

- [56]
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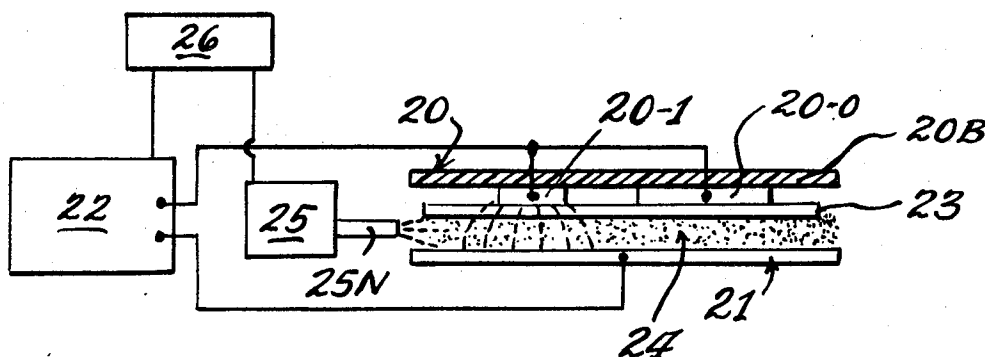
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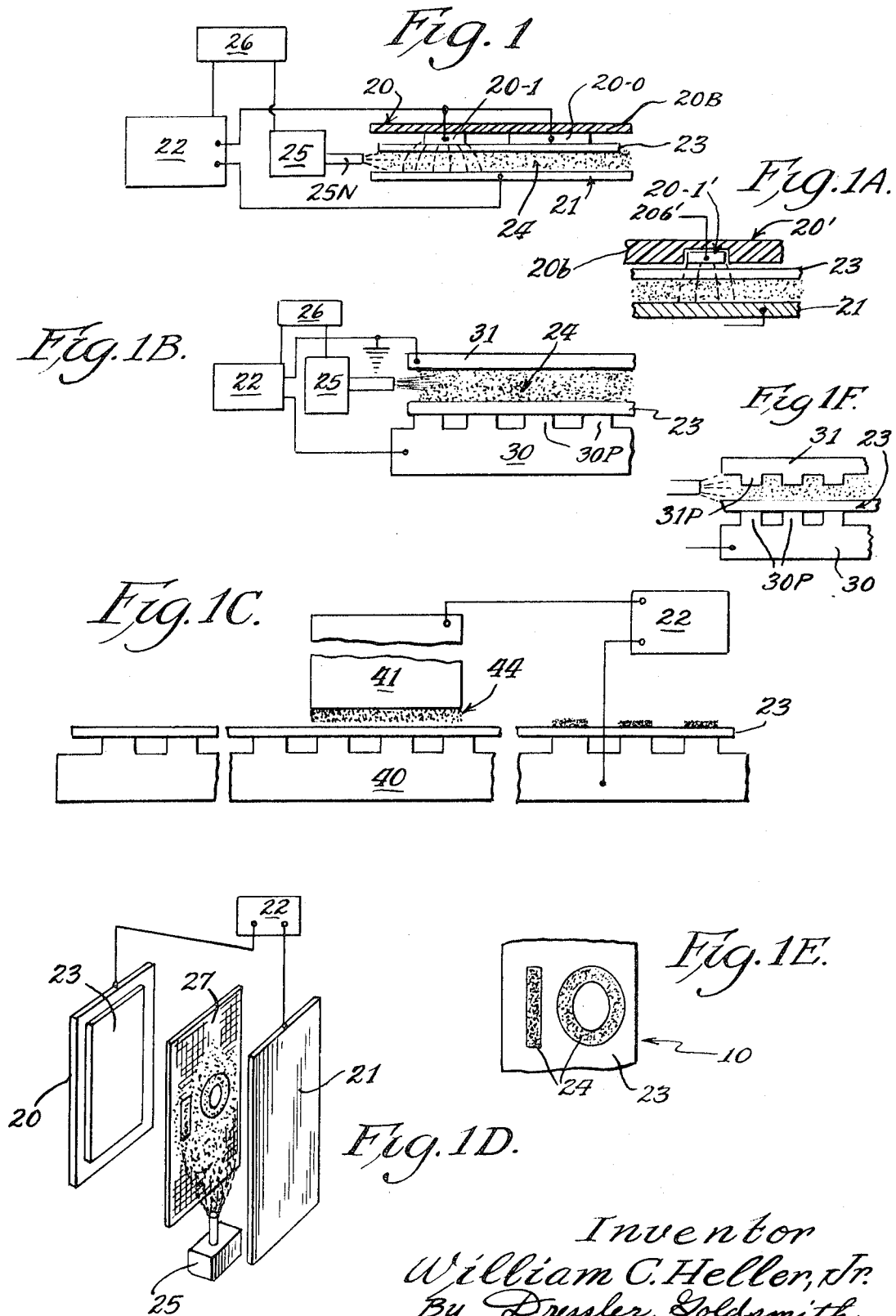
Attorney—J. Patrick Cagney

[57] **ABSTRACT**

A printing method and apparatus is disclosed employing an electric through-field for effecting deposit of electroscopic particles on an electrically insulating particle receiving material. The through-field is controlled by a field plate disposed adjacent the particle receiving material to establish a force on the electroscopic particles capable of driving the particles into permanently lodged engagement in the interstices of the particle receiving material. The field plates may be of a letterpress type or may be an array of individual field poles controlled concurrently or sequentially.

13 Claims, 45 Drawing Figures





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Fig. 2.

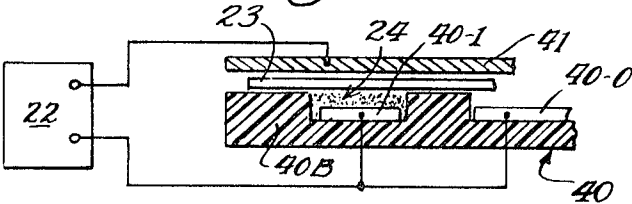


Fig. 2A.

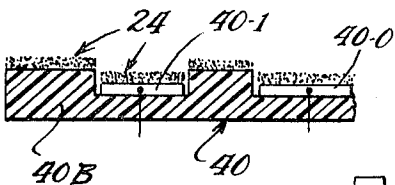


Fig. 2B.

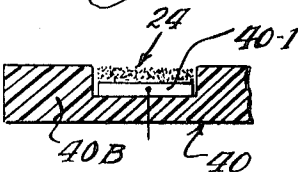


Fig. 2C.

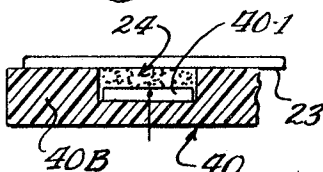


Fig. 3A.

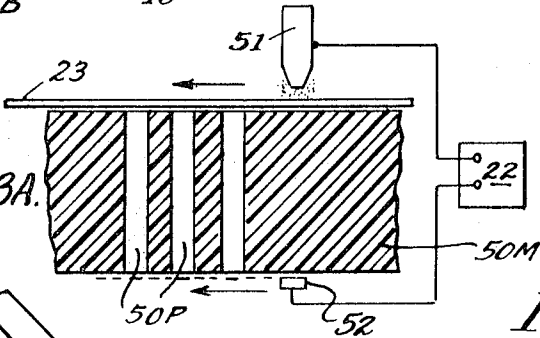


Fig. 3B.

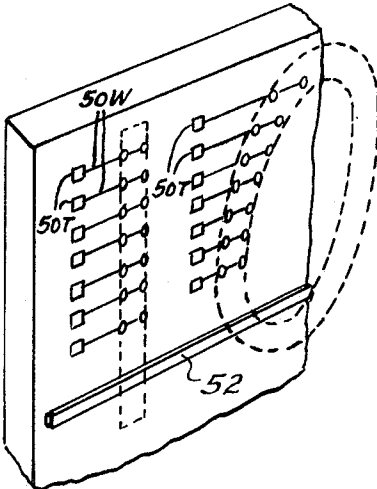


Fig. 3C.

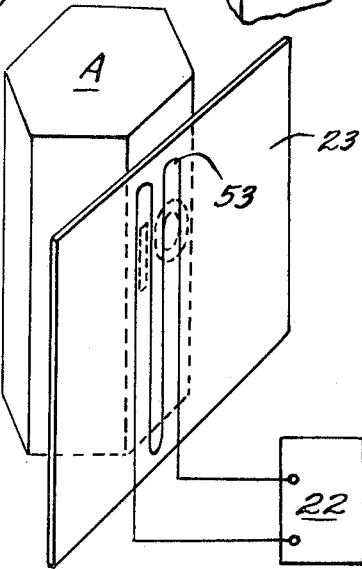


Fig. 3

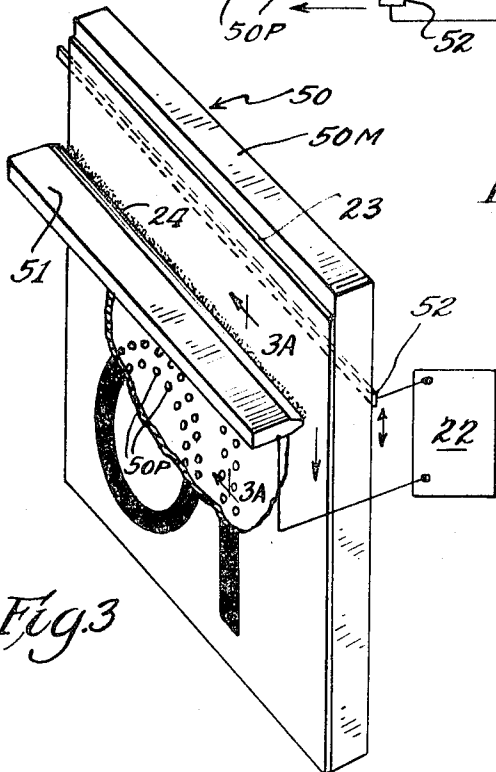


Fig. 5.

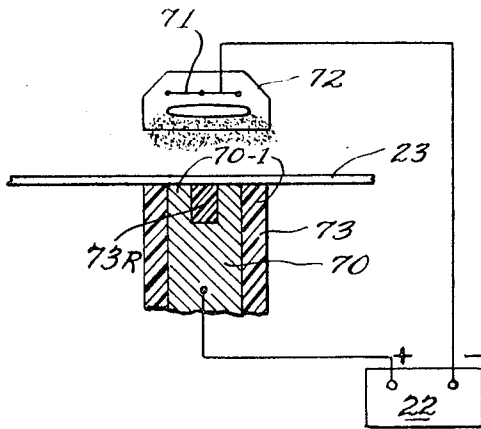


Fig. 5A.

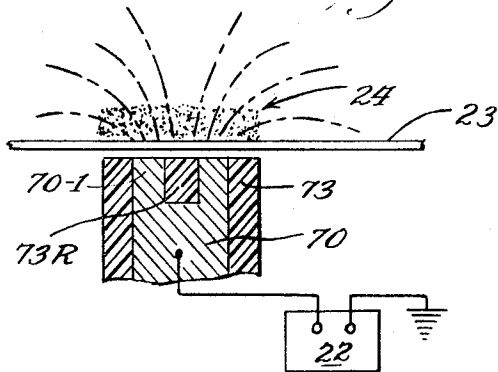


Fig. 5B.

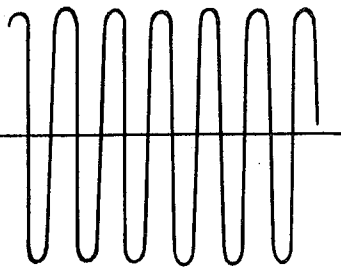


Fig. 5C.

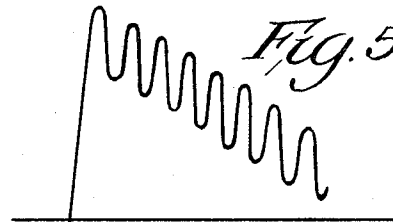
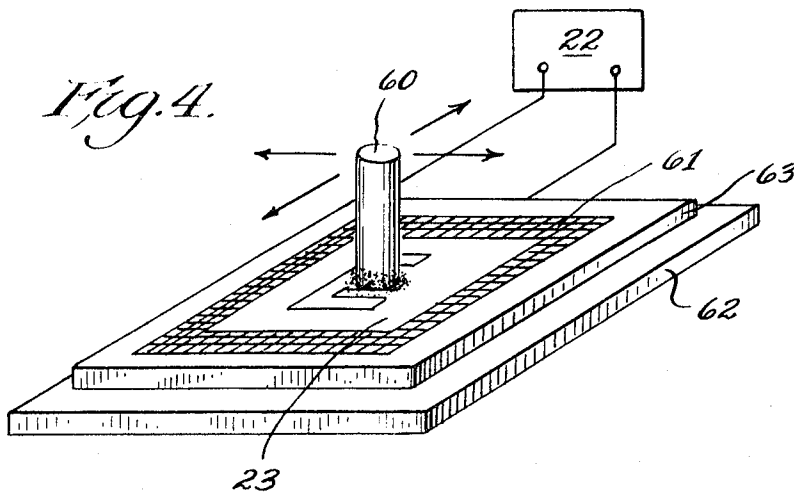
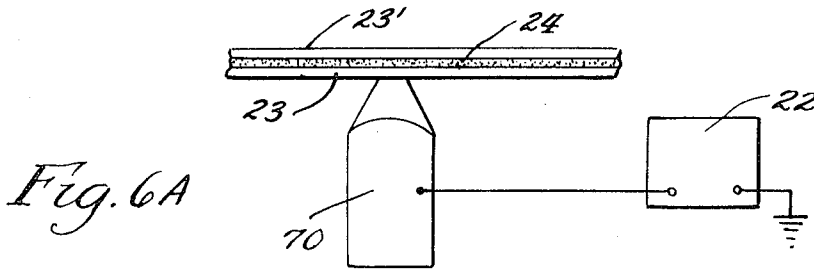
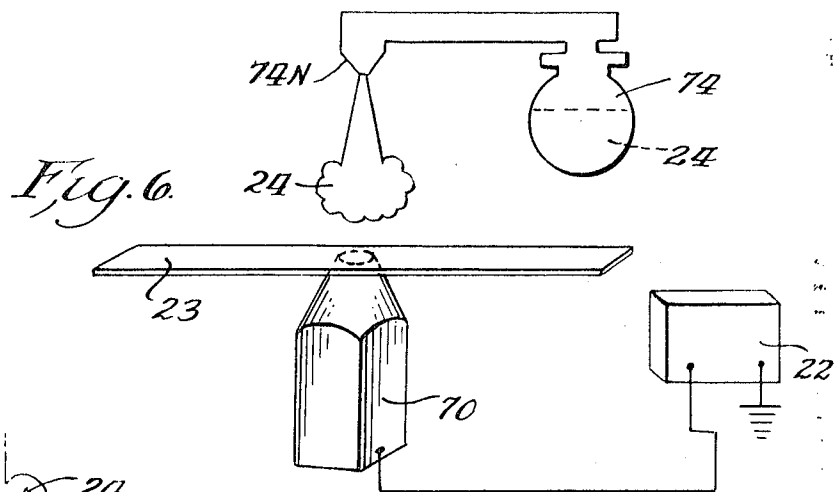
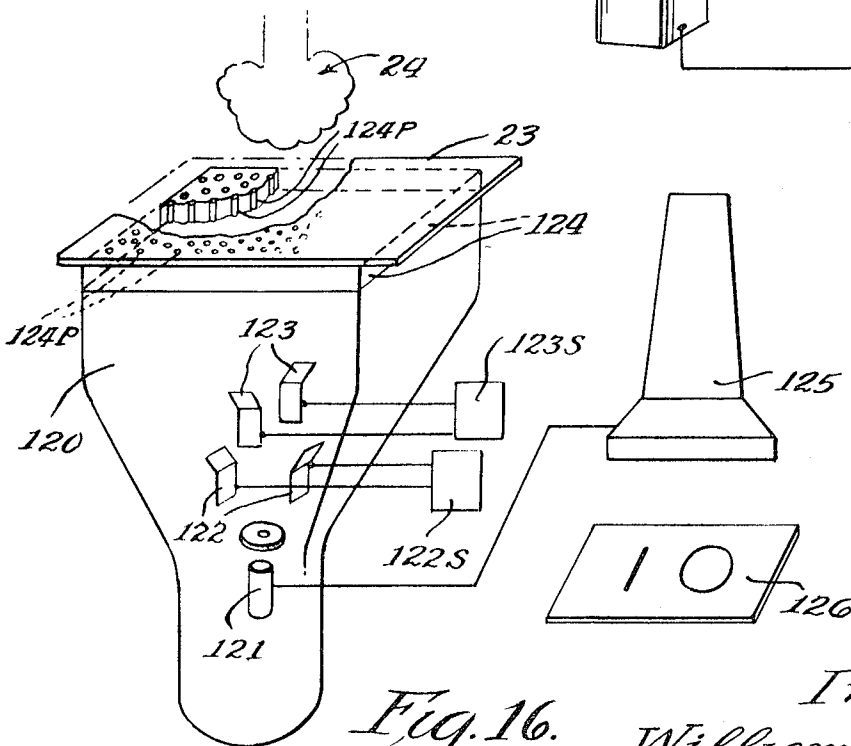


Fig. 4.



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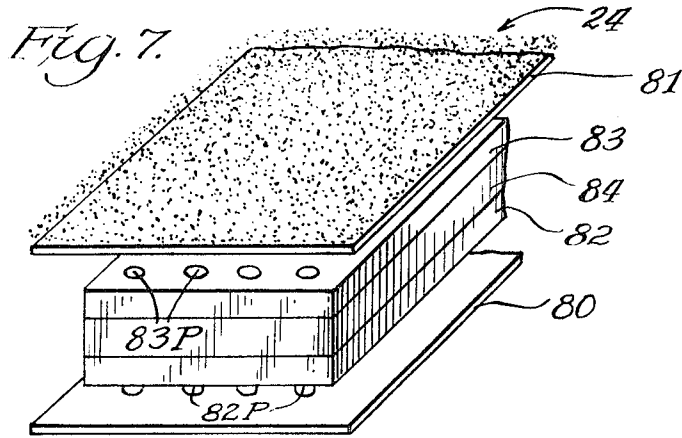
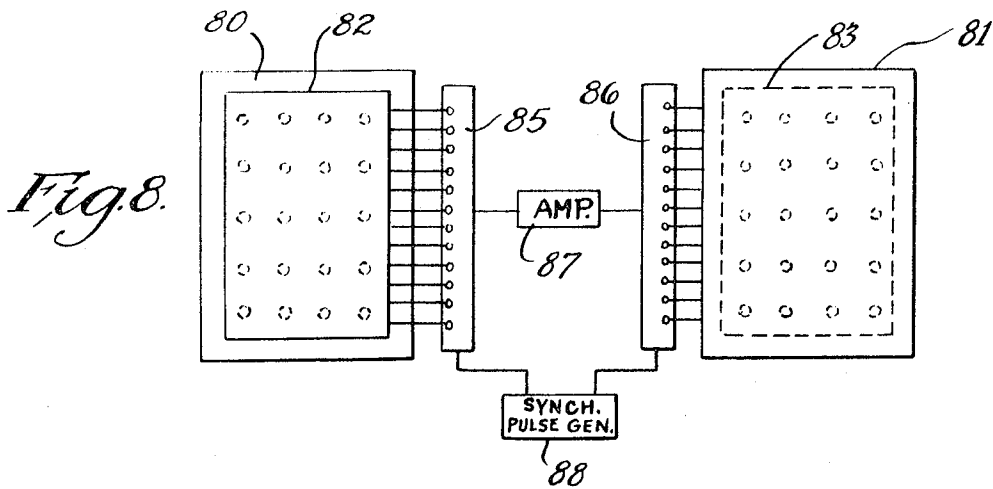
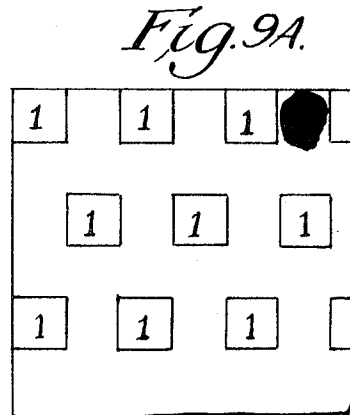


Fig. 9.

1	2	1	2	1	2
3	4	3	4	3	4
2	1	2	1	2	1
4	3	4	3	4	3
1	2	1	2	1	2
3	4	3	4	3	4



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Fig. 10A.

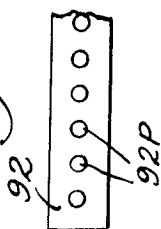


Fig. 10.

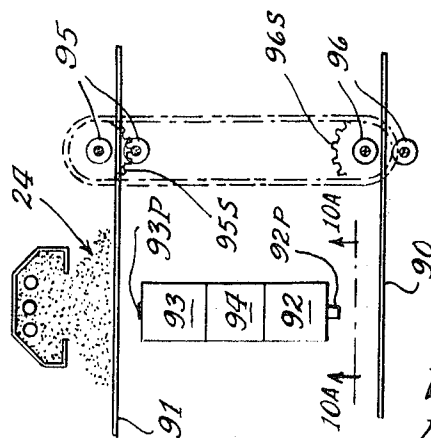


Fig. 11.

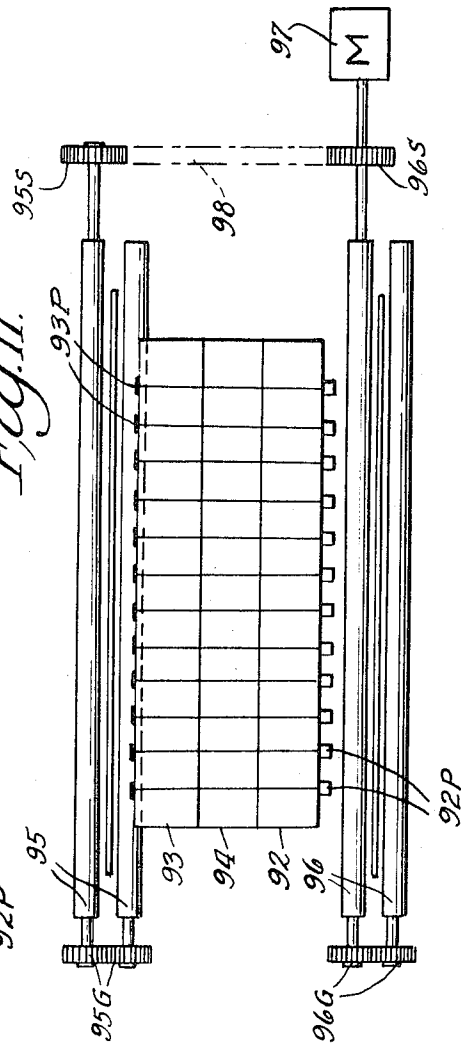
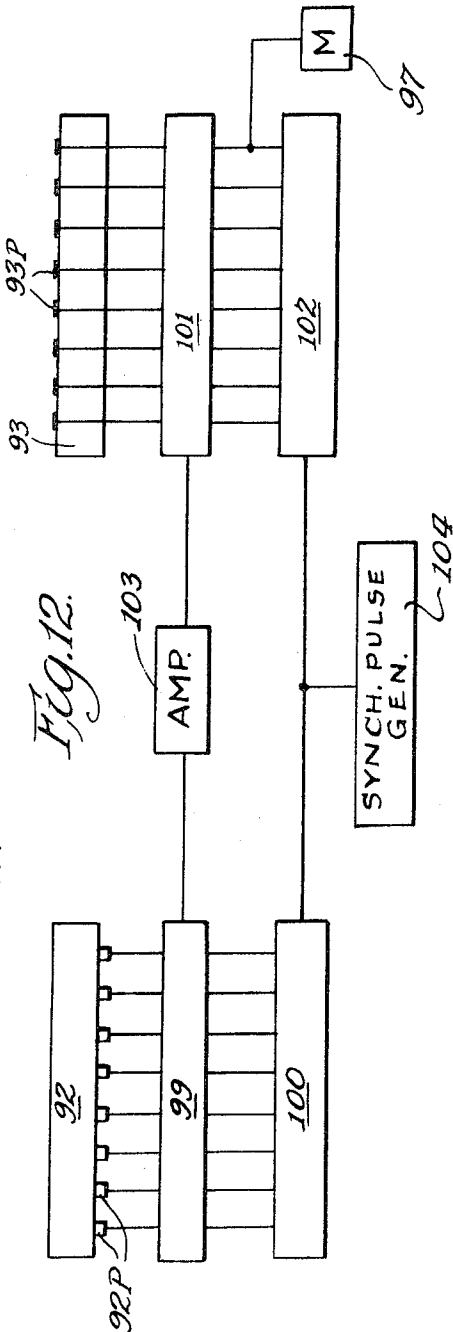


Fig. 12.



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Fig. 10B.

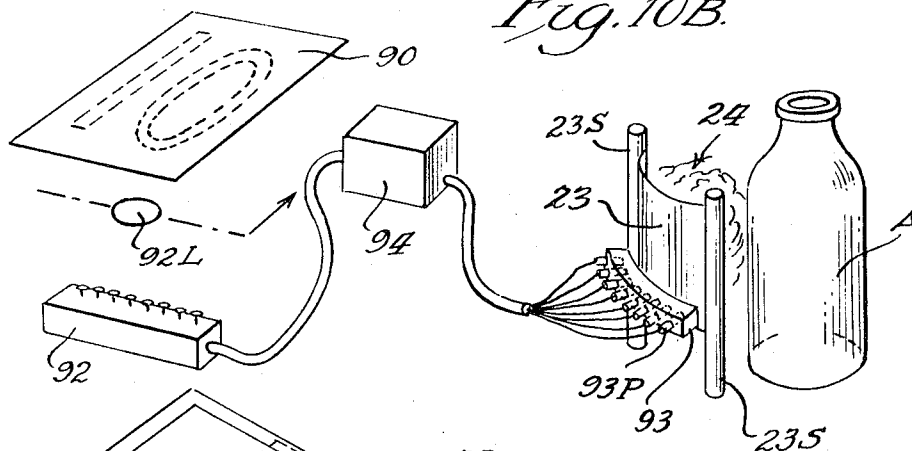


Fig. 10C.

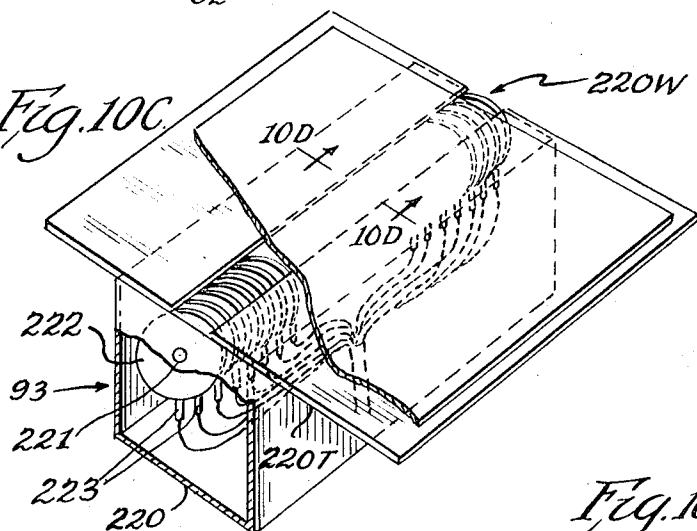


Fig. 10D.

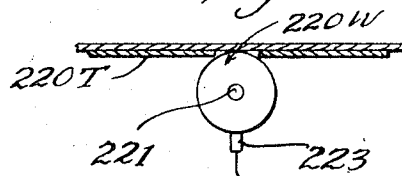


Fig. 10E.

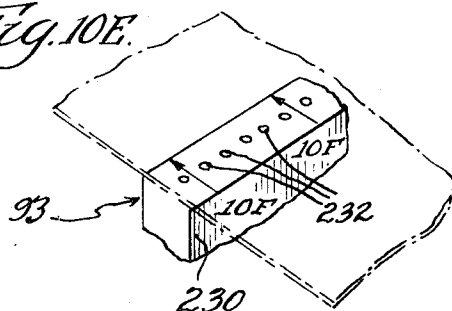


Fig. 10F.

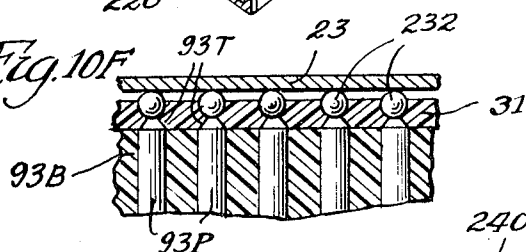


Fig. 10G.

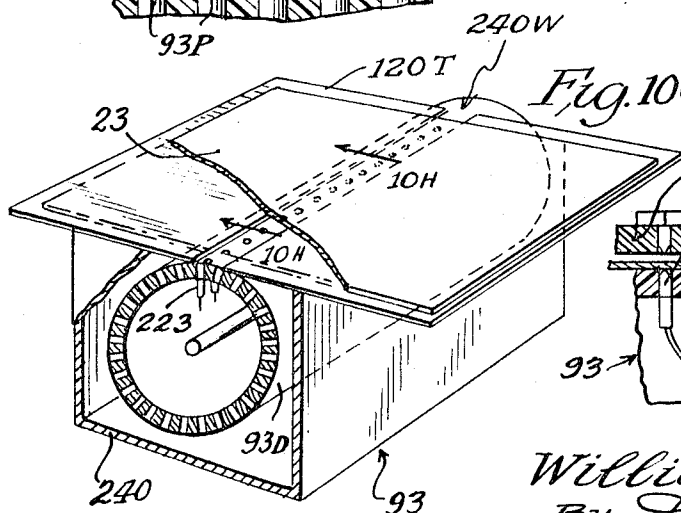
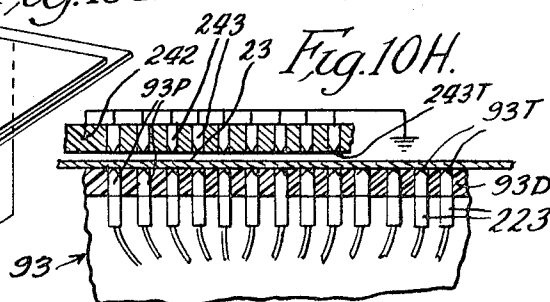
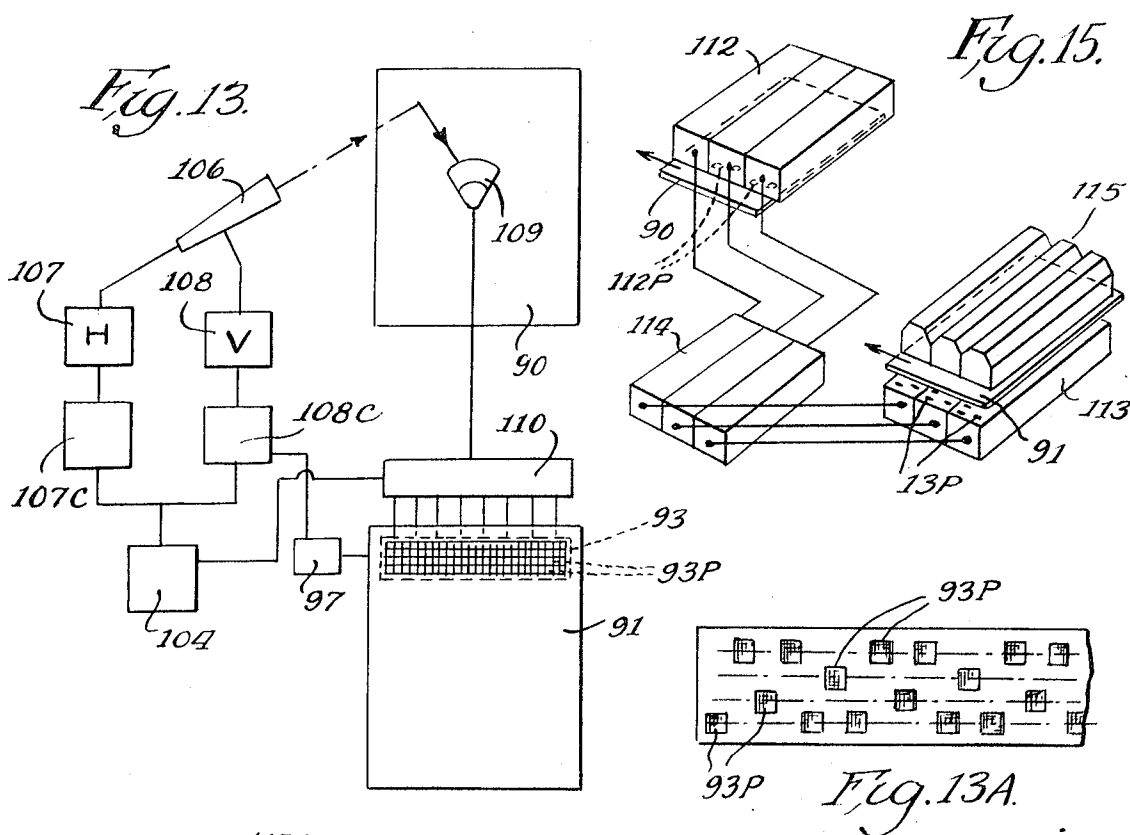
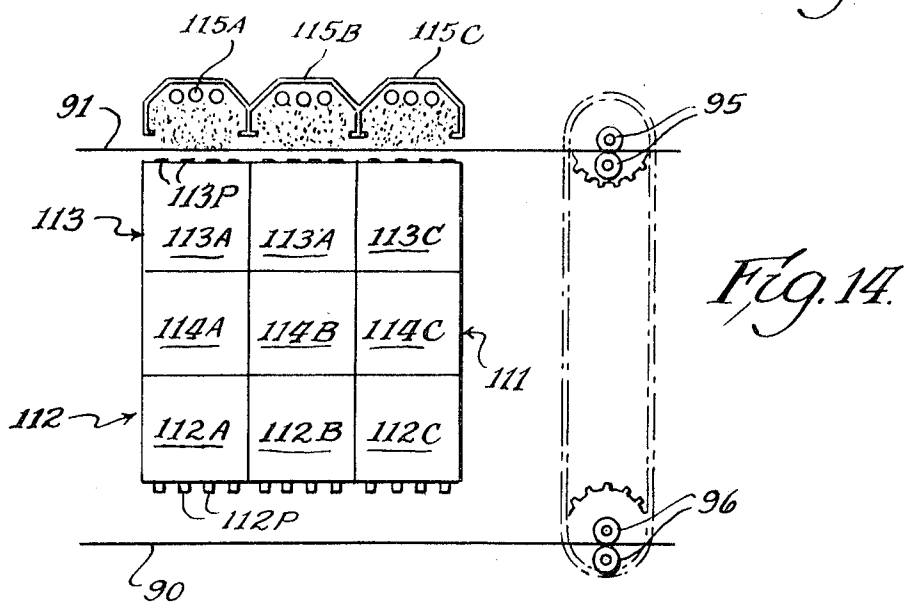


Fig. 10H.



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Fig. 17.

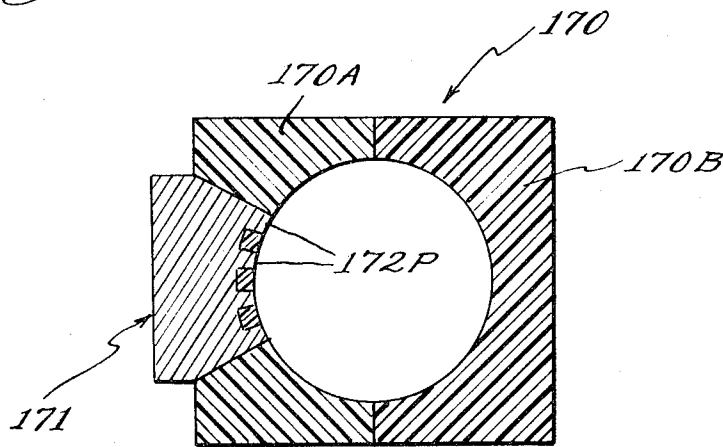


Fig. 18.

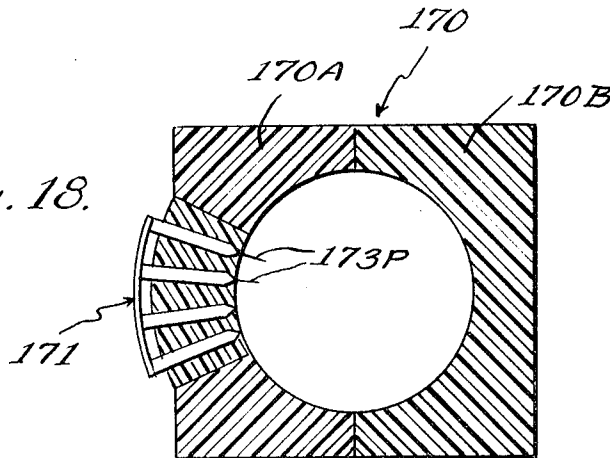
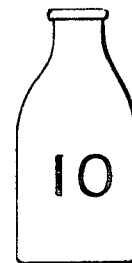


Fig. 19.

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PRINTING METHOD USING ELECTRIC THROUGH-FIELD TO INDELIBLY LODGE PARTICLES

This application is filed as a continuation of pending application, Ser. No. 626,248 filed Mar. 27, 1967, and now abandoned.

This invention relates to methods and apparatus for printing, impregnating or coating by the controlled application of electric fields and, more particularly, the invention is concerned with the deposit of electroscopic particles upon electrically insulating materials, such as paper sheet stock, plastic, fabric or textile materials and so forth by the application of electric through-fields that intercept the insulating material.

The electric field system of this invention provides external control of the deposit of electroscopic particles to enable development of greater electroattractive forces than are realized in current electrostatic processes. A variety of pattern determining and pattern control techniques can be utilized with the electric field system to suit the needs of the various different printing, impregnating and coating applications that are contemplated.

These factors enable the present system to reduce or eliminate some of the known drawbacks in the current electrostatic processes, such as image distortion, extraneous background effects due to static friction, undue sensitivity to humidity conditions, inability to reproduce large solid areas, dependence upon sensitive image plates and the necessity for transfer of image.

A notable drawback in current electrostatic processes is the need for a separate fixing step following deposition of the pattern. The present invention provides a method for permanent marking which can be applied so as to accomplish fixing concurrently with deposit of the electroscopic particle pattern. The method comprises positioning a substantially electrically insulating particle receiving material, such as paper, having a fibrous structure defining a myriad of interstices, distributing finely divided electroscopic particles small enough to be driven into the interstices and imposing an electric through-field to influence the distributed particles in accordance with their charge and to intercept the receiving material and terminate therebeyond to deposit the distributed particles into the interstices in an indelibly lodged relation to the receiving material.

A variable electric through-field can both deposit on impact and can variably act upon the electroscopic particles to work the same between the fibers for achieving indelible lodging thereof. The deposit function can be provided by any process as a preliminary step to final indelible lodging by means of the through-field. Where the deposit function is effected as a preliminary step, and indelible lodging is then to be effected by an electric through-field technique, the pattern of deposit is already determined and the through-field need not be patterned, that is, a set of flat conductive plates or a non-selective field pole array may be utilized.

The system of this invention also finds important application in printing and marking techniques where fixing is accomplished in any conventional fashion after deposit. In addition, in pattern transfer types of marking and printing operations, the invention may be applied to provide pattern deposit without fixing in order that subsequent transfer may be readily accomplished.

Where desired, such as in multi-color printing operations, registry of the receiving material in a predetermined position with respect to the electric through-field enables precise deposit patterns of each color composition to be achieved.

Before referring to the drawings in detail, a number of definitions are given to facilitate descriptive disclosure.

Particle receiving material - the invention has particular application to porous structural sheet material, such as paper stock, which is of a fibrous structure that presents a myriad of interstices for reception of particles in permanently lodged relation. Permanent lodging can also be achieved with paper coated with a thin surface film as the particles can impinge with sufficient velocity to puncture the surface film and become trapped by the film. Such a

trapped particle may penetrate the interstices between the paper fibers to supplement the retaining action. Numerous other dielectric or insulating materials such as sheets of plastic, fabric or textile material, or paperboard may serve as the particle receiving material. Where a plastic sheet is used as the particle receiving material, softening of the plastic, as by heating or chemical treating, promotes particle penetration and permanent lodging. Correspondingly, a wax coated paper sheet may be presoftened to promote particle penetration or wood sheeting may be provided with a heat softenable coating.

For optimum performance where the dielectric constant of the particle receiving material is substantially different from that of air, uniform sheet thickness is desirable to avoid distortion of the electric field and corresponding distortion of the deposition pattern.

The particle receiving material may be the final product, in which case, permanently lodged particle deposition is desirable, or it may serve as a carrier transfer medium to be impressed against another article, in which case, permanent fixing to the particle receiving material is not required. As a transfer medium, the particle receiving material may be a permanent reusable material or even a disposable material. A sheet of Teflon or silicone rubber or glass is particularly suitable as a carrier transfer medium.

Electroscopic particles - in dry power compositions, this expression is employed to indicate any non-conducting or dielectric material or any metallic or magnetic material or combinations thereof so long as the particles may accept and retain a charge to enable an electric field to exert an attractive force thereon. Any of the dry type commercial toners also can be utilized, generally these include insulating materials, such as a rosin modified phenol formaldehyde, polystyrene and styrene-methacrylate copolymer containing a coloring material, such as carbon black in the case of black on white printing. Appropriate color pigments or dyes are used as the coloring agent in multi-coloring printing. Where magnetic particles are used, these include barium ferrite, carbonyl iron, iron oxide, powdered cast iron and the like suitably provided at the desired size and containing a suitable coloring material.

Electroscopic particles may be distributed as a cloud suspension of charged powder or as an ink mist or may be manually, mechanically or electrically dispersed and charged by deposit of corona generated air ions. Triboelectric charging of the particles by scrubbing and mixing with other particles selected from the triboelectric series is also contemplated. Triboelectric charging may also be induced during nozzle discharge from a powder cloud generator. Where the ensuing disclosure refers to one or more of these known techniques to facilitate description and illustration, such references are not intended to restrict the application for the invention.

While the particles may be of the size ranges now commercially employed, there is particular advantage in the use of extremely fine particles, that is, particles such as 0.1 of a micron. Such particles can be charged and accelerated by an electric field to enable actual penetration and permanent lodging in porous structural material, such as paper, where the interstices between the individual fibers can receive and retain such particles.

By way of example, an electroscopic particle mixture comprised of a range of particle sizes some being as large as 1 micron and some being as small as 0.01 micron, as measured with a microscope using 500X magnification, was deposited in permanently lodged relation in a white bond paper sheet bearing the grade designation 16 pound bond, hard finish. For purposes of specific disclosure of the interstitial sheet structure of this paper, the following information is given concerning the characteristics of this paper. According to tests conducted in accordance with Standard No. T-220 M-60 of Tappi Institute, the paper has a thickness of 3.0 mils, a porosity measured as 379 ml of air per minute, a density of 0.77 gm/cm³, a basis weight of 58.96 gm/m² and a smoothness of 79 ml/min on the

wire side and 59 ml/min on the felt side. Permanent lodging of the particles is accomplished on either side of the paper.

While generally the finer the particle the easier it is to achieve permanent lodging, the forces acting to deposit each particle can be made sufficient to drive and fix a particle in a space which was initially smaller than the particle. Flexing of the paper fibers enables permanent seating of the slightly oversize particles and tends to provide a positive mechanical interlock therewith. An optimum particle size can be established relative to each grade of paper.

Where permanent lodging is not convenient to achieve due to the particular particle or particle receiving material properties, a thermally sensitive component such as wax may be employed to assist in fusing the particles by heat activation. The thermally sensitive component may exist as a coating on the primary electroscopic particles or may consist of separate particles suitably intermixed with the primary electroscopic particles. Selected color effects may be obtained in a similar manner by coating or mixing of particles.

Electric through-field - this expression is employed to describe the relationship wherein the field of force intercepts a particle receiving material and terminates on a field plate therebeyond as distinguished from electropainting procedures wherein the particle receiving material also functions as a field plate such that the electric field terminates on the very element which receives the particles. Where a predetermined shape is imparted to the field by virtue of the conductive pattern existing on the field plate, the through-field relationship reduces fringing and field distortion at the insulated deposition surface presented by the particle receiving material. The electric through-field relationship lends itself to arrangements where a pole type scanning structure serves as one field plate and progressively scans the receiving material to define a deposition pattern. Multiple pole scanning arrays are particularly suited to electric through-field configurations.

Finally, with sheets of more uniform thickness, the electric through-field may be arranged to more perfectly approach the equipotential plane at the deposition surface of the particle receiving material. This aids in minimizing the possibility of pattern distortion and it finds particular advantage in multi-color printing applications where accuracy of pattern depositions may be critical.

While a steady state D.C. field can effect particle transfer, a variable force field has the advantage of producing a working action of the particle against the deposition surface. Typically, the variable force field may be either a high frequency A.C., such as 15 KC as an illustrative example, or a damped D.C. pulse having an A.C. component superimposed thereon.

Where permanent lodging is desired by application of D.C., the particle receiving material may be located to maximize the voltage differences between the region occupied by the particles and the region occupied by the receiving material. The particles then impinge with maximum velocity.

Other features and advantages of the invention will be apparent from the following description and claims, and are illustrated in the accompanying drawings which show illustrative embodiments of the present invention.

Before proceeding with the description, it is understood in presenting the disclosure that some known operations that would probably be part of a complete machine for market have been omitted for purposes of simplifying the illustrative disclosure of the invention. In a few applications, it may be desirable to use methods such as mechanical rolling or other pressure application to produce a desired surface texture or condition of the finished copy sheet. Many different schemes for particle recycling are possible and various electric, magnetic and mechanical means for collection of any excess particles could be incorporated as well as a variety of paper handling techniques.

In the accompanying drawings forming a part of the specification, and in which like numerals are employed to designate like parts throughout the same,

FIG. 1 is a diagrammatic elevational view, partly in section, showing an apparatus for electric through-field deposit of electroscopic particles;

FIG. 1A is a fragmentary sectional view showing an alternative plate structure usable in the apparatus of FIG. 1;

FIG. 1B is a fragmentary view showing another embodiment;

FIG. 1C is a fragmentary view showing still another embodiment;

FIG. 1D is an exploded perspective view illustrating a stencil embodiment;

FIG. 1E is a plan view of a sheet bearing a deposit pattern produced by the apparatus of FIG. 1;

FIG. 1F is a fragmentary view showing still a further embodiment;

FIG. 2 is a diagrammatic sectional view, partly broken away, showing another apparatus for electric through-field deposit of electroscopic particles;

FIGS. 2A to 2C are related fragmentary views illustrating a sequence of steps employed in preparing a plate for printing with an article with the apparatus of FIG. 2;

FIG. 3 is an exploded perspective view of an embodiment utilizing an electric through-field arrangement in the environment of a carrier transfer medium;

FIG. 3A is an enlarged fragmentary sectional view taken on the line 3A—3A of FIG. 3;

FIG. 3B is a fragmentary rear perspective view of a patterned multi-pole field plate structure used in the embodiment of FIG. 3;

FIG. 3C is a perspective view illustrating the transfer of the deposit pattern from the carrier to the article and includes an illustration of an induction heating fixing step;

FIG. 4 is a perspective view of an embodiment utilizing a magnetic brush for particle distribution;

FIG. 5 is a fragmentary diagrammatic view showing a shaped field pole arrangement for establishing an electric through-field deposit;

FIG. 5A is a fragmentary diagrammatic view showing another shaped field pole arrangement;

FIG. 5B is a diagram of an A.C. wave train for energizing a variable electric through-field capable of effecting a permanently infused deposit of electroscopic particles;

FIG. 5C is a diagram of a damped D.C. pulse having an A.C. component for energizing a variable electric through-field;

FIGS. 6 and 6A are diagrammatic illustrations of specific embodiments using electric through-fields to produce marking or printing;

FIG. 7 is an exploded perspective view illustrating a composite reproducer unit employing matched matrix arrays of photosensitive elements and field pole elements for producing electric through-field deposits;

FIG. 8 is a schematic view illustrating an electronic scanning arrangement used with matched matrix arrays of photosensitive elements and field pole elements;

FIG. 9 illustrates one type of image pattern subdivision for sequential reproduction by staggered matrix arrays of photosensitive elements and field pole elements;

FIG. 9A illustrates the staggered matrix array to be used at the first station of a sequential reproduction system;

FIG. 10 is a schematic side elevational view of a composite reproducer unit employing matched one dimensional scanning arrays of photosensitive elements and field pole elements for producing electric through-field deposits;

FIG. 10A is a fragmentary view taken on the line 10A—10A of FIG. 10 and shows an aligned row pattern for the one dimensional array;

FIG. 10B is a schematic perspective view of apparatus using an array of photosensitive scanning devices controlling an array of electric field poles associated with a carrier for effecting transfer deposit to an article such as a bottle;

FIG. 10C is a fragmentary perspective view showing a housing containing an array of rotary discs arranged in a one dimensional pattern to provide an anti-friction wheeled contact with the particle receiving material;

FIG. 10D is a fragmentary section on the line 10D—10D of FIG. 10C;

FIG. 10E is a fragmentary perspective view of a housing containing an array of roller bearing contact points for providing anti-friction rolling contact with the particle receiving material;

FIG. 10F is an enlarged fragmentary section taken on the line 10F—10F of FIG. 10E;

FIG. 10G is a fragmentary perspective view of a housing containing a rotatably mounted cylindrical array of successive rows of transfer poles to be energized by a stationary array of matching master poles;

FIG. 10H is an enlarged fragmentary section taken on the line 10H—10H of FIG. 10G;

FIG. 11 is a schematic transverse view of the arrangement shown in FIG. 10;

FIG. 12 is a schematic view illustrating an electronic scanning arrangement used with the matched one dimensional arrays of photosensitive elements and field pole elements;

FIG. 13 is a schematic view illustrating an electric through-field embodiment wherein a flying spot scanner reads an image and supplies information to a one dimensional array of field pole elements;

FIG. 13A is a fragmentary view of the array of field pole elements employed in the arrangement of FIG. 13;

FIG. 14 is a schematic side elevational view of an integrated multi-color reproducer unit employing matched one dimensional staggered arrays of photosensitive elements and field pole elements for each color composition;

FIG. 15 is a schematic perspective view of an articulated multi-color reproducer unit employing matched one dimensional staggered arrays of photosensitive elements and field pole elements;

FIG. 16 is a diagram of a matrix array controlled by a TV type electron beam scanner to produce a selective predetermined shaped electric through-field pattern;

FIG. 17 is a transverse sectional view illustrating the application of the invention in a unique blow mold printing application;

FIG. 18 is a transverse sectional view of an alternative embodiment of field poles applied to a blow mold printing operation; and

FIG. 19 is an elevational view of a printed blow mold article.

Referring first to FIG. 1E, there is shown a product 10 consists of a sheet 23 of particle receiving material having a plurality of finely divided electroscopic particles 24 disposed on one face thereof in a deposit pattern in the shape of the reference numeral 10.

In one illustrative example, the sheet 23 represented in FIG. 1E is of fibrous paper stock, typically a 16 pound, white bond, hard finish, paper sheet characterized by a myriad of interstices. The electroscopic particles 24 that comprise the deposit pattern represented in FIG. 1E are a graded mixture of particle sizes including non-magnetic particles, some as large as 1 micron and some as small as 0.01 micron, with numerous particles of intermediate sizes being included.

Referring now to FIG. 1 of the drawings, a pair of field plate structures 20 and 21 are shown connected to a source 22 of electric power. The plate structure 20 serves as a shaped field plate and includes an insulated base 20B providing mechanical support for conductive plate portions 20-1 and 20-0 which may be applied as surface coatings or in any other fashion. The plate portions 20-1 and 20-0 are connected to the voltage source 22 to assume the same potential and collectively constitute a shaped field plate in the configuration of numeral 10. The plate 21 in this example is of any suitable conductive material of a size to span the shaped field plate and cooperatively define an electric field having a predetermined shape at the region immediately adjacent the shaped field plate. In the illustration, this predetermined shape defines the numeral 10.

A sheet 23 of particle receiving material is positioned immediately adjacent the shaped field plate 20 to be intercepted

by the shaped electric field which terminates on the conductive plate portions 20-1 and 20-0 to define a through-field relationship such that the particle receiving material produces minimum field distortion. Moreover, within the limits of dielectric breakdown, the field intensity may be selected to be quite strong without requiring any specialized coating or insulation characteristics for the particle receiving material.

Electroscopic particles 24 are shown distributed throughout an interplate region spanning the pattern area and located between the field plate 21 and the particle receiving material 23. In this illustration, the particles are represented as a cloud suspension, provided from a cloud generator 25 of any suitable type. The cloud may consist only of deposit particles charged by air ions or charged by triboelectric action on exiting from the nozzle 25N of the cloud generator and carrying a charge selected to produce attractive forces towards the shaped field plate 20. Alternatively, the cloud may include carrier particles selected to produce triboelectric charging of the deposit particles. Finally, the cloud may comprise a mist of ionized ink drops where a wet ink process is used.

A sequencing control 26 is shown connected to the cloud generator 25 and the voltage source 22 to provide an operating sequence in which the cloud generator first distributes the electroscopic particles substantially throughout the air gap between the field plate 21 and the receiving material 23 and the voltage source 22 then imposes an electric through-field to influence the distributed particles and deposit the same on the receiving material in the configuration of the numeral 10 as is shown in FIG. 1E.

In the configuration of FIG. 1, the particles see a potential difference substantially as great as the applied voltage and achieve a high velocity at the time of impingement with the particle receiving material. This gives greater penetration on initial impact so that this configuration is particularly apt for use with a D.C. field as compared with configurations where initial impact occurs at substantially lower particle velocities.

Where the conductive plate portions are in upstanding or projecting relation, there is a more pronounced fringing pattern, as is illustrated in exaggerated fashion in FIG. 1. With pronounced fringing effects, the edges of the shaped deposition pattern are not as clear and well defined as where fringing is avoided. A shaped field plate is illustrated at 20' in FIG. 1A wherein the base 20B' is preformed with patterned recesses to receive the plate portion 20-1' in flush relation or countersunk if desired. The field plate 20' minimizes fringing effect and accommodates flush mounting of the sheet 23.

A letterpress apparatus is illustrated in FIG. 1B wherein the letterpress plate 30 receives a sheet 23 of paper in flush overlying relation and a grounded field plate 31 is disposed in spaced relation to provide an air gap. A cloud generator 25 is positioned to inject a cloud of electroscopic particles 24 across the air gap. A power supply 22 either D.C. or A.C. and appropriately polarized is connected to establish a through-field to deposit the particles upon the regions of the paper overlying the raised character defining portions 30P of the letterpress plate.

In another embodiment, an etched metal letterpress plate 40 is arranged with raised characters pointing upward to receive a sheet of particle receiving paper 23 in contact therewith, as shown in FIG. 1C, and a field plate 41 in the form of a permanent magnet to serve as a "magnetic brush" is scanned across the letterpress plate to progressively develop a shaped through-field in accordance with the upraised portions on the letterpress plate. The magnetic brush carries toner 44 containing both electroscopic and magnetic material, specifically Electrofax toner by Bruning Corp., which are to be deposited on the paper by the effects of the through-field. The electroattractive effect of the through-field upon the charged particles is arranged to be substantially greater than the magnetic hold on these particles. In this embodiment, the power supply 22 provides a source of D.C. voltage and has its positive terminal connected to the letterpress plate 40 and its negative terminal connected to the body of the magnetic brush 41.

Scanning movement of the brush is employed to distribute the toner in the vicinity of the regions of the paper where deposit is to be effected. Thus, with the lower end of the magnet of the magnetic brush 44 located about 1/16 to 1/4 inch above the paper sheet 23 so that agglomerated particles on the brush would lightly contact the paper and with the power supply set for 500 volts, the brush is moved over the surface of the paper resulting in a well defined deposition of toner at those areas of the paper overlying the raised surfaces of the letterpress plate 40, thereby achieving an accurate reproduction of the letters of the letterpress plate.

Successful deposition was also achieved at voltages lower than 500 volts and at higher voltages up to the level where arc-over occurred from the brush 41 through the paper 23 to the plate 40. The particular voltage and spacing is not critical but results can be optimized by selective correlation of the particles, the type of paper, and the magnet strength as well as the voltage and spacing. Where D.C. voltage is employed, the markings were not permanent.

To demonstrate the uses of the permanently infused deposition system of this invention, a stencil arrangement is shown in FIG. 1D wherein cooperating field plate structures 20 and 21 are spaced apart and connected to a power supply 22 to develop a uniform through-field therebetween. A sheet of paper 23 to be printed is positioned adjacent the field plate 20, a stencil 27 of insulating material is positioned intermediately of the field plates and a cloud generator 25 supplies charged electroscopic particles to the gap between the stencil and the field plate 21 to be drawn through the shaped aperture of the stencil and form a corresponding deposit pattern on the paper sheet 23. The stencil 27 may be a woven screen coated or masked over all regions except the 10-shaped region.

A letterpress apparatus generally similar to that of FIG. 1B is shown in FIG. 1F wherein a letterpress plate 30 is again represented with raised character defining portions 30P. In this embodiment, the field plate 31 also includes raised portions 31P in confronting relation to the raised portions 30P to effect a concentration of the through-field pattern. The raised portions 31P may be raised bars or individual characters directly matching the raised character portions 30P, the latter relationship providing more pronounced concentration of the field and higher resolution.

Another apparatus is shown in FIG. 2 wherein a shaped field plate structure 40 includes an insulated base 40B provided with recessed grooves to receive conductive plate portions 40-1 and 40-0 in recessed or countersunk relation to allow for deposition of electroscopic particles 24 in a pattern determined by the shape of the grooves. The other field plate 41 is positioned closely adjacent and the plates are connected to a power source 22 to be energized after the electroscopic particles 24 and the flush mounted particle receiving material 23 are properly positioned. In this configuration, close spacing of the field plates enables high field strengths without excessive applied voltage. While the deposition pattern is largely a function of the particle positioning, the shaped field plate 40 concentrates the through-field to produce maximum attractive force on the particles without danger of dielectric breakdown at the non-recessed regions of the shaped field plate.

While cloud generators may be used for the supply of charged particles, the desired particle distribution may be manually accomplished as illustrated in the sequence views of FIGS. 2A, 2B and 2C. The powder 24 is first broadcast across the entire exposed surface of the shaped field plate, as shown in FIG. 2A, with the excess then being removed from the non-image surface regions to provide the localized powder distribution as illustrated in FIG. 2B. Ionized air, such as may be produced by the corona spray method, is played upon the shaped field plate 40 to charge the localized powder residues. Finally, a sheet of particle receiving material 23 is applied to the shaped field plate 40, as illustrated in FIG. 2C, and the through-field is imposed at the proper polarity to effect pattern deposition upon the sheet 23 as shown in FIG. 2.

A carrier transfer embodiment is shown in FIGS. 3 to 3C wherein a patterned field plate 50 and a cooperating scanning

field plate 51 in the form of an elongated knife-like bar are shown confronting opposite faces of a sheet of particle receiving material 23 which is positioned flush upon the pattern plate. It will be apparent that the sheet of particle receiving material 23 when of uniform thickness assists in defining an equipotential plane.

The pattern field plate 50 is comprised of a molded panel 50M of plastic, such as a molded epoxy resin, having wire-like elements 50P embedded in closely spaced relation to define field poles selectively energizable to produce individually originating electric through-fields. The field poles 50P are here shown in an array to define a deposit pattern representing the numeral 10. For purposes of illustrative disclosure, the wire elements may be of 3-mil diameter spaced 10 mils on centers.

On the rear face, as shown in FIG. 3B, the panel is provided with printed circuit coatings defining wires 50W and contact terminals 50T to cooperate with a wiper arm 52. In FIGS. 3 and 3A, the knife-like scanning bar 51 serves as a one dimensional edged field plate and is of magnetic material to act as a magnetic brush carrying a charge of electroscopic particles which may be a mixture of any of the magnetic or magnetizable particles referred to herein, for example, iron oxide particles coated or mixed with a heat softenable material. The tapering edge presented by the knife-like bar 51 produces an improvement in pattern definition and density as compared with a wide faced field plate. As presently understood, it is believed that the edged field plate presented by this knife-like bar configuration concentrates the field lines and reduces field fringing to produce this result. The scanning bar 51 and wiper arm 52 are connected to corresponding terminals of a voltage source 22 and are progressed in unison so that the field poles 50P are energized sequentially to a polarity opposite to the charge on the particles. A deposit pattern is thereby progressively produced on the sheet 23.

As illustrated in FIG. 3C, the sheet 23 is to serve as a carrier transfer medium to be impressed against the article A to be printed with reference numeral 10. For this transfer operation, permanent lodging on the sheet 23 is not required nor even desirable. A high temperature plastic, such as Teflon, is used for the sheet 23 and a high frequency induction heating coil 53 is shown adjacent the rear face of the sheet 23 for effecting individual heating of the magnetic particles to melt the wax coating and thereby produce permanent fusion of the particles on the article A. In some instances, where the article A is of a heat softenable thermoplastic, raw magnetic particles can be permanently fused thereon. In either case, the high temperature and lubric surface characteristics of Teflon enable repeated use of it as the transfer medium in the described process. In lieu of magnetic particles and induction heating, thermoplastic particles or thermoplastically coated particles may be used with flame heating applied to the rear side of the sheet 23 to accomplish fusing to the article A.

Other adaptations of the invention with the carrier transfer technique use preheat in the case of thermoplastic articles. Instead of Teflon, the sheet 23 may be of silicone rubber.

Another D.C. apparatus utilizing a scanning magnetic brush 60 and a metal screen 61 as cooperating field plate structures is shown in FIG. 4. An insulation base 62 carries a mounting plate 63 having an inlaid metal screen 61 of fine mesh which is provided with a shaped insulating coating. Typical materials suitable for the insulated coating include dichromated gelatin, dichromated polyvinyl alcohol or a photo-polymerizable resin such as is marketed under the tradename Kodak Photo-Resist (KPR). Kodak Photo-Resist has the advantage of being insensitive to humidity.

When the voltage source 22 is connected to apply an electric field between the magnetic brush 60 and the metal screen 61, with a particle receiving sheet 23 applied flush upon the screen, the magnetic brush carrying a charge of electroscopic particles polarized opposite to the metal screen is progressively scanned across the screen to provide a selective deposit pattern over the exposed metal regions of the screen 61.

Another printing or marking technique is represented in FIG. 5 wherein a shaped field pole 70 of conductive material is connected to a high voltage source 22 and is opposed by a shielded corona generating filament array 71 that is mounted within a cloud chamber housing 72 to produce air ions for charging an air suspension of particles that is maintained in the housing. A sheet 23 of particle receiving material is disposed flush against the face of the pole 70 which has endwise projecting character defining portions 70-1 enveloped in an insulating jacket 73 of dielectric material, such as a molded epoxy resin. The dielectric material is also provided to fill any central recesses as shown at 73R. Thus, only the conductive character defining face of the field pole is exposed and the dielectric material concentrates the electric field in the shape of this face and reduces fringing effects such as could arise due to the depth of the conductive pole.

When the high voltage source 22 is energized, air ions are generated to ionize the suspended particles. The electric through-field is concurrently effective to drive the negatively charged particles into the particle receiving material to provide a fixed deposit. In this form, the through-field terminates at the filament array or in part on the charged cloud immediately thereadjacent, however, a through-field of appropriate strength can be developed without providing for such direct termination. An arrangement is represented in FIG. 5A wherein the field pole 70 is not associated with a distinct companion pole. In this form, the through-field flares outwardly and upwardly to terminate on any grounds existing in the apparatus, however, the field assumes a distinct accurate shape as it intercepts the particle receiving material 23 that is located immediately adjacent the field pole. The dielectric jacket 73 on the field pole 70 is particularly important in reducing fringing effects in the arrangement of FIG. 5A.

The cloud of electroscopic particles 24 is represented only diagrammatically in FIG. 5A as it may be provided and supported in any desired fashion, including a corona generating means energized from a different source of electric energy. The individual field poles of the arrangements of FIGS. 5 and 5A may be one type key element of an electric through-field typewriter device or may be one print key of an electric through-field readout for a calculator.

As previously mentioned, the invention employs a variable electric through-field to effect a deposit of electroscopic particles in permanently infused relation. While a D.C. pulse can be employed, greater field strengths are required and this introduces technical complexities in the peripheral equipment. The variable electric field may be in the form of an A.C. wave train of several cycles duration, as shown in FIG. 5B, or in the form of a damped D.C. pulse having a superimposed A.C. component, as shown in FIG. 5C. The damped D.C. pulse is represented as having an exponential decay characteristic but it may be of square wave or other form provided that a substantial A.C. component is also present. By its nature, an electric through-field, since it originates and terminates beyond the particle receiving material, can exert force on a particle both after as well as before the particle is deposited on such material. The important characteristics of these variable electric through-fields for effecting deposit and permanent infusion of electroscopic particles are a sharp rise time for producing maximum particle velocity on initial impact and a substantial variation of the voltage level for producing a pulsating field strength to work the deposited particles more deeply into the interstices of the particle receiving material. In the case of paper, the fibers are capable of bending in the presence of a particle acted on by a pulsing force to enable progressively deeper penetration. This repeated wedging of the particle and corresponding deflecting of the fibers leads to mechanical interlock relationships that provide more positive retention than single impact force fit wedging alone can produce.

By way of illustrative disclosure, other specific arrangements utilizing the electric through-field principles of this invention are shown in FIGS. 6 and 6A. In the arrangement of FIG. 6, a steel stamping die 70, to serve as a shaped field plate,

is mounted with the raised die area in the shape of the letter "J" pointing upward. A power source 22 having an output voltage of 3,000 to 7,000 volts at 60 cycles per second is shown with one terminal connected to the die 70 and the other terminal connected to ground.

A sheet 23 of particle receiving paper is shown overlying and contacting the "J" surface of the die. With the die electrically energized as shown, dry powder toners 24 of commercial type are blown downward toward the paper 23 from an atomizer 74 having an exit nozzle 74N capable of imparting a triboelectric charge as the particles 24 are discharged. Under these conditions, the toner particles 24 are attracted to deposit on the upper surface of the paper 23 to form a well-defined deposit pattern accurately duplicating the shape of the J surface on the die.

This demonstrates that with the electric through-field arrangement of FIG. 6, a second field plate is not an absolute requirement and an electric field intensity established in space in the vicinity of the J surface is great enough to attract particles of dry toner and is sharply defined to a predetermined shape accurately conforming to the letter "J." This also demonstrates that the paper 23 does not distort the electric field enough to detract from the function of producing a deposit of particles in the intended predetermined shape.

The commercial toners used with the embodiment of FIG. 6 include the standard types provided by Xerox Corporation and by Apeco Corporation. In this form, effective printing is achieved with triboelectric charging of the toner particles. Precharging of the toner particles, as by a corona spray, can also be used.

For the sheet of particle receiving material, a number of types of paper are used, including several common types, such as white note pad, yellow note pad, typing paper and absorbent tissues. These ordinary types of paper have produced better results without heat or related types of fixing than have special purpose papers, such as the type having one conductive surface for use in certain latent electrostatic image processes. The described example does not produce permanently lodged deposit of the particles on the paper but since it uses neither charge storing nor latent image techniques, it provides accurately defined deposit patterns with a simple and reliable system that is not sensitive to humidity conditions.

An arrangement providing permanent marking of dry toner particles into white paper is shown in FIG. 6A. A metal stamping die 70 is shown connected to one terminal of power supply 22 which is shown with its other terminal connected to ground. In particular, the rectified voltage output from a 12,500-volt, 15,000-c.p.s. supply is applied to the die 70. One convenient source for such a voltage is the high voltage anode lead of a TV set. Dry toner particles 24 are disposed between two layers of filter paper 23 and 23' to be in the vicinity where deposit is required, layer 23 being in contact with the die 70, and the rectified voltage applied. A permanently lodged deposit pattern is thereby achieved. Similar permanent marking is also achieved where ordinary notebook paper is used as the particle receiving material.

Permanent marking can be achieved more readily by an improved technique using either unrectified A.C. or half-wave rectification or other waveform capable of greater voltage variations than are available at the high voltage anode lead of a TV set. Satisfactory permanent marking can be provided over a range of electric field intensity from about 1,000 volts per inch (e.g., a hundred volts across a 1/8-inch gap) to about the region where corona tends to form, as with the high voltage lead of a television set.

While the foregoing embodiments have related to printing or marking, the invention may also be applied for direct copy work. Here again, there is important advantage in providing for permanent infusion of the electroscopic particles into a particle receiving material such as paper. Permanent copies may thus be provided instantly and without need for a subsequent fixing step. An apparatus utilizing the through-field

principle for providing permanent copies is illustrated in FIG. 7 wherein the original from which a copy is to be made is shown at 80 and the copy is shown at 81. An optical image transducer unit 82 is positioned in predetermined registry with the original 80 and a field plate unit 83 is positioned in corresponding registry with the copy 81. A distributor unit 84 interconnects the image transducer 82 and field plate 83 to produce an ordered deposit pattern on the copy in accordance with the image on the original. In the embodiment of FIG. 7, the units 82, 83 and 84 are integrated in a composite assembly positioned between the original 80 and the copy 81 which are in overlapping relation. The image transducer 82 thus overlies the image on the upper face of the original, while the field plate unit 83 underlies the copy. A cloud of electroscopic particles 24 overlies the copy to be deposited upon its upper face.

The image transducer unit 82 includes a matrix array of individual photosensitive elements 82P, each focused or imaged upon an individual region of the original and cumulatively spanning the entirety of the image area on the original. The field plate unit 83 includes a corresponding matrix array of individual field poles 83P each to be selectively energized, or not, under the control of a single corresponding photosensitive element 82P. The field pole tips are molded in a common insulated mounting block to locate the tips in a common plane and to insulate and segregate the tip fields from each other. Once again, 3 mil wires spaced 10 mils on centers may be used.

The distributor unit 83 is represented only functionally and may be of any form to provide the function of connecting each photosensitive element to control each corresponding field pole. Thus, the distributor unit 84 may include a separate energizing circuit for each field pole and having a separate electronic switch connected to each individual photoelectric element for applying a predetermined polarizing pulse to the corresponding pole to produce a half tone type of reproduction. Alternately, the distributor may provide a separate through circuit for each set of corresponding photosensitive and field pole elements, with each through circuit including amplifying and pulse forming circuitry as desired for producing a reproduction that embodies proper contrast relationships. In each of the arrangements, the selected field poles can be energized simultaneously so that the entire copy is reproduced instantaneously.

A sequential copy function may be employed in accordance with the arrangement diagrammatically illustrated in FIG. 8 wherein the distributor unit includes a separate distributor bank 85, 86 corresponding to each matrix array 82, 83, respectively. Each distributor bank has a terminal array individually connected to the elements of the corresponding matrix array and includes an electronic stepping switch to select the terminals serially for establishing an amplifier 87, which may include a pulse forming unit, between corresponding photosensitive and field pole elements in predetermined sequence. A synchronizing pulse generator 88 is shown connected to the distributor banks 85, 86 to synchronize the electronic stepping switches. This arrangement has the advantage of utilizing common amplifying and pulse forming circuitry but the complete copy cycle is slower.

While an articulated arrangement is illustrated in FIG. 8, it will be understood that the elements 85 to 88 may be embodied in a composite unit such as is shown at 84 in FIG. 7. As described previously, electroscopic particles are distributed across the upper face of the copy sheet and the field pole unit is positioned flush against the other face so that each field pole which is energized to a polarity opposite to that of the charged particles attracts the same to produce a deposit at the overlying copy sheet region, while the copy sheet regions overlying the remaining field poles and insulation regions remain unmarked. The continuous image pattern seen by the matrix of photosensitive elements is thus space quantized and is finally reproduced as a discrete mark and space pattern.

The smaller each field element and the closer the spacing therebetween, the finer is the resolution which can be ob-

tained. Micro circuit techniques can be employed for providing a closely spaced array of photosensitive elements. For example, silicon wafer structures selectively doped at individual areas and fitted with separate electrical connections are suited for high resolution work. Precise optical techniques are available or may be adapted for achieving accurate imaging of the individual wafer areas on the original. Alternatively, the image sensing may employ a matrix array of optical fibers arranged in tightly packed relation and each leading to a separate photoelectric element. Correspondingly, the field plate structure may be comprised of thin wire conductor elements each having an insulating coating or may be comprised of discrete poles provided by integrated circuit techniques.

While the embodiments illustrated in FIGS. 7 and 8 show a matrix array for the image transducer unit, this function can be performed by other devices such as a flying spot scanner or an image orthicon scanner providing a synchronized serial output. Image information can be stored on magnetic tape for feed to the field pole matrix.

An arrangement for achieving high resolution and for eliminating field distortion employs a multi-step copy sequence wherein the original 80 is fictitiously subdivided into four discrete area patterns such as are diagrammatically illustrated in FIG. 9. The first set of discrete areas 1 are copied at a first station by a matched pair of transducer and field pole matrices of the general type shown in FIGS. 7 and 8 but arranged according to the pattern represented in FIG. 9A. Similarly, the areas 2, 3 and 4 are copied at succeeding stations by matrix arrays containing the individual area patterns for 2, 3 and 4 until the entire image area is fully covered. Each set of matrices accommodates wider element spacing and the field poles may be mounted in molded epoxy blocks to provide desired insulation and dielectric characteristics to prevent fringing effects. Various other patterns of subdivision of the image can be selected to produce the same results and advantages but in each case, accurate registry of each matrix and sheet at each station is critical in order to prevent overlap of the deposit patterns.

Instead of providing separate distinct field pole patterns at successive stations, the field pole pattern of FIG. 9 can be indexed lengthwise and transversely at a single station to produce 4 complementary patterns at such station in a fashion to span the entire field. For example, the FIG. 9 pattern is indexed one pole pitch to the left as viewed in FIG. 9 to provide a second pattern filling the lengthwise gaps of the original, then is indexed one pole pitch downwardly to provide a pattern upon one-half of the transverse gaps in the original and finally is indexed one pole pitch to the right to complete the coverage of the transverse gaps and be in position for executing a new cycle of printing.

For many copy applications, it is preferred, as shown in FIGS. 10 and 11, to utilize an image transducer unit 92 employing essentially a one dimensional array of photosensitive elements 92P and a companion field pole unit 93 employing a matching one dimensional array of field poles 93P, with these units being interconnected through a distributor unit 94 and arranged to scan an original 90 and a copy 91 linearly and in synchronism. As illustrated for purposes of disclosure, the original 90 and the copy 91 are fed by synchronously driven pairs of feed rolls 95, 96 and the transducer and field pole units are mounted in fixed back-to-back relation spanning the travel path.

For purposes of illustration, a common drive motor 97 connects directly to one of the lower feed rolls 96 which is equipped with a sprocket 96S carrying a chain 98 that drives a sprocket 95S to power the upper feed rolls 95. Gears 95G, 96G are provided to power drive both rolls of each pair. The motor 97 may operate continuously in which case a distributor 94 comprised of individual through circuits can be employed. Alternately, the motor 97 may be of a stepping type to advance the papers one field pole pitch at a time. Instead of using paper feeding arrangements as shown, the paper may be fixedly registered and the motor may drive the transducer, dis-

tributor and field pole unit. The original 90 is shown lowermost with the transducer unit 92 spaced thereabove and having its photosensitive elements imaged at immediately adjacent areas thereof, each to trace a line scan of the original. The copy 91 is shown uppermost with the field pole unit 93 underlying and substantially flush therewith so that each pole tip traces a corresponding line scan on the copy.

A cloud of electroscopic particles 24 is distributed above the copy and a deposit pattern is effected in accordance with the shape of the through-field established by the selective energization of the pole tip array. The arrangement of FIGS. 10 and 11 can produce continuous marking along each scan line when continuous or D.C. control energy is utilized on the pole tips subject only to image contrast variations on the original. Alternately, a synchronized pulse generator may control periodic sampling of the image transducer unit in synchronized relation to the scanning movement to enable an energizing pulse to be sequenced to each pole tip once during each travel increment of one pole tip pitch.

The distributor unit 94 may be of any of the types referred to in connection with the distributor unit shown in FIGS. 7 and 8. One particular embodiment, as shown in FIG. 12, utilizes sequentially controlled multi-element one dimensional arrays for the image transducer 92 and the field pole unit 93. The transducer unit 92 is connected in one-to-one correspondence with an electronic switch bank 99 which is in turn connected in one-to-one correspondence with a multistage ring counter 100. Correspondingly, an electronic switch bank 101 is connected in one-to-one correspondence to the field pole unit 93 and to a multi-stage ring counter 102. A common amplifier 103 is connected between the electronic switch banks 99 and 101 and a synchronizing pulse generator 104 is connected to the ring counters 100 and 102 to synchronously actuate the same.

The operation of the embodiment of FIG. 12 is that each photosensitive element 92P is continuously sensing a corresponding image and is continuously providing input to a corresponding stage of the electronic switch bank 99. Concurrently, the synchronizing pulse generator 104 actuates the counters 100 and 102 to activate the first stages of each switch bank and establish a through circuit from the first photoelectric element 92P, through the amplifier 103, to the first field pole element 93P, then to activate the second stages of each switch bank to connect the second photoelectric element 92P to the second field pole element 93P, and so on until each array is electronically scanned. At this point, the last stage of the counter 102 actuates the motor 97 to produce one pole pitch distance of travel for registering the image unit 92 and field pole unit 93 with immediately adjacent regions of the original and the copy. Serial scanning of these units is then repeated in the new position.

An articulated embodiment utilizing a one dimensional scanning array is shown in FIG. 10B wherein a carrier transfer type of particle receiving material is shown at 23 for effecting transfer of a deposit pattern to an article A which is here represented as a milk bottle. The scanning and pole arrangement shown in FIG. 10B utilizes the same basic elements that are used in FIG. 10, namely, an image transducer unit 92, a companion field pole unit 93 and a distributor unit 94 interconnecting these elements. The system of FIG. 10B may be either a concurrent signal type, as described in relation to FIG. 10, or a sequential signal type, as described in relation to FIG. 12.

The original 90, which is to control the deposit pattern, is shown with markings representative of reference character ten (10), with the one-dimensional array of photocells of the image transducer unit 92 underlying and focused on the original by means of the lens 92L. In lieu of the lens 92L, a reflecting or focusing mirror or any other suitable device may be employed for imaging the photocells on the pattern that is to be reproduced. The field pole unit 93 is in the form of an arcuate segment disposed in uniformly spaced relation adjacent the correspondingly curved carrier transfer sheet 23 which

may be of Teflon or of any other reusable electrically insulating material. The transfer sheet 23 is shown mounted between a pair of supports 23S which maintain the curved configuration for the carrier sheet. The supports 23S are movable jointly to impress the carrier against the milk bottle A.

A cloud of electroscopic particles 24 is provided adjacent the transfer face of the carrier. As described for previous embodiments hereof, synchronized relative scanning movement is produced between the image transducer unit 92 and the original 90 and between the field pole unit 93 and the carrier 23 progressively to effect a deposit of a particle pattern representative of the original image 10. Thereafter, the supports 23S are movable in unison to impress the carrier against the milk bottle and cause the deposit pattern to transfer to the milk bottle. The transferred deposit pattern may then be fixed thereon in any suitable fashion.

With the arrangement illustrated in FIG. 10B, a D.C. electric through-field is used to effect initial deposit upon the carrier. The through-field in the illustrated arrangement can terminate on any grounded surfaces that may be present but the field is strongly concentrated at the tips of the field poles 93P so that good resolution is obtained even in the absence of a companion field plate. If desired, the carrier 23 may be presoftened to insure retention of the deposit pattern long enough to effect transfer or other materials may be used for the carrier for enhancing temporary retention of the particles.

The one dimensional field pole arrays, as described herein, require relative movement between the field pole unit 93 and the particle receiving material 23. In addition, in some instances, it is desired to maintain actual contact of the field poles with the particle receiving material. In order to eliminate the static electricity effects that may result when a condition of sliding friction exists between the field poles and the particle receiving material, a number of rolling contact types of field pole structures are shown in FIGS. 10C to 10H.

For example, in FIGS. 10C and 10D, the field pole unit 93 includes a housing 220 mounting an insulated support shaft 221 which carries an array of contact discs 222 to serve as the actual field pole elements. The contact discs 222 are positioned to project through a transverse window 220W provided in the top plate 220T of the housing, each disc to effect a progressive rolling line contact with the sheet of particle receiving material 23 to prevent sliding friction and static electricity effects. Each contact disc 222 is energized from a separate electrical wiper rod 223 arranged in one-to-one correspondence with the image sensing elements to be energized thereby, either concurrently or in synchronism, as desired.

Another embodiment, as illustrated in FIGS. 10E and 10F, comprises a field pole unit 93 having a housing 230 wherein the individual pole elements 93P consist of wire conductors arranged in closely spaced side-by-side relation within a molded epoxy block 93B. The tips of the wire conductors are coned, as shown at 93T, and project into a contact layer 231 of lubric plastic, such as Teflon. Each wire conductor is provided with a ball bearing contact element 232 which is journaled in a hemispherical socket provided in the Teflon layer to contact the conductor tip and the particle receiving material and undergo free rotation in situ, thereby eliminating static electricity. It may also be noted that each ball bearing 232 effects substantially a point contact with the particle receiving material to produce a concentrated electric through-field offering increased field strength and higher resolution.

A further anti-friction embodiment is illustrated in FIGS. 10G and 10H wherein successive rows of field poles 93P in the form of wire conductor stubs are shown embedded in a molded epoxy drum 93D which is journaled for rotation in a housing 240 that includes a transverse window 240W through which each conductor is to be presented for contact with the particle receiving material 23. The drum is to be rotatably driven by any suitable device (not shown).

A stationary row of wiper elements 223 are positioned in any suitable fashion for contact with each successive scanning row of field poles 93P at the time when such row is in contact

with the particle receiving material. The wiper elements 223 are controlled from an image transducer unit in the fashion previously described. Another feature incorporated in the embodiment of FIGS. 10G and 10H resides in the use of tipped field poles 93P to produce a concentrated electric through-field pattern. Thus, the conductor stubs terminate in coned tips 93T at their contact ends, these tips being embedded in the insulating plastic block except for the tip faces which are to contact and move in synchronism with the particle receiving material.

To provide maximum concentration of the field from each pole tip 93T, a companion stationary field plate array is shown in FIG. 10H as including a rigid plastic bar 242 having wire-like field plate elements 243 in one-to-one correspondence and having pointed tips 243T facing the tips 93T.

Another embodiment having a field pole unit 93 in the form of a one dimensional array of field pole elements is shown in FIG. 13 wherein the original 90, copy sheet 91, and field pole units 93 are disposed at predetermined positions. In this arrangement, a flying spot scanner 106 is provided with horizontal and vertical deflectors 107, 108, respectively, to develop a two dimensional scanning of the original 90 in a pattern similar to that of the familiar television raster but without interlacing. A single photoelectric sense element 109 is shown to monitor the entire image area scanned by the flying spot scanner and output is fed to a distributor 110 having an electronic stepping switch connected in one-to-one correspondence with the field pole elements.

A synchronizing pulse generator 104 connects to control circuits 107C and 108C for regulating horizontal and vertical scanning travel of the flying spot. The pulse generator 104 also connects to the distributor 110 to sequence output from the sensor 109 to the field pole elements 93P in synchronism with the horizontal sweep of the flying spot. Finally, the vertical control circuit 108C connects to the motor 97 to scan the field pole unit 93 in synchronism with the vertical sweep of the flying spot.

For improved resolution of the essentially one dimensional array of the field pole unit, the individual field pole elements 93P may be arranged in a four row staggered pattern, as illustrated in FIG. 13A. The staggered pattern enables each pole element to trace a distinct line but these distinct lines may be immediately adjacent while still maintaining adequate insulation between the various field pole elements 93P. By way of example, the periphery to periphery spacing of the field pole elements 93P may be about 7 mils.

The basic techniques incorporated in all of the disclosed embodiments are adaptable to multi-color printing or copying processes. In each case, a plurality of stations, one for each color component, are provided each to function for providing a deposit pattern corresponding to each color component. The individual color patterns collectively present a composite image on the finished copy. Where secondary colors are to be produced, overlays of primary color component deposit patterns can be employed. In multi-color processes, accurate registry and freedom from distortion are insured by positioning the particle receiving material in an equipotential plane of the electric through-field at each color station.

An integrated multi-color arrangement of the one dimensional scanning type is shown in FIG. 14 wherein the composite reproducer assembly 111 includes an image transducer unit 112 comprised of a separate section 112A, 112B and 112C corresponding to each color to be sensed and a field pole unit 113 comprised of matching sections 113A, 113B and 113C. Each transducer section comprises a one dimensional array of photosensitive elements 112P which as here represented are in a staggered row configuration to allow convenient physical mounting and electrical isolation while enabling immediately adjacent non-overlapping trace lines. Each field pole section has pole tips 113P staggered in matching relation to the spacing of the corresponding photosensitive elements 112P. A separate distribution unit 114A, 114B and 114C of any suitable type is provided for con-

trolling each pole section from the corresponding transducer section.

In this arrangement, the composite reproducer assembly 111 is mounted in fixed position and the original sheet and copy sheet are fed in synchronism by pairs of feed rolls 95, 96 so that each pair of matching transducer and field pole sections progressively scans and reproduces the correspondingly colored portions of the image. Each field pole section has a shielded corona generating filament and cloud chamber 115A, 115B and 115C, each equipped with an individual color component for the electroscopic particles associated with it. Thus, as shown, a separate colored particle chamber directly registers with each field pole section. Each distributor section 114A, 114B and 114C incorporates control circuitry substantially duplicating that of FIG. 12. Thus, during a single scanning of the image, the deposit patterns for the individual colors are formed progressively and in sequence in accordance with the mounting order of the individual color sections.

An articulated multi-color arrangement of a one dimensional scanning type is shown in FIG. 15 wherein a composite image transducer 112 includes a corresponding section 112A, 112B and 112C for each color and a composite field pole unit 113 includes matching sections 113A, 113B and 113C. Each transducer section uses a one dimensional staggered row array of sense elements 112P and each field pole section has a matched array of pole tips 113P. A composite distribution unit 114 comprised of distribution sections 114A, 114B and 114C is connected between the transducer and field pole units. A separate colored particle chamber 115A, 115B and 115C directly registers with each field pole section. Each chamber is of the cloud chamber type and is equipped with a shielded corona generating filament.

The distribution sections may be either of the type shown in FIG. 12 or may use separate through circuits between each sense element and corresponding field pole, as described in relation to FIG. 7. As represented here, the original sheet 90 and the copy sheet 91 are advanced in registry past the sensing and depositing stations and each color is separately and progressively sensed from the original and reproduced upon the copy. The final colors may be produced by juxtaposition and overprinting where the original includes secondary hues.

In FIG. 16, a closed circuit TV type of copy system uses the electric through-field principle. A modified cathode ray tube 120 is shown with the usual electron gun 121 and deflection plates 122 and 123 but is equipped with a faceplate 124 comprised of a matrix of field poles. A sheet of ordinary paper 23 overlies the faceplate 124 in contacting relation to serve as the particle receiving material. A vidicon camera 125 is shown focused on a sheet of original paper 126 from which copies are to be made. Video signals from the camera 125 are fed to the electron gun 121 to control the beam intensity impinging upon the faceplate. The deflection plate sweep circuits 122S and 123S provide a raster scanning pattern synchronized with the camera scanning pattern.

The faceplate 124 includes a rectangular matrix array of individual wires 124P embedded in an insulating base 124B to provide field poles that are sequentially scanned by the beam to be energized selectively and individually in accordance with the pattern seen on the original 126 by the vidicon camera 125. A cloud of electroscopic particles 24 are shown in the vicinity of the exposed face of the copy paper. These may be charged in any fashion previously described herein to a polarity opposite to the charge developed at each field pole by the electron beam. Each field pole assumes a polarity in accordance with the beam intensity and thereby provides an individually originating electric through-field acting to attract charged particles to deposit the same on the copy paper 23. The deposited particles are subsequently fused in place by any conventional process. It will be appreciated that the input to the cathode ray tube may be derived from any other suitable sequential scanner such as a flying spot scanner. A prerecorded tape or any tape of compatible signalling system

may also be used to supply input to the cathode ray tube. The tube 120 may be provided with a one dimensional array of wires 124P for simplicity, with the paper 23 being moved in scanning relation thereto.

Composite printing and molding arrangements are illustrated in FIGS. 17 and 18 to show an application of transfer printing which is carried out simultaneously with the actual molding of a plastic article. In this concept, dry toner particles are to be applied to a plastic parison while the parison is soft. With the use of dry toner particles, there is no need for treatment of the plastic surface such as is required in ink printing techniques.

For purposes of disclosure, a blow mold, as designated generally at 170, is of split form having mating mold parts 170A and 170B which are shown in section. One of the mold parts 170A incorporates a printing head 171 arranged to serve as an actual portion of the mold. The application of the simultaneous printing technique has particular merit in the case of blow molding and vacuum forming operations in which there is a minimum of sliding motion of the plastic parison against the mold surfaces. In the forms illustrated herein, the mold parts 170A and 170B may be of epoxy, as is known to the art.

In FIG. 17, the printing head 171 is represented in the style of a letterpress die characterized by raised portions 172P defining the characters to be imprinted upon the final plastic article. Epoxy permanently fills the recesses in the face of the die to lie flush with the raised surfaces and present a smooth surface to the parison.

In FIG. 18, the printing head 171 is represented as an epoxy block having a predetermined array of field poles 173P embedded therein and exposed to the mold cavity to define a desired printing pattern.

With either embodiment, a field energizing source (not shown) is connected to energize the print head when the mold halves are open. Toner particles are applied across the head as by a cloud, a magnetic brush, a cascade or any other suitable technique, the toner particles being attracted to the pole faces and held by the effect of the field. Excess toner is then blown or shaken from the head as necessary. The print head holds the toner in place as the mold parts are closed onto the parison. When suitable, the head may be maintained energized for holding the toner in place. The parison is blown in the usual way to fill the mold cavity.

As the warm plastic mold material presses against the toner on the field pole portions, the toner embeds and sticks to the soft surface of the plastic. As in conventional molding, the blown article solidifies as it cools, with the embedded toner being permanently lodged in place. Any excess of toner can be wiped away upon opening the mold halves and removing the finished article.

A finished article such as is produced by either of the embodiments of FIGS. 17 and 18 is illustrated in FIG. 19 in the form of a molded plastic bottle 180 having a molded in situ, permanently fused deposit pattern 181 of finely divided dry type electroscopic particles, here shown in the form of the numeral 10.

The embodiments of FIGS. 17 and 18 can be widely used with thermoplastic mold materials such as polyethylene, polypropylene and polystyrene, or the like, to produce articles characteristically having a non-polar exterior surface. The dry type electroscopic particles are molded in situ in this non-polar exterior surface and by virtue of this relationship are permanently fused in this non-polar surface. The resultant structure is clearly distinguishable from conventionally printed molded plastic articles where the exterior surface is flame treated or the like to produce a polarized surface that can then receive and retain ink spray printing.

Thus, while preferred constructional features of the invention are embodied in the structure illustrated herein, it is to be

understood that changes and variations may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

What I claim is:

1. A method for permanent marking, impregnating, printing and the like with finely divided electroscopic particles comprising disposing a substantially electrically insulating particle receiving material in a predetermined position, said material having a structural composition incorporating a myriad of distributed interstices, freely distributing finely divided electroscopic particles in the vicinity of one face of said material, said particles having a mean size on the order of 0.1 micron to be small enough to be driven into said interstices, and imposing an alternating polarity electric through-field to produce a peak field intensity in a range from about 1,000 volts per inch to the region where corona tends to form, said through-field applying force on said particles and intercepting said material and terminating beyond said position to deposit said distributed particles at least partly into said interstices in an indelibly lodged relation to said material.

2. A method in accordance with claim 1 and including positioning an edged field plate adjacent said face to concentrate said through-field at said face and thereby facilitate formation of field strength sufficient to achieve indelible lodging of said particles.

3. A method in accordance with claim 1 wherein said electric through-field is formed with a predetermined shape to lodge said particles in a pattern corresponding to said shape.

4. A method in accordance with claim 1 wherein said material is conventional porous copy paper.

5. A method in accordance with claim 4 wherein said particles range in size from about 0.01 micron to about 1 micron.

6. A method in accordance with claim 1 wherein said material is conventional porous copy paper, the size of said particles ranges from about 0.01 micron to about 1 micron and said alternating polarity electric through-field is applied at a frequency on the order of 15 KC.

7. A method in accordance with claim 1 wherein said material is conventional porous copy paper and said alternating polarity electric through-field is applied at a frequency on the order of 15 KC.

8. A method in accordance with claim 1 and wherein the step of disposing the particle receiving material includes locating the sheet of such material of substantially uniform thickness in a configuration assisting in defining an equipotential plane and wherein said electric through-field is imposed with predetermined shape to provide deposit of said materials on said particle receiving material in a pattern corresponding to said predetermined shape.

9. A method in accordance with claim 8 and including positioning an edged field plate adjacent said face of said material to effect concentration of the through-field.

10. A method in accordance with claim 1 and wherein the step of imposing an electric through-field comprises selectively imposing a plurality of individually originating alternating polarity electric through-fields to deposit said particles in a pattern corresponding to the locations of said through-fields.

11. A method in accordance with claim 10 and wherein a number of electrical signals are concurrently applied to concurrently establish a corresponding number of individually originating electric through-fields.

12. A method in accordance with claim 10 and wherein electrical signals are sequentially applied to establish said individually originating electric through-fields in predetermined timed relation.

13. A method in accordance with claim 10 and including positioning localized field plate means adjacent said face of said material to effect individual concentration of each of the through-fields.

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