

[54] XEROPRINTING EMPLOYING
LETTERPRESS SURFACE COVERED WITH
A LAYER OF RESISTIVE MATERIAL

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[58] Field of Search 101/DIG. 13, 219,
101/426, 216, 212

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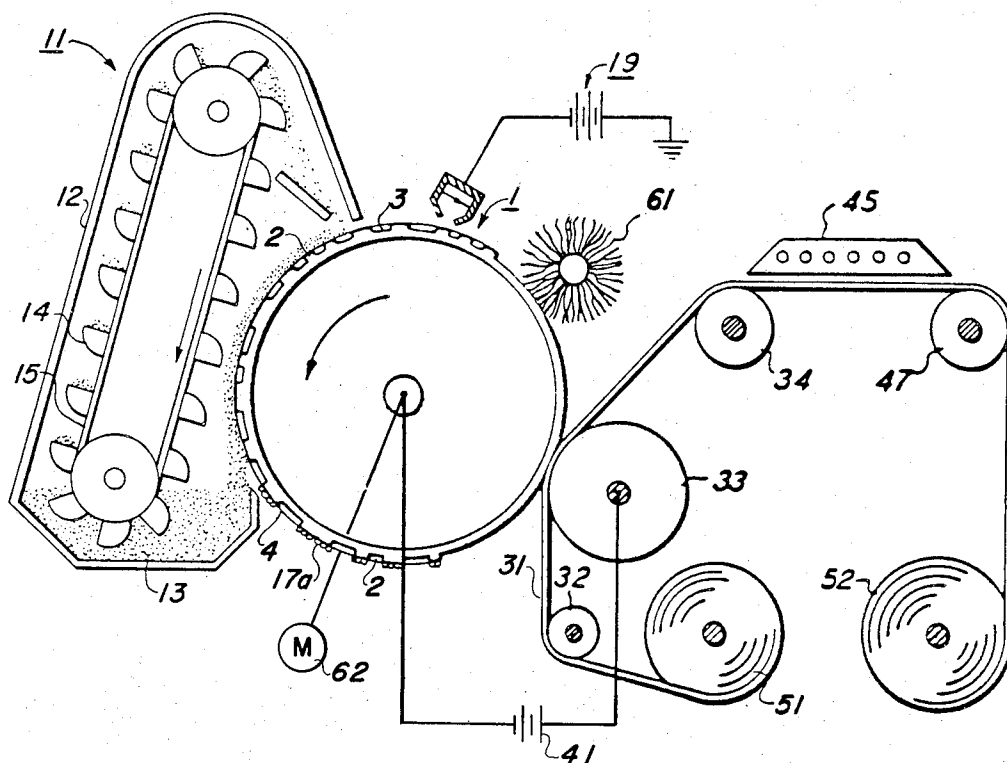
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[57] ABSTRACT

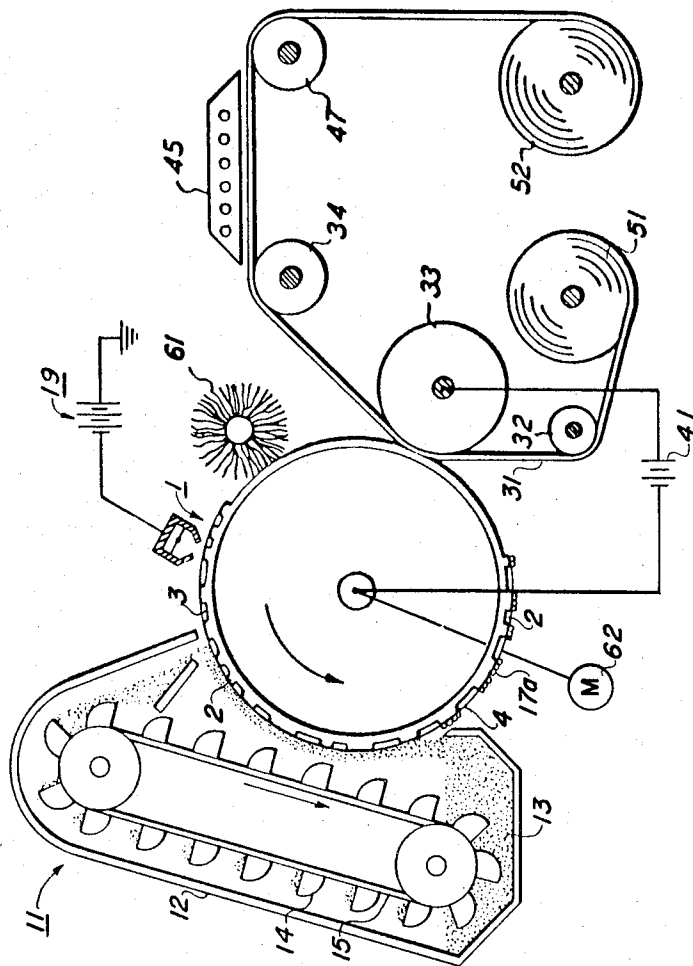
Upon placing an insulating layer into intimate molecular contact with the raised surfaces of a conductive substrate it has been determined that selective discharging will occur when the resulting configuration is exposed to a uniform electrostatic charge such that an electrostatic latent image is produced on the composite member. The system is suitable for forming and developing images in either the charge retaining or discharged areas of the electrically resistive film.

10 Claims, 1 Drawing Figure



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XEROPRINTING EMPLOYING LETTERPRESS SURFACE COVERED WITH A LAYER OF RESISTIVE MATERIAL

BACKGROUND OF THE INVENTION

This invention relates to an imaging system and, more specifically, to a duplicating system employing a relief printing member.

Relief or typographical printing is a contact form of printing whereby the image areas of the printing plate are substantially raised above the flat reference plain of the plate. An ink roller coated with a conventional printing ink is passed across the surface of the relief printing plate. As a result of the raised relief nature of the image characters the printing ink contacts only the raised surface thereby depositing the ink only in the image areas. The ink is then generally transferred to a copy sheet through pressure. This form of printing is referred to as letterpress printing.

Although the most classical form and widely used method of printing, letterpress printing is not without its disadvantages. When printing from a relief image area there is generally required very high pressures and a need for a uniform application of ink to the printing surfaces. In practice, the high pressures employed give rise to what is referred to in the art as "ink splash" at the character edges. Furthermore, when the printing areas are very small the pressure needed is quite low. If the printing areas are large, then a high pressure is required. This pressure differential requires a high degree of initial preparation and process controls. A further disadvantage of letterpress printing is that the inks generally used are viscoelastic and exert considerable tension on the copy paper when the paper is pulled away from the printing plate. This places severe requirements on the surface strength of the copy paper. In addition, with fluid inks the compatibility of the materials utilized in the way of absorbency is a controlling factor as to the amount of ink which is transferred. To alleviate some of these difficulties, a form of printing otherwise known as dry-offset or letterset printing was introduced which uses an intermediate rubber-covered cylinder for transferring the image from the plate to the final copy sheet. However, this process is also not without its disadvantages requiring the use of the intermediate surface, thereby increasing the number of image transfers that must be made which inherently leads to a loss of image quality and an increase in machine and process complexity.

A printing process has been suggested whereby liquid ink is applied selectively to the printing surface utilizing electrostatic lines of force and the ink thereafter transferred from the printing surface to the print receiving material or copy sheet. However, due to the nature of the materials used, this technique has been found to be extremely limited. The printing inks are charged by induction and once out of the field of force the ink droplets will no longer retain a charge. Furthermore, the surface tension forces of the ink are generally greater than any suitable or operable electro-static force. As a result it is generally felt that unless contact is made transfer of the ink is not possible. In addition, special steps must be taken in order to control the selective development of the printing surface.

In still another approach to eliminating the problems encountered with letterpress printing, a system has been devised whereby the relief printing surface is de-

veloped substituting the use of dry powders for conventionally-used printing inks. However, in the use of this system a notable loss of edge sharpness has been detected when developing and transferring from the letterpress plate.

It is, therefore, an object of this invention to provide an imaging system which will overcome the above-noted disadvantages.

A further object of this invention is to provide a novel method for imaging from a relief printing plate.

An additional object of this invention is to provide a novel method for developing a conductive printing member.

Another object of this invention is to provide a substantially pressureless imaging system utilizing a conductive relief printing plate.

Still a further object of this invention is to provide a substantially dry printing process.

Yet still a further object of this invention is to provide a novel relief printing system utilizing the desirable properties of low relief while eliminating the need for added process steps.

Still another object of this invention is to provide a relief printing process with dry powders whereby edge sharpness of the resulting images are markedly improved.

The foregoing objects and others are accomplished in accordance with the present invention, generally speaking, by bringing the printing surface of a conductive relief printing substrate into close proximity with the surface of an electrically resistive film or layer such that the film contacts the surface of the relief areas of the conductive plate and spans the recessed areas. An electrostatic charge is applied to the surface of the high resistivity film so as to establish a uniform potential upon the surface of the film. The areas contacting the conductive relief surfaces are quickly discharged while those areas not directly contacting the surfaces retain their charge and high potential. The resulting fields may then be developed xerographically with electroscopic marking particles or toner utilizing conventional electrostatic development techniques. The resulting developed image is then transferred to the surface of the final receiving substrate and the process repeated until the desired number of copies have been produced.

It has been determined in the course of the present invention that when placing electrically resistive material in intimate molecular contact with the relief surfaces of a conductive substrate that selective discharging will occur when the resistive surface is exposed to electrostatic charge such that an electrostatic latent image is produced on the composite member. The potential (V) applied to a film of resistivity (ρ) decays with time (t) according to the equation

$$V = V_0 e^{-t/RC}$$

where V_0 is the initial voltage applied at $t = 0$, and R is the resistance and

C is the capacitance of the film.

The time constant of discharge (τ) is defined as $t = RC$ and this product is expressed as

$$\tau = K \rho 0.885 \times 10^{-13}$$

where K is the dielectric constant, and is the volume resistivity.

In practice, for the discharged image areas, τ will be longer than the charging time but less than the time be-

tween charging and development. This allows for charging to a uniform potential with the selective discharge of areas contacting the raised conductive surfaces. The resulting latent image may be made visible with conventional electroscopic toner particles. The novel system is suitable for forming and developing images in either the charge retaining or discharged areas of the resistive layer simply by selecting the proper polarity of applied electrostatic charge relative to the polarity of charge on the electroscopic toner particles.

The invention is further described by way of the illustration which represents a diagrammatic sectional view of an imaging apparatus implementing the process of the present invention.

Referring now to the drawing, there is seen a relief printing member generally designated 1 composed of a conductive substrate of raised, relief areas 2 and recessed areas 3. Overlying the surfaces of the relief areas 2 of the printing member 1 spanning the recessed areas 3, is an electrically resistive or dielectric layer of material 4 which is fixed in intimate contact to the respective relief surface areas. In close proximity to the relief printing member 1 is a development unit 11 represented in the present illustration as a cascade type developer which includes a powder container 12 containing a supply of developing material 13. The developer is picked up from the bottom of the container and cascaded over the surface of the printing member 1 by a number of buckets 14 on an endless belt 15. This development technique is more fully described in U.S. Pat. Nos. 2,618,551 and 2,618,552.

As the relief printing member 1 is rotated in the direction of the arrow, a uniform potential is applied to the surface of the controlled resistivity layer 4 by corona unit 19. An electrostatic latent image is immediately formed corresponding to the recessed areas of the conductive substrate. The electrostatic image bearing surface of the dielectric film 4 is brought into contact with the developer 13. The toner particles in the developer are attracted to the surface of the relief member corresponding to the differential in potential established by selective discharge after the charging step set out above. If the image to be developed is that corresponding to the recessed or charge retaining areas of the member, then the toner particles of the developer composition will be charged to a polarity opposite to that of the charge of the latent image. If the image or discharged areas are to be developed, that is, the areas corresponding to the raised portions of the relief printing member, as in the illustration, the toner particles used will exhibit a polarity the same as that of the polarity of the electrostatic latent image.

The toner particles now adhering to the electrostatic latent image on the surface of the dielectric layer are carried so as to contact a copy web 31 which is supplied from feed roller 51 passed over guide roller 32 and brought into intimate contact with the surface of the dielectric layer by conductive transfer roller 33 which is connected by power source 41 to printing member 1. The toner particles are transferred in imagewise pattern to the surface of copy web 31 in response to an electric field established between the conductive transfer roller 33 and the conductive substrate of the relief printing member 1. The potential applied by power unit 41 to the transfer roller is opposite in polarity to the charged toner particles and of sufficient magnitude so as to overcome the attractive forces of the relief mem-

ber so as to effect transfer of the toner particles to the copy web. After passing over the transfer roller 33 the transferred toner image is guided by a second guide roller 34 to a fixing station represented in the present illustration as a heat fixing unit 45. The copy web carrying the fixed image is then directed by roller 47 to be rewound on take-up roller 52. Although image transfer has been represented as being carried out by utilizing a conductive roller, any suitable technique may be employed such as the use of a corona device as in unit 19. When charged area development is used the corona transfer step will recharge the surface of the printing member to the proper potential and polarity by air ionization thereby eliminating the necessity of recharging the surface by unit 19.

The printing surface of the dielectric layer on the relief member continues around to either repeat the cycle or, when the last image is produced, a cleaning brush 61 will be engaged with the surface of the dielectric removing any residual toner material remaining on the film surface and preparing the master for storage and later use. A driving means 62 is provided to rotate the printing member of the system.

The conductive relief member used in conjunction with the present invention may be cylindrical in shape, as illustrated in the accompanying drawing, or it may also take the form of a flat bed press or platen. The difference in height between the recessed and raised areas ranges from about 0.5 to about 5 mils. Obviously, this height may vary and may reach heights comparable to those used with conventional relief printing members such as about 15 to 40 mils. However, for optimum operating conditions and in order to take advantage of the improvements of the present invention, it is most desirable to operate at a relief as minimal as possible. A gravure printing member may be substituted for the relief member when suitable as further described in the examples following. As stated, the relief (or gravure) substrate will be a conductive material such as aluminum, brass, steel, copper, nickel, zinc and alloys thereof. Its resistivity will be less than that of the dielectric or insulation material intimately fixed to the surface so as to act as a ground when charge is applied. Although it is not considered critical, the potential applied to the dielectric layer overlying the conductive relief substrate will be generally in a range of about 500 to about 1000 volts.

The dielectric or electrically resistive material fixed to the surface of the conductive relief substrate may be any suitable material having a resistivity generally between about 10^9 and 10^{14} ohm-centimeters. Typical materials include polyvinylfluoride (Tedlar), polypropylene, polyvinyl chloride, polyvinylidene chloride, and appropriately doped polystyrene, polytetrafluoroethylene, polyethylene terephthalate, and other similar materials. From a practical standpoint and for sharp image reproduction the thickness of the dielectric material will generally be in the order of $\frac{1}{4}$ to 2 mils with best results being obtained utilizing a thickness of about $\frac{3}{8}$ mil.

Although the process of the present invention has been described in conjunction with cascade development, a process more fully described in U.S. Pat. Nos. 2,618,551 and 2,618,552, other suitable development techniques may be used such as powder cloud development, a process more fully described in U.S. Pat. Nos. 2,725,305 and 2,918,910 and magnetic brush develop-

ment more fully described in U.S. Pat. Nos. 2,791,949, and 3,015,305. For solid areas magnetic brush development might be used or cascade development with small carrier beads and a development electrode. Any suitable toner or developer material may be used such as is disclosed in U.S. Pat. Nos. 2,788,288, 3,079,342 and Reissue U.S. Pat. No. 25,136. The toner is generally a resinous material which, once fixed, has the necessary properties to produce a lasting print. Typical developer powders are styrene polymers including substituted styrenes such as the Piccolastic resins commercially available from the Pennsylvania Industrial Chemical Corporation, phenol formaldehyde resins and similar materials.

Any desirable and suitable material may be used as the copy or transfer web for receiving the developed image from the printing member. The transfer material will generally be insulating in nature. Typical materials are polyethylene, polypropylene, polyethylene terephthalate, polyvinyl chloride, ordinary bond paper, and polyvinylfluoride.

Although the fixing mechanism has been represented for purposes of illustration as a heat fixing unit, any suitable technique may be used such as vapor fusing, treatment of the developed image with a regulated amount of heat, as shown, applying or spraying an adhesive film over the toner image or by placing a lamination of plastic material over the surface of the transferred image.

In an embodiment where it becomes desirable to fill the areas previously occupied by the air with a dielectric or insulating inelastic material, so as to prevent the electrically resistive film from contacting the conductive relief member in the recessed, non-image areas, a layer of material may be provided such as a Tedlar sheet having a layer of inelastic cellular foam particles coated thereon. The cell diameters would range from about 25 to 125 microns and comprise such materials as polyurethane or polyethylene foams. The relief member selectively compresses the foam layer to fill the recessed areas and lower the resistivity of the Tedlar in the compressed areas. The layer of foam will be coated to a thickness corresponding to or initially greater than the height differential between the raised and recessed areas. The conductive relief member may be removed and in its place a metallic coating applied such as by painting or flashing to produce the usable member. The original relief plate need not be conductive in this instance and may be a relief plate made up of a non-conductive polymeric material. In this manner many printing masters may be fabricated from one original plate.

To further define the specifics of the present invention, the following examples are intended to illustrate, but not limit, the particulars of the present system. Parts and percentages are by weight unless otherwise indicated.

EXAMPLE I

A one mil thick sheet of Tedlar, polyvinylfluoride, is adhesively fixed to the raised surfaces of a section of steel letterset type having a relief of about four mils. The Tedlar has a resistivity of about 10^{12} ohms-centimeter. The surface of the Tedlar is charged to a positive potential of about 600 volts. The areas contacting the conductive surface quickly discharge. A xerographic developer comprising carrier beads of

resin coated glass, together with positively charged toner particles comprising polystyrene is cascaded across the charged dielectric surface, developing the areas corresponding to the relieved portions or discharged areas of the type. The dusted type face is then brought into contact with a receiver paper sheet and a negative potential of about 1000 volts with respect to the grounded metal type applied to the paper support. The toner particles are transferred from the type to the surface of the receiver paper sheet in an imagewise pattern corresponding to the relieved areas of the type.

EXAMPLE II

The process of Example I is repeated with the exception that doped polyethylene terephthalate (Mylar) is substituted for the Tedlar. Similar results are obtained. The Mylar is doped to have a resistivity of about 10^{11} ohms-centimeter.

EXAMPLE III

The process of example I is repeated with the exception that the relief type utilized represents a relief of about two mils. Similar results are obtained as in Examples I and II.

EXAMPLE IV

The image cells of a conductive gravure member are filled with polyurethane foam particles having a particle diameter size of about 30 microns. A one mil thick sheet of Tedlar is fixed to the surface of the gravure master the image cells of which are about three mils deep. The surface of the Tedlar is charged to a positive potential of about 550 volts. The areas contacting the conductive surface quickly discharge to produce an electrostatic latent image. A xerographic toner composition utilizing toner particles negatively charged is cascaded across the imaged surface developing the areas corresponding to the image gravure cells. The imaged surface is then brought into contact with a receiver paper sheet and a positive potential of about 1000 volts with respect to the grounded metal gravure member applied to the paper sheet. The toner particles are transferred in imagewise configuration to the surface of the paper sheet.

Although the present examples are specific in terms of conditions and materials used, any of the above typical materials may be substituted, when suitable, in the above examples with similar results. In addition to the steps used to carry out the process of the present invention, other steps or modifications may be used, if desirable. The printing member configuration may be prepared by any number of well-known techniques which may be adapted by those skilled in the art. In addition to the materials used in conjunction with the present invention, other materials may be employed which will enhance, synergize and otherwise desirably effect the properties of the present system. For example, instead of an airgap functioning as the area of charge differential, other nonconductive material such as gelatins, electrophotographic toners, wax or other similar materials may be utilized.

Thus, anyone skilled in the art will have other modifications occur to him based on the teachings of the present invention. These modifications are intended to be encompassed in the scope of this invention.

What is claimed is:

1. A method of electrostatic printing comprising the steps of:
 - a. providing a printing member comprising a conductive substrate having raised and recessed areas formed of the same material, there being intimately fixed to the surface of the printing member a layer of electrically resistive material, such that the resistive material contacts the surface of the relief areas of the printing member and spans without touching the recessed areas,
 - b. applying a uniform potential of electrostatic charge to the surface of said printing member thereby producing discharge areas where said resistive material contacts said relief areas, and areas which retain charge where said resistive material spans said recessed areas,
 - c. applying a developer composition to the surface of said imaged printing member to form a visible image on the surface thereof,
 - d. contacting said developed printing member with the surface of the transfer sheet, and
 - e. applying an electrostatic field such that the developer particles are transferred to said sheet in an imagewise pattern.
2. A process as disclosed in claim 1 wherein the height differential between the raised and recessed areas of the conductive substrate ranges from about one to five mils.
3. A process as disclosed in claim 1 wherein said insulating layer has a resistivity of from about 10^9 to 10^{14} ohm-centimeters.
4. The process as disclosed in claim 3 wherein said insulating material has a thickness of at least about $\frac{1}{4}$ mil.
5. The process disclosed in claim 1 wherein steps b through e are repeated at least one time.
6. The process as disclosed in claim 1 wherein said visible image is developed on the portion of the electrically resistive material which contacts the relief areas.
7. The process as disclosed in claim 6 wherein said conductive printing member is a letterpress printing plate.
8. The process as disclosed in claim 1 wherein said visible image is developed on the portion of the electrically resistive material which spans the recessed areas.
9. The process as disclosed in claim 8 wherein said conductive printing member is a gravure printing plate.
10. The process as disclosed in claim 7 wherein said recessed areas of said printing member are prefilled with a compressible inelastic foam material.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,765,330 Dated October 16, 1973

Inventor(s) Robert W. Gundlach

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

1. Column 1, line 67--The word "reflif" should be --relief--.
2. Column 2, line 54--The word "appliPd" should be --applied--.
3. Column 4, line 60--The term "2/3" should be --1/2--.
4. Column 6, line 50--The word "porcess" should be --process--.
5. Column 6, line 60--The word "meatrial" should be --material--.

Signed and sealed this 16th day of April 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

UNITED STATES PATENT OFFICE
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(SEAL)
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