

[54] METHOD OF PRINTING AND APPARATUS THEREFOR

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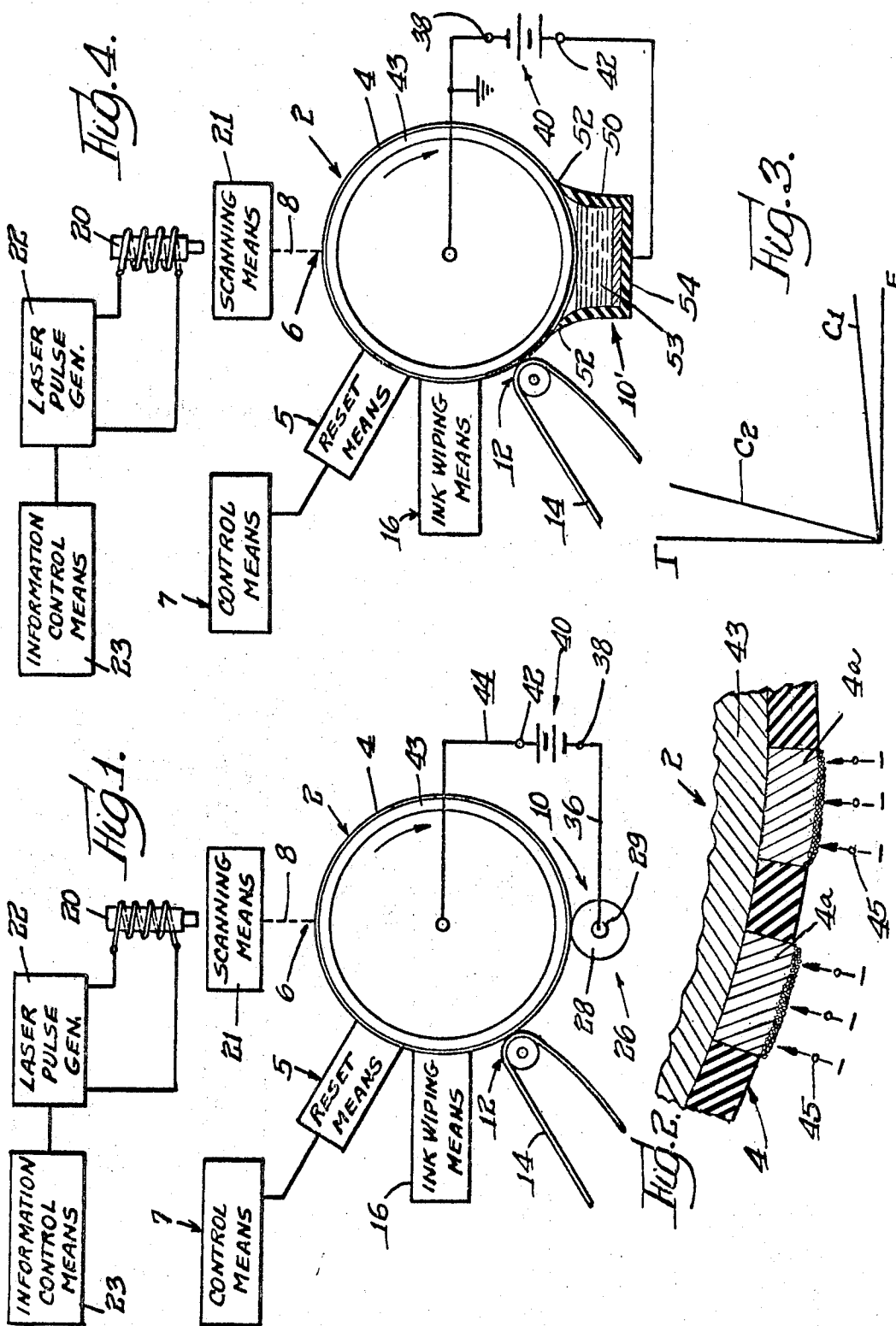
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ABSTRACT

The method of producing a raised image on a surface constituting a printing medium comprising the steps of providing a layer of memory material which is capable, when given amounts of energy are applied thereto, of having discrete portions thereof reversibly altered between a stable condition of high resistance and a stable condition of low resistance, said layer of memory material normally being in one of said conditions, selectively applying a first amount of energy to discrete portions of said layer to alter said layer thereat from said one normal condition to the other condition, and placing said energy subjected layer of memory material in an electro-coating cell where the layer forms an electrode therein upon which is electro-deposited charged particles in the cell over the low resistance portions thereof where the charged particles are neutralized. The method is most advantageously carried out by placing the layer of memory material on the surface of a rotatable drum which rotates the different circumferentially spaced areas of the drum in sequence (a) first to a station which applies said first amount of energy, such as a laser beam, to selected areas of the layer, (b) then to the open side of an electro-coating cell where the electro-deposited particles are applied, (c) and then to a printing station where the deposited particles are transferred to a sheet of material.

6 Claims, 4 Drawing Figures



METHOD OF PRINTING AND APPARATUS THEREFOR

The present invention relates to the printing art and to a method and apparatus for making a printing plate for transferring ink to a sheet of material. Some aspects of the invention relate to a printing system which provides an efficient means for making multiple copies, like the present xerography machines, utilizing a drum with a unique outer layer or coating thereon which facilitates the reception of readily alterable but indefinitely stable printing patterns thereon; capable of selectively receiving printing ink transferable to sheets of material.

The printing plate of the invention is most advantageously made of a memory material comprising a film or layer of semiconductor material like that disclosed and claimed in U.S. Pat. No. 3,271,591, granted on Sept. 6, 1966 to Stanford R. Ovshinsky. (While for purposes of illustration, reference is made to semiconductor materials of the type disclosed in U.S. Pat. No. 3,271,591, other materials having memory characteristics similar to those disclosed in this patent may be utilized in this invention.) The applications of this material heretofore considered were primarily current switching applications in electronic computer memory systems and the like. The semiconductor materials disclosed in said U.S. Pat. No. 3,271,591 may be formed as a film or layer of such material on a substrate or base. Discrete portions of such film or layer of semiconductor material can be reversibly altered between a stable low resistance condition to a stable high resistance condition by the feeding of a suitable voltage to the opposite surfaces of the discrete portions of the semiconductor involved. The discrete portions of such a layer of semiconductor material can be driven from a stable high resistance to a stable low resistance condition when the voltage applied to the opposite surfaces of such portions exceeds a given threshold value. This low resistance condition remains even when the applied voltage is removed from the semiconductor material or when a voltage is reapplied if the current flowing through the low resistance portions thereof is below a reset level or, even if the above the reset level, the current is allowed to flow for an appreciable period of time (e.g. 1-100 milliseconds or more) to enable the local order or localized bonding or molecular structural formation of the material to remain in the low resistance condition.

Assuming the film or layer to be in its stable high resistance condition, desired discrete portions thereof may be altered to a stable low resistance condition by energy applied thereto which can be in the form of energy pulses of sufficient duration (e.g. 1-100 milliseconds or more) to cause the alteration to the low resistance condition to take place and be frozen in. Such desired discrete portions may be realtered to the stable high resistance condition by energy applied thereto which can be in the form of energy pulses of short duration (e.g. 10 microseconds or less) to cause the realteration to the high resistance condition to take place and be frozen in.

Conversely, assuming the film or layer to be in its stable low resistance condition, desired discrete portions thereof may be altered to a stable high resistance condition by energy applied thereto which can be in the form of energy pulses of short duration (e.g. 10 micro-

seconds or less) to cause the alteration to the high resistance condition to take place and be frozen in. Such desired discrete portions may be realtered to the stable low resistance condition by energy applied thereto which can be in the form of energy pulses of sufficient duration (e.g. 1-100 milliseconds or more) to cause the realteration to the low resistance condition to take place and be frozen in.

The reversible alteration of desired discrete portions of the layer or film of the memory semiconductor material between the high resistance or insulating condition and the low resistance or conducting condition can involve configurational and conformational changes in atomic structure of the semiconductor material which is preferably a polymeric type structure, or charging and discharging the semiconductor material with current carriers, or combinations of the two wherein such changes in atomic structure freeze in the charged conditions. These structural changes, which can be of a subtle nature, may be readily effected by applications of various forms of energy at the desired discrete portions of the layer or film and they can produce and store information in various modes which may be readily read out or retrieved. It has been found, particularly where changes in atomic structure are involved, that the high resistance and low resistance conditions are substantially permanent and remain until reversibly charged to the other condition by the appropriate application of energy to make such change.

In its stable high resistance or insulating condition, the memory semiconductor material (which is preferably a polymeric material) is a substantially disordered and generally amorphous structure having local order and/or localized bonding for the atoms. Changes in the local order and/or localized bonding which constitute changes in atomic structure, i.e., structural changes, which can be of a subtle nature, provide drastic changes in the electrical characteristics of the semiconductor material, as for example, resistance, capacitance, dielectric constant, charge retention, and the like, and the changes in these various characteristics may be readily used in determining the condition of the desired discrete portions with respect to that of the remaining portions of the layer or film of semiconductor material for reading out or retrieving the information stored therein.

The changes in local order and/or localized bonding, providing the structural change in the semiconductor material, can be from a disordered condition to a more ordered condition, such as, for example, toward a more ordered crystalline like condition. The changes can be substantially within a short range order itself still involving a substantially disordered and generally amorphous condition, or can be from a short range order to a long range order which could provide a crystalline like or pseudo crystalline condition, all of these structural changes involving at least a change in local order and/or localized bonding and being reversible as desired. Desired amounts of such changes can be effected by applications of selected levels of energy.

The aforementioned alterations can be effected in various ways, as by energy in the form of electric fields, radiation or heat, or combinations thereof, the simplest being the use of heat. For example, where energy in the form of voltage and current is used, both electric fields and heat can be involved. Where energy in the form of electromagnetic energy, such as, photoflash lamp light,

is used both radiation and heat can be involved. Where energy in the form of particle beam energy, such as electron or proton beams is used, in addition to heat, there can also be involved a charging and flooding of the semiconductor material with current carriers which is made possible by the high density of local states in the forbidden band. Since heat energy is the simplest to use and explain, this invention will be considered below by the way of explanation in connection with the use of such heat energy, it being understood that other forms of energy may be used in lieu thereof or in combination therewith within the scope of this invention.

When energy in the form of energy pulses of relatively long duration is applied to desired discrete portions of a film or layer of the memory semiconductor material in its stable high resistance or insulating condition, such portions are heated over a prolonged period and changes in the local order and/or localized bonding occur during this period to alter the desired discrete portions of the semiconductor material to the stable low resistance condition which is frozen in. Such changes in the local order and/or localized bonding to form the stable low resistance condition can provide a more ordered condition, such as, for example, a condition toward a more ordered crystalline like condition, which produces a low resistance.

When realtering the desired discrete portions of the memory semiconductor material from the low resistance condition to the high resistance condition, by energy in the form of energy pulses of relatively short duration, sufficient energy is provided to heat the desired discrete portions of the semiconductor material sufficiently to realter the local order and/or localized bonding of the semiconductor material back to a less ordered condition, such as back to its substantially disordered and generally amorphous condition of high resistance which is frozen in. These same explanations apply where the normal condition of the memory semiconductor material is the low resistance or conducting condition and where the desired discrete portions thereof are altered to the high resistance or insulating condition.

In the memory semiconductor materials of this invention, it is found that the changes in local order and/or localized bonding as discussed above, in addition to providing changes in electrical resistance, they also provide changes in capacitance, dielectric constant, or the like.

The energy applied to the memory semiconductor material for altering and realtering the desired discrete portions thereof may take various forms, as for example, electrical energy in the form of voltage and current, beam energy, such as electromagnetic energy in the form of radiated heat, photoflash lamp light, laser beam energy or the like, particle beam energy, such as electron or proton beam energy, energy from a high voltage spark discharge or the like, or energy from a heated wire or a hot air stream or the like. These various forms of energy may be readily modulated to produce narrow discrete energy pulsations of desired duration and of desired intensity to effect the desired alteration and realteration of the desired discrete portions of the memory semiconductor material, they producing desired amounts of localized heat for desired durations for providing the desired pattern of information in the film or layer of the memory semiconductor material.

The pattern of information so produced in the memory semiconductor film or layer described remains permanently until positively erased, so that it is at all times available for display purposes. The invention is, therefore, particularly advantageous for various memory application. Also, by varying the energy content of the various aforesaid forms of energy used to set and reset desired discrete areas of the memory semiconductor material, the magnitude of the resistance and the other properties referred to can be accordingly varied with some memory materials.

In accordance with the present invention, printing plates may be made from a layer or film of variable resistance memory material as described by initially setting a pattern of high and low resistance conditions in the layer of memory material involved corresponding to the information or data to be printed by the same. This may be most conveniently effected by a pulsed laser beam or spark which is moved to scan the different areas of the layer of the memory material which are to form the active areas of the printing plate involved. The printing plate so treated, or a part thereof, is positioned in spaced relation to an electrode member to form an electrocoating cell in which an electrolyte containing charged particle forming materials are placed. (The term "electrocoating" is used herein generically to cover any electrode deposition process where charged metal ions, charged organic particles or the like are neutralized at an oppositely polarized electrode. Thus, both electroplating and electrophoresis coating processes are encompassed by this term.) The memory material is most advantageously deposited on a metal substrate connected to one of the terminals of a source or a direct current (D.C.) voltage. The aforesaid electrode member is connected to the other terminal thereof to form an electrocoating system wherein charged particles in the form of metal ions or charged ink or paint forming organic particles contained in a suitable electrolyte filling the space between the printing plate and the electrode member are neutralized and deposited at the low resistance regions of the memory material. Where metal layers are deposited, the thickness of the printing plate is increased in the regions of the memory material having a low resistance, so that raised portions on the surface thereof are provided which may accept ink as in the case of a normal printing plate with raised characters. However, in the most preferred form of the invention, the charged particles which are deposited upon the low resistance regions of the memory material form an ink which may be readily transferred to a sheet of paper by direct contact of the printing plate with the sheet material.

It is most advantageous for the layer of memory material to be coated on the periphery of a rotatable drum. In such case, the means for providing a pattern of high and low resistance on selected portions of the layer of memory material, such as the laser beam or spark producing means referred to in the electrocoating cell forming apparatus, a printing station constituting means for moving a strip of paper against the surface of the drum, and a resetting means like a heat radiation means may be conveniently positioned at different circumferential points along the drum periphery so a complete information storage and printing operation can be performed in one revolution of the drum. Since the layer of memory material on the drum periphery can, when it is not subjected to the resetting means,

maintain indefinitely a given pattern of information thereon, it is apparent that, unlike present xerography machines which require a slow light scanning operation each revolution of the drum, multiple copies may be printed at a very high rate of speed and without effecting an information storage operation during each revolution thereof. The aforementioned electrocoating cell forming apparatus may include an open top container with walls of insulating material, the open upper end thereof making sliding contact with the bottom surface of the drum mounted for rotation about a horizontal axis. The container is filled with a charged particle containing liquid electrolyte and the aforesaid electrode member. Alternatively, the apparatus may comprise a liquid absorbent pad or roller impregnated with the electrolyte and charged particle containing materials which pad or roller contacts the drum periphery.

The above and other features of the invention will become apparent upon making reference to the specification to follow, the claims and the drawings wherein:

FIG. 1 is a diagrammatic illustration of the preferred form of the present invention wherein a layer of memory semiconductor material forms a printing plate attached to the periphery of a rotating drum which carries the various circumferentially spaced portions of the drum sequentially past means for setting a pattern of high resistance and low resistance conditions over various discrete portions of the semiconductor layer, electrophoresis cell forming apparatus, a printing station, ink wiping means and memory material resetting means;

FIG. 2 is a fragmentary enlarged sectional view through the layer of semiconductor material at the surface of the drum shown in FIG. 1 as it leaves the electrophoresis cell forming apparatus;

FIG. 3 shows curves C_1 and C_2 respectively illustrating the current-voltage characteristics of the high and low resistance portions of the memory semiconductor layer at the periphery of the drum of FIG. 1; and

FIG. 4 is a diagrammatic illustration of another form of the present invention.

Referring now to FIG. 1, there is shown therein a printing system including a rotating drum generally indicated by reference 2 having an outer peripheral film or layer 4 of memory semiconductor material, most advantageously like that disclosed in said U.S. Pat. No. 3,271,591, wherein discrete portions thereof can be driven to stable high resistance conditions having an amorphous structure, by relatively short bursts of high energy and can be reset to a low resistance condition having a relatively ordered or crystalline structure by relatively long bursts of energy or by bulk heating thereof. The different circumferentially spaced segments of the drum 2 are moved sequentially past a reset means 5 which, when energized by a control means 7 (which may be a manual or computer control), directs heat or other forms of energy upon the entire area of each axial segment or upon discrete portions of the memory semiconductor layer passing thereby to set the same most advantageously to a low resistance condition. (Although much less preferred, the reset means 5 could be a means for setting all segments of the memory semiconductor layer 4 initially into a high resistance condition. However, this alternative of the invention would for most applications of the invention be too slow.) Each reset axial segment of the memory semiconductor layer is moved past a recording station 6

where a pulsed laser beam 8 or other suitable pulsed beam of energy is applied thereto in accordance with the pattern of information to be printed by the drum 2. The pulsating beam 8 of energy preferably scans the drum surface axially at a high speed to modify each data containing segment of the memory semiconductor layer 4 as it passes the recording station 6 to produce a desired pattern of high and low resistance regions in the layer. The portions of the memory semiconductor layer 4 operated upon by the beam 8 are carried to an ink applying station 10 where ink is selectively applied to the portions of the memory semiconductor layer 4 which are in a low resistance condition. The ink coated portions of the semiconductor layer 4 are then moved to a printing station 12 where ink on the memory semiconductor layer 4 is transferred to a sheet of material 14 moved across the drum surface at the peripheral speed of the drum. Portions of the memory semiconductor layer 4 which have passed the printing station 12 may then be moved against any suitable ink wiping means 16 which is effective to remove any excess ink remaining on the drum surface, particularly if a new pattern of information it to be stored on the memory semiconductor layer 4. Otherwise, the ink wiping means may be rendered ineffective where multiple copies are to be printed, as by moving the ink wiping means away from the drum.

Now that the basic components of the printing system have been introduced, additional details on some of these components will now be described. The memory semiconductor layer setting station 6 as illustrated includes a means 20 for producing a narrow well defined energy beam 8, which is a laser beam in the example of the invention being described. The means 20 is illustrated as a laser diode which is caused to generate a pulsed laser beam 8 under control of a laser pulse generator 22. The laser beam 8 under the influence of a beam scanning means 21 is caused rapidly to scan the length of the memory semiconductor layer 4 at a very high speed, so that successive scanning lines of the laser beam 8 affect closely circumferentially spaced segments or lines on the layer 4. The scanning means 21 may, for example, be a mirror system well known in the art. The energization of the laser pulse generator 22 is under control of an information control means 23 which may be a scanning photo-densitometer, a device well known in the art, which scans printed matter and develops pulses responding to the light or dark areas of the information being scanned. The scan control of the photo-densitometer may be operated in synchronism with the laser scanning means 21.

As previously indicated, the short bursts of laser beam energy impinging upon selected areas of the memory semiconductor layer 4 will set these selected areas from their low resistance conditions to their high resistance conditions, the portions of the semiconductor layer untouched by the laser beam 8 remaining in their initially reset or low resistance conditions.

FIG. 3 shows exemplary curves C_1 and C_2 illustrating the voltage-current characteristics of a discrete portion of the memory semiconductor layer 4 when respectively in its high and low resistance conditions. In the low resistance condition, a discrete portion of the semiconductor layer 4 acts as a good conductor of electricity. For example, the resistivity of a low resistance portion of the layer 4 may be about 1 ohm per centimeter and the resistivity of a high resistance portion may be

10^4 ohms centimeter. (The memory semiconductor layer 4 may have a thickness, for example of, 10 microns.) The resistivity and layer thickness examples given above, however, may vary widely.

The ink receiving station 10 illustrates in FIG. 1 is an electrophoresis type electrocoating cell generally indicated by reference 26. This cell most advantageously includes a porous electrolyte wetted pad or roll 28 made of a liquid absorbent material and making rolling contact with the semiconductor layer 4 along the entire axial length thereof. The roller 28 has a central metal shaft member 29 which acts also as an electrode member connected by a conductor 36 to a terminal 38 of a D.C. voltage source 40. The other terminal 42 of the D.C. voltage source 40 is connected by a conductor 44 to the metal frame of the drum 2. It is assumed that the drum 2 has a conductive outer periphery 43 (FIG. 2) which is in good intimate electrical contact with the inner surface of the memory semiconductor layer 4 over the entire extent thereof. Thus, the voltage at the terminal 42 of the D.C. voltage source 40 is applied to all inner surface areas of the memory semiconductor layer 4 through the metal peripheral surface thereof.

Electrophoresis cells are well known in the art and have been heretofore used for applying paint or pigmented ink like materials to an electrode forming surface. The electrolyte in an electrophoresis cell includes generally organic materials, such as emulsified or solubilized opaque resins with dispersed pigments, supplementary surfactants, and generally some organic solvents. Generally, the resin particles are treated so as to be negatively charged particles. The resin particles are preferably carried by the portion of the electrolyte located in the regions of the pad or roll 28 located within the peripheral portion thereof. If the resin particles are negatively charged, the positive terminal of the voltage source 40 is connected to the drum frame 43 and the shaft 29 of the roller 26 is connected to the negative terminal of the D.C. voltage source 40. The negatively charged resin particles from the roll 26 are attracted to the areas of the memory semiconductor layer 4 in a low resistance condition where the negative charge on the particles are readily given up to neutralize the particles. FIG. 2 illustrates the electrophoresis process wherein the charged ink forming particles indicated by reference number 45 become deposited on the regions 4a of the memory semiconductor layer 4 which are in a low resistance condition. The ink coated portions of the memory semiconductor layer 4 are then transferred to the sheet of material 14 moved against the surface of the rotating drum 2.

FIG. 4 shows a printing system like that shown in FIG. 1 with a modified ink applying station 10'. The ink applying station 10' has an electrophoresis cell forming apparatus which includes an open top container 50 made of insulating material and having flexible upper wall portions 52-52 which make a wiping liquid sealing contact with the bottom portion of the rotating drum 2 along substantially the entire axial length thereof. The container 50 is filled with a body of liquid electrolyte 53 carrying ink forming particles. The body of electrolyte 53 fills the space between the portion of the drum 2 passing between the upper portions 52-52 of the container 50 and an electrode member 54 in contact with the electrolyte 53 at the bottom of the container 50. In the example illustrated in FIG. 4, it is assumed that the charged ink forming particles which

are attracted to the drum surface have a positive charge. Accordingly, the electrode member 54 is connected to the positive terminal 42 of the D.C. voltage source 40 and the frame of the drum 2 is connected to the negative terminal 38 of the D.C. voltage source 40. (Of course, the connections to the D.C. voltage source 40 may be reversed when the charged particles in the electrolyte 53 are negatively charged as the particles 45 in FIG. 2.)

The present invention is applicable to the construction of printing plates with raised metal coated portions to form a normal printing plate to the raised surfaces of which are applied suitable inking materials which are transferred to sheets of paper in the normal way. In such case, the apparatus 10' could constitute an electroplating cell where the electrolyte in the container 50 carries suitable positive metallic ions which are attracted to and deposited or collected upon the conductive portions of the memory semiconductor layer 4. Such a printing plate however could not be readily altered.

The present invention has thus provided, among other things, an advantageous high speed printing system utilizing a memory semiconductor material in a unique way. Therefore, when the memory semiconductor material described above is used to form a surface or part thereof of a printing system contemplated by this invention many advantages are obtained. For example, a particular pattern to be printed is quickly and easily modified or completely eliminated and a new pattern put in its place on the same printing surface. Also, once a particular pattern is formed on the surface of semiconductor material it may be used to produce multiple copies in the same manner as a conventional printing plate.

It will be understood that numerous modifications may be made in the most preferred forms of the invention described above without deviating from the broader aspects of the present invention.

I claim:

1. A method of printing comprising: providing a layer of memory material capable, when memory material setting energy is momentarily applied thereto, of having discrete portions thereof reversibly structurally altered from a first stable structural substantially amorphous condition of high resistance to a second stable condition of a more ordered or crystalline structure and low resistance, and capable when memory material resetting energy is momentarily applied thereto of having discrete portions thereof reversibly structurally altered from said second stable condition of a more ordered or crystalline structure and low resistance to said first stable structural substantially amorphous condition of high resistance, each of said structural conditions persisting indefinitely even after all sources of energy have been removed therefrom, the layer of memory material normally initially being in one of said stable conditions; moving said layer of memory material to an energy applying station where said memory material setting energy is applied to selected portions of the layer of memory material to form a given pattern of high and low resistance conditions therein in accordance with the indicia to be printed; moving the energy treated portions of said layer of memory material to a printing ink-applying station where the layer of memory material forms an electrode of an electrocoating cell and an electrolyte containing charged transferable

ink-forming particles is applied thereto together with a source of D.C. voltage connected between the layer of memory material and another electrode contacting said electrolyte, whereby said charged ink-forming particles in said electrolyte are electro-deposited upon the low resistance portions of said layer of memory material; then moving the ink-coated portions of said layer of memory material to a printing station where the ink particles on said layer of memory material are transferred upon a surface to be printed; repeatedly moving the initially energy treated portions of said layer of memory material to said ink-applying station and to said printing station without re-applying any energy to said initially energy treated portions of said layer of memory material, to make additional imprints of said pattern on new surfaces to be printed at the printing station; and after the desired number of printing operations are performed using the previously set pattern of high and low resistance conditions on said layer of memory material then moving the layer of memory material to a resetting station where portions of the initially energy treated portions of said layer of memory material are subjected to said memory material resetting energy to reset the same to said initial one stable condition thereof and to said energy applying station to apply a new pattern of high and low resistance conditions thereon; and then moving said layer of memory material to said ink-applying and printing stations to apply fresh ink thereto by electro-deposition thereof

and to transfer the deposited ink onto a new surface to be printed.

2. The method of claim 1 wherein said electrolyte is supplied to said layer of memory material by an electrolyte-wetted pad contacting said layer of memory material.

3. The method of claim 2 wherein said pad is in the form of a cylindrical roll making rolling contact with the layer of memory material.

4. The method of claim 1 wherein said layer of memory material is applied to a surface of a drum, and said energy applying, printing ink-applying, and printing stations are located at different circumferentially spaced points around the drum.

5. The method of claim 4 wherein said ink particle-containing electrolyte is carried in an open-top housing containing said electrolyte and formed by insulating walls the top portions of which makes sliding contact with the layer of memory material at the bottom of the drum, the electrolyte filling said housing up to said layer of memory material.

6. The method of claim 1 wherein said electrolyte is applied to the layer of memory material by means of an open-top housing containing said electrolyte formed by insulating walls, the top portions of which make contact with said layer of memory material, the electrolyte in the housing touching the layer of memory material.

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