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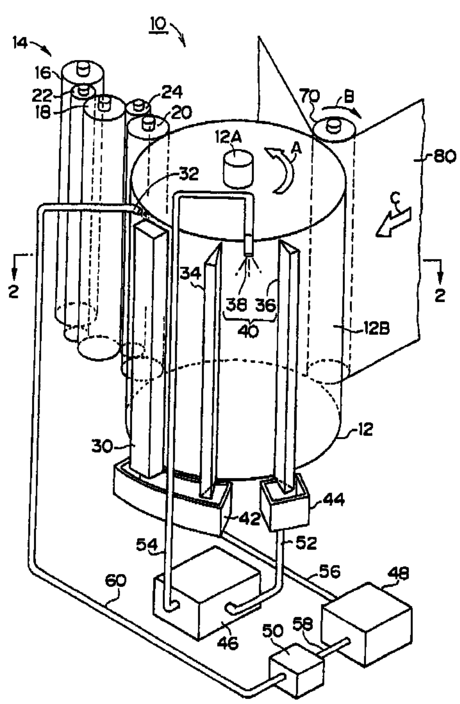
(54) ELECTRICAL COAGULATION PRINTING METHOD AND ELECTRICAL COAGULATION PRINTING APPARATUS

(57) Electrocoagulation printing method and apparatus are provided which prevents formation of undesirable background (fogging) on electrocoagulation printed images. The apparatus includes: a revolving cylinder (12) formed of an electrolytically inert metal and having a continuous passivated surface (12B) as a positive electrode active surface moving along a predetermined path; an inker (32) which feeds electrocoagulation printing ink for the surface (12B); a printing head (30) for forming on the surface (12B) dots of coagulated ink by electrocoagulation; an oil cascade unit (40) which supplies a first oily substance for the surface (12B) and removes fogging ink mixed with the first oily substance from the surface (12B) without altering the dots of coagulated ink; and a pressure roller (70) which brings a printing substrate (80) into contact with the dots of coagulated ink to cause transfer of the dots of coagulated ink from the surface (12B) to the printing substrate (80). The oil cascade unit (40) allows the fogging ink mixed with the first oily substance to be dislodged from the surface (12B) without altering the dots of coagulated ink, and therefore, formation of an undesirable background (fogging) on a printed images can be prevented.

FIG. 1



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Description

FIELD OF THE INVENTION

The present invention pertains to improvements in the field of electrocoagulation printing. More particularly, the invention relates to an electrocoagulation printing method and apparatus which prevent formation of undesirable background on electrocoagulation printed images.

BACKGROUND OF THE INVENTION

In U.S. Patent No. 4,895,629 of January 23, 1990, Applicant has described a high-speed electrocoagulation printing method and apparatus in which use is made of a positive electrode in the form of a revolving cylinder having a passivated surface onto which dots of colored, coagulated colloid representative of an image are produced. These dots of colored, coagulated colloid are thereafter contacted with a substrate such as paper to cause transfer of the colored, coagulated colloid onto the substrate and thereby imprint the substrate with the image. As explained in this U.S. patent, the positive electrode is coated with an olefinic substance, or a dispersion containing an olefinic substance and a metal oxide prior to electrical energization of the negative electrodes in order to weaken the adherence of the dots of coagulated colloid to the positive electrode and also to prevent an uncontrolled corrosion of the positive electrode. In addition, gas generated as a result of electrolysis upon energizing the negative electrodes is consumed by reaction with the olefinic substance so that there is no gas accumulation between the negative and positive electrodes.

The electrocoagulation printing ink which is injected into the gap defined between the positive and negative electrodes consists essentially of a liquid colloidal dispersion containing an electrolytically coagulable colloid, a dispersing medium, a soluble electrolyte and a coloring agent. Where the coloring agent used is a pigment, a dispersing agent is added for uniformly dispersing the pigment into the ink. After coagulation of the colloid, any remaining non-coagulated colloid is removed from the surface of the positive electrode, for example, by scraping the surface with a soft rubber squeegee, so as to fully uncover the colored, coagulated colloid which is thereafter transferred onto the substrate.

When a polychromic image is desired, the negative and positive electrodes, the positive electrode coating device, ink injector and soft rubber squeegee are arranged to define a printing unit and several printing units each using a coloring agent of different color are disposed in tandem relation to produce several differently colored images of coagulated colloid which are transferred at respective transfer stations onto the substrate in superimposed relation to provide the desired polychromic image. Alternatively, the printing units can be arranged around a single roller (a pressure roller) adapted to bring the substrate into contact with the dots of colored, coagulated colloid produced by each printing unit, and the substrate which is in the form of a continuous web is partially wrapped around the roller and passed through the respective transfer stations for being imprinted with the differently colored images in superimposed relation.

The present inventors have observed that the rubber squeegee which is used for removing non-coagulated colloid from the surface of the positive electrode leaves on the surface coagulated colloid (some of coagulated dots scraped by the soft rubber squeegee) and non-coagulated colloid (non-coagulated ink left after having been scraped by the soft rubber squeegee) which is transferred with the colored, coagulated colloid onto the substrate during contact with same. The above-described coagulated colloid and non-coagulated colloid create on a non-image portion an undesirable background (so-called fogging). Further, when black (K), cyan (C), magenta (M), and yellow (Y) coloring agents are used to provide a polychromic image and these images are transferred onto the substrate in superimposed relation, mixing of colors caused by fogging of several colors adversely affects color saturation.

DISCLOSURE OF THE INVENTION

It is therefore an object of the present invention to overcome the above drawbacks and to provide method and apparatus of preventing formation of undesirable background on electrocoagulation printed images.

A first aspect of the present invention is an electrocoagulation printing method comprising the steps of: (a) providing a positive electrode made of an electrolytically inert metal and having a continuous passivated surface as a positive electrode active surface moving along a predetermined path; (b) forming on the positive electrode active surface a plurality of dots of coagulated ink representative of a desired image by electrocoagulation of electrocoagulation printing ink; (c) applying a first oily substance onto the positive electrode active surface to remove fogging ink mixed with the first oily substance from the positive electrode active surface without altering the dots of coagulated ink; and (d) bringing a substrate into contact with the dots of coagulated ink to cause transfer of the dots of coagulated ink from the positive electrode active surface onto the substrate.

In the specification given herein, "fogging ink" means coagulated ink and non-coagulated ink which are left on a non-image portion. According to the present invention, step (c) is carried out by applying on the positive electrode active surface a first oily substance to dislodge fogging ink mixed with the first oily sub stance from the positive electrode active surface without altering the dots of coagulated ink. Accordingly, the fogging ink can be removed from a non-image portion of the positive electrode active surface in such a state that unaltered dots of coagulated ink are left on the positive electrode active surface. Since the fogging ink does not remain on the non-image portion, formation of undesirable background (so-called fogging) on a printed image can be prevented.

A second aspect of the present invention is an electrocoagulation printing apparatus comprising: a positive electrode made of an electrolytically inert metal and having a continuous passivated surface as a positive electrode active surface moving along a predetermined path; ink feeding part which supplies electrocoagulation printing ink onto the positive electrode active surface; a negative electrode for forming on the positive electrode active surface dots of coagulated ink by electrocoagulation; a fogging ink removing part which applies a first oily substance on the positive electrode active surface and removes the fogging ink mixed with the first oily substance from the positive electrode active surface without altering the dots of coagulated ink; and a transfer part which brings a substrate into contact with the dots of coagulated ink to cause transfer of the dots of coagulated ink from the positive electrode active surface to the substrate.

According to the present invention, the fogging ink removing part is used to remove the fogging ink mixed with the first oily substance from the positive electrode active surface without altering the dots of coagulated ink. For this reason, in the same way as in the first aspect, formation of undesirable background (so-called fogging) on the printed image can be prevented.

In this case, polychromic printing may be effected with a plurality of images of different colors (including transparent color) being formed in a plurality of printing apparatuses according to the present invention. In such a printing system, fogging ink of each color can be removed, and therefore, a polychromic image in which deterioration of color saturation caused by mixture of colors is improved can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an outside perspective view of an electrocoagulation printing apparatus to which the present invention is applied.

Fig. 2 is a cross-sectional view taken along the lines 2-2 in Fig. 1.

Fig. 3(A) is a diagram showing the state of the surface of a revolving cylinder at position (a) shown in Fig. 2; Fig. 3(B) is a diagram showing the state of the surface of the revolving cylinder at position (b) shown in Fig. 2; Fig. 3(C) is a diagram showing the state of the surface of the revolving cylinder at position (c) shown in Fig. 2; Fig. 3(D) is a diagram showing the state of the surface of the revolving cylinder at position (d) shown in Fig. 2; Fig. 3(E) is a diagram showing the state of the surface of the revolving cylinder at position (e) shown in Fig. 2; and Fig. 3(F) is a diagram showing the state of the surface of the revolving cylinder at position (f) shown in Fig. 2.

Fig. 4 is an outside perspective view of a printing system when polychromic printing is effected with the electrocoagulation printing apparatus being disposed in tandem relation.

Fig. 5 is an outside perspective view of a printing system when polychromic printing is effected by a single revolving cylinder.

Fig. 6 is a block diagram of a controller of the electrocoagulation printing apparatus.

Fig. 7 is a flowchart which schematically shows an electrocoagulation printing method to which the present invention is applied.

DESCRIPTION OF THE PREFERRED EMBODIMENTS FOR IMPLEMENTING THE INVENTION

First, the structure of an electrocoagulation printing apparatus to which the present invention is applied will be described with reference to Figs. 1, 2, and 6.

As shown in Figs. 1 and 2, an electrocoagulation printing apparatus 10 to which the present invention is applied includes a columnar revolving cylinder 12 serving as a positive electrode at the central portion thereof. The revolving cylinder 12 is axially supported in a vertical direction (i.e., a longitudinal direction) thereof so as to be rotatable around a revolving cylinder shaft 12A in a predetermined direction (i.e., the direction indicated by arrow A in Figs. 1 and 2). The revolving cylinder shaft 12A is connected to a motor 162 (see Fig. 6) via a gear or the like (not shown) and the revolving cylinder 12 is rotated in the direction indicated by arrow A by driving force of the motor 162.

The surface 12B of the revolving cylinder 12 which is defining a positive electrode active surface is made of an electrolytically inert metal such as stainless steel or aluminum, and tin, chromium, nickel, and the like can also be used therefor. Further, the surface 12B is a passivated surface and a passivated layer is formed thereon.

An oiler 14 serving as a positive electrode coating part for coating a second oily substance on the surface 12B of a positive electrode is arranged around the revolving cylinder 12. The oiler 14 is constructed such that an applicator roller 16, a first distribution roller 22, a first transfer roller 18, a second distribution roller 24, and a second transfer roller 20 are each axially supported parallel to the revolving cylinder shaft 12A (in the longitudinal direction thereof) and are disposed in pressure contact with one another. The second transfer roller 20 is provided to contact the surface 12B at a predetermined pressure. These rollers 20, 24, 18, 22, and 16 have a driving section, which is independent of that of the revolving cylinder 12 and formed by a motor, a gear, and the like (which are all not shown). Preferably, the applicator roller 16, the first transfer roller 18, and the second transfer roller 20 are each provided with a peripheral covering of a resilient material which is resistant to deterioration caused by the olefinic substance, such as a synthetic rubber material. For example, a polyurethane having a Shore A hardness of about 50 to about 70 is used in the case of the applicator roller 16 and a polyurethane having a Shore A hardness of about 60 to about 80 is used in the case of the first and second transfer rollers 18 and 20. Meanwhile, the oiler 14 includes a second oily substance feeding portion (not shown) for supplying a second oily substance onto the applicator roller 16.

A printing head 30 serving as negative electrodes is provided at the downstream side of the oiler 14 in the direction indicated by arrow A in Fig. 1, a predetermined distance apart from the surface 12B of the positive electrode (i.e., at a gap between the surface 12B and the printing head 30) and parallel to the revolving cylinder shaft 12A (i.e., in the longitudinal direction of the revolving cylinder shaft 12A). The printing head 30 is provided with a large number of negative electrodes (i.e., pin electrodes), not shown, of which tip ends are perpendicularly directed toward the surface 12B so as to obtain a resolution of at least 200dpi. It is suitable that a gap defined between the pin electrodes (not shown) and the surface 12B is set in the range from about 30 μm to about 100 μm. The smaller the gap the sharper are the dots of coagulated ink produced. It is preferable that at least tip end portion of the pin electrodes is made of electrolytically inert metal such as stainless steel, platinum, chromium, nickel and aluminum. The printing head 30 is connected to a print head control part 164 (see Fig. 6) and the gradation of dots corresponding to the pin electrodes, not shown (which is the gradation of 256 in the present embodiment) is controlled by applied voltage and/or applying time.

An inker 32 serving as an ink feeding part for supplying predetermined ink 110 (see Fig. 3(B)) to the surface 12B of the positive electrode is disposed at the upstream side of the printing head 30 in the direction indicated by arrow A in Fig. 1 and at the downstream side of the oiler 14 in the vicinity of the printing head 30 (see Fig. 2). The inker (ink supply port) 32 is disposed in the vicinity of the upper portion of the surface 12B by a predetermined distance apart from the surface 12B so that the ink flows downward on the surface 12B due to its gravity.

A first squeegee 34 for removing the ink 110 from the surface 12B of the positive electrode and an oil cascade unit 40 serving as a fogging ink removing part are disposed at the downstream side of the printing head 30 in the direction indicated by arrow A in Fig. 1. The oil cascade unit 40 is provided with an oily subatance supply port 38 for supplying a first oily substance 140 (see Fig. 3(E)), and a second squeegee 36 for removing a fogging ink 130 (see Fig. 3(D)) mixed with the first oily substance 140, which the oily substance supply port 38 and the second squeegee 36 will be described later. The first squeegee 34 and the second squeegee 36 are each made from soft rubber having a wedge-shaped (acute-angled triangular) cross sectional configuration and extending along the direction parallel to the revolving cylinder 12 (i.e., the longitudinal direction of the cylinder 12). Respective acute angle portions of the squeegees 34, 36 are brought into slide-contact with the surface 12B. The oily substance supply port 38 is, in the same manner as the inker 32, disposed in the vicinity of the upper portion of the surface 12B by a predetermined distance apart the surface 12B so that the first oily substance 140 flows downward on the surface 12B due to its gravity, The basic structure of the oil cascade unit 40 is as shown in Fig. 1, but the oil cascade unit 40 is shown as a black box in Fig. 2.

A pressure roller 70 forming a part of a transfer part is disposed at the downstream side of the oil cascade unit 40 in the direction indicated by arrow A in Fig. 1 and at the upstream side of the oiler 14 in such a manner as to pressure contact with the surface 12B of the positive electrode and to be axially supported parallel to the revolving cylinder shaft 12A (i.e., in the longitudinal direction of the revolving cylinder 12). Accordingly, when the revolving cylinder rotates in the direction indicated by arrow A, the pressure roller 70 is rotated in the direction indicated by arrow B in Fig. 1.

A substrate 80 is nipped between the surface 12B of the positive electrode and the pressure roller 70. For this reason, the substrate 80 is provided to move in the direction indicated by arrow C in Fig. 1. The electrocoagulation printing apparatus 10 includes a take-up part 172 (see Fig. 6) controlled by a take-up control part 170 at the side where the substrate 80 is wound.

A collected-ink receiver 42 is disposed below the first squeegee 34 so as to receive ink collected by the first squeegee 34. The collected-ink receiver 42 is connected to an ink reservoir 48 via a pipe 56. The ink reservoir 48 is provided with a filter part (not shown) for removing refuse or the like mixed with the collected ink. The ink reservoir 48 is connected to a pump 50 by a pipe 58. The pump 50 allows ink in the ink reservoir 48 to be continuously supplied for the inker 32 by a pipe 60. The pump 50 is connected to a pump control part 168 (see Fig. 6).

A mixture receiver 44 is disposed below the second squeegee 36 so as to receive a mixture of the fogging ink 130 and the first oily substance 140 collected by the second squeegee 36. The mixture receiver 44 is connected by a pipe 52 to a separator 46 which separates the fogging ink 130 and the first oily substance 140 from each other and the separator 46 is connected by a pipe 54 to the oily substance supply port 38. The mixture receiver 44, the pipe 52, the separator 46, and the pipe 54 form circulation means. The first oily substance 140 is separated from the fogging ink 130 by the separator 46 in such a manner as to admix water with the first oily substance and the mixture to form an aqueous phase containing the removed fogging ink and an oily phase containing the first oily substance, separate the oily phase from the aqueous phase (for example, by decantation or centrifugation), filter the separated oily phase to remove therefrom suspended solids and recover the filtered oily phase for circulation back to the oily substance supply port 38. Diatomaceous earth or the like can be used for filtering the oily phase. Accordingly, the separator 46 includes a built-in power source (for example, a motor and a pump), not shown, and the power source is controlled by a separator control portion 166 (see Fig. 6).

As shown in Fig. 6, the electrocoagulation printing apparatus 10 includes a controller 150 for controlling the entire apparatus. Connected to the controller 150 are an operation control part 152 for controlling an operating part 154 such as a keyboard, a mouse, and the like, a display control part 156 for controlling a display part 158 such as a display, a motor driver 160, a print head control part 164, a separator control part 166, a pump control part 168, a paper-feeding control part 178, a take-up control part 170, and an oiler control part 174.

Next, an operation of the electrocoagulation printing apparatus 10 according to the present invention will be described with, reference to Figs. 3 and 7.

When a predetermined power switch (not shown) of the controller 150 is turned on by an operator, the electrocoagulation printing apparatus 10 is actuated. The display part 158 allows display of predetermined information, and when the operator effects a predetermined operation to the operating part 154, the revolving cylinder 12 starts rotating.

In the electrocoagulation printing apparatus 10, first, step S10 in Fig. 7 allows formation of micro-droplets of the second oily substance on the surface of a positive electrode. Namely, the second oily substance is applied onto the surface 12B of the positive electrode by the oiler 14. Examples of suitable second oily substance which may be used to coat the surface of the positive electrode include unsaturated compounds, particularly, unsaturated fatty acids such as arachidonic acid, linoleic acid, linolenic acid, oleic acid, palmitoleic acid and myristoleic acid, and unsaturated vegetable oils such as corn oil, linseed oil, olive oil, peanut oil, soybean oil and sunflower oil. Further, a mixture of two or more kinds of unsaturated compounds may also be used as the second oily substance. The second oily substance is advantageously applied onto the surface 12B of the positive electrode in the form of an oily dispersion containing the metal oxide as dispersoid. Examples of suitable metal oxides include aluminum oxide, ceric oxide, chromium oxide, cupric oxide, magnesium oxide, manganese oxide, titanium dioxide and zinc oxide, and chromium oxide is the preferred metal oxide. Depending on the type of metal oxide used, the amount of metal oxide may range from about 10 to about 60% by weight, based on the total weight of the dispersion. Preferably, the second oily substance and the metal oxide are present in the dispersion in substantially equal amounts. A particularly preferred dispersion contains about 50% by weight of oleic acid or linoleic acid and about 50% by weight of chromium oxide.

The second oily substance is applied onto the surface 12B of the positive electrode by the oiler 14 equipped with a distribution roller extending parallel to the revolving cylinder 12 and having a peripheral coating comprising an oxide ceramic material. The second oily substance is applied onto the ceramic coating to form a film of the second oily substance uniformly covering the surface of the ceramic coating, the film of the second oily substance breaks down into micro-droplets having substantially uniform size and distribution, and the micro-droplets are transferred from the ceramic coating onto the surface 12B of the positive electrode via a transfer roll. As explained in U.S. Patent No. 5,449,392 of September 12, 1995, the use of a distribution roller having a ceramic coating comprising an oxide ceramic material enables one to form on a surface of such a coating a film of the second oily substance which uniformly covers the surface of the ceramic coating and thereafter breaks down into micro-droplets having substantially uniform size and distribution. The micro-droplets formed on the surface of the ceramic coating and transferred onto the positive electrode surface 12B generally have a size ranging from about 1 to about 5 μm.

A particularly preferred oxide ceramic material forming the aforesaid ceramic coating comprises a fused mixture of alumina and titania. Such a mixture may comprise about 60 to about 90 weight % of alumina and about 10 to about 40 weight % of titania.

In some instances, depending on the type of second oily substance used, Applicant has noted that the film of second oily substance only partially breaks down on the surface of the ceramic coating into the desired micro-droplets. Thus, in order to ensure that the film of second oily substance substantially completely breaks down on the ceramic coating into micro-droplets having substantially uniform size and distribution, first and second distribution rollers 22, 24 are provided each extending parallel to the revolving cylinder 12 and having a peripheral coating comprising an oxide ceramic material.

The second oily substance is applied onto the ceramic coating of the first distribution roller 22 by disposing the applicator roller 16 parallel to the first distribution roller 22 and in pressure contact engagement therewith to form a first nip, and rotating the applicator roller 16 and the first distribution roller 22 in register while feeding the second oily substance into the first nip, whereby the second oily substance forms the film uniformly covering the surface of the ceramic coating when passing through the first nip.

In the oiler 14, at least partially broken film of the second oily substance is transferred from the first distribution roller 22 to the second distribution roller 24 and the micro-droplets are transferred from the second distribution roller 24 to the positive electrode surface 12B. Namely, the first transfer roller 18 is disposed between the first distribution roller 22 and the second distribution roller 24 in parallel relation thereto, and the first transfer roller 18 is disposed in pressure contact engagement with the first distribution roller 22 to form a second nip. Further, the first transfer roller 18 is disposed in pressure contact engagement with the second distribution roller 24 to form a third nip. The first distribution roller 22 and the first transfer roller 18 are rotated in register so that the at least partially broken film is transferred from the first distribution roller 22 to the first transfer roller 18 at the second nip, and the second transfer roller 20 is disposed parallel to the second distribution roller 24 and in pressure contact engagement therewith to form a fourth nip. The second transfer roller 20 is disposed in pressure contact engagement with the positive electrode surface 12B to form a fifth nip. The second distribution roller 24, the second transfer roller 20, and the surface 12B are rotated in register in order that the at least partially broken film is transferred from the first transfer roller 18 to the second distribution roller 24 at the third nip, then, the micro-droplets are transferred from the second distribution roller 24 to the second transfer roller 20 at the fourth nip, and thereafter, the micro-droplets are transferred from the second transfer roller 20 to the psitive electrode surface 12B at the fifth nip. Such an arrangement of rollers is described in the aforementioned U.S. Patent Application No. 08/527,866 filed on September 14, 1995.

As described above, in the oiler 14, the second oily substance is applied onto the ceramic coating of the first distribution roller 22, to form the film of the second oily substance for uniformly covering the surface of the ceramic coating on the surface thereof, the film of the second oily substance is at least partially broken down into micro-droplets having substantially uniform size and distribution, the at least partially broken film is transferred from the first distribution roller 22 to the second distribution roller 24, the film is substantially completely broken down into desired micro-droplets having substantially uniform size and distribution on the ceramic coating of the second distribution roller 24, and the micro-droplets are transferred from the ceramic coating of the second distribution roller 24 to the positive electrode surface 12B via a transfer roll. It is desired that the ceramic coatings of the first distribution roller 22 and the second distribution roller 24 comprise the same oxide ceramic material.

As shown in Fig. 3(A), the micro-droplets of the second oily substance 100 transferred onto the positive electrode surface 12B by the second transfer roller 20 of the oiler 14 have substantially uniform distribution on the surface 12B.

Next, in step S20 in Fig. 7, ink is filled into a gap between the positive electrode surface and pin electrodes. Namely, ink is continuously supplied from the inker 32 to the positive electrode surface 12B. The ink is allowed to flow downward along the surface 12B, and is conveyed to the gap due to rotation of the surface 12B in the direction indicated by arrow A in Figs. 1 and 2 to fill the gap. Any remaining ink flowing downward from the surface 12B is collected in the collected-ink receiver 42 and the collected ink is circulated back to the inker 32 via the ink reservoir 48, the pump 50, and the pipes 56, 58, and 60.

As shown in Fig. 3(B), the ink layer is formed to cover the micro-droplets of the second oily substance 100 on the positive electrode surface 12B.

The colloid generally used in an electrocoagulation printing ink is a linear colloid of high molecular weight, that is, one having a molecular weight comprised between about 10,000 and about 1,000,000, preferably between 100,000 and 600,000. Examples of suitable colloids include natural polymers such as albumin, gelatin, casein and agar, and synthetic polymers such as polyacrylic acid, polyacrylamide and polyvinyl alcohol. A particularly preferred colloid is an anionic copolymer of acrylamide and acrylic acid having a molecular weight of about 250,000 and sold by Cyanamid Inc. under the trade mark ACCOSTRENGTH 86. The colloid is preferably used in an amount of about 6.5 to about 12% by weight, and more preferably in an amount of about 7% by weight, based on the total weight of the electrocoagulation printing ink. Water is preferably used as the medium for dispersing the colloid to provide the desired electrocoagulation printing ink.

The ink also contains a soluble electrolyte and a coloring agent. Preferred electrolytes include halides, for example, alkali metal halides such as lithium chloride, sodium chloride and potassium chloride, alkaline earth metal halides such as calcium chloride, metal halides such as nickel chloride, copper chloride and manganese chloride, and ammonium chloride. The electrolyte is preferably used in an amount of about 6.5 to about 9% by weight, based on the total weight of the ink. The coloring agent can be a dye or a pigment. Examples of suitable dyes which may be used to color the colloid are the water soluble dyes available from HOECHST such as Duasyn Acid Black for coloring in black and Duasyn Acid Blue for coloring in cyan, or those available from RIEDEL-DEHAEN such as Anti-Halo Dye Blue T. Pina for coloring in cyan, Anti-Halo Dye AC Magenta Extra V01 Pina for coloring in magenta and Anti-Halo Dye Oxonol Yellow N. Pina for coloring in yellow. When using a pigment as a coloring agent, use can be made of the pigments which are available from CABOT CORP. such as Carbon Black Monarch ® 120 for coloring in black, or those available from HOECHST such as Hostaperm Blue B2G or B3G for coloring in cyan, Permanent Rubine F6B or L6B for coloring in magenta and Permanent Yellow DGR or DHG for coloring in yellow. A dispersing agent is added for uniformly dispersing the pigment into the ink. Examples of suitable dispersing agents include the non-ionic dispersing agent sold by ICI Canada Inc. under the trade mark SOLSPERSE 27000. The pigment is preferably used in an amount of about 6.5 to about 12% by weight, and the dispersing agent in an amount of about

0.4 to about 6% by weight, based on the total weight of the ink.

Subsequently, in step S30 in Fig. 7, when pin electrodes selected correspondingly to an image are electrically energized, dots corresponding to the image are formed on the surface of a positive electrode. Namely, when the pin electrodes (not shown) of the printing head 30 corresponding to image dots are electrically energized, activation of the passive layer on the surface 12B of the positive electrode corresponding to the electrically energized pin electrodes generates multivalent at least trivalent ions which then initiate coagulation of the colloid to form the dots 120. This state is shown in Fig. 3(C).

When the spacing of the pin electrodes is set at a distance which is equal to or greater than the gap between the positive electrode surface 12B and the pin electrodes, it is possible to prevent the pin electrodes from undergoing edge corrosion. When the gap and the diameter of the pin electrode is of the order of 50 μm the pin electrodes are preferably spaced from one another by a distance of about 75 μm (see U.S. Patent No. 4,895,629). On the other hand, when the surface 12B is coated with the second oily substance prior to electrical energization of the pin electrodes, the adherence of the dots of coagulated ink to the surface 12B is weakened and an uncontrolled corrosion of the surface 12B is prevented. In addition, gas generated as a result of electrolysis upon energizing the negative and positive electrodes is consumed by reaction with the unsaturated compound. Accordingly, when the unsaturated compound is used as the second oily substance, no gas is accumulated between the pin electrodes and the surface 12B.

Next, in step S40 in Fig. 7, the non-coagulated ink not associated with the dots and the micro-droplets of the second oily substance are scraped from the positive electrode surface. Namely, after formation of the dots 120, the most part of the non-coagulated ink 110 is removed from the surface 12B by scraping the surface 12B with the first squeegee 34 and the dots 120 of coagulated ink are brought into a sufficiently uncovered state. At this time, the unscraped non-coagulated ink 110 and a portion of dots of the coagulated ink scraped by the squeegee remain, as the fogging ink 130, on the surface 12B. This state is shown in Fig. 3(D). Meanwhile, the non-coagulated ink 110 removed by the first squeegee 34 is collected to be circulated as described above.

In step S50 in Fig. 7, the first oily substance is applied onto the surface of the positive electrode. Namely, the first oily substance 140 is continuously supplied onto the surface 12B of the positive electrode from the oily substance supply port 38. The first oily substance 140 may be of the same type as or the different type from the second oily substance. In the present embodiment, from an economical standpoint, oleic acid which is the same as that used for the second oily substance is used for the first oily substance. Fig. 3(E) shows the state in which the first oily substance is supplied onto the surface 12B.

In step S60 in Fig. 7, the fogging ink mixed with the first oily substance is removed from the surface of the positive electrode without altering the dots. Namely, the fogging ink 130 is removed by applying the first oily substance 140 onto the surface 12B of the positive electrode to cause the fogging ink 130 to be mixed with the first oily substance 140 and by scraping the mixture from the surface 12B by the second squeegee 36. This state is shown in Fig. 3(F).

The mixture of the fogging ink 130 and the first oily substance 140 removed from the surface 12B of the positive electrode is collected the first oily substance 140 is separated from the collected mixture, and the separated first oily substance 140 is circulated back to the oily substance supply port 38.

Finally, in step S70 in Fig. 7, the dots are transferred from the positive electrode surface to a substrate such as a printing paper and an electrocoagulation printed image is formed on the substrate.

As described above, the present embodiment is constructed such that, after the dots 120 of coagulated ink are appeared by removing the non-coagulated ink 110, the first oily substance 140 is applied onto the surface 12B, and the fogging ink 130 mixed with the first oily substance 140 can be removed from the surface 12B without altering the dots 120 of coagulated ink. For this reason, formation of undesirable background (so-called fogging) on a printed image is prevented.

Meanwhile, in the present embodiment, the revolving cylinder 12 is used as the positive electrode, but a moving endless belt as disclosed in U.S. Patent No. 4,661,222 may also be used.

Further, in a preferred embodiment, the oiler 14 includes two transfer rollers and two distribution rollers. However, the present invention can be achieved even when only each one of transfer roller and distribution roller is provided.

Moreover, in a preferred embodiment, transfer of the dots formed on the positive electrode surface to the substrate is effected in such a manner that the positive electrode surface is directly brought into pressure contact with the substrate by a pressure roller. However, the dots formed on the positive electrode surface may also be transferred finally to the final substrate via an intermediate transfer member.

Next, a polychromic image printing system to which the present invention is applied will be described.

First, a printing system in which the above-described electrocoagulation printing system 10 is disposed in tandem relation will be described with reference to Fig. 4. In Fig. 4, the same components as those shown in Figs. 1, 2, and 6 will be denoted by the same reference numerals, and a description thereof will be omitted. Further, in Fig. 4, any one of the electrocoagulation printing apparatuses 10 corresponding to four colors of Y, M, C, and K is not shown.

The above printing system includes four electrocoagulation printing apparatuses 10 used for full color printing. Four colors of ink of Y, M, C, and K are respectively used in the electrocoagulation printing apparatuses 10. A color separated image corresponding to each of the colors is transferred to the substrate 80, and finally, a polychromic image is printed thereon.

This printing system includes substrate conveying rollers 92, 94, and the like, which are supported parallel to the revolving cylinder shafts 12A. These conveying rollers are each provided to properly hold a state in which the substrate is nipped by the positive electrode surface 12B and the pressure roller 70.

Further, connected to the controller 150 are control parts 152, 156, 160, 164, 166, 168, and 174 of these electrocoagulation printing apparatuses 10. The controller 150 controls each electrocoagulation printing apparatus 10 at a predetermined timing. Meanwhile, this printing system has a single paper-feeding control part 178 and the take-up control part 170.

This printing system prevents formation of fogging which is caused by transfer of fogging ink of each color onto the substrate 80, and therefore, polychromic image printing can be effected in which deterioration of color saturation caused by mixture of colors is improved.

Next, a printing system similar to that disclosed in U.S. Patent No. 5,538,601 will be described. The printing system disclosed therein is, as shown in Fig. 5, constructed in such a manner that printing stations 88 corresponding to the four colors and formed from the parts of the electrocoagulation printing apparatus 10 excepting a revolving cylinder 12' are disposed around the single revolving cylinder 12' of the electrocoagulation printing apparatus 10. In Fig. 5, the same components as those shown in Figs. 1, 2, 4, and 6 are denoted by the same reference numerals, and a description thereof will be omitted. Further, in this figure, any one of the four printing stations 88 of Y, M, C, and K is not shown.

The above printing system has a single revolving cylinder 12, single paper-feeding control part 178, and single take-up control part 170. The substrate 80 is fed by a roller (not shown) in the direction indicated by arrow D in Fig. 5 and is sequentially conveyed in the directions indicated by arrows E, F, G, H, and I.

According to this printing system, in the same way as the printing system shown in Fig. 4, formation of fogging due to the transfer of fogging ink of each color onto the substrate 80 is not caused, and therefore, the polychromic image printing can be effected in which deterioration of color saturation caused by mixture of colors is improved, and a compact-type printing system can be provided.

Meanwhile, even in each of the above-described polychromic printing systems, a moving endless belt may be used as a positive electrode in the same way as in a monochromatic printing apparatus.

Further, in each of the above-described polychromic printing systems, the same type of ink (for example, the same color ink) may also be used repeatedly in each of the printing apparatuses or in each of the printing stations.

Claims

1. An electrocoagulation printing method comprising the steps of:

(a) providing a positive electrode made of on electrolytically inert metal and having a continuous passivated surface as a positive electrode active surface moving along a predetermined path;
(b) forming on said positive electrode active surface a plurality of dots of coagulated ink representative of a desired image by electrocoagulation of electrocoagulation printing ink;
(c) applying a first oily substance onto said positive electrode active surface to remove fogging ink mixed with the first oily substance from said positive electrode active surface without altering said dots of coagulated ink; and
(d) bringing a substrate into contact with said dots of coagulated ink to cause transfer of the dots of coagulated ink from said positive electrode active surface onto the substrate.

2. An electrocoagulation printing method to which the electrocoagulation printing method according to claim 1 is applied,

wherein a plurality of printing stages is defined which is arranged at predetermined locations along said path and each use different electrocoagulation printing ink, steps (b), (c), and (d) are repeated several times, thereby several images are reproduced at respective transfer part on said substrate.

3. An electrocoagulation printing method according to claim 1 or claim 2, wherein said first oily substance is selected from the group consisting of unsaturated fatty acids and unsaturated vegetable oils.

4. An electrocoagulation printing method according to claim 1 or claim 2, wherein said step (b) includes the steps of:

(i) providing a plurality of electrolytically inert negative electrodes electrically insulated from one another and arranged in rectilinear alignment to define a series of corresponding negative electrode active surfaces disposed in a plane parallel to the longitudinal axis of said positive electrode and spaced from the positive electrode active surface by a constant predetermined gap, said negative electrodes being spaced from one another by a distance at least equal to said electrode gap;

(ii) coating the positive electrode active surface with a second oily substance to form on said surface micro-droplets of the second oily substance;

(iii) filling said electrode gap with said electrocoagulation printing ink;

(iv) electrically energizing selected ones of said negative electrodes to cause selectively coagulation of the electrocoagulation printing ink and adherence of coagulated ink onto the positive electrode active surface coated with the second oily substance opposite the electrode active surfaces of said energized negative electrodes while said positive electrode is rotating, thereby forming dots of said coagulated ink; and

(v) removing any remaining non-coagulated ink from said positive electrode active surface.

5. An electrocoagulation printing method according to claim 4, wherein said step (b) (ii) includes the steps of: providing first and second distribution rollers extending parallel to said positive electrode and each having a peripheral coating comprising an oxide ceramic material; applying said second oily substance onto the ceramic coating of said first distribution roller to form on the surface thereof a film of said second oily substance uniformly covering the surface of said ceramic coating, said film of second oily substance at least partially breaking down into micro-droplets having substantially uniform size and distribution; transferring the at least partially broken film from said first distribution roller to said second distribution roller so as to cause said film to substantially completely break on the ceramic coating of said second distribution roller into said micro-droplets having substantially uniform size and distribution; and transferring said micro-droplets from the ceramic coating of said second distribution roller onto said positive electrode active surface.

6. An electrocoagulation printing method according to any one of claims 1, 2, and 4, wherein a mixture of fogging ink removed from said positive electrode active surface and the first oily substance is collected, the first oily substance is separated from the collected mixture, and the separated first oily substance is applied again onto said positive electrode active surface.

7. An electrocoagulation printing method according to claim 6, wherein said first oily substance is separated from said mixture by admixing water with said mixture to form an aqueous phase containing said removed fogging ink and an oily phase containing said first oily substance, separating said oily phase from said aqueous phase, filtering the separated oily phase to remove therefrom suspended solids, and recovering the filtered oily phase for reapplication onto said positive electrode active surface.

8. An electrocoagulation printing apparatus comprising:

a positive electrode made of an electrolytically inert metal and having a continuous passivated surface as a positive electrode active surface moving along a predetermined path;

an ink feeding part which supplies electrocoagulation printing ink onto said positive electrode active surface;

a negative electrode for reproducing on said positive electrode active surface dots of coagulated ink by electrocoagulation;

a fogging ink removing portion which supplies a first oily substance onto said positive electrode active surface and removes fogging ink mixed with the first oily substance from said positive electrode active surface without altering said dots of coagulated ink; and

a transfer part which brings a substrate into contact with the dots of coagulated ink to cause transfer of the dots of coagulated ink from said positive electrode active surface to said substrate.

9. An electrocoagulation printing apparatus according to claim 8, further comprising a coating part for coating the positive electrode active surface with a second oily substance.

10. An electrocoagulation printing system comprising a plurality of apparatuses according to any one of claims 8 and 9, wherein said plurality of apparatuses each use the same and/or different electrocoagulation printing ink to reproduce an image at a transfer position on said substrate.

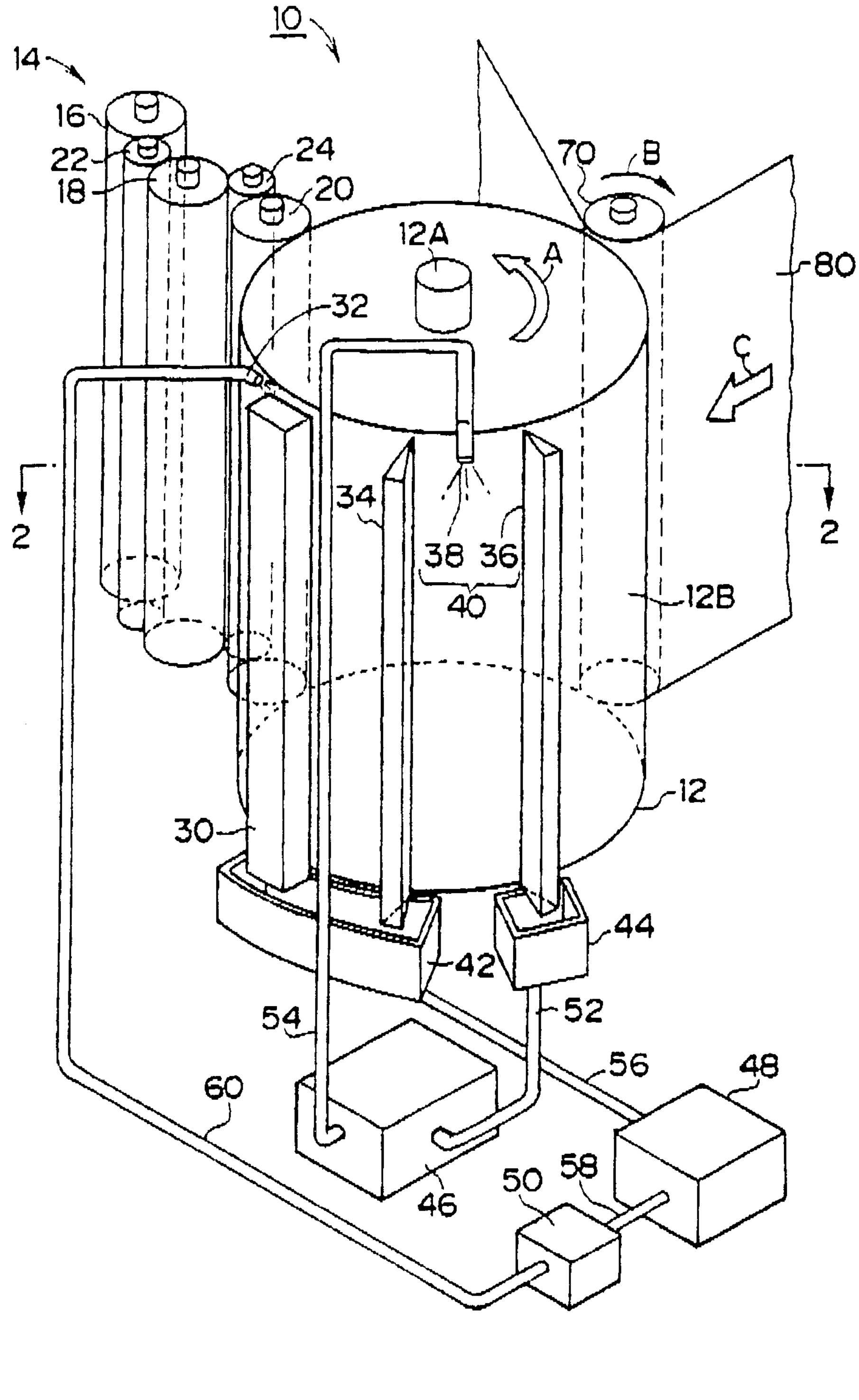
11. An electrocoagulation printing system equipped with the positive electrode according to claim 8 and a plurality of printing stations having the ink feeding part, the negative electrode, the fogging ink removing part, and the transfer part according to claim 8,

wherein the plurality of printing stations are arranged at predetermined positions along said predetermined path and each use the same and/or different type of electrocoagulation printing ink to reproduce an image at a transfer position on said substrate.

12. An electrocoagulation printing apparatus according to claim 8, further comprising:

circulation means in which a mixture of fogging ink removed from said positive electrode active surface and the first oily substance is collected, the first oily substance is separated from the collected mixture, and the separated first oily substance is applied again onto said positive electrode active surface.

FIG. 1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C
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FIG. 2

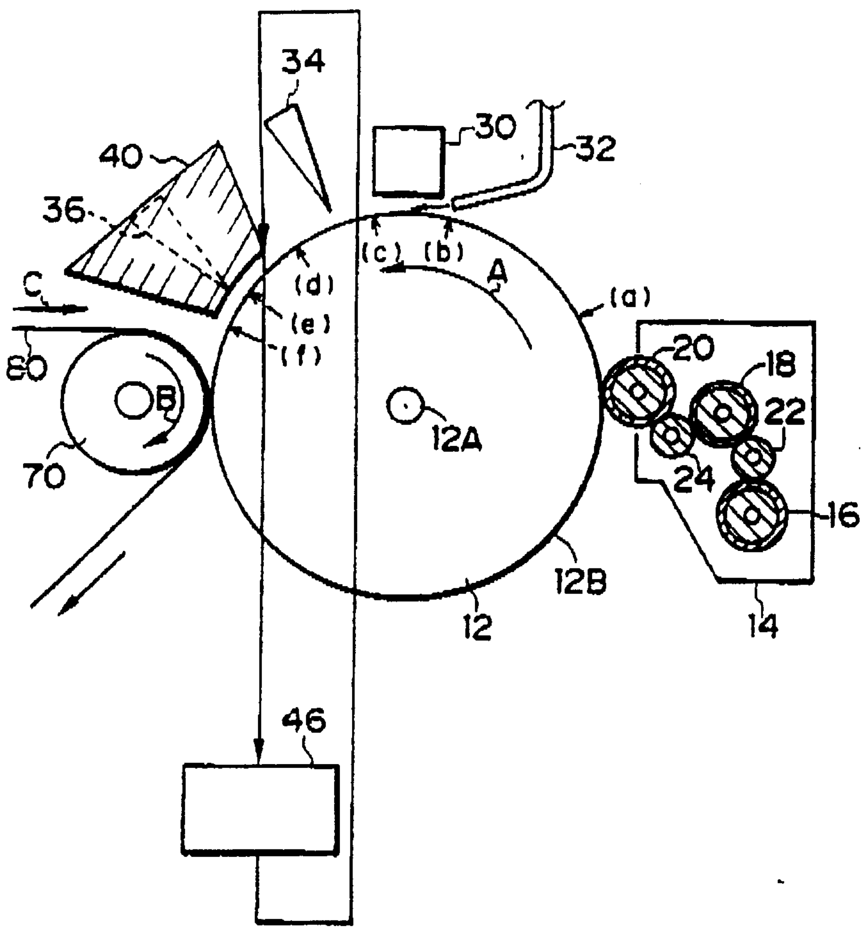

FIG. 3

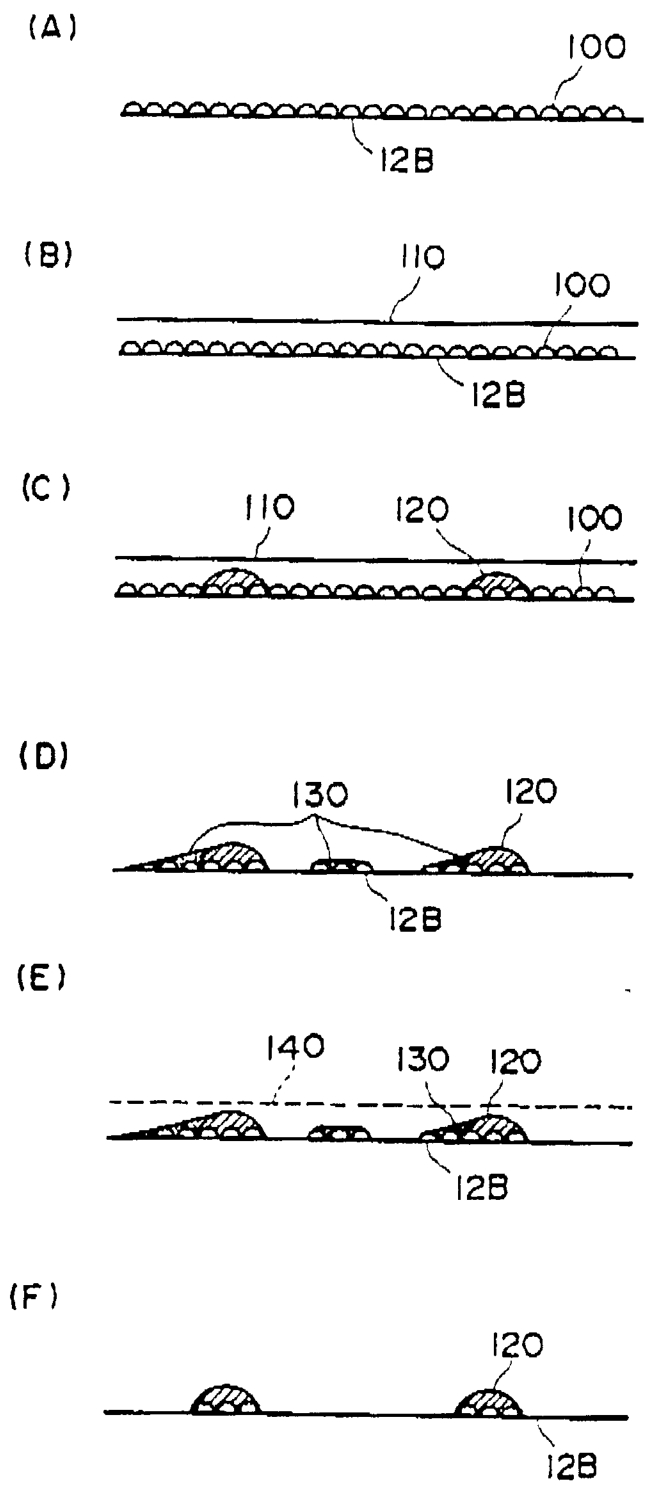
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FIG. 4

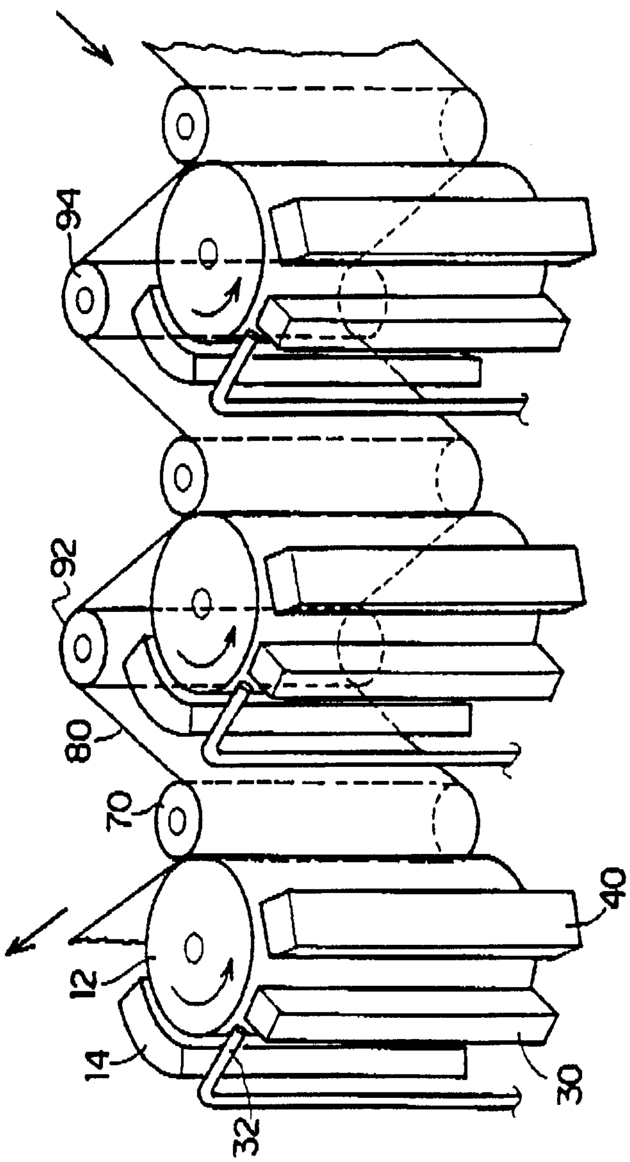

FIG. 5

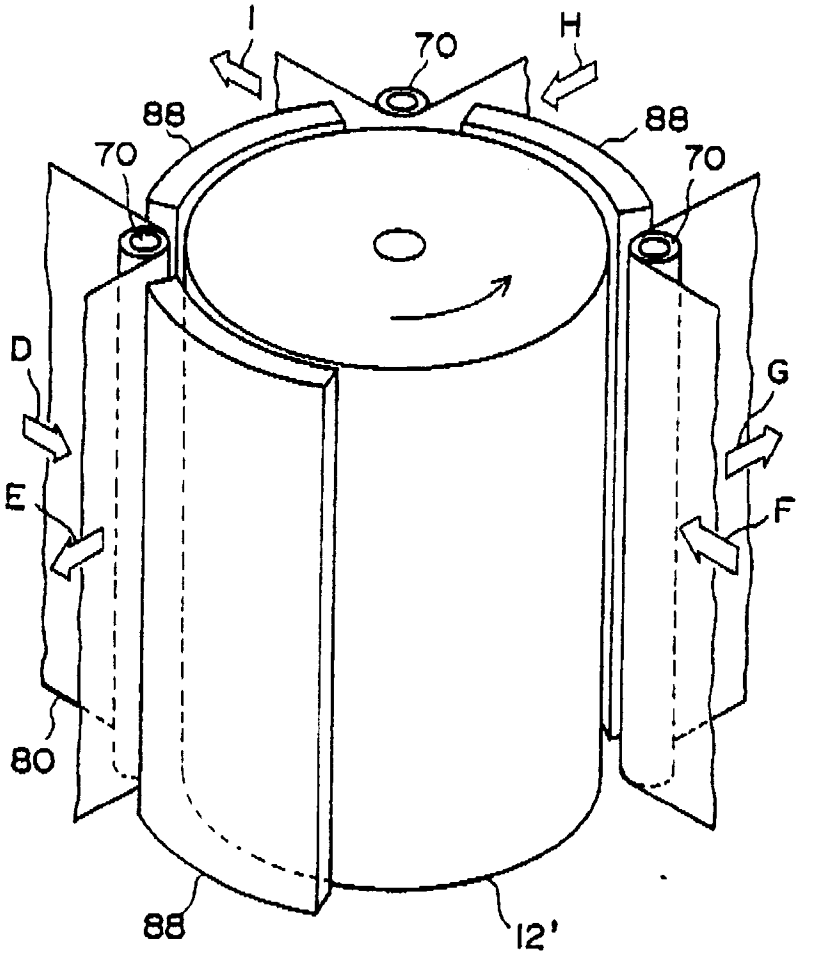

FIG. 6

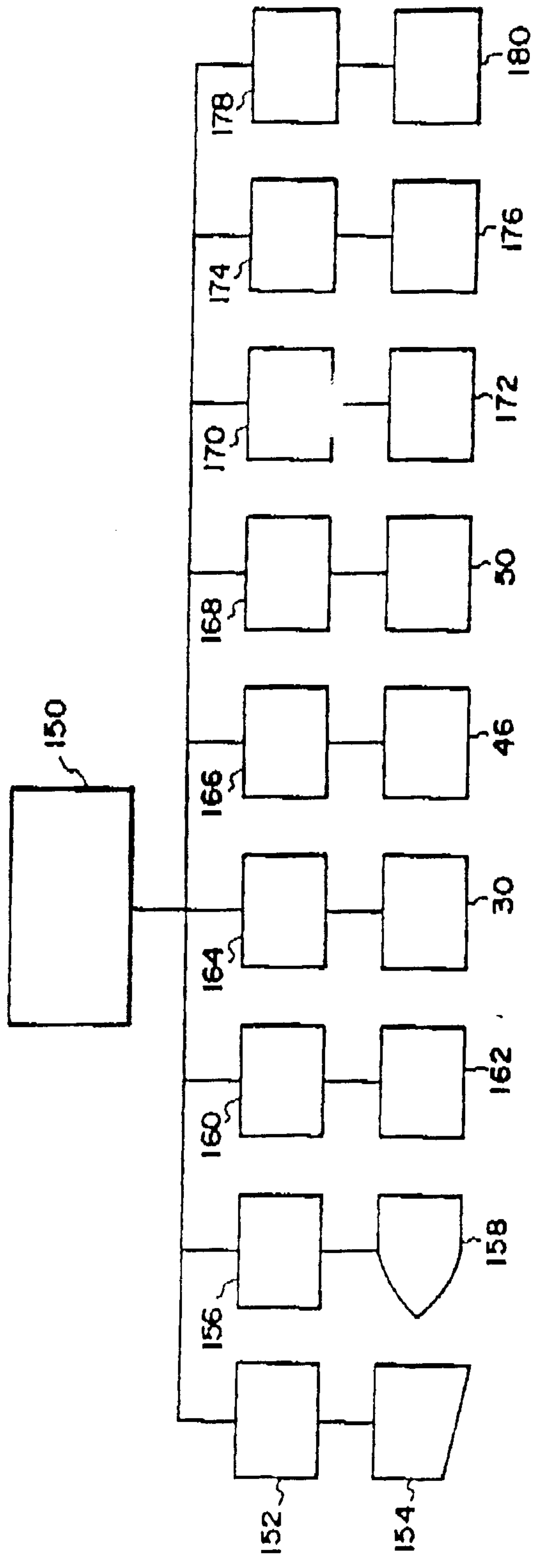
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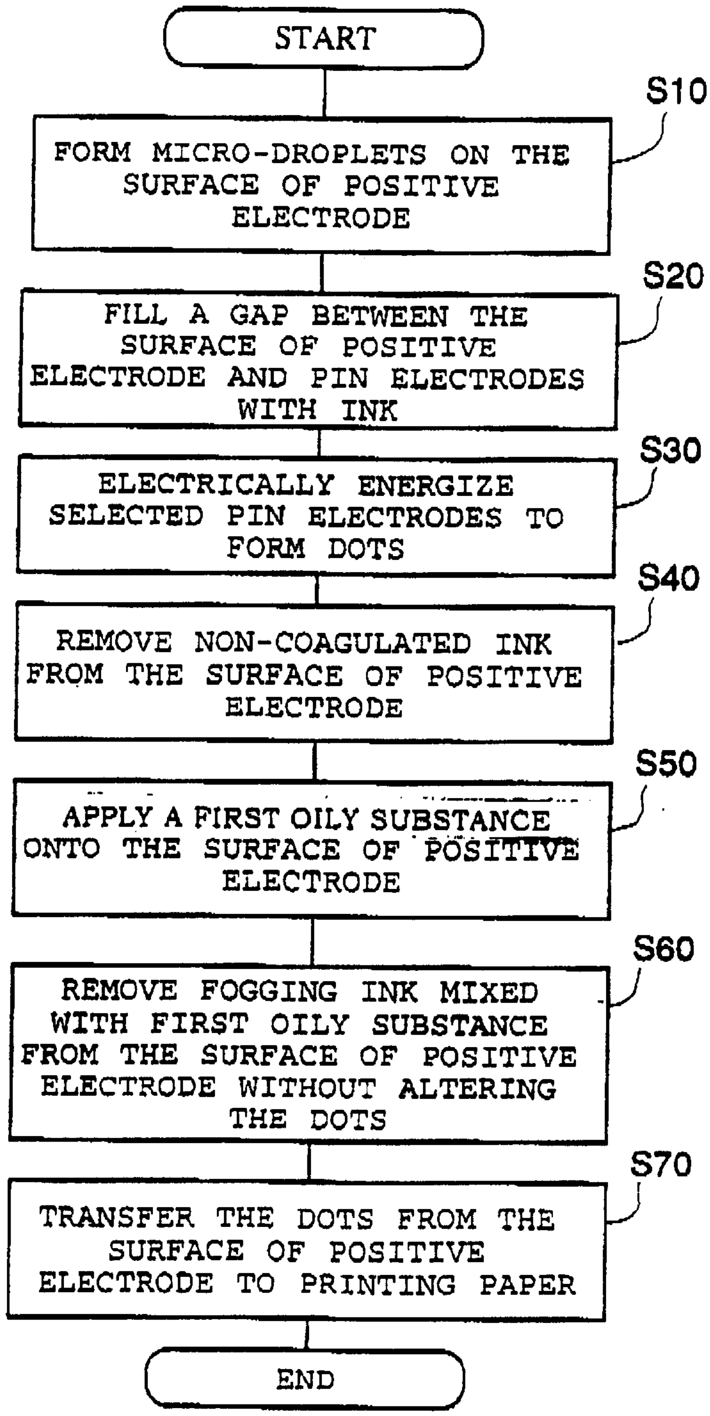
FIG. 7


START
S10
FORM MICRO-DROPLETS ON THE SURFACE OF POSITIVE ELECTRODE
S20
FILL A GAP BETWEEN THE SURFACE OF POSITIVE ELECTRODE AND PIN ELECTRODES WITH INK
S30
ELECTRICALLY ENERGIZE SELECTED PIN ELECTRODES TO FORM DOTS
S40
REMOVE NON-COAGULATED INK FROM THE SURFACE OF POSITIVE ELECTRODE
S50
APPLY A FIRST OILY SUBSTANCE ONTO THE SURFACE OF POSITIVE ELECTRODE
S60
REMOVE FOGGING INK MIXED WITH FIRST OILY SUBSTANCE FROM THE SURFACE OF POSITIVE ELECTRODE WITHOUT ALTERING THE DOTS
S70
TRANSFER THE DOTS FROM THE SURFACE OF POSITIVE ELECTRODE TO PRINTING PAPER
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/00418

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 G03G15/00, B41J3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^6 G03G15/00, B41J3/00, B41M5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922 - 1997
Kokai Jitsuyo Shinan Koho 1971 - 1997
Toroku Jitsuyo Shinan Koho 1994 - 1997
Jitsuyo Shinan Toroku Koho 1996 - 1997

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 4-504688, A (Elcorsy Inc.), August 20, 1992 (20. 08. 92) & WO, 9011897, A & EP, 467904, A1 & CA, 1334017, A1	1 - 12
A	JP, 62-240582, A (Elcorsy Inc.), October 21, 1987 (21. 10. 87) & EP, 235700, B1 & CA, 1279603, A1 & AT, 70221, E & DE, 3775084, C	1 - 12
A	US, 4895629, A (Elcorsy Inc.), January 23, 1990 (23. 01. 90), Cite in the application (Family: none)	1 - 12

☐ Further documents are listed in the continuation of Box C.　☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
February 28, 1997 (28. 02. 97)	March 11, 1997 (11. 03. 97)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)