

United States Patent

Pym

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[54] ELECTROSTATIC COPYING

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[52] U.S. Cl.101/153, 101/150, 101/170

[51] Int. Cl.B41f 9/00

[58] Field of Search.....101/153, 170, 150

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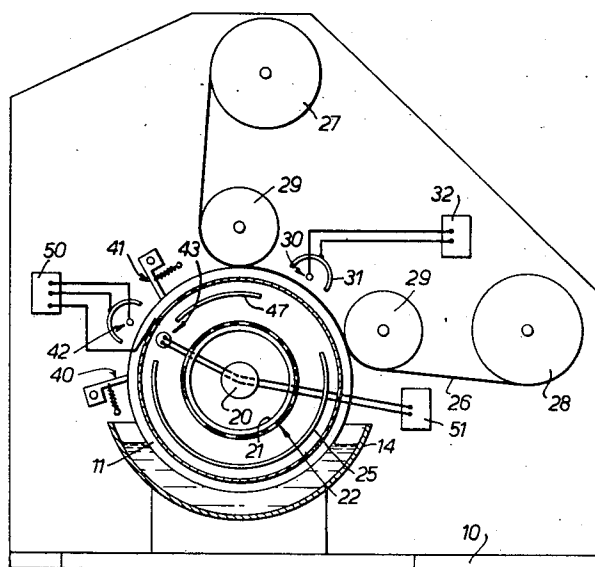
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[57] ABSTRACT

A method and apparatus for printing or copying, using a gravure cylinder and a controlled electrostatic field for governing the movement of ink from the gravure cells. The control of the field is performed by applying controlled illumination onto a photo-conductive material below or within the cells, or the ink or ink particles may itself be photo-conductive.

10 Claims, 12 Drawing Figures



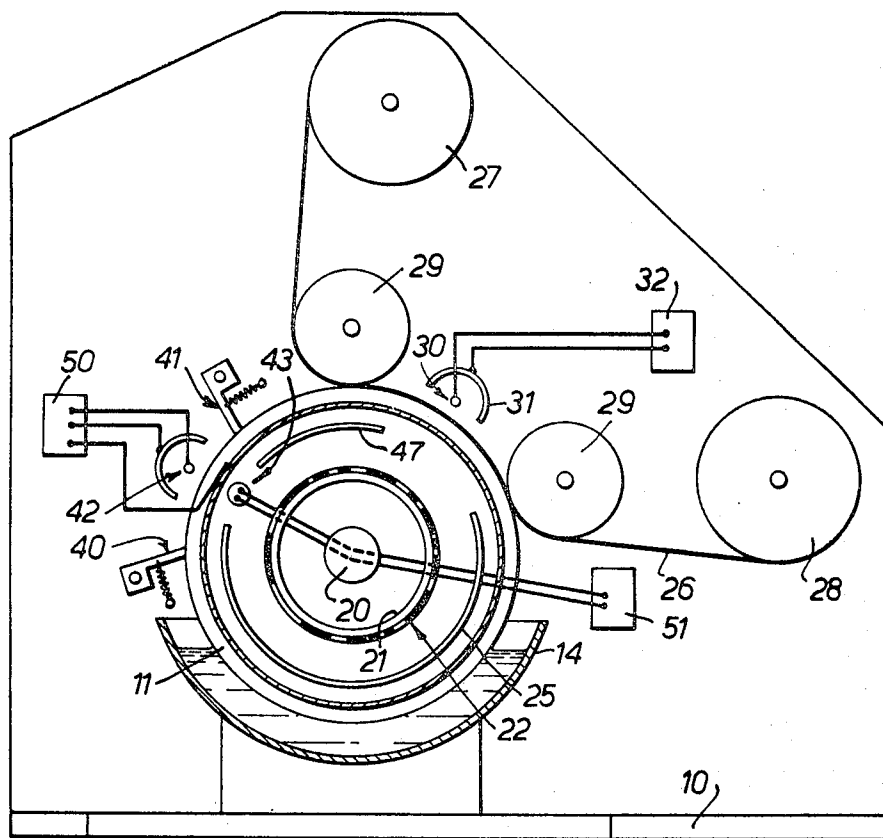


FIG. 1.

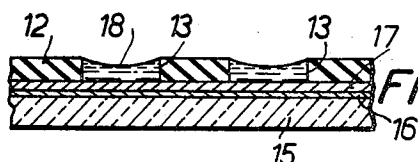


FIG. 2.



FIG. 3.

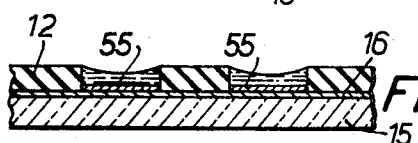


FIG. 7.

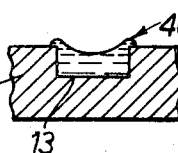


FIG. 4.

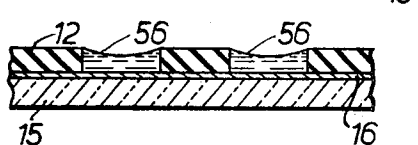


FIG. 8.

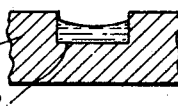


FIG. 5.

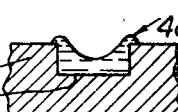


FIG. 6.

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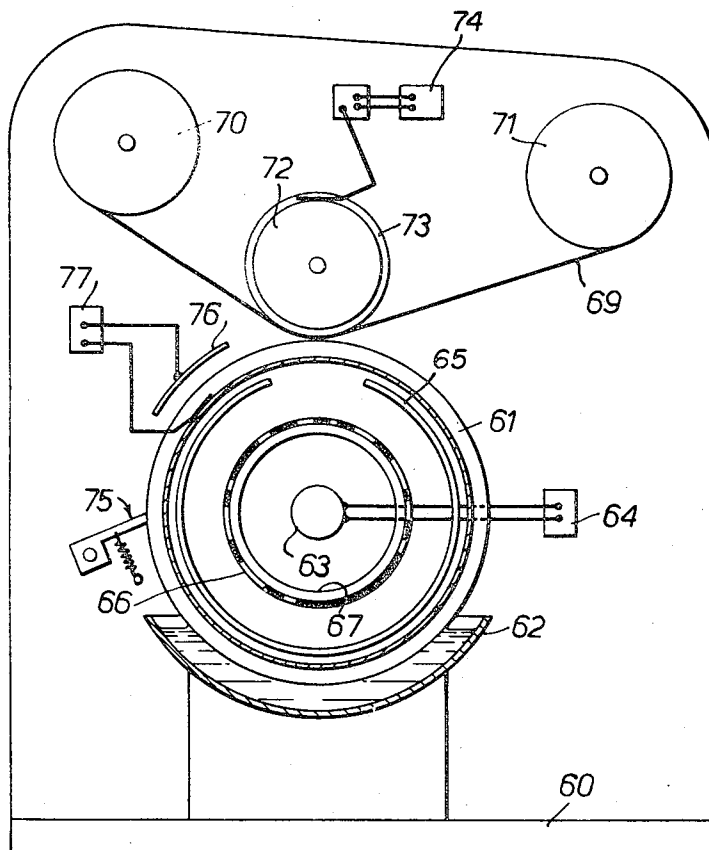


FIG. 9.

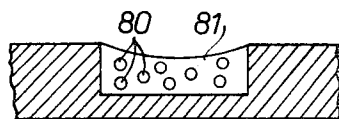


FIG. 10.

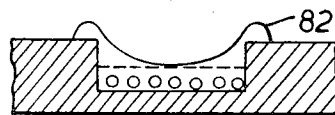


FIG. 11.

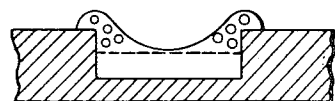


FIG. 12.

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ELECTROSTATIC COPYING

Electrostatic copying is a well known successful process but suffers from a number of difficulties and limitations. For example in the well known xerographic methods a powdered dry ink is used, and in practice it is necessary that the powder particles should be above a certain minimum size which results in a certain lack of definition in the final image. It is also an inherent difficulty in the process that the field tends to become darkened or speckled by stray particles of powdered ink, the speed of the process is necessarily limited in view of the need for the dry powdered particles to be cascaded over the charged surface of the impression cylinder, and furthermore the image applied to the final product has appreciable thickness which is unacceptable or undesirable if printing a book for example, where many pages must be placed on above the other.

Several attempts have previously been made to employ electrostatic methods in conventional printing machines for assisting in the transfer of ink from the impression surface to the paper or other article to be printed. Although such methods have advantages in that the transfer of ink does not require the same degree of pressure as hitherto, the electrostatic procedures are essentially used merely to assist the normal printing operation and the basic limitations of conventional printing processes are not significantly altered.

Conventional printing methods themselves suffer from a number of limitations and disadvantages. The machinery is normally extremely massive in order that the very heavy printing pressures can be achieved across the whole of a large impression cylinder, the inking apparatus for an impression cylinder, the inking apparatus for an impression cylinder is usually extremely complex in order to provide uniform inking, any change in the image to be printed requires a complex mechanical change-over operation, and well-known difficulties are experienced in color printing or when using slow drying inks.

Accordingly it is an object of the present invention to provide an improved method and apparatus for printing or copying which will at least partly overcome some of the defects of known printing methods and of electrostatic copying methods.

From one aspect the invention consists in a method of printing or copying using an imaging member having a plurality of closely spaced small recesses or crevices, such as a gravure-type plate, etched over substantially the whole effective printing field, in which a liquid ink or other pigmented medium is introduced into the crevices or recesses in the imaging member surface, and a controlled electrostatic field is set up between the member surface and an article to be printed, or a transfer element, so as to cause the ink to be transferred from selected portions of the imaging surface.

The controlled electrostatic field may be set up in various ways. For example a controlled electron beam may be caused to sweep over an insulating surface to "spray" a charge onto the surface, using the equivalent of a cathode ray tube. Alternatively a multiplicity of small electrodes may be positioned closely adjacent to one another over the field, and each individually connected to an electronic switching device arranged selectively to control the energization of the electrodes.

Preferably however the electrostatic field is obtained by means of a photo-conductive material which is selectively exposed to light, and conveniently, in some forms of the invention, the photo-conductive material is combined with and lies behind the gravure plate. Thus in one example the photo-conductive material lies in the cells of the gravure plate. In such case it is preferably limited to the lower parts of the cells, allowing room for the ink above, and also ensuring that the photo-conductive material will not be physically exposed at the surface and damaged.

From this aspect the invention is based on the fact that in the presence of an electrostatic field ink in the cells of the gravure plate will tend to rise up towards or above the surface of the plate and thus will be more readily transferred to the article to be printed. It is of course important that any ink in cells from which no image is required should not be transferred. Thus according to a preferred feature of the invention the liquid ink is first applied to the cells of the gravure plate, an electrostatic field is then applied causing ink to rise in the cells, the upstanding ink is removed, and the printing electrostatic field (which is of greater magnitude than the first applied field) is then applied, to transfer ink from the plate to the article. In a particular preferred procedure the surface of the gravure plate is first inked overall and then wiped clean by a doctor blade, an electrostatic field is then applied causing the ink to rise somewhat in all the cells, and this upstanding ink is then removed by a further doctor blade. The field is then removed so that the remaining ink in the cells falls below the surface of the plate, such that in the absence of an electrostatic field no image will then be transferred from any cell. When the controlled printing electrostatic field of greater magnitude, is subsequently applied, ink will then only be transferred from the selected cells so as to produce the required image.

In conventional gravure printing methods half-tone effects can be achieved by varying the depth or transverse dimensions of the individual cells and according to another preferred feature of the invention a similar half-tone effect is obtained by varying the strength of the electrostatic field selectively over the field to be printed, so as to cause varying quantities of ink to be transferred from individual cells of the plate. A similar result may be achieved by applying an inverted variable field (that is to say a field corresponding to a "negative" photographic image of the desired printing pattern or image) to the plate after all the cells have been filled with the ink, and then removing upstanding ink from all the cells, so that when the field is removed varying quantities of ink are present in the individual cells. The final printing electrostatic field may then be applied uniformly over the whole field and it will be seen that varying quantities of ink will then be transferred from the individual cells of the plate.

The invention also consists in apparatus for printing or copying comprising a movable (e.g. rotary) imaging member having a plurality of closely spaced small recesses or crevices, over substantially the whole imaging surface, means for applying a liquid ink or other pigmented medium to the surface of the member, means for conveying an article to be printed, or a transfer surface, past the surface of the member, and transfer means for establishing a controlled electro-

static field between the imaging member and the other surface to transfer ink from selected portions of the imaging surface.

The transfer means may be of various types. In one form the ink itself is photo-conductive and the transfer means includes optical projection means for illuminating the ink selectively in the cells of the cylinder, so as to cause the ink to rise differentially in the cells. Alternatively the ink may contain pigment or toner particles of a photo-conductive material. In another form of apparatus according to the invention the transfer means includes a layer or film of photo-conductive material, and optical projection means for illuminating the photo-conductive material selectively.

The photo-conductive material may be positioned in the cells of the imaging member, or behind the cells. In one preferred form of the invention the cylinder comprises an inner transparent insulating backing or support layer, then a transparent conducting layer, then a photo-conductive layer, and then the outer insulating gravure surface layer.

The invention can also be combined with a process for controlling the color and/or tone of a printed image. According to this control process the liquid printing medium or toner comprises pigment or toner particles in a liquid base, and a controlled electrostatic field is applied between the liquid medium and the article to be printed, the particles being capable of being charged electrostatically so as to move within the liquid in the direction of the field, and thus vary the tone and/or color of the image transferred to the article.

In such cases the particles are preferably non-conducting, and have a natural electrostatic charge, and if of one color they are preferably contained in a colorless liquid.

Alternatively the liquid medium may incorporate particles of two different tones or colors, which are differentially influenced by the applied electrostatic field, whereby a preponderance of one type of particles moves towards the surface of the medium. For example the particles may be of different polarity so as to tend to move in opposite directions in the field.

According to another preferred feature of this aspect of the invention the applied electrostatic field may have a high frequency component, with a variable applied bias, so as to vary the effective ration between the width or duration of the different values of the field. Thus preferably the frequency is so related to the speed of the article to be printed that the resultant variations in the tone, color, or quality of the image are spaced apart at distances smaller than the normal resolving power of the human eye, e.g. comparable with, or less than, the transverse dimensions of the cells of the gravure plate.

The invention may be performed in various ways and two specific embodiments, with a number of possible modifications thereof, will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic end view of a light-modulated printing apparatus according to the invention,

FIG. 2 is a fragmentary sectional view on a highly enlarged scale through the wall of the rotary cylinder forming part of the apparatus of FIG. 1,

FIGS. 3 to 6 are views similar to FIG. 2 illustrating four successive stages in the control of the ink within individual cells of the cylinder,

FIGS. 7 and 8 are views similar to FIG. 2 illustrating two further possible methods of constructing the surface layers of the cylinder,

FIG. 9 is a diagrammatic end view of another embodiment of printing apparatus according to the invention, and

FIGS 10 to 12 illustrate diagrammatically the movement within the cells of the ink and pigment particles under the influence of applied electrostatic fields.

In the first example illustrated in FIG. 1 the apparatus comprises a main frame 10 provided with bearings (not shown) supporting a hollow rotary cylinder unit 11 mounted on a fixed horizontal rotary axis. The construction of the cylinder wall is illustrated in FIG. 2. The external surface of the cylinder is formed by a layer 12 of an opaque electrically insulating material (for example a hard synthetic plastics material such as an epoxy resin) having a large number of small cells 13 distributed uniformly over its external surface, resembling the etched cells of a conventional gravure cylinder. The linear spacing of these cells 13 may for example be approximately 80 to 200 cells per inch. This external surface runs in an ink bath 14 into which the lower part of the cylinder dips. Beneath this external gravure type layer 12 are three further layers forming a composite multi-layer construction. The innermost layer 15 is a rigid structural hollow cylindrical glass drum acting as a transparent or translucent support. Outside this glass layer is a thin translucent electrically conductive layer 16 such as a thin layer of a tin compound applied by electro-deposition, and outside this conductive layer is a thin layer 17 of a photo-conductive material such as zinc oxide. Outside this photo-conductive layer there may be applied, if required, a thin opaque insulating layer (not shown) to prevent stray light passing through the cells 13 in the outer gravure layer 12.

Centrally within the hollow cylinder unit 11 is mounted an elongated light source 20 running axially over the whole printing width of the cylinder, and surrounded by a hollow rotary transparent cylindrical support 21, and means are provided for mounting a photographic negative 22 of the image to be printed around this support tube, which is caused to rotate with the main cylinder 11, thus causing the negative to rotate in synchronism. Partly surrounding the negative is a stationary part-cylindrical opaque mask 25. Externally of the cylinder unit, feed means are provided for causing a paper web 26 to be fed continuously from a supply spool 27 to a winding spool 28 around two intervening guide rollers 29 which hold the web in close contact with the surface of the gravure layer 12. The rollers 29 hold the web in contact, or in close proximity with, the surface 12 over an appreciable arc of the surface and means are provided for applying an electrostatic field between the gravure surface layer 12 and the paper web 26 in this transfer section. In this illustrated example the field is generated by a positive electrode 30 mounted within an earthed screen 31, and connected to an electrostatic charging unit 32. The electrode 31 is here positioned in the zone between the two rollers 29, but alternatively the electrode may be positioned at the

pressure point of a roller, or may itself constitute a roller.

With the apparatus as so far described it will be seen that the light from the central source 20 will be transmitted radially outwards only through the transparent portions of the photographic negative 22 and in sectors not blocked by the mask 25 this transmitted light will pass through the inner glass layer 15, and the translucent conductive layer 16 and will impinge upon the photo-conductive layer 17 thus rendering these exposed areas of the photo-conductive layer more conductive. When the electrostatic printing field is then applied between the external electrode 30 and the translucent conductive layer 16 of the cylinder unit, (which is earthed, as will be described below), the strength of the field will be materially greater at those cells 13 in the gravure surface layer which overlie exposed areas of the photo-conductive layer 17. Consequently ink in those cells, as illustrated at 18 in FIG. 2, will rise appreciably, while ink in the remaining cells will not. An ink image corresponding to the photographic negative 22 will thus be transferred to the paper web 26.

The apparatus described above could be used for a printing operation where the paper web 26 is not pressed heavily against, or does not come into contact with, the surface layer 26 of the gravure cylinder layer. If pressure is applied however it is likely that ink will be transferred from all the cells 13 of the gravure surface as in a conventional gravure printing method. In order to prevent transfer of ink from cells where no image is required the apparatus further includes an electrostatic doctoring system including a first doctor blade 40 engaging the surface 12 of the cylinder as it leaves the ink bath 14, and a second doctor blade 41 between the first doctor blade and the transfer or printing section formed by the rollers 29. Between the two doctor blades 40, 41 is located an electrostatic field generating electrode 42 on the external side of the gravure surface 12, and internally within the hollow cylinder 11 is mounted a further light source 43 applying a uniform continuous illumination to the photo-conductive layer 17 through a gap in the mask 25. Thus as the surface of the gravure layer 12 leaves the ink bath 14 excess ink is first wiped off the surface by the first doctor blade 40 leaving each cell 13 substantially filled with ink as illustrated diagrammatically at 45 in FIG. 3. Then under the influence of the electrostatic field from electrode 42 and the uniform illumination from light source 43 the ink in all the adjacent cells of the gravure surface is caused to rise upwardly somewhat above the surface, as illustrated at 46 in FIG. 4. This upstanding ink is then removed by the second doctor blade 41. A stationary internal mask 47 following this auxiliary light source 43 prevents illumination then reaching the photo-conductive layer as the cylinder rotates and the collapse of the field causes the ink to fall in the individual cells 13, as illustrated in FIG. 5, to a level considerably below the original level after leaving the first doctor blade 40. By controlling the strength of this auxiliary field, through an adjustable electrostatic charger 50, or varying the intensity of illumination, at source 43, through an adjustable controller 51 it is possible to remove sufficient ink from all the cells to ensure that in the absence of the final selective printing or transfer field at 30 no ink

will be transferred from the cells 13 and no unwanted images will occur. When this transfer field is applied the ink rises in the selected cells as illustrated at 48 in FIG. 6.

In this example the final printing field is produced by the external electrostatic corona charging unit 30 positioned adjacent the external surface of the gravure cylinder and outwards of the paper web, situated between the two web feed rollers 29. Alternatively the final printing or transfer field may be applied by using a pressure roller with a conductive rubber surface layer connected by slip rings to one side of a high tension voltage supply, the other side of the supply being connected by slip rings to the conductive layer 16 or the photo-conductive layer 17 of the rotary cylinder unit.

In a modified form of apparatus according to the invention illustrated in FIG. 7, the glass insulating drum 15 is first coated externally with a thin translucent conductive layer 16 applied for example by electro-depositing tin as in the previous example, and a hard tough insulating layer to form the gravure surface 12 is applied externally, formed for example of any epoxy resin. As in the previous example, this outer hard surface has a large number of closely spaced small cells 13 formed therein, extending down to the conductive layer 16, and in each of these cells is applied a shallow layer 55 of a photo-conductive material, which is limited to the lower part of each cell. The apparatus operates in substantially the same manner as described above since it will be noted that the effect of the controlled electrostatic printing field is only to vary the degree to which ink rises in the individual cells. Alternatively, as illustrated in FIG. 8, the photo-conductive layer may be omitted, the gravure surface 12 being applied directly over the translucent conductive layer 16, and the ink 56 is itself a photo-conductive material.

In order to assist the rise of the ink in the cells it may be preferred to incorporate a porous layer immediately adjacent to and underlying the gravure layer 12 so as to allow air, ink, or other fluid, to enter at the bases of the cells and thus allow the ink to move more readily, or as a pellet or slug, towards the top of each cell under the influence of the electrostatic transfer field.

In the second example illustrated in FIG. 9 the apparatus is designed to operate as an electrostatic printing machine and comprises a base 60 supporting in bearings a main hollow rotary cylinder unit 61 mounted on a fixed horizontal rotary axis. The external surface of the cylinder is similar to that described with reference to FIG. 2, and comprises a layer of an opaque electrically insulating material (for example a hard synthetic plastics material such as an epoxy resin) having a large number of small cells in its external surface, resembling the etched cells of a conventional gravure cylinder. This external surface runs in an ink bath 62, into which the lower part of the cylinder dips. Beneath this external gravure-type layer are three further layers forming a composite multi-layer construction. The innermost layer is a structural hollow cylindrical glass drum acting as a transparent or translucent support. Outside this glass layer is a translucent electrically conductive layer such as a thin layer of a tin compound applied by electro-deposition, and outside this conductive layer is a thin layer of a photo-conductive material such as zinc oxide.

Centrally within the hollow cylinder unit is mounted an elongated light source 63 running axially over the whole printing width and supplied from an electrical supply source 64. The light is partly surrounded by a fixed opaque hollow cylindrical mask 65, and means are provided for mounting a photographic negative 66 of the image to be printed on a transparent drum 67 inside the mask, the drum being connected to rotate with the cylinder 41 so that the negative is rotated in synchronism with the cylinder. Externally of the cylinder unit feed means are provided for causing a paper web 69 to be fed continuously from a supply spool 70 to a winding spool 71 being guided by a roller 72 to pass in close contact with the surface of the gravure layer. The surface layer 73 of this roller is electrically conductive, and is electrically connected by slip rings to an electrostatic charging source 74, which thus acts to apply an electrostatic field between the gravure surface layer and the paper web 69 in this transfer section, adjacent the pressure point of the roller. In addition the apparatus includes a doctor blade 75 for removing excess ink from the gravure surface after leaving the ink bath, and an electrostatic charging electrode 76 adjacent the gravure surface immediately before it reaches the pressure roller, this being connected to an electrostatic generator 77.

With the apparatus as described it will be seen that light from the central source 63 will be transmitted radially outwards only through the transparent portions of the photographic negative 66 and where not obstructed by the mask 65 this transmitted light will pass through the inner glass and the translucent conductive layer and will impinge upon the photo-conductive layer thus rendering these exposed areas of the photo-conductive layer more conductive. When the electrostatic printing field is then applied between the external electrode roller surface 73 and the translucent conductive layer of the cylinder unit, the strength of the field will be materially greater at those cells in the gravure surface layer which overlie exposed areas on the photo-conductive area.

The ink used may be of many different types, but preferably contains pigment particles which are capable of moving within the ink under the influence of the applied electrostatic field. In the present example it is assumed that the ink contains pigment particles of one color, in a colorless liquid medium, and the particles are non-conducting and of a type which have a natural positive electrostatic charge. After passing under the doctor blade 75 the particles 80 are initially distributed at random throughout the ink 81 in the cells as illustrated in FIG. 10, and as the cells move under the electrode 76, which in this case is arranged to produce a positive field, the particles are attracted towards the base of each cell, as illustrated in FIG. 11, such that the upper part 82 of the liquid in each cell has a smaller proportion, or even a complete absence of such pigment particles. The liquid itself will tend to rise in each cell, as illustrated in FIG. 11, under the influence of an applied electrostatic field, irrespective of the direction or polarity of the field. If the electrode surface 73 of the impression cylinder 72 is also charged to produce a positive electrostatic field at the printing position, FIG. 11 situation will occur and the general tone of the printed image will thus be decreased, since the color-

less liquid predominates at the upper part of each cell. If on the other hand the impression cylinder surface 73 is charged to produce a negative field the pigment particles will be attracted to the upper parts of the cells as illustrated in FIG. 12, and the tone of the printed image will be increased, or heightened.

The ink may be of a type containing two different pigment particles, of differing polarity, e.g. a fluorescent green/yellow gravure ink as supplied under the trade name Fishburne No. QX 1513. In this ink the pigment particles are such that under the influence of an electrostatic field the various types of particles tend to become charged and move within the liquid base according to the sign of the supplied field either in opposite directions, or in the same direction but to differing degrees.

In any case it will be understood that only the upper part of the ink in each gravure cell is transferred to the paper or other articles to be printed so that, in the case of an ink as specified above for example, if the green particles move to the upper part of each cell the image will have a green hue, while if the yellow particles move to the upper part of each cell the image will have a corresponding yellow hue.

In order to increase the depth of the tone or hue the applied electrostatic field can be increased either in strength or in duration. For example the electrostatic electrode 76 before the impression point may be adjustable in size and position, to vary the time during which the ink in the cells is subject to the applied field. In any case since the movement of the particles 80 in the cells is dependent on time it may be necessary to vary the electrostatic field strength in accordance with variations in web speed.

In order to provide a controlled tone variation effect over the whole image area the electrostatic charging source 77 may be arranged to produce a variable electrostatic field having a high frequency component of typically sign wave characteristic, or a typically square wave characteristic, may be applied, with a variable bias. As the paper web moves over the gravure print cylinder this tends to produce bands of different tones or hues and in order that the individual bands should not be easily distinguished by the naked eye the frequency of the applied field in relation to the web speed such that the bands are not of substantially greater width than the individual gravure cells. Thus for a gravure plate having 100 lines per inch and a web speed of 100 ft/minute the frequency should be in excess of 2,000 cycles/second.

The control features mentioned above may equally be applied to ink containing two different types of pigment particles having both different polarity and different color or tone. It then becomes possible to produce a complete color change rather than a mere alteration of tone or hue.

The invention can also be extended to multi-color single drum printing. Single color tone control can be achieved by advancing or retarding either the application of the electrostatic field, or when a photo-conductive material is provided by varying the illumination, prior to the impression point, so that a greater or lesser number of pigment particles are moved to the upper part of the cell.

It will be understood that it is also possible to control the electrostatic field by photo-conductive material positioned on the side of the printed article opposite from the gravure printing surface. Thus the insulating gravure surface layer may be mounted upon an electrically conductive layer, on a cylinder unit having ink applying means as described, while a further cylinder unit is mounted on the other side of the paper web having a glass supporting surface, an overlying translucent conductive surface, and an outer photo-conductive surface, with internal optical projection means to control the areas of the photo-conductive surface which are to be exposed, so as to vary the electrostatic printing field applied between the two cylinder units across the paper web. In any case it will be understood that instead of a photographic negative other optical projection systems or scanning devices may be employed, including cathode ray projection tubes, television tubes and the like, and these may be positioned either internally or externally of the gravure cylinders, with appropriate arrangement of the effective layers of the cylinder surface.

The method and apparatus of the invention can provide printing or copying of high definition since a liquid printing ink can be employed with pigment particles of extremely small size and the system has all the advantages of a conventional gravure printing process with the added advantages of electrostatic transfer of ink and control of the image. Extremely high printing speeds can be expected and the size and weight of the apparatus can be very considerably reduced by comparison with conventional printing presses in view of the great reduction or elimination of the printing pressure at the paper web. The system is extremely flexible since the image to be printed can be changed merely by substituting a new photographic image, or where electronic systems such as television projectors or computers are adopted no mechanical operation will be required at all. The system is substantially independent of cylinder circumference and can be truly continuous, for example for repeat pattern printing, where even conventional gravure printing cylinders must be hand etched over the joints of wrap-around negatives. Multi-color printing can easily be achieved by increasing the number of units and most importantly, since the transfer of ink is controlled by the application of electrostatic fields and illumination rather than pressure and viscosity, rapid feed back systems can be applied to control the printing quality merely by varying the electrostatic fields or the illuminations. The potential "development" speed is extremely high by comparison with existing methods, and is only limited by the rate of rise and fall of the ink in the cells. Since the ink need not be transferred from the cells to the paper until after the paper has come into contact with the cylinder, sideways spreading of the image can be limited and the clarity and resolution of the final image increased. Moreover as explained above half-tone work can be achieved in a somewhat similar manner to that of conventional half-tone gravure, by using a photo-conductive material whose resistivity changes in accordance with the amount of illumination so that the field strength across the individual cells will be varied accordingly and thus vary the quantity of ink transferred. Further, in conventional photo-conductive drum

systems, employing either powder or liquid development, it is necessary to wipe off the old developed image, before a new one may be applied. This is difficult in practice to achieve, particularly with liquids. The above system eliminates the need for this.

In one convenient system a continuous micro-film can be projected using a simple lens system onto the inner surface of the cylinder unit, thus providing continuous sequential operation if required.

The method and apparatus of the invention obviously have particular advantages as applied to continuous high speed printing operations but can also be applied to methods of printing books for example where different pages of a book are printed sequentially before the next book is printed. This may be of considerable value where small numbers of books are to be printed. Furthermore the invention can also be applied to advantage in copying procedures to obtain copies of high clarity and resolution and at high speed.

For simplicity, the single term "copying" is used in the appended claims, to refer both to printing and to copying.

I claim:

1. A method of copying using an imaging member having a surface formed with a plurality of closely spaced small recesses of uniform size distributed substantially uniformly over said surface, comprising introducing a liquid printing medium into said recesses in said imaging member surface, projecting an optical image onto photo-conductive material located in each of said recesses, to cause portions of said photo-conductive material to become locally and temporarily conductive in the pattern of said optical image, establishing an electrostatic field at said surface of said imaging member, the local strength of said field being varied by reason of and in accordance with the said conductive pattern of said photo-conductive material, whereby said liquid printing medium is lifted partly out of corresponding ones of said recesses, removing the upstanding liquid medium with a doctor blade, discontinuing the controlled electrostatic field to allow the liquid medium to collapse into said recesses, and thereafter establishing a substantially uniform electrostatic field to transfer the remaining liquid medium from said recesses in the form of a negative image onto an article to receive said pattern.

2. Apparatus for copying, comprising a rotary imaging member having a plurality of closely spaced small recesses of uniform size distributed uniformly over a surface thereof, and a layer of photo-conductive material lying in each recess, means for introducing a liquid printing medium into each of said recesses, means for projecting an optical image onto said photo-conductive material to render parts thereof conductive, means for establishing an electrostatic field at said surface of said imaging member, whereby the strength of said field varies over the surface of said imaging member in accordance with the pattern of conductive areas in said photo-conductive material, and means for conveying an article to receive said pattern past said surface of the member, whereby said printing medium is transferred in a corresponding pattern onto said article.

3. Apparatus according to claim 2, in which said photo-conductive material is in the form of a continu-

ous layer behind said recesses, and said optical projection means is situated on the rear side of said photo-conductive layer.

4. Apparatus according to claim 2, in which said imaging member comprises an inner transparent insulating member, a surrounding transparent conducting layer, a photo-conductive layer surrounding said conductive layer, and an insulating surface layer formed with said recesses.

5. A method of copying using an imaging member having a surface formed with a plurality of closely spaced small recesses of uniform size distributed substantially uniformly over said surface, comprising introducing a liquid printing medium into said recesses in said imaging member surface, projecting an optical image onto photo-conductive material located in said recesses to cause portions of said photo-conductive material to become locally and temporarily conductive in the pattern of said optical image, establishing an electrostatic transfer field between said surface and an article to receive said pattern, the said electrostatic field being of variable strength over different sections of said surface by reason of said conductive pattern of photo-conductive material, whereby said printing medium is transferred onto said receiving article from those of said recesses of the imaging surface which lie adjacent to said conductive portions of said photo-conductive material.

6. A method of copying using an imaging member having a surface formed with a plurality of closely spaced small recesses of uniform size distributed substantially uniformly over said surface, comprising introducing a liquid printing medium into said recesses in said imaging member surface, projecting an optical image onto photo-conductive material located adjacent said recesses to cause portions of said photo-conductive material to become locally and temporarily conductive in the pattern of said optical image, establishing an electrostatic transfer field between said surface and an article to receive said pattern, the said electrostatic field being of variable strength over different sections of said surface by reason of said conductive pattern of photo-conductive material, whereby said printing medium is transferred onto said receiving article from those of said recesses of the imaging surface which lie adjacent to said conductive portions of said photo-conductive material.

7. A method of copying using an imaging member having a surface formed with a plurality of closely

spaced small recesses of uniform size distributed substantially uniformly over said surface, comprising introducing a liquid printing medium into said recesses in said imaging member surface, projecting an optical image onto photo-conductive material located adjacent each of said recesses, to cause portions of said photo-conductive material to become locally and temporarily conductive in the pattern of said optical image, establishing an electrostatic field at said surface of said imaging member, the local strength of said field being varied by reason of and in accordance with the said conductive pattern of said photo-conductive material, whereby said liquid printing medium is lifted partly out of corresponding ones of said recesses, removing the upstanding liquid medium with a doctor blade, discontinuing the controlled electrostatic field to allow the liquid medium to collapse into said recesses, and thereafter establishing a substantially uniform electrostatic field to transfer the remaining liquid medium from said recesses in the form of a negative image onto an article to receive said pattern.

8. Apparatus for copying, comprising a rotary imaging member having a plurality of closely spaced small recesses of uniform size distributed uniformly over a surface thereof, and a layer of photo-conductive material lying behind each recess, means for introducing a liquid printing medium into each of said recesses, means for projecting an optical image onto said photo-conductive material to render parts thereof conductive, means for establishing an electrostatic field at said surface of said imaging member, whereby the strength of said field varies over the surface of said imaging member in accordance with the pattern of conductive areas in said photo-conductive material, and means for conveying an article to receive said pattern past said surface of the member, whereby said printing medium is transferred in a corresponding pattern onto said article.

9. Apparatus according to claim 8, in which said photo-conductive material is in the form of a continuous layer behind said recesses, and said optical projection means is situated on the rear side of said photo-conductive layer.

10. Apparatus according to claim 8, in which said imaging member comprises an inner transparent insulating member, a surrounding transparent conducting layer, a photo-conductive layer surrounding said conductive layer, and an insulating surface layer formed with said recesses.

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