Oct. 14, 1969 K. JOANNOU 3,473,074

GROUND ELECTRODE STRUCTURE FOR ELECTROPRINTING SYSTEM

Filed Aug. 31, 1967 3 Sheets-Sheet 1

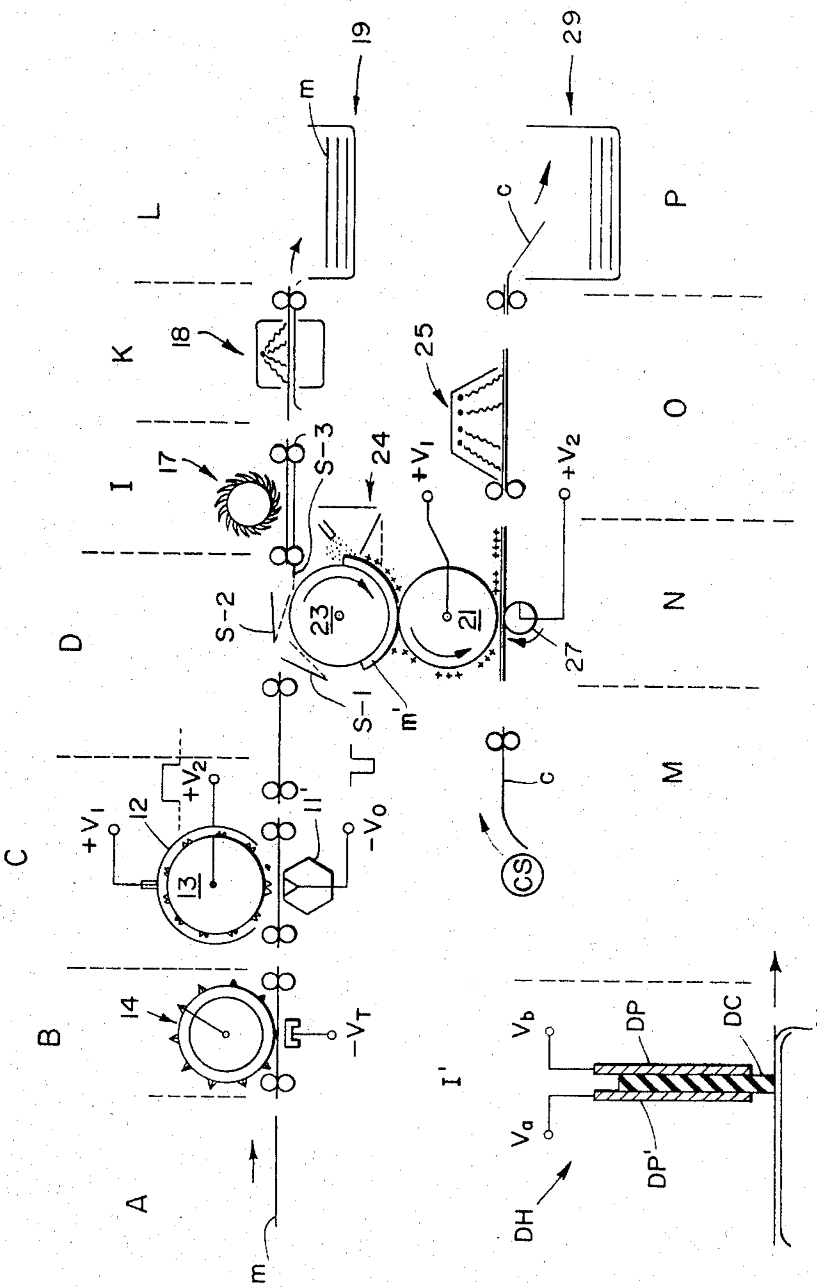

FIG. I

FIG. IA

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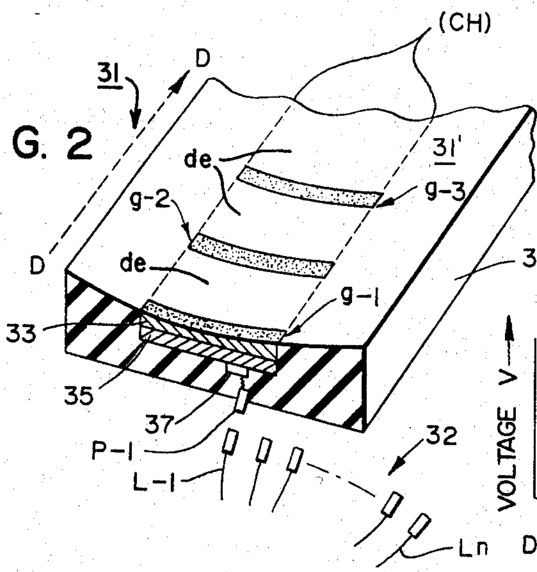
FIG. 2



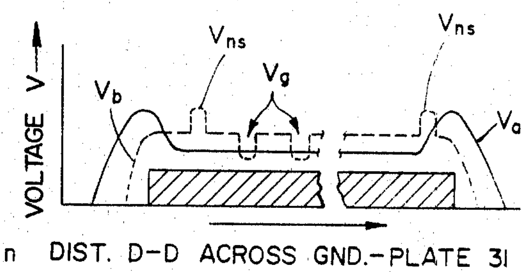


FIG. 3

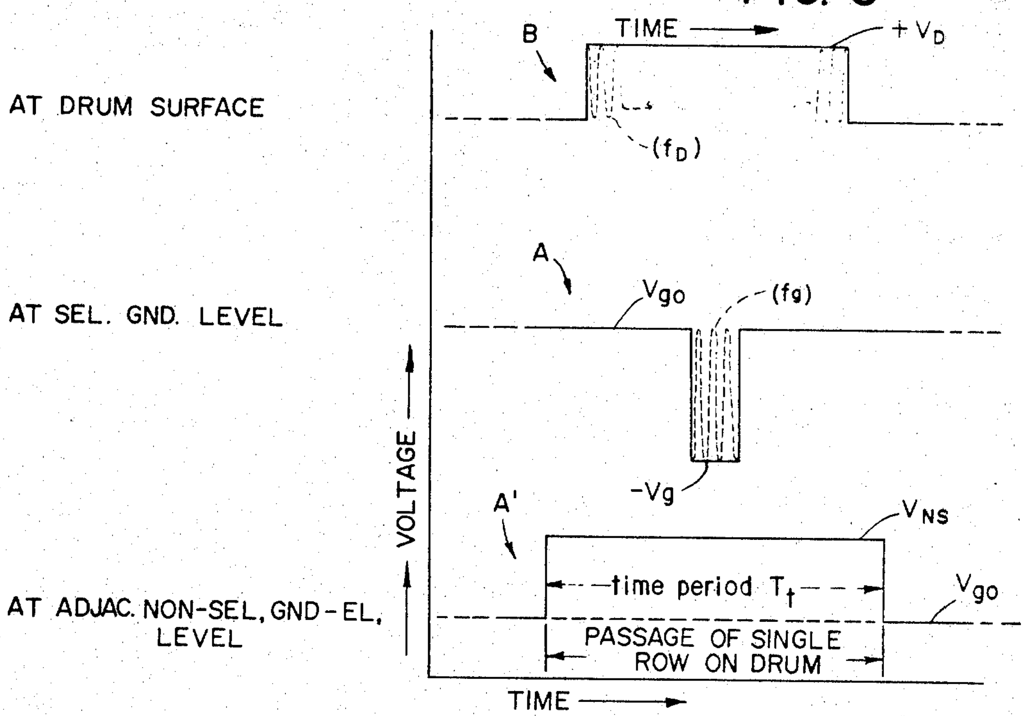


FIG. 4

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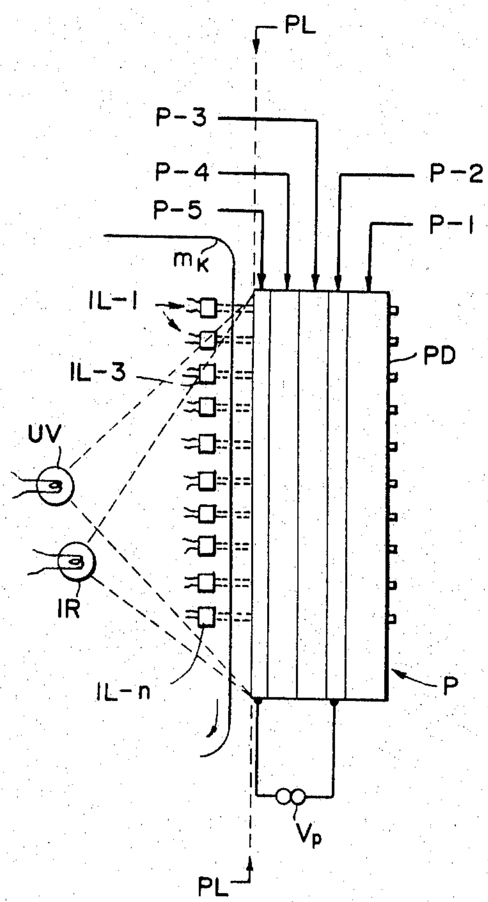

FIG. 5A

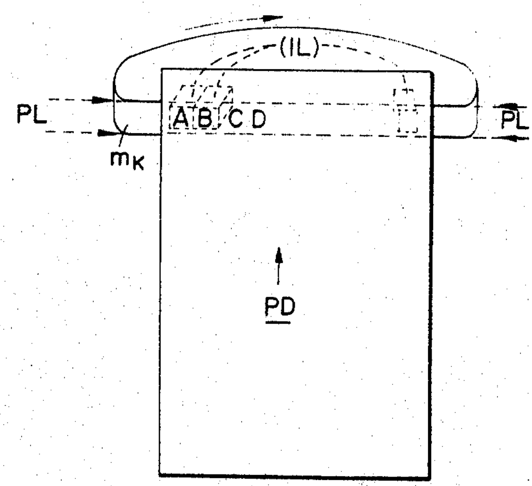

FIG. 5B

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GROUND ELECTRODE STRUCTURE FOR ELECTROPRINTING SYSTEM

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U.S. Cl. 313—351 2 Claims

ABSTRACT OF THE DISCLOSURE

An electrostatic printing system for imaging ("master") dielectric sheets from a charged, raised-font print-drum, thereafter toning the dielectric and transferring the toner-pattern to copy sheets, the dielectric master being optionally re-toned and retransferred, or cleaned for re-use, or developed for permanent storage. According to one refinement feature, this dielectric master may be discharged with an electrostatic contact probe. By another feature of the embodiment, the print-drum is confronted by an array of "mosaic" ground electrodes, one for each print position, each mosaic comprising a matrix of conductors, such as silver paint dispersed in a non-conductive mesh, each "selected" ground electrode mosaic preferably being attractingly charged in synchronism with the passing, selected row of the drum and in opposing voltage relation with adjacent "non-selected" electrode mosaics.

Background, features of the invention

In the data processing arts, we are witnessing revolutionary technical advances, mostly in electrical signal handling; less so in the man-communication area. Such advances have reduced the time required for handling information signals as well as in size-reduced, cost-reduced and simplified central processing units. But since such information signals still typically begin and end with man, they still need better means of rendering human-perceptible output, such as the printed copy customarily provided by high-speed printers. Unfortunately, improvements in this end of the computer, the terminal output end, have not kept pace with the stated improvements in speed, size-reduction and simplification. For instance, the common high-speed "impact-type" printer of today is typically the slowest and most cumbersome portion of a data processing system. Workers in the art have for some time tried to eliminate the problems of impact printers and have turned to "non-impact" printers as a solution. The present invention teaches an improved non-impact "electrostatic) printing arrangement especially adapted for high-speed computer output; yet with a minimum of expense and variance from the familiar operating mode of impact printers.

Workers in the art of electrostatic printing have tried, and are still trying, to provide a practical electrostatic high-speed printer for data processing applications. My attention was drawn to the use of a raised-font type electrostatic imaging plate, such as a typical impact-printing-drum, for generating a latent electrostatic printing image which, in turn, may be developed. The present invention is directed towards improving an electrostatic printing system using such a raised-font imaging plate. For instance, I have found that using a unit record dielectric medium instead of the conventional continuous-web dielectric is unexpectedly efficient. Such a medium may be toned, powder-transferred and, optionally, re-toned, permanently developed, or cleaned, in a very different manner from the web and with unique advantages. Therefore, it is an important object of the present invention to provide an electrostatic printing system suitable for producing high-speed printer output for computers and the like. It is a related object to produce such output using discontinuous, unit-record, dielectric media.

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Another object of the invention is to provide such a printing system wherein the ground electrode may be simpler and more efficiently, more conveniently fabricated; as well as providing a more efficient imaging of the dielectric.

Another object is to provide a toner (powder-pattern) transfer as aforedescribed, by means of a charged metallic transfer drum in an arrangement wherein the toning and/or copy-printing steps may be done entirely asynchronous of the imaging steps.

Another concern of the invention is to provide such an electrostatic printing system using a discharge station wherein the imaged dielectric may be cleaned and "erased" electrostatically with a contact probe.

Other objects and advantages will appear as the description proceeds. In accordance with one embodiment of the invention, described in detail below, a unit record dielectric is imaged between a rotating print-drum electrode and a "mosaic" ground electrode having at each column-position thereacross, an electrically isolated matrix electrode, this arrangement being operated so that one, or several, lines of print may be electrostatically imaged on the dielectric (much after the manner of high-speed impact-printing, using the type roll thereof) this dielectric thereafter being transported asynchronously downstream of this imaging station for toning. Adjacent the toning station and downstream, a metallic transfer drum is arranged to contact-and-charge-transfer the toner-pattern from the dielectric onto copy sheets, once or repeatedly. After this copy-transfer sequence, the dielectric may be selectively transported to one of several stations, a cleaning station and/or a discharging station (e.g. to erase the document and prepare it for re-use) or to a developing-fixing station to permanently fix the image on the dielectric.

In the figures, wherein like reference in the words denote like parts:

FIGURE 1 is a schematic flow-chart indicating the elements and methods in a (multi-copy) electrostatic printing system according to the invention, while FIGURE 1A shows an enlarged section of a charge-erasing probe optionally includable, at station I, in this system;

FIGURE 2 is a partial perspective showing of a "mosaic" ground electrode apt for use in the electrostatic imaging portion of the system of FIGURE 1;

FIGURE 3 is a representation of a preferred voltage profile across a ground electrode like that in FIGURE 2, according to the invention and, for comparison, a typical prior art voltage profile;

FIGURE 4 is a voltage timing chart indicating electrode voltage relations at an imaging station according to a preferred charging technique of the invention, the change of voltage levels with time being indicated across exemplary ("selected" and "non-selected") potrions of the ground electrode and an associated confronting surface of an imaging drum;

FIGURES 5A and 5B are side and front schematic showings, respectively, of an alternate printing/display system.

At the outset it will be helpful to understand that the general purpose of the system in FIGURE 1 is to reproduce, electrostatically and selectably, one or more copies (*c*) of printed material, this printing being originated at a print drum **13** (electrostatically imaged). Drum (type roll) **13** has raised character font and is operated much in the manner of a type roll in a conventional high speed impact printer for computer printout. To originate the electrostatic (character) image, a master sheet *m* is swept past print drum **13** at print station C where an elastrostatic image of a selected font (row) is applied, this image being developed and transferred to copy sheets *c* by a copy drum **21**. Master *m* may then either be recirculated for multiple copy or be cleaned and discharged with a corona charging of opposite polarity (to that of the imaging), such as at station I (I′), or it may be used to retain a permanent master copy—e.g. for offset-printing; such as by toning and fusing it at station K and then storing it in hopper **19**, or it may be discarded. Even at the outset, workers in the art will perceive that the general outlines of the system have novel characteristics such as the use of a master unit record *m* for accepting and optionally storing, the original electrostatic image (esi). This is unlike the continuous (web, drum etc.) imaging media in conventional systems. Besides its obvious advantages, such as facilitating cleaning of the image medium (e.g. for re-use), such as developing and retaining it for a permanent record etc., this "esi-master" also advantageously allows one to separate the imaging functions from the copying functions. This, for instance, can mean that after a first page-image has been generated on a first master *m*–**1** and transferred to copy drum **21**, a second master record *m*–**2** may be thrust into station C to be imaged during the time required to make one or several copies of *m*–**1** (on sheets *c* at copy station N). In this manner, copying can proceed faster than, and in parallel with, imaging; further the copy speed can be many times that of the imaging speed so that an image may be rather slowly and carefully rendered, while being, later, very quickly copy-transferred, the latter being a less fussy process. Furthermore, this simple copying system allows a variable number of copies, e.g. 1, 2 up to 10 to be very conveniently selected without complex mechanisms or the like—simply by directing recirculation of *m* about roll **23**.

To describe the embodiment of FIGURE 1 in more detail, let it be understood that a unit record "master" dielectric *m* is conventionally injected at an input station A (e.g. by unspooling a tape roll and cutting to length—not shown) to be imaged and transferred as follows. Here, and throughout the characterization of this system, it will be understood by those skilled in the art that the description is very schematic and only highlights the essential novel features. The bulk of the mechanical and electrical details (such as sheet transport mechanisms, mounting supports, voltage supply means power supplies, and the like) are left to the imagination of those skilled in the art since these are well known, conventional elements. Master medium *m* may comprise any "electrostatically-imageable" unit record, such as resistive paper sheet coated with a dielectric, such as Lucite, polyethylene, acrylic or the like. Master *m* is transported by rollers (schematically shown here and elsewhere) past a print station C (Station B is optional and will be discussed later) at a prescribed transport speed for printing characters thereon in line-by-line fashion as in the manner of a high-speed impact printing system (and column-by-column within each line). In fact, print drum **13** may comprise an embossed metal (font) drum as used in such systems, being somewhat modified for generating electrostatic images in association with ground assembly **11′**. Drum **13** is rotated as indicated, at high speeds past the "printline" (defined by its tangent parallel to ground electrode assembly **11′**) while the master *m* is stepped past this line (the imaging locus). A corona charging shield **12** is provided to positively charge the surface of print drum **13** in a known manner so that when ground assembly **11′** ("selected" plate *g* thereof—see FIGURE 2) experiences a prescribed electrical "firing pulse" (timed to coincide with the passage of a prescribed selected embossed character on drum **13**, as known in the art) the potential difference will apply electrostatic (charge) image of the selected font onto the surface of master *m* at (the proper associated column position thereof). This potential difference is preferably generated in coincidence with a positive select pulse ($+V_2$) on drum **13** and a negative fire-pulse ($-V_0$) at that column position on ground assembly **11′**. Assembly **11′** includes ground block **31** (cf. FIGURE 2), as described below according to another feature of the invention.

Thus, as described in detail below in connection with FIGURE 4, imaging drum **13** is preferably charged by corona shield **12** to a prescribed positive "printing" voltage $+V_1$ (during every print revolution when printing is to be effected, e.g. at about +200 volts), while an added, "step-level," voltage pulse $+V_2$ (e.g. at about +600 volts) is applied during the passage of each row of font. Thus, when one of the column-characters is a certain row is to be electrostatically-imaged onto a sheet *m*, that row of font being "stepped-up" to about +800 volts (cf. V_D, FIGURE 4), the column-plate segment (*g*) of block **31** corresponding to that column-position will be "select-charged" (e.g. to about 300 volts, cf. $-V_g$ in FIGURE 4). This will establish a prescribed "transfer potential" V_t between the "selected" ground electrode portion and that row of characters on drum **13** as it passes the ground assembly **11′**. Drum **13** will be understood as separated from the surface **31′** (cf. FIGURE 2) of ground block **31** by a constant prescribed separation distance, defining this minimum transfer potential difference V_t (here assumed at about 1,100 volts). Referring to FIGURE 4, it will be understood, for purposes of illustration, that this potential difference V_t will be the (non-algebraic) sum of voltage V_D on the drum and voltage $-V_g$ on the "selected " ground electrode (i.e. the sum of their absolute values). Thus, V_D+V_g is approximately V_t (or greater), whereas either voltage alone is well below that and their coincidence is required for an "imaging" to occur.

According to a feature of the invention when a "selected" ground plate portion (i.e. a column-electrode, e.g. *g*–**1**, *g*–**2** etc. in FIGURE 2) is so charged (during a "transfer time," T_t) in synchronism with the passage of drum **13**, all adjacent, "non-selected," column-electrodes will have been charged at an opposing (repulsing) voltage V_{NS} (FIGURE 4, e.g. about +500 volts).

Thus, during this time (T_t) these non-selected electrodes will not, in the slightest, attract any (imaging) ions, but rather will repel them and confine the imaging to the "selected" columns. In the prior art such "non-selected" ground plate portions will typically "float," inducing ghost imaging, and the like. This "opposed charging" scheme is schematically indicated in the multicolumn voltage profile V_b of FIGURE 3 where the potential V_b across ground block **31** is plotted as a function of distance D—D (see FIGURE 2 also). Thus, where a typical "continuous-conductor" type prior art ground block would have a voltage profile like curve V_a, exhibiting harmful "edge effects" and poor voltage-isolation, a mosaic array of separate, independent ground electrodes constructed (as plates, or conductor-segments *g*–**1**, etc. in FIGURE 2) and charged in the foregoing manner, according to the invention, will have the preferable flattened voltage profile V_b. Profile V_b will be understood as eliminating these "edge-effects," being much flattened. Further, according to the foregoing (selected/non-selected) "opposed charging" pattern, prescribed attracting or repelling voltage peaks will be presented at each ground electrode mosaic *g* (corresponding to a particular column position). These peaks represent either a negative, attracting, potential V_g (for a "selected" column electrode like *g*–**1** etc.) or else a more positive repelling potential V_{NS} (for a non-selected column-electrode). It will be readily apparent to those skilled in the art that such a discrete, selective, "opposed-polarity" voltage-profile is highly conducive to better and sharper image generation, and to improved signal-to-noise ratios and the like. It is conveniently implemented by the separated-column-electrode construction of the invention (per FIG-

URE 2) together with the mentioned opposed-polarity voltage-profile (per FIGURES 3, 4) so that (with the repulsive charging of non-selected mosaics *g*), the ionic transfer to the selected electrodes (*g*) is far more efficient and the image sharper.

As an improvement feature, the aforedescribed electrostatic imaging station may be optimized for better ion generation and transfer by using high frequency (*hf*) charging, either of the imaging electrode (drum **13**) or of the (selected) ground electrode (*g*), preferably of both. It was at first thought that the amount of ions generated might be increased and the reliability of charge-transfer improved by flooding the inter-electrode (drum-ground) gap with UV (ultra-violet) radiation, thereby also helping to make the system independent of environmental conditions (e.g. humidity changes). HF charging of the drum and/or ground electrodes is superior to this, however. For instance, it generates no undesirable heat as does the UV radiation. The specific frequency employed will depend upon the R-C constant of the charging circuits, including the electrode-to-ground resistance and capacitance (these may be made variable; note that air gap resistance can easily vary, e.g. with humidity changes) upon the R-C characteristic of the dielectric layer (on the master *m*), and upon the resistance of the master-backing, if any, (e.g. paper—cf. moisture content). With the described system and using an acrylic coated paper as the master medium *m*, a charging frequency range of 4.5–10 megacycles (mc.) (preferably about 4.5 mc.; see pulses f_D, f_g in FIGURE 4) was found suitable.

As aforesaid, station B is optional. It comprises form-imaging means, such as raised-font drum **14** and associated ground electrode means (operated in the manner of station C above), adapted to impress each master *m* with a fixed-pattern format (e.g. margin lines, indicia, etc.) supplementary to the variable (printing) patterns of station C and to be developed and copied therewith. The ground electrode (at the $-V_t$ terminal) may comprise one like assembly **11'** at station C, described above. Alternatively, in certain cases, a rotatable metal drum may be used for either ground electrode, and may also be adapted to advance sheet *m*, as known in the art.

The independent (mosaic) type ground electrode construction referred to above, will be understood as preferably comprising an embodiment like ground block **31** in FIGURE 2. Block **31** comprises a non-conductive substrate **31''**, the transfer surface **31'** of which may preferably be shaped to conform with the confronting surface of the imaging electrode (i.e. curved print drum **13**). Surface **31'** has a channel cut centrally thereacross as the locus of the print columns (channel CH in phantom, aligned along print-line direction D—D). Block or base **31** may be comprised of a suitable, "workable" non-conductor, i.e. a dielectric plastic such as amphenol or the like. Channel CH provides a convenient means of locating and housing the aforementioned separate column electrodes (independent plates) *g*–**1**, *g*–**2** etc.,—separated by dielectric insulating zones "*de*"—preferably in the following manner.

At each column-locus (print position) along D—D, channel CH (which may be a fraction of an inch deep and somewhat wider than the height of characters on drum **13**) is coated with a conductive layer **35** to fill channel CH part-way, but only at each column-locus (i.e. about as wide as a character-column on drum **13**, being registered under a respective one thereof). A single illustrative conductive layer **35** (for the first print position, *g*–1) is indicated in FIGURE 2, though one will be understood at each drum-column location. Connector pins (such as P–1 for the first print-position) are inserted from the opposite side of substrate **31''**, such as by drilling, together with associated connectors **37** to establish an ohmic contact with each respective conductive layer **35** (e.g. 132 for 132 print-columns on type roll **13**). With a pin *p* for each of the print positions, an associated array **32** of energizing leads L may be provided to be removably connected onto each pin (e.g. lead L–**1** being insertable for ohmic connection with *p*–**1**, L*n* with p-n, etc.). Each layer segment **35** (and associated superposed layer **33**) will be sufficiently longer than character-height (normal to D—D) as necessary to provide a prescribed dwell time T_t (see FIGURE 4) in that direction, though its width (direction D—D) should be relatively the same so as to maintain the print position width.

Superposed and registered upon each conductive layer **35** is affixed an associated semiconductive facing layer **33** filling the depth of channel CH to be conformed therewith at the curved exposed surface **31'**. Each layer **33** (one for each column locus *g*–**1**, *g*–**2**, etc.) may be understood as comprising a discrete ground-electrode (for a respective column) and comprising conductor-particles rather homogeneously dispersed throughout a dielectric matrix (e.g. a resin vehicle with metal particles) and intended for presenting a matrix of many separate discrete conductive points along each column electrode surface *g*–1, *g*–2 etc. For instance, a semi-conductive paint such as a homogeneous mixture of metal particles dispersed in a resin paint may be used to provide this "grainy" layer. Alternatively, a very convenient method is to affix a fine dielectric mesh (e.g. plastic grid) atop layers **35** and lay a conductive paint therein (e.g. liquid silver), the mesh providing the desired regular separation between conductive points. It is intended that such a surface present a plurality of conductive points (conductor matrix) rather than a gross continuous conductor (at each column position) so as to eliminate the aforementioned "edge-effects" and the like at each column-locus—this being effected in somewhat the way that providing a mosaic of discrete, separate column-electrodes *g*–**1**, *g*–**2** etc. across ground block **31** eliminates these undesirable effects across the overall plate (e.g. across **31** as illustrated in FIGURE 3).

One of the principle advantages to a novel ground electrode construction like the embodiment in FIGURE 2 is its convenience of fabrication. For instance, channel CH may be very conveniently cut (to the proper width) into the transfer face **31'** of substrate **31**, thus establishing the height-locus of each ground-electrode to be deposited therein; pin-connectors *p*–**1** etc. may then be readily inserted from the other side of **31** to communicate with CH such as by embedding in holes drilled at respective column position; and conductive layers **35** may then be laid down in channel CH in connecting ohmic relation with these connectors at each column-locus (defining electrode width thereby), such as by painting, plating or the like. A single, continuous conductive layer can be deposited entirely covering the bottom of channel CH and thereafter separations etched away so that segments **35** extend only across the character-width of their associated print-position. The semiconductive layers **33** may then be deposited to register on a respective segment **35**, being laid down in like manner, such as by plating selectively only onto layers **35**, by painting thereacross and removing the portions not covering conductive layers **35**, and so forth. Workers in the art will recognize that such a fabrication convenience is a distinct advantage in this art, since it not only produces a superior operating array of ground electrodes, but can be fabricated quite inexpensively and yet with reliable dimensional-control.

Metal-surfaced transfer drum

The toning and (powder-) image-transfer stations D, N, respectively in FIGURE 1 will be understood by those skilled in the art as functionally representing the zone where the imaged master *m*, after electrostatic-imaging thereof at station C, is to be transported for development and copy-transfer. At toning unit **24** a toner powder is quite conventionally applied to *m*, this powder-pattern thereafter being transferred to an aluminum drum **21** and thence to a copy sheet *c*, according to this feature of the invention. Thus, in the illustrated embodiment, at development station D, the master (see *m'*, enlarged for clarity) is directed down into engagement with a constantly rotating developer drum **23** according to the selected position of a conventional diverter S–2 and, while held on drum **23**, is transferred past toner unit **24** so that, as known in the art, the powder developer is caused to cling only to the electrostatically-imaged areas. Details of unit **24** are not shown and may comprise such well-known means as a magnetic brush. Drum **23** then further rotates master *m* into "near-tangency" (barely touching) with the surface of aluminum transfer drum **21**, kept rotating at about the same surface velocity and charged to a prescribed transfer voltage $+V_1$. It will become apparent that the developer powder pattern, or a goodly (depth) portion of it, may be thereby transferred to cling to the surface of drum **21** and be swept down into transfer-contact with a copy sheet *c*, the latter being advanced between drum **21** and cooperating charged idler roll **27**. Thereafter, the "now-printed" copy *c* may be transported to a following fixing station O to be fixed, such as by heat fuser **25** or the like, and thereafter be stacked in an output container **29** at output station P.

According to this feature of the embodiment, I have found that it is surprisingly advantageous to form transfer drum **21** so that its surface comprises a conductive metal finished to a rather high degree of smoothness. The transfer voltage $+V_1$ impressed on the surface of drum **21** should be great enough to assist the contact-transfer of the developer from developer drum **23** (this powder will touch drum **21** sufficiently to transfer mostly by contact, though partly electrostatically according to $+V_1$; this voltage being not so great as to appreciably degrade latent, electrostatic image on the passing *m'*; e.g. about a few hundred volts used with the described embodiment). One advantage of this arrangement, of course, is that $+V_1$ can be modulated to attract only a prescribed portion of the developer, leaving the remainder clinging to master *m'* to be used again, either in a second pass at drum **21**, or else as a permanent record (e.g. being fused at fixing station H), or the like. For good results, the preferred surface comprises smooth aluminum (or a like stable, non-oxidizing metal) and is finished to a smooth, semi-mirror, smoothness, since excessive grain produces "edge effects." Another advantage of this feature is that, where desired, a master *m'*, once developed, may be recirculated by drum **23** past drum **21** repeatedly (this being allowed by diverter S–3, with re-toning at unit **24** as necessary) so that drum **21** is repeatedly impressed with the same developed esi pattern—thus providing a selectable multiple-copy capability. (Of course, in some cases, one powder transfer onto drum **21** may provide it with sufficient developer to make a number of successive transfer copies without retoning.)

Those skilled in the art will recognize another advantage, in that so providing a unit record dielectric *m* as an image carrier together with the just-described developer-transfer station (D, N) also facilitates an unlimited copying capability—yet one that is convenient to control and easy to implement. As aforesaid, it will also be recognized that here, copy speed may be many times imaging speed (the latter at station C). Moreover, versatility is achieved by the ability to allow selection of a variable number of copies without complex equipment modifications. For instance, copy-out of from one to five copies of a particular master *m* may be selected simply according to when the pick-off diverter S–3 (shown in phantom in pick-off condition) commanded to operate (and peel *m* off drum **23**, to then be advanced into station I). With high-speed develop-transfer speeds, such a selection range in the number of copies need not delay the arrival or copying of a following master *m* either. Those skilled in the art will also recognize that another advantage of using such a unit record dielectric is that, after the "real time" copying has been effected, the master may be stored (e.g. either developed or retaining its electrostatic image) for future use (e.g. being later used as a master for offset printing, for subsequent powder-transfers etc.). Note above that station I is a cleaning station adapted for selectively (where the image is not to be fused at station K or otherwise maintained for storage) removing toner-powder with a scrubbing brush **17** or the like, as known in the art.

Another feature of the system relates to means for cleaning and discharging the dielectric medium *m*. It has been found that such media are capable of storing latent images for several days and of being subjected to a number of toner-transfers (such as at station N described above) without destruction of the original latent image. In many cases, even, sufficient toner powder remains clinging to master *m* for repeated transfers without re-toning. Thus, should one want to re-use this master, such as for storing new images, it is advisable to "refurbish" it by removing the powder and neutralizing (erasing) the latent electrostatic image. In evolving several such refurbishing methods, I developed the following preferred method wherein a wiping means, such as brush **17** at station I in FIGURE 1, is first applied to the master *m* (to be refurbished), thus removing the toner therefrom and, then, applying a discharging means, such as the erase-head, DH in FIGURE 1–A to remove the latent image.

When brush **17** is used for this wiping means, it will preferably be comprised of electroscopic material (e.g. fur bristles for attracting positively charged powder, glass for negative powder) and will be rotated to lightly contact (sweep) gently across the surface medium *m* so as to oppose its advance through station I, gently wiping away all remanent toner. It will be recognized that the wiping means may alternatively comprise a soft pad or web (made adhesive in certain cases) entrained around a cylindrical drive hub (as with brush **17**) to opposingly sweep advancing medium *m* with minimum surface contact. In certain cases, a pad may be formed as a soft web and conventionally entrained about a roller system conventionally to drive it and bring a longer cleaning surface into contact with the master.

The second phase of this preferred refurbishing process involves discharge master *m* erasingly after the above wiping so as to erase the latent esi on the dielectric coating thereof. As illustrated in FIGURE 1–A this is preferably effected with an electrostatic high-frequency erase-head (transducer) DH excited with a high voltage, high frequency signal. Station I' will be understood as preferably incorporated into station I with wiping brush **17** disposed upstream of transducer DH. Transducer DH is arranged so that its projected tip lightly brushes across record medium *m* as it is advanced therepast and is somewhat analogous to a magnetic erase head for erasing a magnetic medium. This electrostatic erasing should leave the medium in a neutral state; and hence, I prescribe a high frequency AC energization, DC energization leaving a net charge characteristically. Transducer DH preferably consists of a shim DC of high-dielectric material, such as barium titanate about 5 to 6 mils thick, mounted between a pair of brass plates DP, DP' so as to contact passing medium *m*. Shim DC is preferably coated with silver conductive paint, or the like, on both sides for better ohmic contact with plates DP, DP' and protrudes about 5 mils therebeyond as the tip for contacting medium *m*. An 800–1000 volt AC signal of 30 to 60 kc. is applied to the plates between terminals V_a, V_b to generate the erasing field through shim DC (in any event, not below about 300 volts). This erasing method was found especially effective for media in the order of about one-inch wide; for wider media, precautions should be taken to accommodate loading problems due to the voltage source as well as capacitance heating. Those skilled in the art will recognize that modified probes may be used in certain cases for such AC erasing; for instance, by modifying the materials and configuration of the dielectric shim and of the energizing-support means, etc.

Another method, less preferable and somewhat more conventional, for discharging (erasing) the dielectric medium *m* involves using corona discharge means for subjecting the record-dielectric surface to an "ionic bath" of opposite polarity to that of the latent image. For instance, a positive latent image may be erased by imposition of a negative corona discharge, leaving a net negative charge, typically, on the medium so that when a new esi image is impressed and toner is laid down, the erasing negative charge will repel the powder and thus only in the positive latent image areas will toner collect. However, if the surface of the medium is not very smooth and contains "piles," a non-uniform corona charge pattern will occur creating field gradients which will collect some powder, remaining as "background." Of course, the discharge rate according to this method will depend somewhat upon the number of corona wires and the level of corona voltage. In some cases, it may be desirable to additionally subject the opposite (non-image) side of the medium to a similar, but opposite-polarity, corona, that is, a corona impressing ions having the same polarity as the latent image areas. However, the aforementioned high frequency (AC) discharge method is preferred to this (DC) type erasing, since it can leave the medium in an electrically neutral state.

As an alternate to the aforementioned "two-step" refurbishing method (that is, removing the toner and discharging the dielectric), an alternate "single step" approach was found wherein the medium is passed through a shower of metallic granules which act to collect the remanent powder. These granules can thereby become tribo-electrically charged in such a manner as to discharge the latent image areas, at least to some extent. As these granules are tumbled across the surface of a developed image record, they will collect more and more powder until it is all removed. For continuous operation, however, it is somewhat difficult to remove the powder from the granules, or even to monitor the effectiveness of this cleaning process; therefore, here also, a two-step approach may be used wherein the remanent powder is first removed by the aforementioned soft-brush pad or web and the record then passed through the granule shower. However, one limitation on this method is a possible deterioration of the medium and surface scratching by the impact of these metallic granules.

FIGURES 5A and 5B show another recording system of the type adapted for high-speed computer print-out, as well as for display or the like. In general, this arrangement will be seen to comprise an endless belt type mask m_k adapted to be swept along a prescribed printing line plane PL—PL between radiation sources IL and a radiation-transducer panel P for producing radiation-images at prescribed print positions along PL—PL in the visible (or other) radiation spectrum, for display and/or recordation. A radiation source IL is provided to be selectably energizable in timed synchronism with particular areas of a mask so as to impress particular patterns at a particular column position along PL—PL.

More particularly, panel P preferably comprises an image-storage panel including an electro-luminescent layer P–3 adapted to be radiation-imaged from the direction of mask m_k through a translucent back-electrode layer **P–5** and an associated control layer P–4 as known in the art. Application of a pattern of prescribed radiation (wavelength etc. to which layer P–3 responds) can excite character-indicating (activated) portions of P–3 to produce a visible image at the viewing surface PD, being controlled through viewing electrode P–2 and transparent base sheet P–1, as known in the art. Preferably, the radiation pattern is generated at each print position (column) along PL—PL by an associated source (IL–1 through IL–N) positioned there to suffuse this column zone with the prescribed radiation at character-select times. Preferably, sources IL comprise fast (electrically switched), inexpensive infra-red sources such as gallium-arsenide injection lasers or the like. Such sources will be usually associated with a contrast source UV such as an ultraviolet (e.g. Xenon) lamp adapted to "activate" all the columns across PL—PL to thereafter be selectively erased by energized ones of lamps IL, timed to project their erase-pattern of IR through a prescribed (synchronously timed and selected) passing portion of mask m_k and thereby erase the outline of a prescribed character at this column on viewing surface PD. Associated with source UV is a prescribed infra-red source IR adapted to similarly suffuse all the positions across PL—PL, however, with an erasing (IR) radiation to thereby erase an entire print-line (all columns) and prepare for a new set of images (defining the succeeding print-line). It will be understood, that, except for character-cutouts, mask m_k opaque to IR radiation and hence that from lamp IR must be synchronously passed through a clear segment thereof or diverted optically therearound or the like. Alternatively, to using IR, the image may be erased by the proper selection of voltages on the layers of P, as understood in the art. As indicated in FIGURE 5B the character images produced along PL—PL may be viewed on surface PD and may, of course, be used to generate a recorded line of visible print images. These may be used for display or to record on optically responsive media, such as a Xerographic plate, zinc oxide paper or the like. It may be particularly advantageous to form plate P to be periodically stepped across plane of line PL—PL (as indicated by the arrow) so that the imaging system may form successive lines of print to be retained on panel P for prescribed viewing and/or copying. Note that panel P may be either a sheet to be stepped as indicated or made into an endless belt, or a drum, etc.

For the particular embodiment described, the image-generation may proceed as follows: the ultraviolet source UV is switched on preparatory to recording a first "line of print" image on P, the UV acting to flood all columns (along PL—PL) with light-stimulating energy. Character (or other) images will then be selectively formed at each column according to which cut-out portion of mask m_k is passing when the associated laser IL is turned-on. Mask m_k, of course, may preferably comprise either an opaque belt made transparent at the image-portions (so that IL erases the outline of the image) or, alternatively, comprise a transparent belt which is opaque only along the outline of an image (with IR, instead, erasing everything except the character-outline). The latter method allows lamp IR to erase rather conveniently, simply being kept "on" and directed through the mask while several character-opacities pass. Thus, either the images or their background may be radiating from surface PD. A bias-voltage V_p is supplied across **P–5**, **P–2** to retain and store this image. After the desired display and/or recording period, the print-line, or lines, on PD may then be erased by energizing infra-red source IR to suffuse those portions of it. The writing command energization of IL–**1** etc. may be timed and generated locally, or from a remote unit, e.g. for remote printer installation.

Precharged zinc oxide coated paper may be used as known in the art for copying these radiation images by simply precharging the paper sheet and then positioning it operatively confronting surface PD, the resultant esi being later developed as known in the art. Because of the fast switching time of the laser sources, IL, image generation will be very fast. Panel P will be seen as capable of storing and, even intensifying, the image or converting it to a prescribed wavelength at PD. Of course, one must match the imaging radiation with the spectral response of panel P and the copy medium. A page of print may conveniently be copied since being thus quickly generated on moving panel P, the entire page may be then transferred, at rest, to the copy means, which thus will not have to be stepped line-by-line past it.

In summary, it will appear that the invention above-described provides improved electrostatic imaging means and associated copy generating means. More particularly, it teaches an improved ground electrode construction and a related charging technique. It will be apparent that the novel ground electrode taught advantageously provides electrically isolated charged areas only at respective print positions and thus eliminates a great deal of distortion and uncontrollably-variable potential gradients in the imaging process. An associated advantage is the advantageous simplicity of fabrication by simple methods which are particularly apt for rendering such isolated electrode portions. This construction was seen to provide a conductor-matrix at each column ground-electrode and involved associated fabrication methods particularly advantageous. It will further be apparent that such a system, and especially such ground electrode construction, lends itself to a novel advantageous technique for differentially charging the image source plate, the "selected" ground electrodes and the "non-selected" ground electrodes, at imaging time. It will be apparent that by using unit-record dielectric sheets as the media for forming electrostatic images, a great convenience is derived, such as in the ability to separate the imaging portions of the system from the copying portions (and also to segregate associated transports, modify their speeds, etc.). It also allows multiple use of a medium (for multiple copies) and/or the storage of such a (master) medium for later use (e.g. by developing it or refurbishing it). It will further be apparent that an advantageous smooth-metal, charged transfer drum has been taught whereby the imaged, developed medium may be isolated physically from the imaging stations and the copying medium and may be re-used, the copy operation being made independent of, and much faster than, the image-transport operations.

While in accordance with the provisions of the statutes there have been illustrated and described, the best forms of the invention known, it will be apparent to those skilled in the art that changes may be made in the apparatus described without departing from the spirit of the invention as set forth in the appended claims, and that in some cases, certain features of the invention may be used to advantage or substituted for without a corresponding change or substitution in other features.

What is claimed as novel and desired to secure by Letters Patent is:

1. A composite ground electrode structure for use in an electrostatic printing system as part of an imaging station wherein said imaging station includes a cylindrically shaped print drum having conductive raised-font character segments affixed thereto and means for applying a first

potential to said character segments, said system being adapted to have a dielectric medium interposed between said print drum and said composite ground electrode structure in a manner to permit an electrostatic charge transfer to occur between said electrode structure and said character segments of said print drum within predetermined zones of said medium, said composite ground electrode structure comprising:

(a) a non-conductive ground block having a concave transfer surface positioned opposite said print drum;

(b) a plurality of column electrodes each imbedded in said block and defining a discrete rectangular area lying in said concave transfer surface, said rectangular areas being mutually spaced and aligned in said transfer surface and respectively corresponding to character segments of said print drum in registry therewith along said zones, each of said electrodes comprising a non-conductive mesh having the interstices thereof filled with a hardened conductor material there to present an array of discharge tips in said discrete rectangular area; and

(c) a like plurality of connector pins imbedded in said non-conductive ground blocks each electrically connected to one of said column electrodes.

2. A composite ground electrode structure as defined in claim 1 wherein each of said discrete column electrodes comprises a layer of non-conductor vehicle material and an array of separate conductor particles homogeneously dispersed therethrough such as to be cross-sectionally continuous therethrough to present chargeable electrical tips at said transfer surface.

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