowable ink materials wherein accurate metering and positive shut off are novel characteristics.

A still further object is to provide a method for forcing flowable inks, including both viscous liquids and powdered materials, into an electrostatic field with greatly improved accuracy of metering, for printing on a variety of media.

A further object is to provide apparatus and method for metering the flow of powdered printing inks into an electrostatic field, that utilize intermittent, high frequency vibration as a control medium.

Other objects of the invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of the specification wherein like reference characters designate corresponding parts in the several views.

FIGURE 1 is a perspective view of one form of apparatus embodying the principles of the present invention;

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1, and showing the valve mechanism in a closed position;

FIGURE 3 is a view similar to FIGURE 2, but illustrating the valve in an open position;

FIGURE 4 is a perspective view of apparatus embodying the principles of FIGURES 1, 2 and 3, as applied to the printing of a cylindrical or multisided article;

FIGURE 5 is an enlarged sectional view taken along the line 5—5 of FIGURE 4;

FIGURE 6 is a sectional view illustrating the principles of the invention being applied to the metering of fluid inks;

FIGURE 7 is an elevational view, showing the principle of FIGURES 1, 2 and 3 applied to the use of a continuous metering screen;

FIGURE 8 is an elevational view similar to FIGURE 7, but showing the principle of FIGURE 6, for feeding liquid ink, applied to the use of a continuous metering screen;

FIGURE 9 is a perspective view of apparatus embodying the principles of the present invention, and useable with either liquid or powdered inks, and embodying a continuous printing screen; and

FIGURE 10 is a fragmentary sectional view of the apparatus of FIGURE 9.

It is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

A brief preliminary view of the invention

Essentially, in the present invention, a screen or other medium capable of being vibrated or capable of being moved in a manner to impart vibratory frequencies to a mass of ink or colorant positioned adjacent to a decorating or transfer screen, is utilized to meter and control the flow of the colorant through the image of the decorating screen in a highly accurate manner, controllable to an interval of the order of one-third or one-fifth second in duration. The screen is characterized as a foraminous control means that, in combination with the decorating screen, controls flow of fluent ink through the decorating screen.

In a particular embodiment of the invention, a vibratory screen is used at the back side of the decorating screen. This forms a logical introduction to a specific description of the invention and accordingly this first embodiment will now be described in detail.

The screen apparatus of invention: FIGURES 1, 2 and 3

By reference to FIGURES 2 and 3 of the drawings, it will be noted that a decorating screen **10** is fastened to the bottom of a container **12**. The decorating screen **10** carries an image layer **14**, FIGURES 2 and 3, on its bot-

tom surface. The layer **14** has image openings **16** therein. The image openings **16** are adapted to pass ink or, in broad terms a fluent printing medium, in accordance with the configuration of the image and thus produce an image during a printing operation, on an article being printed. In the drawings, the article being printed is designated by the reference numeral **18**. This is illustrated as a plate-like item, and is positioned in juxtaposed decorating relationship to one surface of the decorating screen **10**.

The image **16** in the image layer **14** is suitably produced by the steps of coating the decorating screen **10** with a photosensitive emulsion layer **14** and exposing for proper imagery, followed by development processing of the exposed image to produce a functional image whereby the layer **14** is removed in selected areas, permitting the screen to pass a printing medium such as ink or powdered printing material when called upon to perform that function.

The fixed screen

It is to be understood that the decorating screen **10** is fixed in space. Cooperating with the fixed screen **10**, and providing metered flow of printing colorant material, is a movable screen or equivalent means **20**. The two cooperating elements **10** and **20** function as a highly accurate valve system that provides both positive shut off and positive flow of a printing colorant through the two when the valve system is actuated in a manner to be hereinafter described.

The movable control screen

As shown in FIGURE 1, the movable screen **20** is mounted in adjoining relation directly above the printing screen **10**. This movable screen **20**, of course, is without a printing image; therefore, the mesh openings **22**, FIGURES 2 and 3, are open to pass the colorant **30** therethrough.

This screen **20** is suitably of the same mesh size as the image screen **10**. Thus when the openings **22** of the sliding or movable screen **20** and the openings **24** of the image screen **10** coincide, the printing colorant **30** can flow. However, when the openings of the two screens **20** and **10** do not coincide, the effect is that of a positive shutoff valve preventing flow of the colorant material.

Operation of the invention

FIGURES 2 and 3 most clearly illustrate the operation of the invention. Before describing the operation however, it should be pointed out that a substrate **18** is positioned an appropriate distance from the image layer **14** of the printing screen **10** and can be positioned on a grounding plate **26**.

An electrical potential may be developed between the decorating screen **10** and the grounding plate **26**; thus the electrical potential is imposed upon the substrate **18** carried by the grounding plate. Since the ink particles or medium **30** contact the decorating screen, they too are subjected to the potential of the decorating screen. Thus, a potential or electrical differential is developed between the ink or colorant **30** and the substrate **18**.

This causes the colorant to jump the gap **28** and thus an image **34**, FIGURE 3, is transferred to the substrate **18**, when the following conditions exist:

(1) The potential is applied; and
(2) The movable screen **20** is actuated so that the colorant **30** is permitted to flow through, or is forced to flow through the decorating screen **10**.

The closed position of the valve.—For exemplary purposes, the embodiment of FIGURES 1, 2 and 3 is to be understood as utilizing a powdered ink **30**. In FIGURES 2 and 3, this is represented as a mass **30** of puverulent or particulate material that is placed upon or supported upon the movable screen **20**. By reference to FIGURE 1, it will be understood that such body **30** of powdered printing material is retained within the container **12**.

When the openings **24** of the decorating screen **10** are closed by the mesh medium of the movable screen **20** being positioned thereover as in FIGURE 2, the decorating screen is effectively closed. Positive shut-off valve action is thus present. Thus, there is no movement of printing colorant **30** to the decorating screen **10**.

It will be understood therefore that with this condition of parts, a valve is effectively produced by the apparatus of the present invention.

The open position of the valve, FIGURE 3.—When the openings **24** of the decorating screen **10** and the openings **22** of the movable screen **20** coincide, as shown in FIGURE 3, the valve is open. Thus, powder from the mass **30** is permitted to flow, or is forced to flow through the image openings **16** of the decorating screen **10**. This is illustrated by the dotted arrow **32**.

Thus the particles **30** are forced to jump the gap **28** by the applied potential between the substrate **18** and the decorating screen **10**. Thus, the image **34** is built up on the substrate **18**.

The element **58** in FIGURE 1 is an actuator for vibrating or moving the screen **20** at any desired frequency.

Decoration of a circular article

In FIGURES 1, 2 and 3, the broad principle of the present invention has been illustrated with reference to a plate-like article or substrate **18**. The illustration has been made with an article that does not have a smooth surface, as is evidenced by the irregularities **19** thereof. Nevertheless, the substrate or article **18** in FIGURES 1, 2 and 3 is generally a plate-like medium.

Within the extended scope of the invention, however, the printing of circular or cylindrical articles such as bottles and analagous containers can be effected. This is shown in FIGURES 4 and 5. Here, also, multisided articles such as polygons are contemplated.

A word at this point is in order before describing the specific details however. Thus, the decorating screen must conform at least generally to the peripheral contour of the article being printed. In this case, of course, the decorating screen will have a generally circular or at least semicircular or semicylindrical configuration in order to be positioned close to the periphery of the article, with a small gap therebetween. For exemplary purposes, a bottle **46** is shown in FIGURES 4 and 5.

A hopper or container **36** is provided, and the bottom of this hopper is formed as the decorating screen **38**, and this screen has an image layer **40** on the bottom side with image openings **42** therein. Decorating screen **38** is of generally semicylindrical configuration and thus a uniform air gap **44** is provided between the screen **38** and the periphery of the container **46**.

Note, however, that the screen **38** does not minutely conform to the peripheral contour of the container **46**. Thus, the container **46** has an indentation **48** in the peripheral surface. The screen **38** does not follow this indentation, but instead, may be of uniform, semicircular configuration. Thus, the screen **38** can be shaped over a stock mold and therefore need not be tailormade to the peripheral contour of the container **46**. Thus, a variety of containers of the same general diameter as the container **46** can be processed by the single screen **38**, though not of exactly the same surface configuration as between themselves.

Above the decorating screen **38** is positioned a movable or slidable metering screen **50**. In accordance with the general principles of the invention, the metering screen **50** closely conforms to the contour of the decorating screen **38**, to provide a positive valve action as previously explained.

A mass **30** of powdered ink is placed in the hopper **36** to overlie the two screens **38** and **50** and be instantly available.

The edges of the metering screen 50 are formed as slide bars or elements 52, and these are set into grooves 54 formed in the bottom walls of the hopper 36.

At each of the ends, the metering screen 50 is suitably formed as slide plates 56 that pass through narrow slits in the end walls of the hopper 36. Suitable wiping felts or the like are used to prevent loss of the powder 30 through the slits during movement of the metering screen 50.

Vibration or movement is imparted to the metering screen 50 by means of an actuator 58 or the like. This is a mechanical device, suitably actuated by electrical, fluid, or other energy.

An electrostatic potential is imposed between the decorating screen 38, ink 30, and the container 46, with a suitable power source 11.

Operation of the embodiment of FIGURES 4 and 5

The principle of operation herein involved is the same as that previously discussed. Thus, the article 46 is moved up into printing relationship along the arrow line 60 and stopped an appropriate distance from the decorating screen 38 to produce the air gap 44. Thereafter, in a single step, electrical potential is applied between the decorating screen 38 and the article 46, and the metering screen 50 is actuated for an appropriate interval. Thus, an image with a highly accurately metered amount of ink is produced, in an instant.

Thereafter, the article is moved down along the arrow line 60 and transferred to another processing situs. Another container 46 is then moved into place, and the printing cycle repeated.

The fluid colorant aspect of the invention: FIGURE 6

The principle of the present invention is not to be considered as limited to powdered inks only. Thus, flowable materials such as liquid inks, of a highly viscous nature, can be processed by the invention. This is shown in FIGURE 6.

In this aspect of the invention, it is to be understood that the cooperating screens, i.e., the image screen 10 and the metering screen 20, function as a valve and thus provide positive shut off of the flowable material. Actually, in a high speed printing operation, a certain amount of leakage can be tolerated, because such leakage will be taken up by the articles being printed, passing in printing relationship to the apparatus, in a rapid and high speed manner.

In this aspect of the invention, a printing operation analogous to that of the conventional silk screen process is provided, i.e., wherein the article is rotated and the screen moved along to provide an axially extending line contact with the periphery of the article being printed. However, in accordance with this embodiment of the present invention, the contact pressure between the screen and the article being printed is reduced to substantially zero, and electrostatic force is optionally used to facilitate ink transfer between the decorating screen and the article being printed. Thus, a very high speed operation is contemplated.

As shown in FIGURE 6, a flat decorating screen 10 has an image layer 14 on the lower surface, and the image layer has image openings 16 therein. This combination of elements 10, 14 and 16 forms the bottom of a container 62 that retains a body of fluid ink material 64.

Above the decorating screen 10 is a slidable metering screen 20 having slide bar elements 52 along the sides, slidable in grooves 54, formed in the walls of container 62. The metering screen 20 is moved back and forth in the nature of the previous screens, between open and closed positions relative to the decorating screen 10. This provides regulated flow of the fluid ink material 64 from the container 62 to the image openings 16.

The movement of screen 20 is distinguishable from the vibratory movement of the metering screens previously described for feeding powdered materials. Thus, where a powdered ink is employed, the metering screen is moved forth and back relatively rapidly in the nature of a vibrational movement. With fluid ink, however, relatively slow movement is used, in the nature of a valve closing and opening.

In the powdered ink embodiment, previously described, electrostatic energy and gravity were relied upon to move the ink between the decorating screen and the article being printed. Here however, the ink is viscous and needs additional propelling force since the printing cycle must be very rapid indeed. Therefore, pressure is applied to the ink to force it to flow when the valve mechanism is opened. Accordingly, the arrows 66 represent application of force as by gas pressure above the body of ink 64; or as by a head of hydraulic liquid retained above the body of ink, but of a nature to be immiscible with the ink; or as by a piston pressed against the body of flowable ink 64. It is to be understood of course that the magnitude of the pressure is tailored to the viscosity of the ink, commensurate with ambient temperatures and the like, in order to provide the printing speed desired.

Operation

As the valve system 10, 20 is operated by moving screens 10 and 20 into mesh with one another, for a selected interval of time, the pressure represented by arrows 66 causes the ink to flow downward through the two screens and into the image openings 16 and be slightly exuded below the bottom surface of image layer 14, as indicated at 68.

As the container 46 rotates, in the arrow direction 70, in light to zero pressure contact with the image layer 14, the ink exudate 68 is transferred to the surface of the container 46. At the same time the container 46 rotates in the arrow direction 70, the screen system 10, 20 also moves to the right in the arrow direction 72.

An image 74 is thereby imparted to the periphery of the container 46.

If desired, an electrostatic potential from a source 11 can be applied across the printing gap, if a gap exists between the decorating screen 10 and the article 46. This will aid transfer when there is no contact between the periphery of the container 46 and the image layer 14 of decorating screen 10.

The continuous metering screen aspect

Within the extended scope of the invention, the broad principle of moving the metering screen relative to the decorating screen in any manner, to control the flow of ink is to be encompassed. Thus, instead of the metering screen being moved back and forth or to and fro, as was discussed relative to FIGURES 1–3 inclusive, it can be moved in one direction only at all times. Thus, the metering screen can be endless in the nature of a continuous belt.

The endless screen embodiment of FIGURE 7

As shown in FIGURE 7 the principle of FIGURES 1, 2, and 3 is extended to an endless belt-type metering screen, wherein metering screen movement may be either continuous or intermittent, and in one direction.

The intermittent aspect.—This will encompass an endless metering screen wherein the entire length is perforated so as to provide a mixing and feeding action all along its length, as the screen passes in metering relationship along an appropriate surface of the decorating screen.

The continuous aspect.—However, FIGURE 7 also illustrates an endless metering screen that can be continuously moved. This simplifies the control factors as will be evident to those skilled in the art.

Thus, spaced rum rollers 76 and 78 are rotatably supported in space with their axes aligned. The endless belt-like screen 80 laps the drum rollers 78 and 76. At least

one of the drum rollers 76, 78 is power driven from a source not shown in order to drive the belt-like screen 80.

The screen 80 is divided into two types of zones. Thus it is generally impervious, as by being impregnated with a layer of heat-resistant, but flexible resin. This material is flexible to permit the belt to lap the drums 76, 78. However, there are areas where the mesh of the belt-like screen are open or perforated as at 82.

A container 12 is suitably placed in encompassing relationship along the lower flight 84 of the screen 80. Narrow slits or openings are provided in the end walls of the cotnainer 12 to pass the endless screen 84.

The bottom of the container 12 is formed from a decorating screen 10, generally similar to the geater detail of FIGURE 2; and this carries a suitably developed image exemplified by opening 16. A mass 30 of powdered ink is maintained in the container 12 above the functional flight 84.

A ground plate 26 supports a substrate 18, upon which an image is being formed.

Operation

In this aspect of the invention, the screen 80 is continuously moved in the arrow direction 86. However, the actual feed of the ink 30 is intermittent. Thus, feeding is effected only when a perforated area 82 passes through the container 12 and over the decorating screen 10 to activate the flow of ink particles 30. Otherwise the impervious areas of the screen 80 are over the decorating screen 10 and this prevents flow of ink particles 30.

This intermittent flow permits the replacement of the printed substate 18 with an unprinted substrate for a repetitive printing operation without interrupting the continuous movement of the screen 80.

An electrostatic printing force is applied by means of a power source 11 connected between the decorating screen 10 and the backing plate 26 and substrate 18.

Continuous screen application: Fluid inks FIGURE 8

The basic principle of feeding fluid inks, as shown in FIGURE 6 of the drawings, is also applicable to a continuous metering screen.

In accordance with this aspect of the invention, a continuous metering screen is moved either intermittently or continuously. The perforated area 82 is suitably provided in the metering screen 80 for continuous movement of the screen. Alternately, the screen may be entirely perforated for intermittent movement.

A container 62 holds a supply of fluid ink 64. As described relative to FIGURE 6, the container 62 is suitably a pressurized vessel with the ink being fed in from a pressurized source by means of a conduit 88. A decorating screen 10 forms the bottom of the container 62.

In this aspect of the invention, as in FIGURE 6, but both distinguishable from FIGURE 7, the printing of a cylindrical article such as a container 46 is encompassed. As in FIGURE 6, the screen 80 must move in rolling contact with the periphery of the container 46 to transfer the ink image. If a flat substrate be printed, of course, movement of that substrate would be required up into printing engagement with the decorating screen.

In order to load the image area of the decorating screen 10, there must be relative movement between the perforations of the metering screen 80 and the perforations of the decorating screen 10.

Operation

This is provided in two ways as follows in accordance with this aspect of the invention:

(1) The continuously moving metering screen. With the partially perforated metering screen 80, a perforated area 82 is passed through the container 62 to load the decorating screen 10. Then the decorating screen 10 is moved in the arrow direction 72 with simultaneous rotation of the container 46 in the arrow direction 70. This transfers an image to the container 46.

Thereafter, the container 46 is replaced by an unprinted unit and the decorating screen 10 reversed in direction, back to the solid line position for repeat of the printing cycle.

The decorating screen 10 can be loaded during this reverse movement if desired.

Since the metering screen is continuously moved, the perforated area 82 would pass across the decorating screen during its reverse movement in the arrow direction 72.

(2) Here the metering screen 80 is intermittently moved. Here, the metering screen 80 is entirely perforated. Loading of the decorating screen is effected by holding the metering screen still and reversing movement of the metering screen from the dotted to the solid line positions. This provides relative movement between the two screens for the loading cycle.

During the printing phase of the cycle, the decorating screen 80 and metering screen 10 move together to retain the load "fixed" in the image of the decorating screen. No ink flow is called for at this time.

However, at the end of the printing phase, both screens stop and the metering screen is so held. Then, the decorating screen 10 is reversed. At this time the decorating screen is loaded with ink for the next cycle, by relative movement between the two screens.

The continuous decorating screen embodiments: FIGURE 9

In this aspect of the invention, the decorating screen 108 is of continuous form and is either continuously or intermittently moved. An advantage of the invention will become apparent in this aspect of the invention by the cooling of the printing screen to prolong its life. A very serious problem in the electrostatic printing of hot containers, such as glass bottles, just after they are ejected from the forming molds, has been encountered. The image layer carried by the decorating screen is of a gelatinous nature. This is not resistant to high temperatures, such as those encountered by radiation from a hot glass container. Even if distances are maintained to prevent disintegration by the heat, heat distortion is nevertheless present. Ideas have been proposed to remedy this situation, including polishing the decorating screen so that the heat absorption is maintained at a minimum. A more ideal solution of this complex problem would be to construct the screen with adequate heat sinks or to intermittently cycle the screen in and out of the printing area so that the infrared radiation exposure is kept to short duration.

In accordance with this aspect of the invention, both of the latter are effected, i.e., cooling and cycling of the screen and further, line printing of the powdered material is developed in a new manner.

Turning now to FIGURES 9 and 10 of the drawings, it will be noted that spaced drums 90 and 92 are rotatably journaled by suitable means not shown, and are lapped by a continuous decorating screen 94. The decorating screen 94 carries an image area 16. One of the drums 90, 92 is suitably driven by a power source such as a gear motor, not shown.

It is rather important to this aspect of the invention that the drums 90, 92 are cooled as by circulating heat exchange medium such as water. Inlet and outlet conduits 98, 100 are provided for the purpose of circulating the heat exchange medium to and from a suitable heat exchanger not shown.

From the foregoing, it will be noted that as the continuous decorating screen 94 is moved, it will be in contact with the cooled drums 90, 92 shortly before and after exposure to the hot object 102. Thus the screen 94 will be preserved against warpage, distortion, or heat disintegration.

Alternately, or if desired for supplementing the cooling effect of the drums **90**, **92**, a cooled block **104** is positioned in heat absorbing relationship to the upper flight **108** of the continuous screen **94**.

The line contact powder applicator for use with this embodiment is best shown in FIGURE 10.

A hopper **106** is positioned between the upper flight **108** and the lower flight **110** of the continuous decorating screen **94**. Hopper **106** has inwardly converging bottom walls **112** and the bottom is very narrow and elongated in the nature of a thin, slit-like element.

An elongated and very narrow metering screen **116** is supported along the edges by slide members **52** that fit into grooves **54** in the sidewalls of the hopper **106**.

A vibrator **58**, FIGURE 9, is connected to the screen **116** at one end to move the screen back and forth in the arrow direction **118**. In this aspect of the invention the vibrator **58** is suitably operated at all times to provide a constant feed condition of the powdered ink material **30**, carried within the hopper **106**.

It is to be understood that the vibrating screen **116** feeds a thin line of powder **30** from the bottom of the hopper **106**.

As the image areas **16** of the continuous decorating screen **94** move past the line-like vibrating screen **116**, the powdered link **30** is passed as an image line to the periphery of the electrically charged, and rotated container **46**.

This is essentially the type of action produced by a squeegee cooperating with a silk screen in accordance with known principles of the prior art. However, it is to be understood that the present means for accomplishing the result is novel.

Extended scope of the invention

This invention is to be understood as broadly encompassing a plurality of screens of identical mesh size or equivalent that are so phased relative to one another that when the open mesh of each coincide, there is flow through the system. When the open mesh are out of phase, a positive shut off action is provided that is adapted to control the flow of fluent materials including both powders and viscous liquids.

Within the extended scope of the invention, foraminous materials are to be considered applicable to the principles set forth.

Within the scope of the present invention, a plurality of screens is to be understood as encompassing two or more. These, when properly phased relative to one another, can function as a pump not only to permit the flow of materials which have an external driving force exerted thereagainst; but also may act to propel materials which may or may not have an otherwise external driving force imposed thereagainst.

Within the broad scope of the invention, any suitable means can be used for driving the movable or metering screen. Mechanical means have been shown. Further, a broad range of frequencies may be applied from perhaps five per second up to ultrasonic frequencies. The shorter the interval of printing and the higher the number of vibrations per interval, the more accurate will be the control imposed upon the flowable ink material.

Within the broad scope of the invention, printing can be effected either with the decorating screen in actual contact with the article being printed or with the decorating screen spaced from the article being printed, with electrostatic force means being imposed upon the ink to force it to jump the gap between the decorating screen and the article being printed.

This invention is not to be limited to horizontally disposed decorating screens merely because the drawings have been so oriented. Instead, any orientation is contemplated, where there is a propulsion force present to move the fluent ink to and through the printing screen from the side on which the metering screen is positioned.

What is claimed is:

1. In a printing system,
a container having an opening,
a decorating screen carrying a printing image through which a fluid printing ink can be passed, said decorating screen being extended across said opening of said container in planar array, with the printing image exposed,
a metering screen mounted within said container in closely adjacent relationship to said decorating screen,
said screens being so formed that when the mesh openings thereof are positioned in coinciding relationship, a fluid ink material will flow through the screens,
means mounting said metering screen within said container and for linear movement parallel to and relative to said decorating screen,
means for moving said metering screen relative to said decorating screen to permit flow of a fluid ink therethrough,
a body of fluid ink within said container,
means imposing a hydraulic pressure on said body of ink tending to force said ink to flow through said screens on a flow setting thereof,
means for positioning an article to be printed in printing relationship relative to said decorating screen,
and means for passing the periphery of said article to be printed and said decorating screen in printing relationship with one another when said printing image is loaded with ink.

2. In a printing system,
a container having an opening therein,
a decorating screen carrying a printing image through which a fluent printing ink can be passed, said decorating screen being extended across said opening of said container in planar array, with the printing image exposed,
an endless metering screen mounted for linear movement through said container in closely adjacent relationship to the non-exposed side of said decorating screen,
said screens being so formed that when the mesh openings thereof are positioned in coinciding relationship, a fluent ink material can flow through the screens,
means mounting said metering screen so that a portion thereof will pass in linear relationship within said container and in parallel relation over said decorating screen,
means for moving said decorating screen,
a body of fluent ink material within said container,
means biasing said ink material into engaging relationship with said portion of said endless metering screen within said container to force said ink to flow through said screens when the mesh openings of said screens are in coinciding relationship,
and means for passing the periphery of an article to be printed and said decorating screen in printing relationship with one another when said printing image is loaded with ink.

3. In a printing system,
a container having an opening,
a decorating screen carrying a printing image through which a fluid printing ink can be passed,
said decorating screen being extending across said opening of said container in planar array, with the printing image exposed,
an endless metering screen mounted for linear movement through said container in closely spaced adjacent relationship to said decorating screen,
said screens being so formed that when the mesh openings thereof are positioned in coinciding relation, a fluid ink material can flow through the screens,
means mounting said metering screen so that a portion thereof will pass linear relationship within said con-

tainer and in parallel contacting relationship over said decorating screen,
means for moving said decorating screen,
a body of fluid ink within said container,
means applying pressure to said ink within said container, forcing said ink to flow through said screens,
and means for passing the periphery of an article to be printed and said decorating screen in printing relationship with one another when said printing image is loaded with ink.

4. In a printing system,
an endless decorating screen supported for linear movement through space,
said decorating screen carrying a printing image through which a fluent printing material can be passed, said printing image being on the exposed surface of said decorating screen,
a container extending transversely of a flight of said decorating screen and having a slit-like opening in adjacent relationship to the screen surface opposite said exposed printing image surface,
an elongated metering screen slidably mounted in said slit-like opening of said container,
means for slidably moving said metering screen within said container,
said screens being so formed that when the mesh openings thereof are positioned in coinciding relationship, a fluent ink material can flow therethrough,
a body of fluent ink material retained within said container and in contacting relationship with said metering screen, available for flow through said screens, when said screens are positioned to permit such,
and means for passing the periphery of an article to be printed and said decorating screen in printing relationship with one another when said printing image is loaded with ink.

5. In apparatus for printing,
an exposed decorating screen carrying a printing image on one surface through which a fluent ink material can be passed,
foraminous control means positioned in contiguous relation to the other surface of said decorating screen, said control means in combination with said decorating screen being effective to control flow of fluent ink through said printing image,
said screen and foraminous control means each having openings of relative size to permit flow of fluent ink material therethrough when the openings coincide and block flow when the openings do not coincide,
and means for moving said decorating screen and said control means parallel relative to one another to move said openings alternately into and out of a position

to produce metered flow of fluent ink material through said printing image, for direct transfer to an article positioned in juxtaposed relation to said printing image.

6. The invention of claim 5 including an article to be printed positioned in juxtaposed relation to said printing image, and electrostatic means connected to said decorating screen and to said juxtaposed article to be printed, imposing an electrostatic force between said decorating screen and said article.

7. In a method of printing,
the steps of
positioning an article to be printed in juxtaposed decorating relationship to one surface of an exposed decorating screen having a printing image, extending transversely therethrough,
covering the opposed surface of the decorating screen with a foraminous control means that in combination with said decorating screen controls flow of fluent printing ink material through said decorating screen from said opposite side,
biasing a mass of fluent printing material against said barrier and toward said printing screen for flow through the printing image,
and moving the barrier parallel to the screen and alternately into and out of a position relative to said screen which permits said fluent material to flow therethrough so that a metered amount of said fluent material flows through said printing image for direct transfer onto the article to be printed.

8. The invention of claim 7 including the step of imposing an electrostatic potential on said decorating screen and the article to be printed.

References Cited by the Examiner

UNITED STATES PATENTS

1,718,686	6/1929	DuBelle	101—367
1,861,914	6/1932	Gridley	101—114
2,239,619	4/1941	Murgatroyd et al.	
2,335,461	11/1943	Smith	101—114
2,863,383	12/1958	Johnson	101—126
3,031,956	5/1962	Worth	101—367 X
3,081,698	3/1963	Childress et al.	

FOREIGN PATENTS

1,124,517	3/1962	Germany.

ROBERT E. PULFREY, *Primary Examiner.*

N. A. HUMPHRIES, E. S. BURR,
Assistant Examiners.