

Oct. 10, 1967

C. A. SIMMONS

3,345,944

DUPLICATION OF ELECTROSTATIC PRINTING

Filed June 30, 1961

4 Sheets-Sheet 1

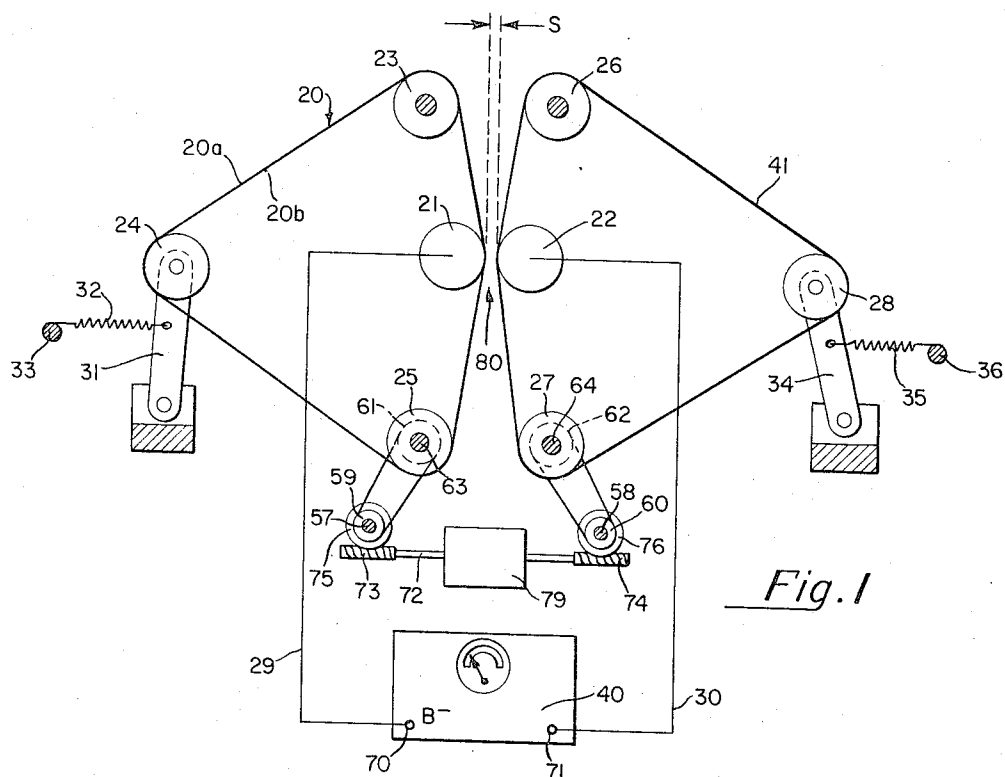


Fig. 1

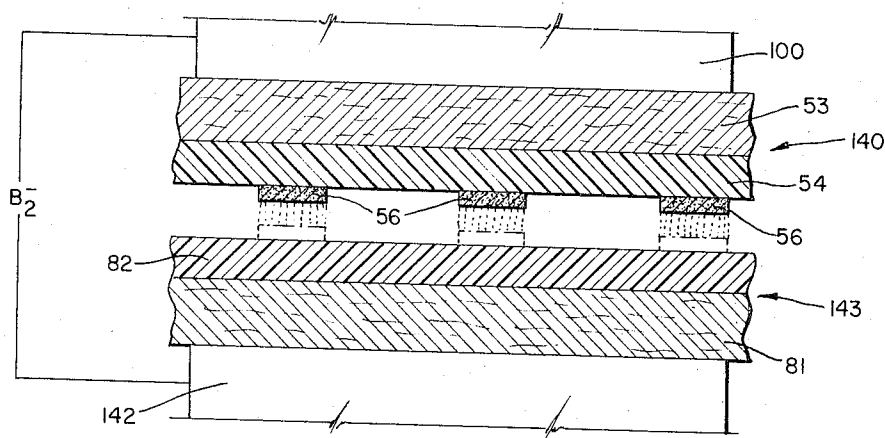


Fig. 3

INVENTOR.

CHARLES A. SIMMONS

BY

Joseph P. Kates

ATTORNEY

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C. A. SIMMONS

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4 Sheets-Sheet 2

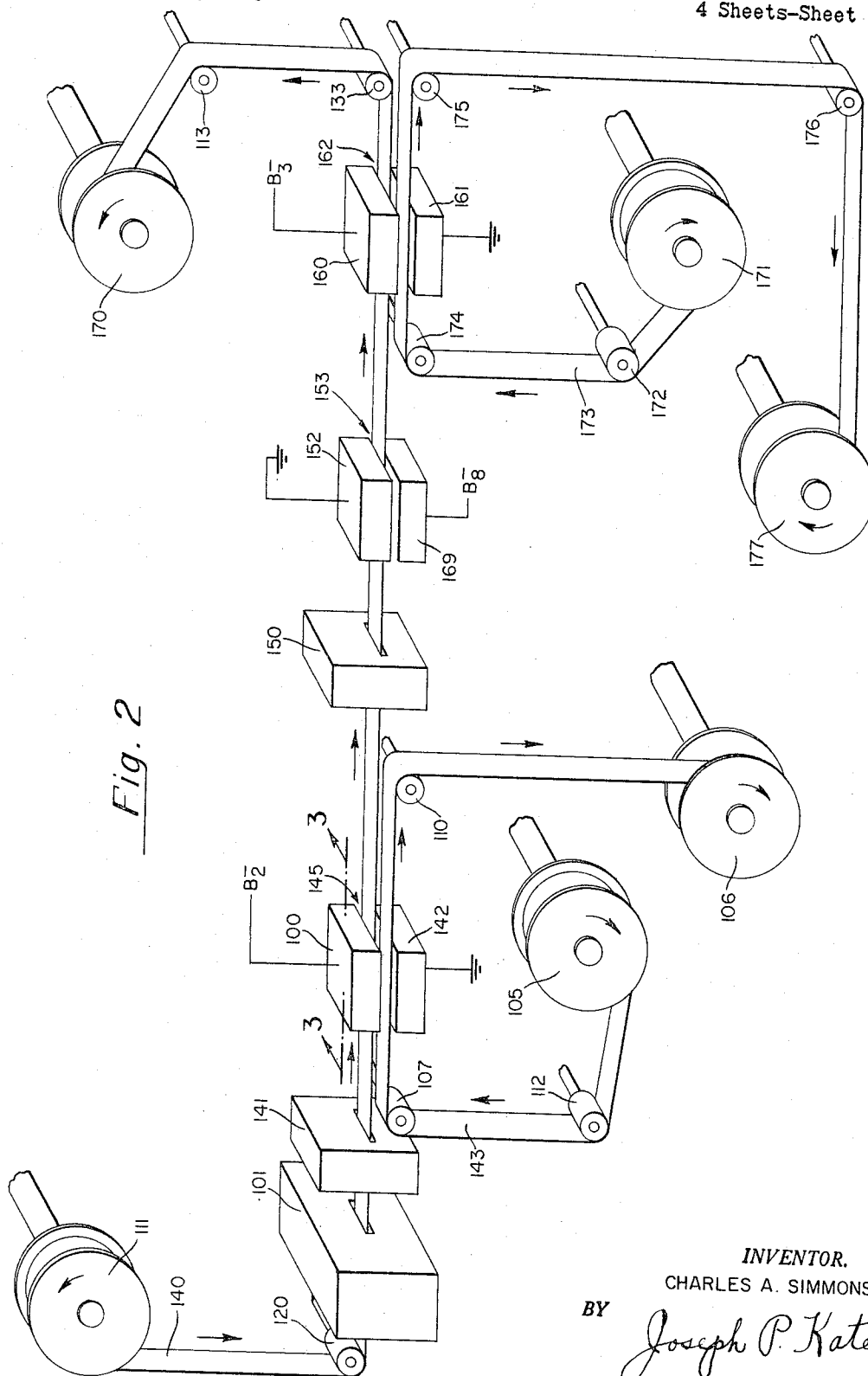


Fig. 2

INVENTOR.

CHARLES A. SIMMONS

BY

Joseph P. Kates

ATTORNEY

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C. A. SIMMONS

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Fig. 4

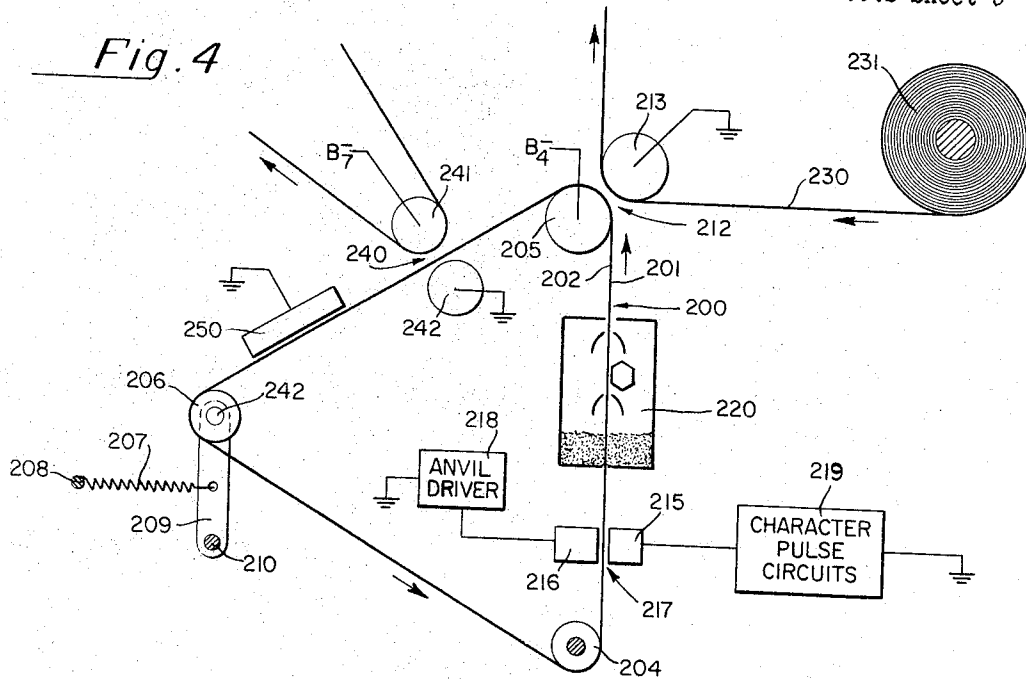
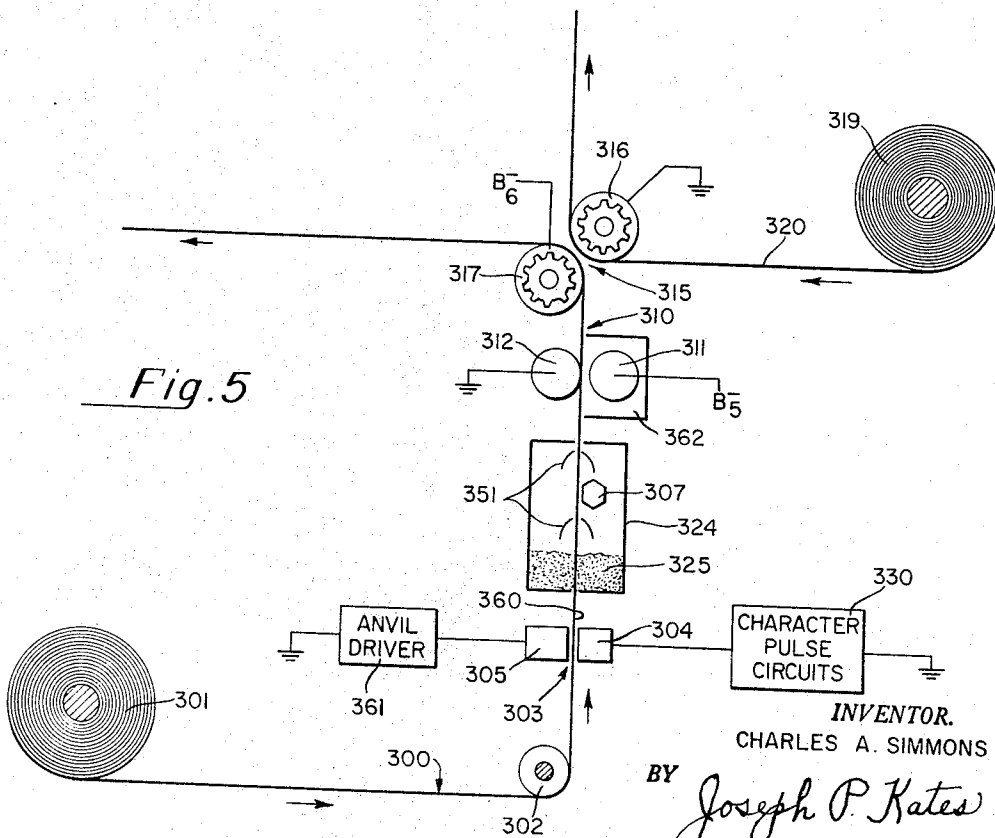


Fig. 5



INVENTOR.
CHARLES A. SIMMONS
BY *Joseph P. Kates*
ATTORNEY

Oct. 10, 1967

C. A. SIMMONS

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4 Sheets-Sheet 4

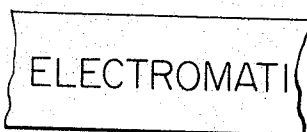


Fig. 6A

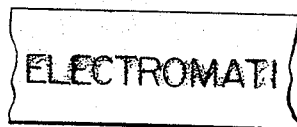


Fig. 6D

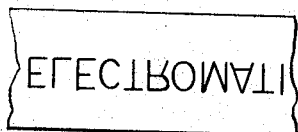


Fig. 6B

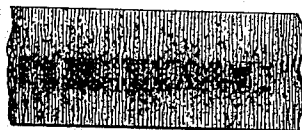


Fig. 6E

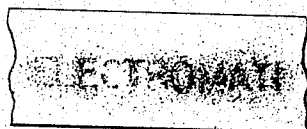


Fig. 6C

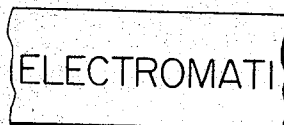


Fig. 6F

INVENTOR.

CHARLES A. SIMMONS

BY

Joseph P. Kates
ATTORNEY

1

3,345,944

DUPLICATION OF ELECTROSTATIC PRINTING
Charles A. Simmons, Malvern, Pa., assignor to Burroughs Corporation, Detroit, Mich., a corporation of Michigan
Filed June 30, 1961, Ser. No. 121,247
7 Claims. (Cl. 101-426)

This invention relates to a means and method of making duplicate copies from an electrostatic printed and inked master. More particularly, this invention relates to the transfer of dry ink particles from an inked but unfixed master copy by the application of an electric field from the master to the copy and it relates further to erasure of fringe and background noise upon application of an electric field in the opposite direction.

In the present invention, a pair of electrodes are disposed to present opposed surfaces to form a station therebetween. The longitudinal axes of the electrodes are parallel. A relatively narrow gap is provided between the adjacent portions of the exterior opposed electrode surfaces. Through this gap are drawn simultaneously, a dielectric coated master paper on which dielectric electrostatic charging and inking has occurred and a copy paper. The surface of the dielectric paper opposite that containing the charged and inked message is positioned in abutment to one of the electrodes. This electrode is maintained at a relatively high negative potential of the order of minus seven hundred to minus fifteen hundred volts. The copy for better results is made of conductive paper with a dielectric layer upon which the ink is transferred. The copy may be also other types of mediums suitable for receiving and displaying the inked message. The copy is drawn in abutting relationship against the second electrode. The second electrode is grounded. The electric field across the electrodes is applied thus in a direction from master to duplicate copy. This electric field causes transfer of the ink from the charged and inked spots on the master copy to the duplicate. If the electric field is reversed, the background and fringe inking is transferred from the master copy to a collector or another paper.

By means of the invention, the electrostatic charged and inked pattern on the master is duplicated as a mirror image of the master on a copy. Also, by reversing the electric field, the background noise is cleared from an electrostatically charged and inked master. The transfer of ink from the master to the copy is effected at a first duplicating station. At a similar station, a reverse electric field is applied across a pair of electrodes. The reverse electric field station is disposed before message transfer at the printing station and/or subsequent to transfer at the printing station. The reverse field toward the master and its abutting electrode removes noise background which appears in the form of ink due to attraction by charges on the master of opposite polarity to the message. The opposite polarity charges inadvertently are induced or otherwise inadvertently occur and attract the conductive ink. The ink which comes from fringe and/or background noise is gathered by a collector or another copy paper when the electric field is reversed from ink transfer direction.

In the electrostatic printing process, to which the present invention relates, the indicia to be printed, such as letters, lines, dots, etc. are first formed as invisible electrostatically charged surface areas on a recording medium by means of silent electrical discharges from a first suitably shaped and/or suitably positioned print electrode or selected electrodes of an array of print electrodes towards a second anvil electrode or group of anvil electrodes, the recording medium being disposed between the first and second shaped electrodes or first and second shaped arrays of electrodes. Subsequently, the discharged areas are made visible by application of finely divided, conductive,

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pigmented powder to the surface of the recording medium. This powder is the developing agent or ink. The inked powder is held to the medium by electrostatic attraction substantially over the charged areas only. Disadvantageously, some inking powder is held to the medium in the form of noise which occurs over areas which are charged unintentionally. These charges are induced, etc. around the fringe of the intentionally charged areas and in the background. The ink adhering to the fringe and background charged and inked surfaces represents unwanted fringe and background noise.

In this electrostatic printing process, the powder image thus obtained is fixed by heat (or pressure) to produce a permanent record.

Such electrostatic printing systems are described in U.S. Patent 2,919,170 to H. Epstein for Means for Electrostatically Recording Signals, issued Dec. 29, 1959, and U.S. Patent 2,955,894 to H. Epstein for Page Printing Apparatus, issued Oct. 11, 1960. Both of these patents are assigned to the Burroughs Corporation, the assignee of the present invention.

The apparatus described in these patents is suited particularly to high-speed production of a printed record. Higher operating speed is critical in many applications such as directly recording the output of electronic computers or of telemetering receivers, because of the high rate of data output produced by such equipment and presented as output to be printed. The apparatus of the above-cited patents provides rapid and satisfactory production of a single copy of output data at a very fast rate.

Such systems require a simple, economical and sometimes a continuous method of making copies. The method of making copies is preferably automatic. It is advantageous to use a process with technical similarities to the patented processes to produce copies additional to the first copy produced.

In the electrostatic printing means of the above mentioned patents, a voltage is applied to a pin acting as a cathode. The pin is located above a sheet of polyethylene, polystyrene, or other dielectric layer which together with a supporting relatively conductive paper layer forms the recording medium. Application of sufficient voltage to the pin initiates a discharge to the polyethylene coating (dielectric surface) of the paper, depositing the charge in the polyethylene. The spot of charge occurs below the pin.

In this invention, after the dielectric layer of the recording medium is charged in spots to form the message, as described in the above-mentioned electrostatic printing process patents the spots are inked. However, the message is not fixed as in these patented processes. The ink is the conductive inks used in the above-described electrostatic printing process. This recorded and inked recording material is the master for producing multiple copies in accordance with the invention. The master is superimposed over but spaced slightly from the surface of copy recording material. The copy recording material may be ordinary paper suitable for printing but is preferably dielectric surfaced paper having a polyethylene or polystyrene layer and a relatively conductive paper layer. High voltage is applied to the back of the master. The copy back is grounded. When the electric field is applied in the direction from master to copy, the ink is transferred from the charged spots on the master to form a duplicate (actually a mirror image of the master) on the copy. When the field is reversed (before or after the copy duplicating process), the background and fringe inking is transferred from the master to a collector or another paper. Where the copy includes a dielectric medium, the ink transferred to the copy is fixed in the copy. In the case of non-dielectric paper, the copy paper is inked only.

The master ink markings (spots) are transferred to the

copy medium so that the copy receives the message duplicate (mirror image) of the master ink spots.

The method and means of the present invention provides a method and means optional to that of copending patent application Ser. No. 121,276 to Richard Sakurai for Electrostatic Printing Copy Duplicating System, filed May 23, 1961, now U.S. Patent No. 3,194,674, entitled "Apparatus and Method for Duplicating Messages Which Are Electrostatically Charged, Developed and Fixed on a Master Dielectric Medium Onto Copy Media Capable of Retaining Electrostatic Charges" and assigned to the Burroughs Corporation. Each possesses advantages and usefulness for certain applications. In these applications, the method and means of the present invention and that of the next previously mentioned patent application provides many important advantages over prior art multiple copy methods which involve transfer of electrically controlled developer powder from an insulating non-conducting image layer to a strip of transfer material. The prior art methods include that of U.S. Patent No. 2,576,047 of R. Schaffert issued Nov. 20, 1951, for Method and Apparatus for Printing Electrically. Such prior art methods are cumbersome and are not adaptable readily to electrostatic printing. They do not provide the reliability and accuracy of the transfer method and means of the present invention.

Accordingly, an object of the present invention is to provide a simple, economical, accurate, practical means and method for making clearly visible copies from an electrostatic printing produced master which has been charged and inked wherein the method and means of the invention comprises additional electrostatic printing steps and means wherein the inked master forms the cathode electrode for transfer of ink to a copy.

Another object of the present invention is to provide a method and means for producing copies utilizing the advantages of the electrostatic printing method and means and wherein the copy is a mirror message duplicate of the inked master.

Another object of the present invention is to provide a system and method for providing copies from a master by electrostatic printing means wherein the master can be erased where required, re-inked with provisions for erasing after re-inking where required, many times to produce many copies, which system and method employs the advantages afforded by the electrostatic printing process and wherein production of the master is as simple as the electrostatic printing process.

Another object of the present invention is to provide a simple, economically operated electrostatic process and means to provide copies which are mirror image message duplicates of a master, utilizing the electrostatic printing process of making multiple copies from an electrostatically produced master, the copies being produced by electrostatic means wherein the charged spots of the master are inked and are used as cathodes when superimposed in closely spaced relationship above the copy recording medium, when a voltage is impressed across the master and copy, wherein the differential in potential is sufficient to provide a discharge of ink between the master and the copy.

Another object of the present invention is to provide an electrostatic means and a method of transfer of inked intelligence from an inked electrostatically produced master recording medium to a copy.

Another object of the present invention is to provide a means for transfer of the inked spots from an electrostatically produced and inked master to a copy by electrostatic means wherein the master, which is at a transfer potential with respect to the copy transfers its ink by discharge across a gap between master and copy and wherein by reversing the electric field, the background fringe and noise ink retained on the master is erased and to provide for copying a continuously changing master wherein the charged message on the master is destatisticized after duplicating, to enable duplication of a sequence of messages.

Another object of the present invention is to provide an erasing station to remove ink caused by fringe and background noise around the inked charged intelligence on an electrostatically printed and inked master representing the output of an electrostatic printing process by applying a field in a first direction to duplicate the intelligence in mirror image message form, the background noise and fringe then being erased by applying an electrostatic field in the opposite direction so that a clear erasure operation is performed on the master and the master may be re-used.

While the novel and distinctive features of the invention are particularly pointed out in the appended claims, a more expository treatment of the invention and principle and in detail, together with additional objects and advantages thereof, is afforded by the following description and accompanying drawings, in which:

FIG. 1 is a schematic representation illustrative of a first embodiment of the duplicating apparatus and method of the present invention;

FIG. 2 is a schematic representation of another embodiment illustrative of the complete duplicating apparatus and method of the invention and wherein provision is made for more than one duplicate (mirror image) copy of the master message including re-inking and erasure of the master;

FIG. 3 is an enlarged representation of a section of the embodiment of FIG. 2 taken in the direction of the arrows 3—3 and illustrating the relationship of the electrodes, the relatively conductive and dielectric layers of the master, the electrostatically charged and inked intelligence on the master, and the transfer of the ink spots representing the intelligence to the copy;

FIG. 4 is a schematic representation of another embodiment of the invention providing for duplication on a copy and for erasure, destatisticizing and printing of new messages in a recycling chain;

FIG. 5 is a schematic representation of another embodiment of the invention wherein after printing and inking of the master, its fringe and background noise are erased, and then transfer of the inked message onto the copy material is effected;

FIG. 6A is an illustration of the condition of the master after charging and inking and before ink transfer to the copy;

FIG. 6B is an illustration of the copy after ink transfer at the duplicating station of the invention from the master of FIG. 6A to the copy;

FIG. 6C is an illustration of the master after ink transfer to the copy;

FIG. 6D is an illustration of the master after ink transfer and re-inking, where fringe or background noise has not occurred to an appreciable extent; and

FIG. 6E is an illustration of the original after re-inking after the original ink was transferred from the master to the copy;

FIG. 6F is an illustration showing clearing up of the FIG. 6E re-inked original after removing background in the background and fringe ink removal station of the invention.

In the electrostatic printing method and apparatus in which applicant's invention is applicable, and as described in the aforementioned patents assigned to the assignee of the present invention, a recording material comprising a carbonaceous paper or other material tape or sheet coated with a dielectric such as polyethylene, polystyrene, etc. is drawn through the space and passed between a first print electrode and a second anvil electrode. The two electrodes are spaced apart. Upon providing a sufficiently high potential difference across the electrodes, a discharge occurs from the print electrodes toward the second electrode. The discharge is intercepted by the dielectric on the recording medium. The charge is believed to penetrate to some depth into the dielectric. Subsequently, the recording medium, e.g. tape, is moved through solid ink particles which are conductive. After the tape passes through the

ink particles, it becomes visible by the adherence of the ink to the tape where charged.

In the present invention, the conductive ink deposited upon the tape provides a source of emission of ink particles. The ink deposited on the recording material (tape) is a conductive, finely divided powder. Upon being placed in a relatively high-voltage field wherein high voltage is applied to the recording medium back opposite the face containing the inked message, a discharge of the ink occurs from the inked charged spots. This ink is discharged toward a second recording medium to form a mirror image of the ink spots of the master.

The ink utilized in the electrostatic printing devices and methods of the patents assigned to the assignee of the present invention is acceptable in the present invention where under the influence of the high-voltage field therebetween the ink flows from the master charged and inked surface to the copy. An example of acceptable inks comprises a dispersion which consists of nine (9) parts by weight of hydrocarbon resin, Picco 450H (Pennsylvania Industrial Chemical Corp.) or equal; nine (9) parts by weight of styrenated hydrocarbon resin, Piccoflex 115 or equal; twelve (12) parts conductive carbon, Statex F-12 (Columbian Carbon) or equal; less than one (1) part by weight of soya lecithin, Yelkin TTS (Ross and Rowe) or equal; and less than seventy (70) parts by weight of industrial xylene solvent, Picco Hi-Solv X or equal. The amounts of lecithin and solvent are adjusted to give the finished dispersion a viscosity of less than fifty-three (53) on the Krebs scale. The dispersion is ball-milled with steel balls or otherwise treated to a degree of dispersion so that the dispersion is sieved through 100 mesh. The milled dispersion has a Hegman guage number less than three (3). The dry dispersion has an average electrical square surface resistance not exceeding 1500 ohms.

This is spray dried to a free flowing, electrically conductive powder. The spray-dried product is aged for at least six (6) weeks in open containers before further processing. The dried and aged product is sieved through 140 mesh (by an Abbe Turbosifter, for example). The carrier of the liquid dispersion is protected from freezing. The ink is known as thermoplastic electrostatic recording ink, type 1128.

A form of ink of good conductive properties which has been tested for the inventive process is that described in patent application Ser. No. 676,716 for "Electrographic Printing Ink" of Charles P. West and Jacques Benveniste, which application is assigned to the assignee of the present invention. That ink is an inking powder in which all the particles are all of substantially the same composition, and are uncharged, electrostatically in their normal unused condition. The ink is high electrical conductivity. This ink is made by spray drying a ball-milled slurry comprising a carbon black, a synthetic resin, a solvent and a wetting agent and selecting a preferred distribution of sizes with the resulting particles, either by regulation of the process itself or by subsequent screening if necessary. The ink is dry, black, electrically conductive, of relatively low specific gravity, and flows freely. An example of one formulation of such a slurry follows:

	Percent
Carbon black: "Statex F-12" (Columbian Carbon Corp.)	41
Resin: "Picco 450H" (Pennsylvania Industrial Chemical Corp.)	59

The above are percentages by weight in a dry mixture of the two components.

	Percent
Solvent: "Toluene, Industrial"	63
Wetting agent: "Soya Lecithin Yelkin TTS (Ross & Rowe, Inc.)"	1.6

The last two percentages are by weight in the wet mixture.

"Yelkin TTS" is an oil soluble commercial lecithin

(62% with soybean oil) of fluid consistency, which has a brilliant amber color according to the "Handbook of Material Trade Names" by O. T. Zimmerman and I. Lavine, published by Industrial Research Service, Dover, N.H., 1953 edition, which described this product on page 631.

This slurry is ball-milled to form a dispersion of the carbon black in the dissolved resin. For example, in preparing a laboratory sample (2,000 grams) of such a dispersion, the mixture is loaded into an Abbe Assay ball mill with a 22-pound load of one-half inch steel balls and the mill rotated at 36 r.p.m. for eight hours. The better the dispersion of the slurry, the less viscous and less thixotropic it is and in general the better the conductivity of a mass of the dry ink obtained therefrom.

When suitable dispersion has been accomplished, the slurry is dried in a spray dryer. As manufactured by the Bowen Engineering Company, for example, this comprises an atomizer, a drying chamber and a size-selective collector. The slurry is fed into the atomizer where it is broken up into droplets which are then carried to a co-current vortex of hot air in the drying chamber to remove the solvent. The resulting dry particles are directed by the air stream into one or more collectors of the cyclone type. The adjustment of these collectors may serve to supply particles restricted to the desired size range directly or subsequent screening may be resorted to. In the laboratory-type Bowen dryer a centrifugal-type atomizer is used with a wheel speed of approximately 12,000 revolutions per minute to give an optimum yield of particles in the desired size range.

The properties of the components and their proportions and the slurry from which the powdered ink is formed are not extremely critical, although there are certain preferred ranges of values. Carbon black is chosen from a class known in the trade as "conducting furnace blacks," of which the various grades of "Statex" are examples, are most suitable to supply conductivity to the ink. Graphite, as a source of carbon in general, does not give as high electrical conductivity as is desired.

As to the resin, many synthetic and natural resins have properties suitable for the described purposes. Certain thermoplastic hydrocarbon resins and combinations of resins manufactured by the Pennsylvania Industrial Chemical Company, which have the prefix, "Picco" as part of their names, have proved satisfactory for this use, a specific example, "Picco 450H" being given above. In addition, Panarez 6-210 (Pan American Chemical Co.) and certain of the phenolic Bakelite resins have proved suitable.

The "Picco" resins are coumarone-indene resin products having melting points ranging from well below 100° C. up to about 120° C. and are disclosed in U.S. Patent No. 2,287,513, F. W. Corkery and R. H. Bailey, issued June 23, 1942, and assigned to the Pennsylvania Industrial Chemical Corporation of Clareton, Pa., and are described in a brochure headed with the name "Picco" and entitled "Piccoumaron-Para-Coumarone Indene Resins" available from the assignee of U.S. Patent No. 2,287,513. "Picco 450H" resin is a catalytically synthesized coumarone-indene polymeric resin of moderate molecular weight having a degree of polymerization responding to a melting point of about 112° C. by the ball and ring method and having a color in the lightly colored range equivalent to a color figure no greater than 3 on the para-coumarone resin color scale. "Panarez" resins sold by Pan American Chemical Corporation, New York, are hydrocarbon resins derived from petroleum sources, produced by the polymerization of olefins and diolefins, and available in color grades ranging from pale lemon to dark brown with a normal softening point of 200-220° F. or 93-104° C., according to "The Condensed Chemical Dictionary, 5th ed., revised by Arthur and Elizabeth Rose, Reinhold Publishing Corp., N.Y. 1956, at page 819. Panarez 6-210 has a softening point just below 140° C. and color of 2½ on

the Gardner Scale. Alternatively, a phenolic resin with similar thermoplastic properties as aforementioned involving similar softening points and melting points suitable for heat fixing during brief exposure to a temperature around 300° F. or 150° C. but without unwanted softening under usual conditions can be utilized.

The specific gravity of the resin particles should be low, preferably not more than about 4.0, to reduce the effect of gravity. For heat fixing, thermoplastic resins having suitable softening temperatures (relative to the printing medium employed) are selected. The upper limit of this temperature for use with paper media is around 300° F.

The percentage of resin to carbon (by weight) in the finished ink is about 0.8 to 1.6. To give the desired conductivity to the dry ink, the carbon should be present as at least 35 to 40 percent of the mixture of resin and carbon.

The resin solvent should be suitable for the type of resin used with weight given to for toxicity and other properties. Toluene, benzene and xylene are suitable solvents for hydrocarbon resins while alcohol is suitable for some phenolic resins. The amount of solvent used is that required to give a dispersion viscosity suitable for efficient milling and for feeding to the atomizer. Most solvents are used in the range of 55 to 70 percent by weight in the wet mixture. A small amount of wetting agent is beneficial in processing the slurring. As high as about 2.6% has been satisfactorily used. An excessive amount produces a sticky, poorly flowing powder.

Ink particle sizes should be such that d_g , the geometric mean of the particle diameters, is within the range of 12 to 40 microns and 98% by weight of the particles have diameters within the range of 5 to 80 microns.

The ink must flow freely when applied to the surface of the printing medium. Hence, the angle of repose of the mass of powder should not exceed 40% with respect to the horizontal.

This is the ink which may be normally used in applicant's electrostatic printing technique as described in the aforementioned patents. The disclosure herein of certain electrostatic ink formulations and methods of manufacture is by way of illustration and not by way of limitation of the invention. Other inks may be used which after electrostatic charging of a dielectric surface and inking will transfer themselves as a mirror image to a copy when placed between the master inked and the copy surfaces at a difference in potential between the surfaces to cause a discharge of the ink from the dielectric ink surface cathode toward the other surface.

Various materials are utilizable for the electrostatic printing recording medium master in the method and means of this invention. In one preferred form, the master recording medium is made of a backing layer or web of paper on one side of which is bonded a thin layer of high resistivity dielectric material. The period of time necessary to establish an electrostatic charge on the dielectric layer in the electrostatic printing means prior to the transfer station where ink is transferred from the master to the copy is of the order of 10^{-9} seconds (one nanosecond) or less. This makes it possible to move the recording medium through the printing station, where the electrically charged areas are established, at a high rate of speed. The ink transfer from master to copy subsequent to the electrostatic printing and inking steps is appreciable being very many times slower than the step of charging the dielectric with the message in the printing step.

A suitable material for the recording medium master of the present invention is described in U.S. patent application Ser. No. 714,767 of Robert E. Benn and Herman Epstein, filed Feb. 12, 1958, for Electrographic Process and now forfeited in favor of continuation application Ser. No. 255,715, filed Jan. 25, 1963, for "Recording Medium and Process of Developing Latent Electrostatic Charge on a Recording Medium" and both being assigned to the assignee of the present invention.

In the medium of that patent application, the dielectric layer of the recording medium is made of a thin plastic material having resistivity of high value such as polyethylene or polystyrene, for example. The backing layer is of paper of approximately .003 inch thick. Bonded to one side of the backing layer of the recording medium is a thin dielectric layer which is approximately .0005 inch thick. The dielectric layer is made of polyethylene to which has been added substantially 15%, by weight, of titanium dioxide as a pigment. One formulation of backing layer is 1,500 pounds of dry, unbleached Scandinavian pulp with substantially no alum or sizing added, plus 75 pounds of standard commercial grade carbon black. The polyethylene coating is extruded onto the paper.

Another formulation satisfactory for the backing layer consists of 1,500 pounds of dry, fully bleached, Scandinavian pulp, 75 pounds of carbon black, 25 pounds of starched sizing and 70 pounds of alum. The electrical resistivities of backing layers made of either formulations are of the order of five times 10^6 ohm-centimeters or more. The resistivity of the backing layer is a function of the amount of carbon black dispersed in the layer. The amount of carbon black to be added to the batch of pulp to obtain a given resistivity is determined empirically.

Backing layers of electrical resistivities in the range from 10^5 to 10^9 ohm-centimeters, produce good inking at reasonably high rates of travel. Backing layers having a resistivity greater than 10^{10} ohm-centimeters are not satisfactory. Papers of less than 10^5 ohm-centimeters are not satisfactory for use with electrostatic printing apparatus when back switching is used. Where a single back electrode is used, there is no lower limit for the minimum value of backing layer resistivity.

Generally, papers whose resistivities are primarily determined by ionic conductors dispersed in the papers have not without means such as humidors to control the moisture problem proved to be as commercially desirable as carbon black. The reason for this is that the resistivity of the backing layer is then primarily a function of its moisture content. When moisture content is low, resistivity of the paper is greater than the upper limit of desired range of values.

The capacitance per unit area of a one-half mil (.0005 inch) thick layer of polyethylene is substantially 1,100 microfarads per square inch. With a three mil (.003 inch) backing layer having a resistivity of five times 10^6 ohm-centimeters, the time constant of the recording medium is approximately 6.1 microseconds. The amount of charge in an equivalent capacitor is a function of the time constant of the circuit.

The paper is made additionally conductive by use of more carbon black in the backing. The capacitance across the backing layer is reduced and the resistivity reduced accordingly where a carbonaceous backing is utilized.

The foregoing are merely illustrative and that any type of tape, paper, or other medium may be employed which is utilizable with the electrostatic printing process described wherein the presence of a suitable electrostatic field between two electrodes, a shaped discharge occurs from one of the two electrodes onto a dielectric paper which is inserted between the electrodes and which charge paper is subsequently inked, may be employed.

Referring to FIG. 1, an original copy or master paper tape 20 is provided upon which by the electrostatic process is printed the original message. A mirror image of the message intended to be duplicated is printed on the master 20. The master medium 20 is not restricted to paper tape. Its configuration and constituency takes other forms in accordance with suitability for use without departing from the scope of the invention. In the embodiment of FIG. 1, tape 20 comprises a paper layer disposed on the side marked 20b. The dielectric layer on the side 20a is printed with a message. The paper layer is conductive relative to the dielectric layer. Dielectric layer 20a is charged with the message at an electrostatic printing station of the type

shown in the aforementioned patents assigned to the assignee of the present invention, and is inked. The inked message is not fixed. A paper tape 41 is provided which is structurally similar to tape 20. Optionally, paper 41 is any type of suitable recording media, including ordinary paper. The tape 41 receives a mirror image duplicate of the message on the master 20 when passed through the transfer station 80. The transfer station 80 comprises a first drum transfer electrode 21 and a second drum transfer electrode 22. A variable voltage supply 40 supplies voltage from zero to -1500 volts from a B- terminal 70. Voltage supply 40 has a grounded terminal 71. The transfer head electrode 22 is grounded at terminal 71. Optionally, lead 30 may be dispensed with and drum electrode 22 left floating except for connection through tape 41, and hereafter described roller 28 and linkage 34 to ground through support means (not shown). Transfer head electrode 21 is connected through conductive lead 29 to the negative terminal 70 of variable voltage supply 40.

Now referring to FIG. 3, wherein is shown an enlarged schematic representation of the transfer step and means which, although taken as a section of FIG. 2, illustrates the ink transfer method and means generally, the electrode 100 is connected to a source of negative voltage B_2^- which may be of the order of -1500 volts. Electrode 142 may be grounded. The voltage on each of electrodes 100 and 142 is such that the potential difference across them is of the order of -700 to -1500 volts depending upon ambient factors such as spacing. This voltage may be D.C. or may comprise coincident pulses with or without D.C. bias of one of electrodes 100 and 142 with respect to the other. Assume a potential difference of the order of -1500 volts is disposed across conductive plates 100 and 142. The dielectric tape 140 bears against plate 100 with its paper backing layer 53 bearing against plate 100. Its dielectric layer 54 contains the charged and inked characters formed by spots 56. Simultaneously, the blank tape 143 which is preferably dielectric material such as that of recording surface 140 is disposed with the conductive layer 81 in bearing relationship with plate 142. Any paper suitable for receiving and retaining the ink from spots 56 is suitable. The ink described hereinabove in detail is suitable for example to form the spots 56. The negative voltage on plate 100 with respect to the voltage on plate 142 causes transfer of the ink particles from the spots 56 onto the surface 82 of tape 143 as shown by the dashed line representations in FIG. 3.

Referring again to FIG. 1, a pair of rollers 23 and 25, with a print roller 21, and an opposite pair of rollers 26 and 27, with a print roller 22 form oppositely disposed, very obtuse triangular arrangements. The respective print heads 21 and 22 form apices such that a gap S is formed between the nearest opposite points of the circumferences of the duplicating print electrodes 21 and 22. With increasingly smaller gap distance S, readier transfer of ink from the master 20 to the copy 41 is provided. Disposed opposite respective duplicating electrodes 21 and 22 are rollers 24 and 28. The spacing around of rollers 23, 24, and 25 and drum electrode 21, is such as to accommodate the length of tape 20 from which the ink message is transported around the substantially quadrilateral path thus formed. Rollers 26, 22, 27, and 28 are similarly spaced to accommodate the length of tape 41 onto which the mirror image of the master is imprinted. Spring tension means comprising lever 31, anchor means 33 and spring bias means 32 tension the tape around the rollers 23, 24, 25 and electrode 21. Similarly, tension means comprising lever 34, anchor 36 and spring 35 tension the duplicate of mirror image receiving copy tape 41 around the rollers 28, 26, 27 and the electrode 22.

The tapes are moved synchronously through the space between the transfer heads 21 and 22 at the same rate of speed and in the same direction. Tape 20 is transported around the points where it bears on surfaces of rollers 25, 24, and 23, and drum 21 and, as shown at tape portion

400, is drawn tautly between drum 21 and roller 25. Similarly, recording-receiving tape 41 bears against rollers 27, 28, and 26, and electrode 22. The transport means comprises motor 79 which drives shaft 72. At the ends of shaft 72 are fixedly mounted worm gears 73 and 74. Worms 73 and 74 drive respective spur gears 75 and 76. On shafts 57 and 58 common to respective gears 75 and 76 are rollers 59 and 60. Rollers 61 and 62 are mounted behind respective rollers 25 and 27 on common shafts 63 and 64 respectively.

As the master tape and the duplicate tape advance past the transfer heads 21 and 22 which are at required potential differences, the ink on the characters on the dielectric surface 20a of the master 20 is transferred to the corresponding facing surface of the copy 41 as a mirror image. This transfer takes an appreciable time. Interruption means (not shown) may be provided to hold the message master and the copy line by line in an interrupted advance so that complete transfer is effected. Conventional means including stepping switch and associated mechanism for step-by-step advancement of the master end of the tape and of the copy in synchronism are contemplated.

The distance S between the drums 21 and 22 is a parameter which affects the ink transfer from master to copy. For example, but not limiting the scope of the invention, the embodiment of FIG. 1 operates with satisfactory results within a range of distances S between the facing surfaces of the master and copy tapes 20 and 41 at the printing station 80 at the point of tangency. Gap spacing S varying between .0005 inch to approximately .003 inch has been successfully utilized and with the above-described ink and with lycopodium powder ink known to the art under applied voltages varying from seven hundred (700) volts to 1400 volts. With voltages of 800 to 900 volts, with a gap of .005 inch approximately, very satisfactory duplicating occurred.

Referring to FIG. 2 of the drawings, this duplicating system inventive embodiment enables duplication of more than one copy. Plate electrodes are provided at the duplicating stations. However, drum-shaped electrodes could be used.

A master supply reel 111 supplies dielectric paper 140 under a roller 120. The dielectric paper then is passed through an electrostatic charging station 101 of the type of the above-described patents on inventions of Epstein and of Epstein et al. The mirror image of the message desired to appear on the duplicate copies is imprinted in invisible form by electrostatic charging in station 101 on dielectric medium 140. Dielectric medium 140 then is drawn through an inking station 141 where the charged mirror image of the desired message is inked. Then dielectric 140 is drawn with its conductive layer in surface adjacent abutting relation across plate electrode 100. Plate electrode 100 is connected to a source of negative voltage B_2^- . Disposed parallel to and in opposite relation to plate 100 is an anvil electrode plate 142. Plate 142 is grounded. Plates 100 and 142 are aligned and spaced so as to enable drawing of master dielectric recording medium 140 therethrough and in superimposed spaced relationship to the top surface of medium 143 in the order of space between mediums 140 and 143 of between .0005 inch to .003 inch. The copy tape 143 is drawn in abutting relation to and against the lower plate 142. The plates 100 and 142 are thereby spaced the thickness of the master tape 140 plus the thickness of the copy tape 143, plus the gap between the lower dielectric surface of tape 140 upon which is imprinted the charged and inked characters to be duplicated and the upper surface of recording medium 143 which upper surface is adapted to receive the inked characters from the surface containing the charged and inked characters of tape 140. The tapes 140 and 143 are in aligned parallel relationship with the opposite facing surfaces being the surface of tape 143 upon which the transfer of printing is to be effected, and the charged and inked underside of tape 140.

Recording medium 143 is supplied from a supply reel

105 and passed under roller 142 and over roller 107 and thence in superimposed abutting relationship with the plate 142.

After being drawn through station 145, the copy tape 143 has transferred thereon a mirror image of the inked message on the dielectric under-surface of the master 140. Tape 143 is drawn around roller 110, and it is then rolled up on take-up roll 106. It should be understood that where a dielectric-coated tape or paper is used for the receiving-recording medium 143 that the ink may be fixed before being disposed and stored on take-up reel 106. In the case of paper where the fixing of the ink is not required or desired, the take-up reel 106 rolls up the paper 143 directly after it leaves the duplicating station 145. After transfer of its ink from its dielectric surface on which is printed the charged and inked message to the recording medium 143, the master 140 is re-inked in inking station 150. Upon being inked in inking station 150, a considerable amount of ink appears as background noise on the dielectric surface of tape 140. This is shown in FIG. 6E.

In order to remove this background noise, the master tape 140 after leaving re-inking station 150 is passed through a noise and background fringe ink erasing station 153. Erasing station 153 comprises a grounded electrode 152 and an electrode 169 charged negatively from source B_8^- . This creates an electric field in the opposite direction to that of the transfer station of electrodes 100 and 142. The electric field of the station comprising electrodes 152 and 169 removes the background noise interfering with the re-inked original by reversal of the field applied to the master when transferring ink. With electrode 169 at a potential between minus 700 and minus 1500 volts with respect to electrode 152, the background noise on master 140 is removed leaving a clear, re-inked original as shown in FIG. 6F. After leaving noise ink erasing station 153, the master recording material 140 is passed through a second duplicating station 162. A source of negative voltage B_3^- of the order of -700 to -1500 volts is provided for electrostatic ink transfer voltage on the electrodes of station 162. Station 162 comprises a first plate electrode 160 and a second grounded plate electrode 161. Plate electrode 160 is connected to source B_3^- and is at a transfer potential with respect to plate 161. The master charged and re-inked dielectric medium 140 is drawn through station 162 with its dielectric printed and re-inked surface transported opposite to, and its paper support surface disposed adjacent to plate electrode 160. After being drawn through the station 162, tape 140 is drawn around a portion of the circumferential surface of roller 133 and roller 113 and is wound on take-up reel 170. An additional supply reel 171 of copy recording material 173 is passed around rollers 172 and 174 and through the station 162 in abutting relation to the ground electrode 161. The message receiving surface of copy material 173 is disposed in slightly spaced relationship to and aligned with the dielectric surface of the master recording medium 140. Ink transfer from the re-inked master 140 to the opposed surface of the copy 173 is effected in station 162. After leaving the station 162, where the ink transfer has occurred onto the surface of copy 173, copy 173 is drawn around a portion of the circumferential surface of roller 175 and roller 176 and is stored on take-up reel 177.

Where the recording medium 173 is a dielectric, the ink which has been transferred thereto may be placed in a fixing station.

The master recording medium may be passed through additional duplicating or transfer stations repeatedly to get as many copies as desired before winding it on the take-up reel.

In the embodiment of FIG. 4, wherein, for example, different messages may continuously be printed and erased with a continuous message recorded on the copy, tape 200 having a dielectric surface 201 and a conductive support layer 202, is drawn continuously around the triangular

configuration formed by rollers 204, 205, and 206. The continuous loop of recording tape 200 is drawn taut by bias spring 207 which is anchored at anchor attachment 208. The arm 209 is rotatably and pivotally supported at pivot means 210. Arm 209 rotatably supports roller 206 on a stud 242. Spring 207 is a tension spring which normally urges the arm 209 to rotate toward fixed securing means 208. Spring 207 tensions the tape 201 sufficiently to be drawn taut, but not sufficiently to break the tape 201 nor to cause friction against the surfaces of cylinders 204, 205, and 206 to an appreciable braking extent. Drum 205 is made of conductive material such as metal to form a first electrode of a transfer station 212. The other electrode of duplicating station 212 comprises a drum 213 which is grounded. The drum electrode 205 is connected to a source of negative voltage B_4^- which is of the order of between negative 700 to negative 1500 volts. The tape 200, after being drawn around roller 206 and 204 is drawn through printing station 217. Printing station 217 comprises print head electrode 215 and anvil electrode 216. Print electrode 215 is energized from character pulse circuits 219 such that electrostatic printing in accordance with a desired message occurs onto the dielectric coded paper 200. Anvil electrode 216 which may be segmented or which may comprise a series of anvils is the other electrode of the electrostatic printing station. Anvil driver 218 pulses anvil 216 coincidentally with character pulses from circuit 219 onto selected pins or onto a character electrode in head 215 which together are of sufficient voltage to cause discharge from head 217 onto dielectric medium 200. This electrostatic printing station 217 may be of a type described in the aforementioned patents to H. Epstein and to H. Epstein et al. which are assigned to the assignee of the present invention. They are electrostatic printing types charging station of the type wherein from either formed electrodes or preferably a print head comprising a plurality of pins, the formed electrode or appropriate pins are energized so that an invisible message discharge occurs from the head 215 toward the anvil electrode 216. This discharge is intercepted by the dielectric 201 on the dielectric-coated paper 200 such that a charged invisible message appears thereon in accordance with actuation of character pulse circuits 217 and anvil driver 218. The voltages between the first and second electrodes 215 and 216 which provide the electrostatic discharge are effected by negative pulses from the character pulse circuit which together with positive pulses applied to the anvil electrode 216 from the anvil driver circuit 218 cause this discharge. Alternatively, the polarities of these voltages could be reversed to produce the desired electrostatic printing, and appropriate modification of the other circuits could be made. The difference in potential between electrode 215 and anvil electrode 216 during coincident pulsing is sufficient to cause electrostatic printing discharging to occur. The message printed on the dielectric surface of master 200 is predetermined to be a mirror image of the message which is desired to be printed on a copy medium. The tape 200 is then drawn through inking station 220 where solid powdered ink, as described in the aforementioned patents assigned to the Burroughs Corporation, is applied to the charged characters to form a visible, inked message. After leaving inking station 220, the tape is drawn around drum electrode 205. Drum electrode 205 together with grounded drum electrode 213 forms an ink transfer or copy marking station 212. A source of negative potential B_4^- of the order of minus 700 to minus 1500 volts is connected to electrode 205 to keep electrode 205 at transfer potential with respect to electrode 213 which is grounded. A copy medium supply reel 231 supplies copy tape 230. Tape 230 is drawn around the portion of the peripheral surface of electrode 213 which is closely adjacent to the surface of electrode 205 and toward a take-up reel or a viewing device (not shown).

At transfer station 212, upon passage of the charged and inked tape over the drum electrode 205 and with the

application of sufficient voltage to electrode 205 from source B_4^- , the ink of the message on the master 200 is discharged from the master 200 and is applied in a normal projecting direction onto the adjacent surface areas of receiving copy recording material 230. The advance of tape recording material media 200 and 230 is synchronized to advance at the same speed and in the same direction past transfer station 212. After being unwound from supply reel 231 and upon being printed upon as a mirror image of the master medium 220 at the station 212, the tape 230 then is optionally fed as output which is read or in the alternative is stored. The gap at station 212 between the electrodes 205 and 213 is made optimum in accordance with ambient conditions and parameters such as the material, the potential to which the electrodes are biased together with other pertinent factors and optimum transfer results.

At the transfer station 212, the ink which transfers onto the copy paper is not entirely removed. Before reprinting other characters thereon, the remaining ink and noise should be erased and the charge must be erased. Removal of the ink is done at erasing station 240 which comprises a pair of drum electrodes 241 and 242 similar to the drum electrodes 205 and 213 of ink transfer station 212. The difference is that the field is reversed. That is, the electrode 242 is grounded and the electrode 241 is at a negative potential B_7^- of the order of -700 to -1500 volts as in the case of duplicating station 212. The voltage needed depends upon gap spacing and other ambient conditions. The electrodes may be spaced apart as in the case of recording station 212 and upon passing through the reverse electric field between the electrodes 241 and 242, the fringe inked areas and background noise ink is removed. This noise ink results from positive charged fringe areas induced by and surrounding the negative charged message areas in the dielectric medium on the tape and from ink clinging because of stray charged areas in the tape dielectric layer.

When the master and copy tapes touch, transfer of ink from master to copy at the transfer station 212 is faster than when a gap is maintained between master and copy tapes. The speed of the tapes for transfer where master and copy tapes touch is about three or four feet a minute. Where a gap is maintained, the speed at which the tapes may travel for good transfer is not more than three or four inches a minute approximately.

However, if the master and copy are drawn through the transfer station in contact, this touching of master and copy generates noise when the master is pulled from the copy after leaving the station.

If the backing is made of a metallic substance such as polyester aluminum film, rather than paper, or if a highly conductive carbon paper is used as backing, the time for ink transfer is speeded up considerably. A polyester film sold by the E. I. du Pont de Nemours under the trademark "Mylar" comprising a film or thin sheet of polyethylene terephthalate, the polymer formed by the condensation reaction between ethylene glycol and terephthalic acid when glued to a sheet of aluminum foil forms this laminated polyester aluminum film. Aluminized "Mylar" comprising aluminum vapor condensed on one surface of "Mylar" in a vacuum is very satisfactory also as backing to speed up the transfer of ink. The RC time constant of the capacitance of the capacitor formed by the backing, the dielectric and the air gap wherein the backing and air gap act as plates of a capacitor with the dielectric therebetween plus the resistance of the resistor formed by the backing for the dielectric layer is lowered by a lower resistance metal or carbon backing layer. Thus, the time for transfer of ink from master to copy across the gap is shortened many times from the worst case tape discharge of half a second.

It is contemplated to use an interrupted line by line or character by character advance of tape past the transfer station with stoppage of tape advance for the dura-

tion of substantially the discharge period where required by greater time for transfer than for printing.

Upon being drawn in the gap between electrodes 242 and 241, since the background noise and fringe of the characters is due to electric charge of a polarity opposite to that of the characters, a field inverse to that of the field across station 212 when applied, will cause removal of this noise. The removed ink particles are disposed of in any of various ways known to the art. For example, they could be caught in a receptacle (not shown) or brush or vacuum means may be utilized. It is also possible to rotate the drum electrode 241 so that its surface is continuously brushed so that a brushed surface continuously is presented to the tape as it passes through erasing station 240.

After exiting from the noise erasing station 240, the tape 200 is cleared of ink. However, it retains charges in accordance with the original message.

These charges are erased in order that a new message may be printed. The charges on the tape are neutralized in a destaticizer, for example.

Various neutralizers or destaticizers known to the art may be utilized for destaticizer (static charge remover) 250. For example, one machine suitable for use as neutralizer 250 is the "Simco Static Eliminator" sold by the Simco Company, 920 Walnut St., Lansdale, Pa.

Optionally switching means are provided to remove power from or otherwise inactivate the neutralizer 250 and the printing station 217 so that the same message may be reinked and the message transferred to copies for as many copies as may be desired. Also, inactivation of neutralizer 250 and station 217 may be effected for several copies in accordance with the number desired and resuming of printing of different messages may occur after the desired number are obtained with attendant erasure of the charge on the tape by neutralizer 250 for each charge of message.

Following removal of the charges, the clear dielectric tape 200 is passed around cylinders 206 and 204. Tape 200 then is fed through printing station 217 where a new message is applied from the character pulse circuits 219 in conjunction with the cooperating anvil driver 218.

Referring to FIG. 5 of the drawings, a relatively lengthy message from a reel 301 of recording material 300 is printed in a continuous elongated message. Dielectric material 300 is unrolled from supply reel 301 and passed around a portion of the circumferential surface of roller 302. Dielectric material 300 then is drawn through the electrostatic charging station 303. The character pulse circuits 330 provide voltages to select the character to be printed on heads 304. Print heads 304 may be a line of 72 aligned print heads looking into the figure, each head having a matrix of 5 x 7 pins. Selective pins in each print head to form a character desired to be printed are energized by pulsing of appropriate pins forming an outline of the character desired. This pulsing is provided by voltages from character pulse circuits 330 onto each of the aligned heads 304. These pulses are not sufficient alone to provide electrostatic discharge of invisible characters onto dielectric surface 360 of material 300. Oppositely poled pulses are applied from anvil driver circuit 361 to selected ones of aligned anvil electrodes 305 in accordance with the positions perpendicular to the figure on material 300, where it is desired to print the characters selected by circuits 330. Coincidence of pulses on selected anvils of anvils 305 plus oppositely poled pulses on selected pins of matrices (not shown) or alternatively selected character-shaped electrodes of heads 304 (also not shown) causes discharge from the heads 304 to anvils 305 which have this coincident voltage applied.

Thus, character pulse circuits 330 in conjunction with anvil driver voltages from anvil driver 361 cause heads 304 to project invisible non-disruptive dielectric charges towards anvil electrodes 305. These charges are intercepted by the recording medium dielectric 360 of the

recording medium 300. The message is charged on medium 300 accordingly. Preferably, a mirror image of the copy to be made is charged on recording dielectric medium 300. The invisibly charged dielectric medium 300 then is drawn through inking station 324 which contains solid ink 325, baffles 351, and a means 307 to agitate the medium 300 to cause removal of uncharged ink particles from uncharged areas. The medium 300 on emerging from inking station 324 has the message spots outline appearing visibly on it because of conductive ink adhering to the charged spots which were charged on the medium at station 303. After inking, the medium 300 is drawn past noise ink erasing station 310. Erasing station 310 comprises a grounded drum electrode 312 over which the tape bearingly slides and a drum electrode 311 which is spaced from electrode 312 but aligned therewith on the opposite dielectric surface side of tape 300. Electrode 311 is connected to a source of negative voltage B_5^- of the order of -700 to -1500 volts. Grounded electrode 312 and aligned negatively biased electrode 311 provide an erasing station for removing spot fringe and background noise ink particles. Upon emerging, the inked message with background noise and fringe removed appears clearly on medium 300. Then medium 300 is drawn around drum electrode 317. Drum electrode 317 and a grounded drum electrode 316 comprise an inked message transfer station 315. The ink transfer station 315 is poled to provide an electrical field opposite in direction to the electrical field of erasing station 310. Charged ink particles created by inducing a charge in the ink clinging to positively charged areas are removed in erasing station 310 and collected in collector 362. Charged ink particles created by inducing a charge in the ink clinging to the negatively charged spots are transferred in transfer station 315.

The master medium 300 is bearingly drawn around a portion of the circumference of cylindrical-shaped drum electrode 317 in continuous abutting relationship. The dielectric surface 360 of the tape 300 faces the grounded electrode 316. The conductive surface of tape 300 is disposed in sliding abutting relationship with the electrode 317. Simultaneously, copy medium 320 which may be dielectric paper or which may be ordinary paper such as accounting tape is unwound from supply reel 319 and drawn around the portion of the cylindrical surface of cylindrical-shaped drum 316 which faces the opposite parallel cylindrical surface portion or drum 317. The gap between the nearest facing surfaces of the drums 317 and 316 is very small. This gap comprises the thickness of the medium 300, plus the thickness of the medium 320, plus a small gap between the media 300 and 320 of the order of between .0005" to .003" (inch) approximately. The distance could be such that the media 300 and 320 touch. However, this would create noise upon separation of the media.

At transfer station 315, the ink on the characters, which were created as invisible electrically charged areas by the character pulse circuits 330 in conjunction with the voltages from anvil driver 361, is removed substantially from tape 300 and applied onto tape 320 which now bears the visible inked message in mirror representation of the originally charged and inked message.

The original master shown in FIG. 6A is charged and inked in an electrostatic printing station but not fixed. Referring to FIG. 2, for example, as illustrative of the process in conjunction with FIGS. 6A, 6B, 6C, 6D, 6E, and 6F, after being charged in electrostatic printing station 101 and inked in inking station 141, the master appears as in FIG. 6A. In the FIG. 1, this would be the condition of the master tape as threaded onto rollers 23, 24, 25 and drum 21. In FIG. 4, this is the condition of medium 200 on being drawn through printing station 217 and inking station 220, and the condition of tape 300 in the FIG. 5 embodiment after being drawn through station 303 and inking means 324. FIG. 6B shows the

copy after ink transfer as a visible mirror image of the printed and inked master. For example, this is the copy 143 of FIG. 2 on leaving transfer station 145 where ink from master 140 was transferred thereon by the applied electrostatic field between plates 100, the potential of source B_2^- and grounded plate 142. It is desirable, usually, in practice that the original of FIG. 6A be a mirror image of the true character representation desired to be viewed on the copy.

FIG. 6C shows the appearance of the original master after ink transfer, for example, as tape 140 appears after exit from station 145 and before entry into re-inking station 150. After re-inking as in station 150, the master dielectric recording material 140 appears as shown in FIG. 6D and the re-inked message is clearer and darker. FIG. 6E shows the original after the re-inking, when a considerable amount of noise is imprinted back. This is a common condition especially as in the FIG. 1 embodiment after passing around drum 25, where noise can occur. These striations of FIG. 6E must be removed before ink transfer. Where the noise condition occurs, an ink noise erasing station such as station 153 of FIG. 2 is required so that fringe and background noise ink is removed prior to ink transfer. The condition appears to occur whether or not electrode 22 of FIG. 1, for example, is left floating (either by retaining lead 30 or removing lead 30) so that ground must be reached through the conductive tape and through the roller members 26 or 28, and the corresponding support members. The opposite electrode 21 is highly charged in the negative direction by conductor 29 connected to source 70 of voltage B^- . The appearance of the re-inked recording medium after erasing noise as in erasing station 153 and before retransfer of ink is illustrated in FIG. 6F.

While the principles of the invention have now been made clear, there will be immediately obvious to those skilled in the art many modifications in structure, arrangement, proportions, the elements and components used in the practice of the invention, and otherwise, such are particularly adapted to specific environments and operating requirements, without departing from those principles. The conductivity and type of master and/or copy recording material may be varied, different inks could be utilized, various mechanical expedients and applications of transfer stations, erasing stations and neutralizing stations could be made. For example, instead of the neutralizing means shown, the master recording media could be passed again through a second solid ink bath identical to bath 220 of FIG. 4 instead of through neutralizer 250 to remove charges. Such alternative erasing is shown in FIGS. 1 and 2 and on page 7 of U.S. patent application Ser. No. 861,927, now U.S. Patent No. 3,108,895 of Richard S. Howell for Method and Apparatus for Erasing Developed Images, and assigned to the Burroughs Corporation, the assignee of the present invention. The appended claims are intended to cover and embrace any such modifications within the limits only of the true spirit and scope of the invention.

What is claimed is:

1. A method of making copies corresponding to input information provided by an electrostatic recording process comprising, electrostatically charging areas corresponding to a message on a dielectric-coated, conductive backing master medium, applying neutral conductive dry ink particles to said charges, then on completion of said ink applying step, positioning said master inked upon surface in facing slightly separated relationship to a first electrode of an aligned pair of electrodes with the medium side opposite the inked side disposed contiguous to the second electrode of the pair and simultaneously applying an electric field of a voltage of the order of 700 to 1500 volts approximately to said master medium in a direction to erase ink clinging to said master medium due to background noise charges and to erase ink accumulated due to charges induced on the fringe of said infor-

mation boundaries while retaining said message ink on said master, said noise comprising, ink disposed on areas of said master medium which areas are charged oppositely to said message charges, collecting said noise ink, positioning said master medium in closely spaced opposed facing message relationship to a copy message receiving medium, applying a second voltage of the order of 700 to 1500 volts approximately in a direction to cause transfer of the ink from said charged message on said master medium toward said copy medium, said application of second transfer voltage being of duration to cause ink transfer to a desirable amount for visibility of said message on said copy, said copy message representation being a mirror image of the charged and inked message representation on said master.

2. A method for duplicating the intelligence of an electrostatically recorded message comprising charging a first dielectric surface recording medium on its dielectric surface with electrostatic charges corresponding to the message intelligence, inking said charges on said dielectric surface with a conductive ink, disposing a second information copy medium in aligned juxtaposition with said dielectric message information bearing surface of said first medium in opposed facing medium inked and medium information receiving surface slightly separated relationship, applying a voltage between said first medium and said second copy medium in a direction and of sufficient magnitude to cause transfer readily of the ink as a mirror image from said first medium inked dielectric surface to said second information receiving recording medium, positioning said first medium inked and transferred from surface in facing slightly separated relationship to a first electrode of an aligned pair of electrodes with the medium side opposite the inked side disposed contiguous to the second electrode of the pair and simultaneously applying an inverse voltage to said first medium dielectric surface to remove background noise and fringe ink from said first medium, and without neutralizing the information charged on said first medium, and re-cycling said first dielectric medium through additional inking, transfer and inverse voltage applying steps.

3. Means to provide copies displaying the information of an electrostatic printed message, said means comprising means to provide a supply of dielectric-coated conductive material supported master recording medium, electrostatic printing means to charge the dielectric surface of said recording medium in accordance with a mirror image pattern of said message to be displayed, inking means to ink said charged message pattern, said ink being a conductive ink, means to provide a supply of copy recording media, a transfer station to provide a mirror image of the inked pattern of said master on said copy recording media, said transfer station comprising a first and a second electrode, means to supply voltage to said first electrode, said second electrode being grounded, means to draw said first recording medium in abutting slidable relationship contiguous to said first electrode with its medium message recorded face facing away from said electrode, means to draw said copy in abutting slidable relationship contiguous to said second electrode, said transfer station further comprising means whereby said second electrode, said copy, said first electrode and said master are positioned in aligned parallel relationship with said copy being slightly spaced from but in superimposed parallel aligned relationship with respect to said master, when in said transfer condition, said means to supply said voltage applied to said first electrode being adapted to supply voltage of magnitude and polarity to provide an electric field which causes said inked pattern on said master to be transferred to said copy in mirror image message duplicating relationship, noise ink erasing means disposed between said inking station and said transfer station, said erasing means comprising a third and a fourth electrode disposed in parallel closely adjacent sur-

face relationship, means to draw said master in contiguous abutting slidable relationship with said third electrode, means to ground said third electrode erasing station electrode, means to apply voltage to said fourth erasing station electrode, wherein said erasing station fourth electrode voltage applied is of direction opposite to the direction of the voltage applied to said transfer station first electrode and of substantially the same magnitude such that removal of background noise ink and ink fringe of the charged inked portions is effected prior to the transfer process.

4. Means to provide copies displaying the information of an electrostatic printed message, said means comprising means to provide a supply of dielectric-coated conductive material supported master recording medium, electrostatic printing means to charge the dielectric surface of said recording medium in accordance with a mirror image pattern of said message to be displayed, inking means to ink said charged message pattern, said ink being a conductive ink, means to provide a supply of copy recording media, a transfer station to provide a mirror image of the inked pattern of said master on said copy recording media, said transfer station comprising a first and a second electrode, means to supply voltage to said first electrode, said second electrode being grounded, means to draw said first recording medium in abutting slidable relationship contiguous to said first electrode with its medium message recorded face facing away from said electrode, means to draw said copy in abutting slidable relationship contiguous to said second electrode, said transfer station further comprising means whereby said second electrode, said copy, said first electrode and said master are positioned in aligned parallel relationship with said copy being slightly spaced from but in superimposed parallel aligned relationship with respect to said master, when in said transfer condition, said means to supply said voltage applied to said first electrode being adapted to supply voltage of magnitude and polarity to provide an electric field which causes said inked pattern on said master to be transferred to said copy in mirror image message duplicating relationship, a second inking means to re-ink said master medium, means to draw said master medium through said re-inking station to thereby replenish ink onto said charges on said master medium after the ink is removed in the first transfer station, a noise ink erasing station comprising a third and a fourth electrode, said noise ink erasing station further comprising means whereby said third and fourth electrodes are spaced to receive said master therebetween in slidable abutting relationship with the third electrode, means to bias said third and fourth erasing station electrodes substantially at the same amplitude but opposite in direction to the bias of said first ink transfer station first and second electrodes, whereby said opposite bias erases background ink and fringe ink noise present on the master after re-inking, means to supply a second copy medium, a second transfer station comprising a fifth and a sixth electrode, said second transfer station further comprising means whereby said fifth and sixth electrodes are spaced to receive said master medium in sliding abutting relationship to said fifth electrode and to receive said second copy medium in sliding abutting relationship to said sixth electrode, means to bias said fifth and sixth electrodes to transfer ink from said master medium to said copy medium when said last-named two media are positioned between said fifth and sixth electrodes.

5. Apparatus for transferring information, represented by an electrostatic charge pattern on a master record medium, from said master record medium to a copy record medium comprising an inking station for applying developer ink to said master record medium to develop the electrostatic charge pattern thereon, a transfer station including a pair of spaced apart transfer electrodes, an erasing station including a pair of spaced apart erasing electrodes, drive means for repetitively feeding said

master record medium along a circulatory path and through said inking station and between the spaced apart electrodes of said transfer station and said erasing station, means for feeding a copy record medium synchronously with said master record medium between the pair of electrodes of the transfer station with the master record medium in contact with one of the transfer electrodes and the copy record medium in contact with the other transfer electrode and with the master record medium spaced from the copy record medium a distance on the order of substantially less than a few hundredths of an inch, means for applying a difference in potential across the pair of electrodes of the transfer station of such magnitude and of such electric field direction sufficient to cause transfer of the ink pattern on the master record medium to the copy record medium, and means for applying a difference in potential across the pair of electrodes of the erasing station of sufficient magnitude but in the direction opposite to the electric field applied by the transfer station for removing background and fringe ink from the master record medium but ineffective to neutralize the electrostatic charges thereon.

6. Apparatus according to claim 5 characterized further by the provision of an electrostatic printing station positioned in operative relation to the feeding path of the master record medium for printing an electrostatic charge pattern thereon, and means for inactivating said

printing station when said charged master record medium is to be repetitively recirculated for making successive copies thereof.

7. Apparatus according to claim 6 characterized further by the provision of a neutralizing station positioned in operative relation to the feeding path of the master record medium and located in advance of said electrostatic printing station for neutralizing electrostatic charges on the master record medium.

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DAVID KLEIN, *Primary Examiner.*