

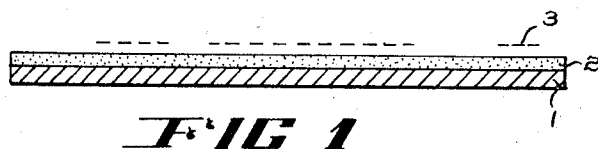
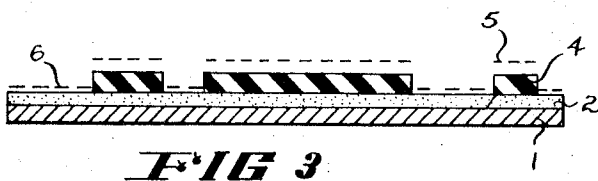
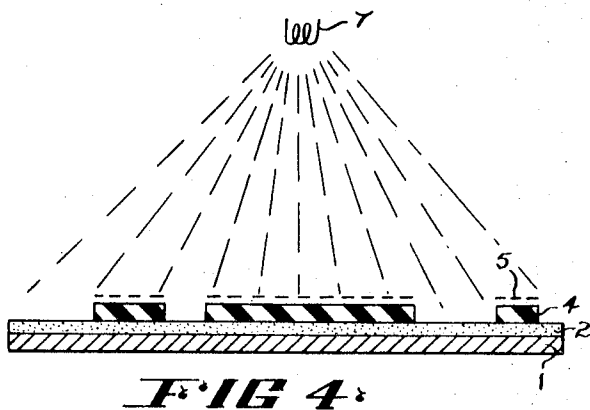
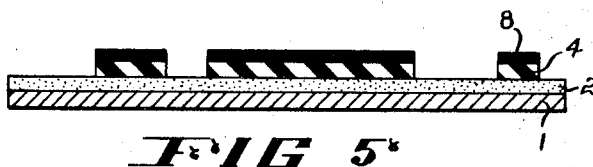
April 27, 1971

J. MATKAN
ELECTROSTATIC PRINTING METHOD EMPLOYING
A PIGMENTED LIGHT FILTER

3,576,624

Filed Oct. 17, 1967

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

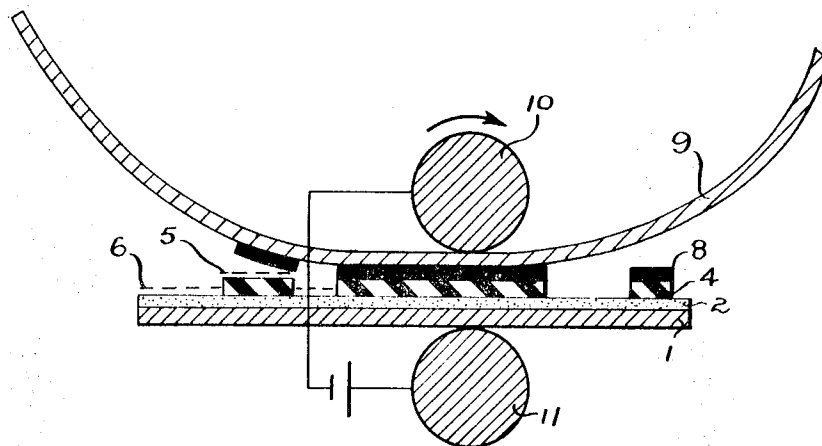


FIG 6

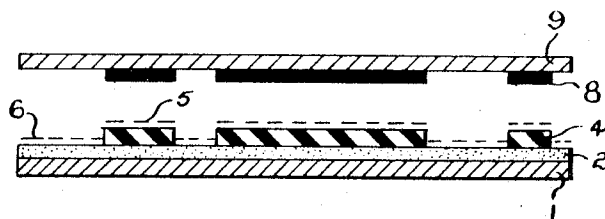


FIG 7

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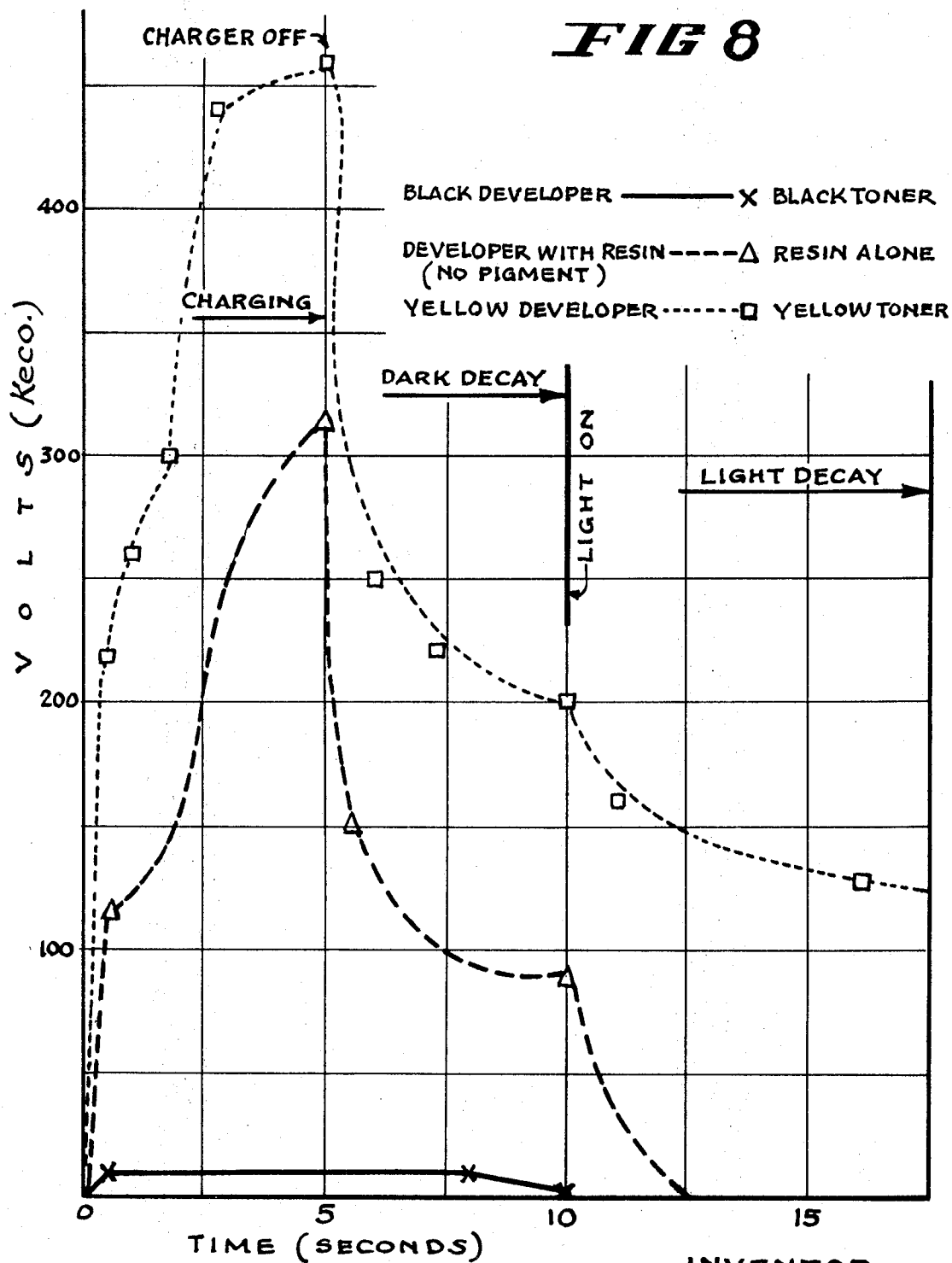
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3 Sheets-Sheet 3



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3,576,624

ELECTROSTATIC PRINTING METHOD EMPLOYING A PIGMENTED LIGHT FILTER

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Continuation-in-part of application Ser. No. 340,173, Jan. 27, 1964. This application Oct. 17, 1967, Ser. No. 675,984

Int. Cl. G03g 13/14

U.S. Cl. 96—1.3

3 Claims

ABSTRACT OF THE DISCLOSURE

Superior prints in a multiple series, using electrostatic phenomena, are obtained by first preparing a master image using a developer of yellow color established as being effective to sustain a charge over a period of time far in excess of a master image prepared from a developer of black color or one which omits yellow pigment.

This application is a continuation-in-part of application Ser. No. 340,173, filed Jan. 27, 1964, now abandoned.

This invention relates to electrostatic printing and in particular it relates to a method of producing plurality of prints or copies from an electrostatic master sheet bearing the image to be reproduced, characterized in that a difference exists in the electrostatic charge holding capacities of the image bearing and non-image bearing areas contained on the printing surface of such master.

Electrostatic printing in its widest form can be described as a process wherein an insulating surface is provided with an electrostatic charge pattern in selective areas conforming to an image and wherein such charge pattern is subsequently rendered visible by applying a dry developer powder or a developer material suspended in an insulating liquid dispersant in order that such developer may be attracted and held electrostatically to the charged areas contained on the insulating surface. The developed image may be fixed to the surface of the insulator or transferred to another surface and fixed thereon, if desired.

Electrophotography is a special case of electrostatic printing and usually it involves the following process:

A relatively conductive backing member such as metal or paper sheet having deposited thereon a photoconductive material, such as for instance vitreous selenium or a particulate photoconductor such as for instance zinc oxide or lead monoxide and the like in a resin matrix, is subjected to a corona discharge whereby a uniform electrostatic charge is deposited on to the photoconductive layer. Such charged photoconductive layer is then exposed to a light or X-ray pattern whereby the irradiated areas become discharged whereas the shielded areas remain charged and thus form a latent electrostatic image. Such latent electrostatic image is then rendered visible by applying a dry developer powder or a developer material suspended in an insulating liquid dispersant in order that such developer may be attracted and held electrostatically to the charged areas. The developed image may be fixed to the surface of the photoconductor or it may be transferred to another surface and fixed thereon, if desired.

The term xerography is generally used in connection with selenium as the photoconductor and dry powder developers in an electrophotographic process as hereinbefore described.

Reproduction of images such as for instance copying of documents by electrostatic printing has been accomplished by prior art processes. According to one such

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process the image of the original to be copied is projected onto a charged selenium surface which is subsequently brought into contact with dry developer powder and the developed image is transferred onto a copy sheet whereon it is then fixed by heat fusing.

According to another prior art process the image of the original to be produced is projected onto a charged photoconductive zinc oxide coated paper sheet to form a latent electrostatic image thereon. Such latent image is developed with a dry powder developer and fixed by heat fusing onto the zinc oxide surface or the developed image is transferred onto a copy sheet and heat fused thereon.

According to still another prior art process the hereinbefore described electrostatic latent image formed on the zinc oxide coated paper is developed with toner material suspended in an insulating liquid dispersant, and there are known toner formulations which are capable of rendering the developed image to become fixed upon evaporation of the liquid dispersant. We have found that such developed image can be transferred onto a copy sheet and we have also found that it is possible to obtain by repeated transfer several copies of progressively reduced quality from one such image.

Certain inherent disadvantages exist in each of the foregoing processes. Although excellent for the continuous production of high quality single copies or copies of a limited number from originals, neither of these processes is specifically adapted for duplication work, that is, for the production of a plurality of copies from one and the same original. In the case of the process involving the selenium, dry developer powder, transfer onto copy sheet and heat fusing, the steps of charging, exposing and developing have to be performed prior to each step of transfer onto each copy sheet and therefore if it is desired to produce a large number of copies from one original, this process becomes relatively time consuming. In addition, although cheap copy material can be used, the apparatus usually employed in this process is relatively expensive. In the case of using zinc oxide coated paper for forming and developing the latent electrostatic image thereon, in addition to the time consuming requirements of charging, exposing and developing each print, this process is also economically unsuitable for duplication purposes since each copy involves the use of one zinc oxide coated paper and in the case of a large number of copies the process may become prohibitive in view of the relatively high cost of the zinc oxide coated paper.

The process generally used for duplication is one in which a printing master is first prepared from the original to be copied and then such master is employed in a relatively expensive machine to print the desired number of copies by the off-set lithographic process. The number of copies or prints obtainable from one such master depends on the strength and quality of such printing master and there are so called short run masters capable of printing for instance several hundred copies and there are so-called long run masters which are capable of printing many thousands of copies. It is possible to produce and to image off-set lithographic masters by the electrophotographic process.

It is a general object of this invention to provide a method of and means for the production of a plurality of copies from one original.

Another object is to provide an electrophotographic printing process which is faster than the prior art electrophotographic printing processes in producing a plurality of copies from one original.

Still another object is to provide an electrostatic printing process wherein inexpensive copying material of any desired quality can be used.

A further object is to provide an electrostatic printing process which can be mechanized if so desired by relatively simple and inexpensive means.

A still further object is to provide a method of and means for preparing and imaging an inexpensive electrostatic master capable of producing a multiplicity of copies or prints when used in the process subject to the present invention, and in particular superior prints achieved by a unique preparation of the master image using a yellow developer.

The foregoing objects and other advantages will become apparent from the following specification:

The method of producing multiple copies from a master according to this invention consists in:

(a) Producing an electrostatic image on a photoconductor surface supported on a relatively conducting base.

(b) Producing a master by developing such electrostatic image with developing material hereinafter referred to as imaging toner comprising electrically insulating medium capable of supporting an electrostatic charge in proportion to the thickness of such deposited developer material when subjected to radiation of the type intensity which renders the said photoconductor surface conductive.

(c) Successively producing a multiplicity of copies by

(1) Forming an electrostatic charge over the whole surface of such master;

(2) Subjecting such charged master to radiation capable of discharging the photoconductor surface in non-image areas which are not shielded by the insulating developer material;

(3) Developing the remaining electrostatic image contained on the insulating image areas with a liquid developer comprising a toner suspended in an electrically insulating carrier liquid hereinafter referred to as the printing toner;

(4) Transferring the developed image to a copy sheet while wet by bringing the copy sheet into contact with the master while subjecting to an electrical field to move the developed image from the master to the copy sheet;

(5) Separating the copy sheet from the master; and

(6) Evaporating the said carrier liquid from the copy sheet to fix the said image to such copy sheet.

By using the method outlined, a highly effective yet simple duplicating system is achieved in that the master can be produced from an ordinary photoconductive sheet such as for instance a zinc oxide coated paper sheet by forming thereon the insulating image by any of the known xerographic methods, after which such master is immediately ready for the printing process without further treatment. Such master can immediately be put into use in a duplicating machine which merely requires to form an electrostatic charge on the master, to discharge to non-image areas by radiation, to develop and to transfer electrostatically, the electrical field applied during the transfer step being sufficient to re-charge the master for the subsequent developing step, although separate charging could again be used prior to the light discharge step is such was felt desirable.

FIG. 1 shows a photoconductive sheet with an electrostatic image produced thereon;

FIG. 2 shows the image developed with an insulating medium to produce a master sheet;

FIG. 3 shows the master in its fully charged state;

FIG. 4 shows how the master is discharged by radiation such as light in the unshielded non-image areas;

FIG. 5 shows the remaining electrostatic image developed with the printing toner;

FIG. 6 shows how the image is transferred in an electrostatic field;

FIG. 7 shows the transferred image on the copy sheet and the master containing an over-all electrostatic charge which remains from the transfer step shown in FIG. 6. The master is now in a condition corresponding to the

state shown in FIG. 3 and thus ready to produce the next copy by repeating the steps shown in FIGS. 4, 5 and 6; and

FIG. 8 presents graphical representations of the performance of sheets imaged with different developers.

Referring now to the accompanying drawings, the photoconductive printing element to be used for preparing the electrostatic master consists of a relatively conductive backing member 1 such as for instance metal foil or a sheet of paper preferably of high web strength having deposited on one side thereof a photoconductor layer 2. Such layer may comprise a particulate photoconductor embedded in a resin matrix or binder, such as zinc oxide, lead monoxide, mercury iodide and the like or it can be an organic photoconductor such as for instance anthracene, or it can be a layer of selenium or the like which may be evaporated onto the backing member.

Preferred photoconductors are those which are characterized by the flow of a relatively high photocurrent while being illuminated and which exhibit relatively strong memory effects in that they are not readily capable of accepting and supporting an electrostatic charge after exposure to light. Dye sensitized zinc oxide and so called panchromatic zinc oxide as manufactured by the New Jersey Zinc Company were found to be suitable in this respect.

Binder substance for the particulate photoconductor can be selected from a large group of synthetic and natural resins or waxes or the like and should have a relatively high dielectric strength and should be resistant to the liquid dispersant employed for the printing toner.

Examples of suitable resins are the alkyds, polyesters, acrylics, Epons, silicone, vinyl and ether resins. The optimum proportion of the particulate photoconductor to the binder in the final coating may vary depending upon the nature of the photoconductor and of the binder substance, and for example the optimum proportion of the photoconductor zinc oxide to an alkyd resin binder can be said to be between from three to four parts of zinc oxide to one part of the alkyd resin by weight.

The photoconductive printing element can be charged by subjecting it to any known electrostatic charging device such as for instance to a corona discharge from a series of wires or points held at a relatively high DC potential such as for instance 7000 volts above the base plate upon which the printing element has been placed in such manner that the photoconductive layer faces such points or wires. The polarity of such wires or points can be negative in the case where zinc oxide is being employed as the particulate photoconductor in the printing element.

The charged photoconductive printing element may be exposed to the mirror image of the original to be reproduced by means of any suitably arranged optical projection device or the exposure can be made by direct contact and illumination through the original to be reproduced provided such original is sufficiently transparent or the exposure may be made by the reflex method in which case the backing member of the printing element has to be sufficiently transparent.

After exposure the remaining electrostatic latent image 3 supported on the photoconductive layer 2 (FIG. 1) is developed in the imaging toner.

The imaging toner can be a dry powder developer or it can be a liquid developer but in any case such toner must be capable of forming an insulating image 4 on the photoconductive layer 2, FIG. 2, such insulating image being capable of supporting an electrostatic charge and also being resistant to the liquid dispersant employed for the printing toner. Natural or synthetic resins or waxes may be used to form such images. In the case of the dry developing process for instance finely ground thermoplastic phenolic resin powder can be applied by any means known in the prior art to the charged and exposed photoconductive printing element and the image can be

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fixed by heat fusing. In the case of the liquid developing process the imaging toner may be a resin such as for instance polystyrene, low density polyethylene, rubber modified polystyrene, silicone resin, vinyl resin, acrylic resin, alkyd resin, ethyl cellulose, ethyl hydroxy ethyl cellulose, chlorinated rubber, rubber latex, bitumen and the like or a natural resin such as for instance gum damar or gum copal and the like or the ester of a natural gum or a hydrogenated rosin or a wax such as beeswax or carnauba wax and the like, suspended in an insulating liquid dispersant such as for instance a hydrocarbon or a halogenated hydrocarbon of adequate electrical volume resistivity such as not less than 10^9 ohm-cm. and of a dielectric constant of approximately 3 or less. Liquids such as cyclohexane, perchlorethylene and the like are suitable dispersants for certain resins of appropriate solubility. Other substances may be incorporated into the imaging toner such as for instance varnishes, oils, dispersing agents, polarity control agents, relatively insulating and opaque particulate substances such as pigments which are capable of supporting an electrostatic charge on the image areas in that such particulate substances act as light filters and thus prevent the photoconductive layer beneath such image areas from becoming conductive while being illuminated, and the imaging toner can also contain colouring matter such as pigments or water or alcohol soluble dyes to facilitate visual inspection of the quality of the imaged master.

Such imaging toner can be formulated to give image deposits of varying thickness and consequent varying charge holding capacity.

The step of developing may be carried out in a body of the imaging toner suspended in the liquid dispersant or by the use of a mechanical applicator for such liquid toner. After the developing step the electrostatic master should be preferably rinsed in an insulating liquid substantially similar to the liquid employed as the imaging toner dispersant or in an insulating liquid which is a weaker solvent than such dispersant in order to remove any toner from the non-image areas. The electrostatic master should then be dried to obtain complete evaporation of the dispersing or rinsing liquid. There are liquid imaging toners which are capable of forming an image which becomes fixed to the surface of the photoconductive layer upon evaporation of the dispersing or rinsing liquid and there are other liquid imaging toners which are capable of forming an image which can be fixed by heat fusing after evaporation of the dispersing or rinsing liquid. The fixing properties of various imaging toners together with proportioning and dispersion techniques are fully illustrated in the examples following this description. It will be realized that very high image resolution is obtainable by using liquid toners in the step of imaging the electrostatic master since the size of the particles constituting the imaging toner suspended in the liquid dispersant is in the colloidal range and therefore true reproduction of the original without loss in definition due to image coarseness is attainable.

The master prepared in accordance with the foregoing disclosure can be now employed to reproduce the original.

In the first step of the reproduction cycle an electrostatic charge is formed on the surface of the master. In FIG. 3 is shown a master in its fully charged state and it will be noted that electrostatic charges are formed both over the image areas 5 and over the non-image areas 6. The preferred method of forming such electrostatic charges consists in passing a metallic or conductive roller over and in intimate contact with the surface of the master while the backing of such master is contacted with a conductive support member such as for instance another conductive roller or a conductive plate or the conductive surface of a cylinder onto which such master may be placed and connecting said roller in contact with the surface of the master and said supporting member in con-

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tact with the backing of the master to a source of high tension DC supply. In this preferred method we found that an electrostatic charge can be formed on the master probably by so-called charge migration at voltages which are too low for an actual corona discharge effect and therefore in this preferred method it is possible to employ lower voltages than in other methods known in the prior art. Employing this preferred method it is also possible to insert the transfer or copy sheet between the surface of the master and the front roller that is the roller passing over such surface and to form an electrostatic charge on the surface of the master through such copy sheet. The voltage required for forming the electrostatic charge by this preferred method depends on the bulk resistivity of the master and of the copy sheet and has to be below the dielectric breakdown point of these materials. Specific voltages are quoted in the examples following this specification. It is however also possible to form the electrostatic charge on the master by subjecting it to a corona discharge device as previously described in this disclosure. The polarity of the front roller contacting the surface of the master or that of the wires or needles facing such surface in the corona discharge device has to be selected in relation to the charge acceptance characteristics of the master and if for instance the master contains zinc oxide as the photoconductor which is capable of supporting a negative electrostatic charge only the polarity of such front roller or wires or needles has to be negative. In the examples following this specification the polarity employed is quoted in each case.

It should be noted that such step of forming an electrostatic charge on the master is not necessarily a separate step in the reproduction cycle but as will be disclosed in the following description, such electrostatic charge is formed on the surface of the master during the transfer step.

In FIG. 4 is shown the following step wherein the undesired charge contained on the non-image areas 6 (FIG. 3) is removed by exposure to radiation such as for instance an incandescent or an ultraviolet or an infra-red source 7 whereas the electrostatic charge contained in the image areas 5 is retained due to the shielding action of the insulating image 4. It should be noted that it is also possible to form the electrostatic charge on the image areas only by forming such charge in the presence of radiation as hereinbefore described whereby the non-image areas are rendered sufficiently conductive so as to be incapable of accepting an electrostatic charge.

Referring now to FIG. 5, the electrostatic master containing the charged insulating image 4 can be developed to attract the printing toner material 8 to the image areas in a body of the printing toner suspended in a liquid dispersant in which case it may become desirable to apply a biasing electrode, as known in the prior art, in close proximity to the imaged surface in order to enhance the rate of toner deposition, or such image can be developed in a mechanical applicator suitable for the liquid printing toner.

The printing toners can be of any desired colour and such toners comprise basically a particulate pigment of the desired colour, a dispersing agent such as for instance an oil or resin or varnish and one or more agents which are capable of supporting mechanically the image deposit during the transfer operation such as for instance waxes or latex forming substances such as for instance ethyl cellulose and the like. Such toner is suspended in an insulating liquid dispersant such as for instance a hydrocarbon or a halogenated hydrocarbon of adequate electrical volume resistivity such as not less than 10^9 ohm cm. and of a dielectric constant of approximately 3 or less. Such liquid dispersant for the printing toner should have a sufficiently low solvent power so as to be incapable of solvating or swelling the image on the electrostatic master and such liquid dispersant should contain at least a proportion of a relatively slow evaporating liquid so that par-

ticle mobility of the printing toner can be maintained during the subsequent transfer operation. Liquids such as for instance Odorless Mineral Spirit and naphthas of low solvent power are suitable for this purpose. Formulations of printing toners with suitable liquid dispersants are illustrated in the examples following these descriptions.

The transfer operation is to be performed upon removal of the electrostatic master from the liquid dispersant for the printing toner and while the toned image is still wet. The actual transfer operation can be carried out by various means such as for instance by bringing the wet image bearing surface of the electrostatic master in rolling contact with the copy sheet whereby such copy sheet absorbs or adsorbs liquid dispersant which also allows absorption or adsorption transfer to occur. The preferred method of transfer is shown in FIG. 6 where the wet image bearing master and the copy sheet 9 are passed between a pair of conductive rollers comprising a front roller 10 located behind the copy sheet 9 and a supporting roller 11 located behind the backing 1 of the master, the rollers having a potential applied between them which causes the transfer to take place or to be aided electrostatically. The pressure of such rollers is preferably such that only light contact between the electrostatic master and the copy sheet takes place and the voltage whereby the transfer is effected is preferably such that it is just below the point where the dielectric formed by the electrostatic master and the copy sheet breaks down. The polarity of the rollers can be immaterial with respect to certain printing toners, but if it is intended to form an electrostatic charge on the master during the transfer step by means of the front roller 10, the charge acceptance characteristics of the master must be considered as disclosed hereinbefore.

In the illustrative examples following these descriptions the preferred polarity as applied to the roller 10 placed behind the copy sheet is given in each case. It should be noted that the transfer step can be also carried out by employing the front roller 10 in a manner as hereinbefore described but replacing roller 11 by some other conductive supporting member such as for instance a flat conducting plate or the conductive surface of a cylinder onto which the master may be placed, and it is also possible to carry out such transfer step by employing a corona discharge device as described in the foregoing in which case the voltage required must be substantially higher than that necessary in the preferred method.

The copy sheet 9 can be separated from the electrostatic master after the transfer operation as shown in FIG. 7, and upon evaporation of the liquid dispersant the image 8 absorbed or adsorbed by the copy sheet 9 becomes fixed thereto due to the binding or adhesive properties of the dispersing and image supporting agents contained in the printing toner. It will be noted in FIG. 7 hereof that after separation of the copy sheet electrostatic charges remain on the master both on the image areas 5 and non-image areas 6, such charges being formed during or remaining after the electrostatically assisted transfer step in particular when such transfer step is carried out in accordance with the preferred method as hereinbefore described.

After the transfer step the master being in the condition as shown in FIG. 7 can be employed again immediately for subsequent transfer reproductions by repeating the steps of discharging the non-image areas by radiation and developing the image areas with the printing toner prior to each transfer operation.

The number of reproductions obtainable from one electrostatic master depends on the web strength of the paper employed as the backing member, on the strength of the photoconductive coating deposited on such backing member, on the strength of the insulating image and on the method of transfer. Metal sheet or foil may be used as the backing member for the electrostatic master. Employing relatively high web strength paper, an appropriate photoconductive coating and the imaging toners as dis-

closed in the following examples, hundreds of copies can be produced by transfer from one master.

In order to obtain a particular length of run it may in some instances be desirable to reinforce or increase the insulating image deposit on the master. This can be readily achieved by increasing the image deposit on the image bearing photoconductive printing element by recharging such printing element and re-developing in the imaging toner any desired number of times. It may be also advantageous to select such image forming toner substances which can be heat fused onto the surface in order that higher mechanical strength may be obtained.

It will be apparent that the insulating image formed on the photoconductive surface can be transferred while wet or mobile onto some other surface such as for instance a metal foil or some other substantially conductive material and fixed thereon to produce an electrostatic master of the so-called long-run type.

There has been described a process for the production of a plurality of copies from one original, and it will be realized that it is possible to adapt relatively simple and inexpensive mechanical means to this process in order to produce a printing or duplicating apparatus operating at a relatively high speed in which all the steps of the present process are carried out automatically.

The following examples will serve further to illustrate the principles of the present invention and the manner in which it can be performed. Since many changes could be made by one skilled in the art of electrostatic printing in the following formulations, selection of materials and manner of performing the operations involved in the process without departing from the scope thereof, it is intended that all matter contained in the following examples shall be interpreted as illustrative and not in a limiting sense.

EXAMPLE 1

The photoconductive coating was prepared from the following ingredients:

	Grams
Zinc oxide "Photox 801" -----	900
Rhodene M8/50 resin -----	600
Toluol -----	250
4% manganese naphthenate -----	3
4% cobalt naphthenate -----	3

The components were milled together and applied as a coating to a sheet of art paper to form the photoconductive printing element. The coating was allowed to dry for 48 hours.

The photoconductive printing element thus prepared was charged in a corona discharge device as hereinbefore described, the potential applied to the surface being 7000 volts DC of negative polarity. The charged surface was then exposed by projection to the mirror image of the original to be reproduced and the so formed electrostatic latent image was developed in an imaging toner of the following composition:

	Grams
Permanent Yellow GG -----	50
Varnish -----	200

The varnish in this example was prepared by heating for one-half of an hour at 500 degrees Fahrenheit a mixture of

	Grams
Hydrogenated rosin -----	80
Polymerized linseed oil -----	320

The pigment and the varnish were milled to form an imaging toner concentrate which was subsequently suspended in the liquid dispersant n-heptane in the proportion of 1 part of toner concentrate to 150 parts by weight of the dispersant. The developing operation was carried out by immersing the printing element in a body of the toner contained in a vessel. The developed image was rinsed in n-heptane and allowed to dry whereupon it became fixed to the surface.

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The master so formed (FIG. 2) was then employed to produce a multiplicity of copies in an arrangement as shown in FIG. 6. The image bearing surface of the master was contacted with a light weight bond paper as the copy sheet and together with such copy sheet passed through the rollers. The potential applied between the rollers was 1.5 kv. DC, roller 10 being of negative polarity. Using a heavy sheet the potential applied was 2.5 kv. In each case a charge was formed on the surface of the master after separation of the copy sheet. Such first copy sheet was then discarded and the surface of the master was then exposed to a 150 watt incandescent lamp located in a distance of 24 inches from the master.

The charged electrostatic master was passed through a bath containing the printing toner, and subsequently the toned image bearing surface of the master was contacted with another copy sheet and passed together with such sheet between the two metallic rollers at a speed of approximately six inches per second. The pressure applied between the said rollers was created only by the weight of the top roller and was approximately equivalent to four ounces per linear inch of contact. The voltage applied between the rollers was the same as previously, that is, 1.5 kv. for the light weight bond paper and 2.5 kv. for the heavy weight bond paper, the polarity of roller 10 again being negative.

After passage through the rollers the copy sheet was separated from the electrostatic master, which was then found to contain sufficient electrostatic charge deposited during the transfer step to allow for immediate re-toning with the printing toner for a subsequent transfer copy to be produced.

Various colour printing toners were employed to tone the imaged master and the formulation of four of such printing toners is disclosed in the following:

Black printing toner:	Grams
Microlith Black CT	80
Microlith Blue 4GT	40
Varnish	325
Paraffin wax	200
Blue printing toner:	
Microlith Blue 4GT	40
Varnish	100
Paraffin wax	70
Red printing toner:	
Fastel Pink B Supra	50
Varnish	100
Paraffin wax	70
Yellow printing toner:	
Permanent Yellow GG	40
Varnish	200
Paraffin wax	100

The varnish as used in the foregoing formulations contained

	Grams
Hydrogenated rosin	80
Polymerized linseed oil	320

The components were heated together at 500° F. for one-half hour.

In each of these toners the varnish forms the fixing medium upon evaporation of the liquid dispersant.

In each of the four toner formulations given, the components were homogenized by heat blending, followed by milling. Milling was performed on a bar mill, operating pressure 100 p.s.i. Each concentrate was separately suspended in a liquid dispersant of relatively slow evaporation rate such as Shellsol T solvent, in the proportion of 0.1-3.0 grams concentrate per 100 grams of liquid dispersant. Dispersion was attained by using mortar and pestle.

EXAMPLE 2

Using Example 1 above, a varnish was first prepared by blending 320 parts of polymerized linseed oil and 80 parts of hydrogenated rosin, heating the components at

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500° F. for 30 minutes and cooling. To a portion of the varnish was added 40 parts of yellow pigment, Hostaperm yellow 11-1200 66 powder, and the mixture milled to the proper consistency.

A portion of the resulting material was dispersed in the insulating carrier liquid or dispersant, n-heptane, to form a toner dispersion, as in Example 1.

The sheet of photoconductive paper, Example 1, was charged and exposed in the normal manner to an image, and developed by immersion in the yellow toner dispersion of this example to produce the visible image for the master. The sheet was dried and standard electrophotographic measurements were made. Similar measurements were made on a photoconductive paper on which was deposited image-wise a layer of the varnish used above as the imaging material, but without the yellow pigment, serving as a master.

The test consisted of charging each imaged sheet with a high voltage corona, allowing a 5 second dark decay time, and then exposing the sheet to light. Surface voltage measurements were made after the light exposure. In the case of the sheet with the resin coating devoid of the yellow pigment, two seconds after the light exposure the sheet was completely discharged and there was no residual voltage. However, in the case of the master image developed with the yellow developer of this example, there was a residual charge of over 100 volts which was not dissipated in a 20 second period.

Thus, the yellow pigment serves as an optical filter and as such screens out wavelengths which would normally cause photoconductive discharge of the electrophotographic or photoconductive paper. The particular yellow pigment used was a transparent pigment which does not act by reflecting light because of particle size, but it actually filters light. Therefore, the principle of the optical filter to prevent discharge of an electrophotographic sheet is a primary factor, and the particular toner formulation is only incidental to this principle.

The foregoing test was verified using a yellow (image) master and a black (image) master for comparison, four transfer copies being attempted from each under identical conditions. The toner for the black image was standard for single development work of the usual kind (non-transfer) but no legible transfer copies could be obtained therefrom in contrast to legible transfers obtained from four successive charges and developments when using a yellow master image in accordance with this example.

The phenomenon is apparent in FIG. 8. The plotted data were obtained from tests using a photoconductive sheet patterned with a standard black toner, as used in the industry, a second photoconductive sheet patterned with the developer varnish containing the yellow transparent pigment of this example, and a third photoconductor sheet patterned with the same varnish as used on the second sheet but devoid of the yellow pigment. The sheets were otherwise identical, the photoconductor being ZnO in each instance.

In FIG. 8, the ordinate is representative of volts. The solid line shows the results obtained from the pattern of black toner; the dashed line shows the results when the image was one obtained from the unpigmented varnish referred to above; and the dotted line shows the results when the image was obtained from the same varnish having the yellow pigment of this example.

The unpigmented varnish itself presents an image or pattern which decays less rapidly than a standard black toner for electrostatic images produced conventionally as a single copy non-transfer process as heretofore known, which is to say that the black developer is so conductive as to be virtually incapable of retaining a charge during the re-charging cycles as would be entailed under this invention in preparation for duplicate copies in repeated series. The yellow image, on the other hand, was superior in all respects in ability to hold a subsequent charge for repeated transfers, accounting for the superior transfer

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copies that can be obtained in the course of repeated charging and re-imaging cycles.

It also seems apparent that there is a combined effect between the properties of the photoconductor coating and the filtering band of the toner which produces an unexpected advantage where the toner deposit itself may be far from being sufficiently insulating to accomplish the observed effects, especially since a zinc oxide photoconductive surface has its light absorption peaks largely in the short visible and ultraviolet ranges and is minimally absorptive in the long visible range embracing yellow wavelengths. In this sense then there is a low-conductivity optical filtering toner which passes a band of radiation only in the range where the receptivity of the photoconductive surface is low. Therefore, if yellow is present in sufficient amount, the presence of another color such as red will not detract from the result.

Hence, while I have illustrated and described preferred embodiments of my invention, it is to be understood that these are capable of variation and modification.

Materials mentioned by trade names in the foregoing specification may be described as follows:

Microolith Black CT—a resinated carbon black pigment manufactured by Ciba Ltd.

Microolith Blue 4GT—a resinated phthalocyanine blue pigment manufactured by Ciba Ltd.

Fastel Pink B Supra—an organic blue shade red pigment manufactured by I.C.I.

Permanent Yellow GG—a yellow pigment manufactured by Hoechst, Germany.

Photox 801—a photoconductive grade of zinc oxide manufactured by New Jersey Zinc Co.

Rhodene M8/50—an isophthalic alkyd resin manufactured by Polymer Corp., Australia.

I claim:

1. The method of producing multiple copies from an electrostatically prepared master comprising:

- (a) producing an electrostatic image of predetermined polarity charge on a surface of photoconductor material which material becomes electrically conductive when subjected to radiation of a particular intensity, said photoconductor surface being supported on a relatively conducting base;

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- (b) preparing a master image by developing the electrostatic image with a liquid developer comprising an insulating carrier liquid in which is dispersed a pigment which deposits a layer capable of acting as a light filter and of such color as to inhibit the photoconductor surface from so becoming conductive when illuminated; and

- (c) producing a multiplicity of copies from the master image by repeated cycles as follows:

- (1) uniformly charging the photoconductor surface including the master image with said charge;
- (2) uniformly illuminating the photoconductor surface with radiation including that of said particular intensity to discharge the photoconductor surface in the non-image areas;
- (3) applying developer liquid of the desired copy color to the illuminated master, and transferring the image of the desired color to a copy sheet.

2. A method according to claim 1 in which the photoconductor surface is defined by zinc oxide and in which the pigment is yellow.

3. A method according to claim 2 in which the predetermined charge is a negative charge.

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