

April 14, 1964

H. E. CLARK ETAL

3,129,115

XEROGRAPHIC DEVELOPING APPARATUS

Filed April 17, 1961

3 Sheets-Sheet 1

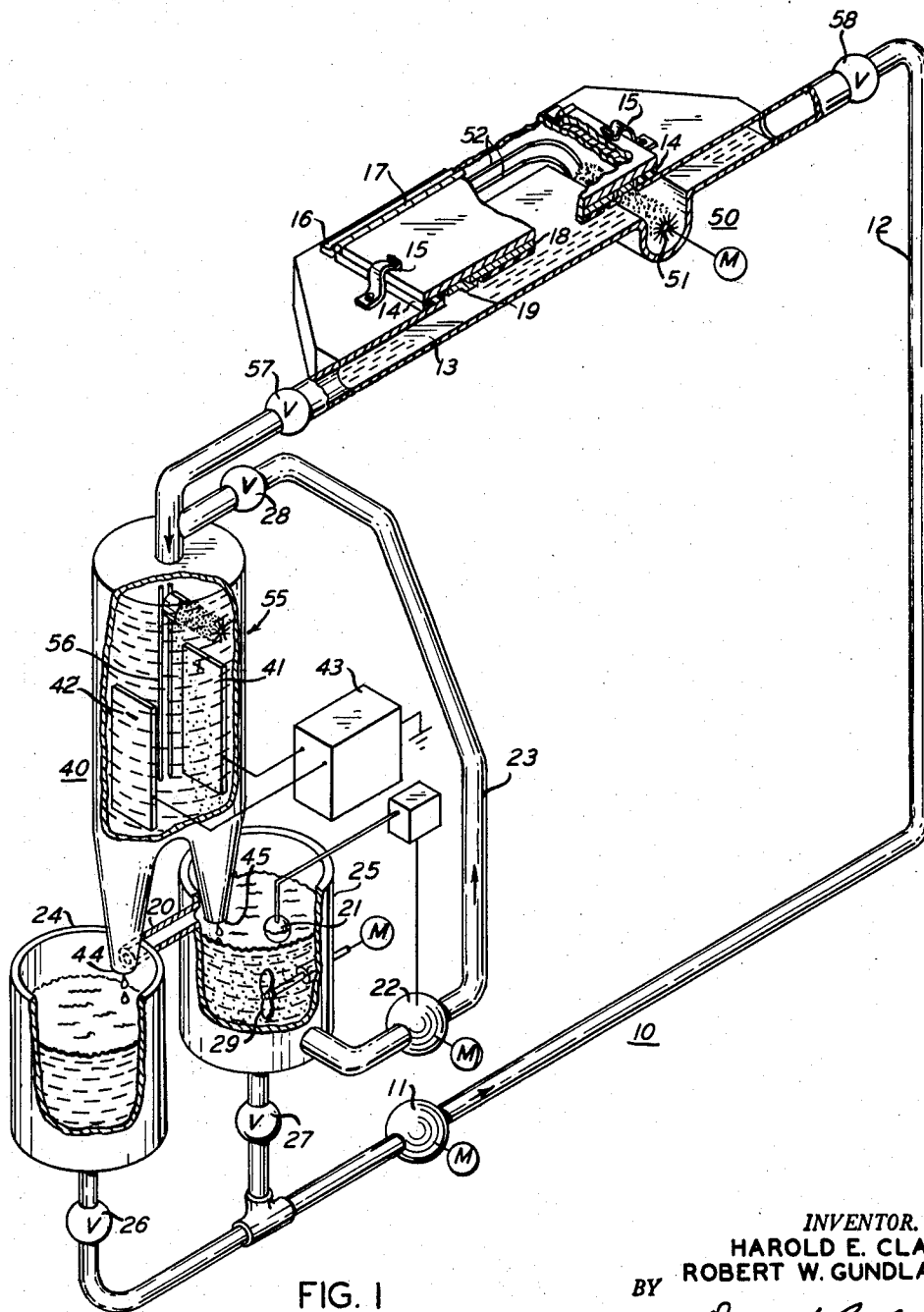


FIG. 1

INVENTOR.
HAROLD E. CLARK
BY ROBERT W. GUNDLACH
Robert W. Gundlach
ATTORNEY

April 14, 1964

H. E. CLARK ETAL

3,129,115

XEROGRAPHIC DEVELOPING APPARATUS

Filed April 17, 1961

3 Sheets-Sheet 2

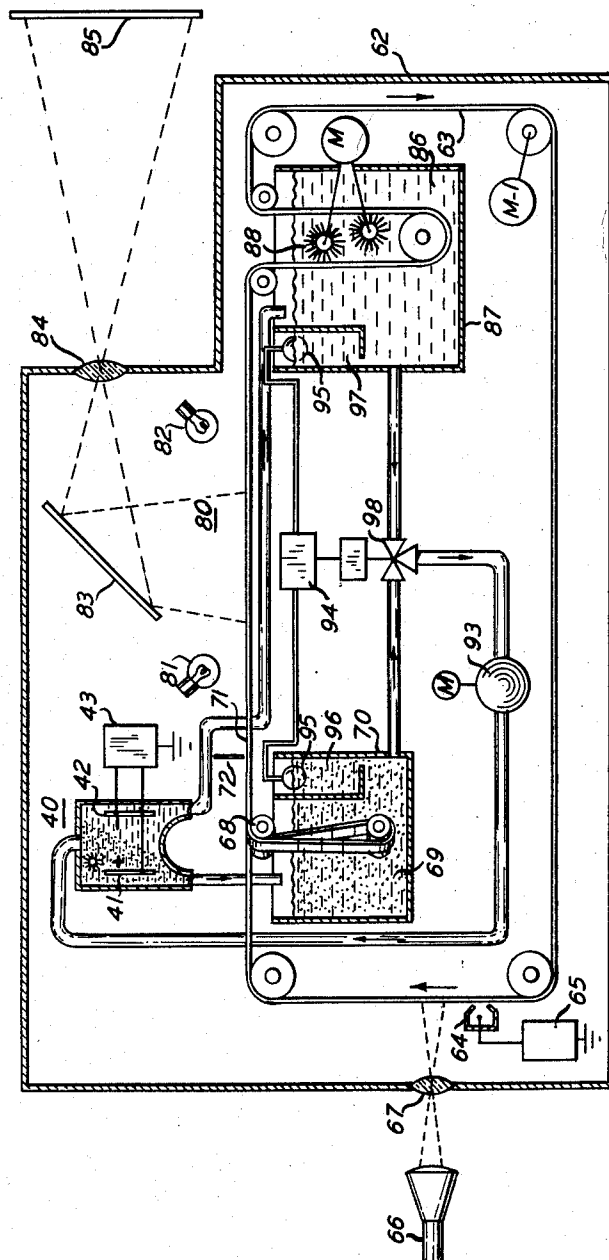


FIG. 2

INVENTOR.
HAROLD E. CLARK
BY ROBERT W. GUNDLACH

Daniel Rubin

ATTORNEY

April 14, 1964

H. E. CLARK ET AL

3,129,115

XEROGRAPHIC DEVELOPING APPARATUS

Filed April 17, 1961

3 Sheets-Sheet 3

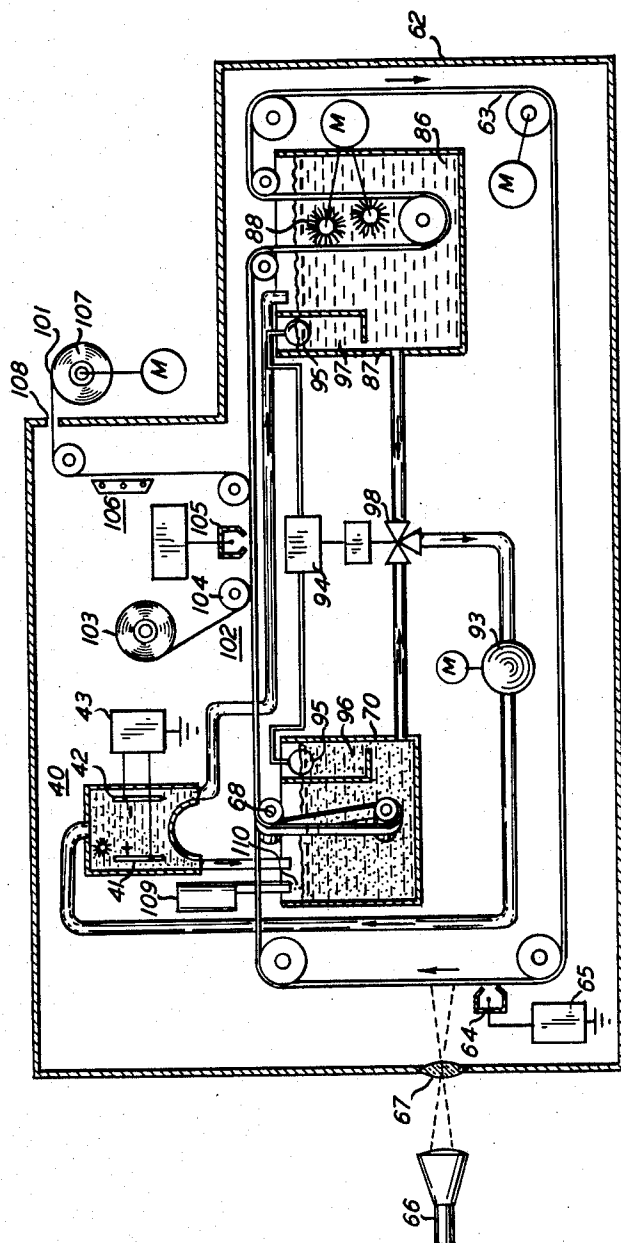


FIG. 3

INVENTOR.
HAROLD E. CLARK
BY ROBERT W. GUNDLACH

Daniel Ruben

ATTORNEY

1

3,129,115

XEROGRAPHIC DEVELOPING APPARATUS

Harold E. Clark, Penfield, and Robert W. Gundlach, Victor, N.Y., assignors to Xerox Corporation, a corporation of New York

Filed Apr. 17, 1961, Ser. No. 103,344

6 Claims. (Cl. 118—637)

This invention relates to xerography and in particular to improved method and apparatus for developing electrostatic latent images on a xerographic plate whereby to produce visible images thereof.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 6, 1942, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced in the form of activating radiation, as for example, visible light, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the radiation intensity that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material such as an electroscopic powder or marking particles that are brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed xerographic image is utilized for varied purposes and for example, may be transferred to a support surface to which it may be fixed by any suitable means.

Development of electrostatic latent images is achieved by placing the developing material within a field range of the electrostatic image whereby to effect mutual attraction and, as disclosed in the prior art, includes development by means of a dry powder as disclosed in Walkup Patent 2,618,551, or by means of liquid materials in which developer may be suspended. A form of liquid development is disclosed in Mayer Patent U.S. 2,877,133 in which a latent image-bearing plate is brought into surface contact with a liquid of high electrical resistance that contains solid developer particles which are attracted therefrom to the select image portions on the plate. As in dry development, development by liquid techniques may be effected on an expendable xerographic plate on which the image remains permanently, or in the instance of a reusable xerographic plate, the developed image may be transferred to a secondary support surface to which it is permanently affixed and the plate cleaned and cycled for reuse as is now conventional in xerography. Still another use of the formed image may be for scanning or projection purposes such as disclosed in copending application Ser. No. 738,520, filed May 28, 1958, in the name of Clark et al.

The present invention is specifically directed to improved method and apparatus of developing electrostatic latent images on a xerographic plate utilizing the principles of liquid development and is directed in particular for use in connection with reusable xerographic plates from which a developed image must be removed before recycling of the plate.

In either instance of reusing a xerographic plate, the plate must be cleaned before recycling. It has been found that plates having been subjected to techniques of liquid development are easily cleaned, if they are cleaned before the developed image has solidified, preferably by washing in a clear liquid having a substantial absence of developer and which may for example, be chemically the same as the liquid employed for conveying suspended developer to the plate. In the instance of cleaning a plate from which a developed image has been transferred to

2

a secondary surface, there occurs a consumption of developer material from the system that requires a replenishment in order to maintain the developer in the liquid at a desired consistency of concentration. In the instance of cleaning a plate where the developed image has not been utilized for forming a permanent image, it has been discovered that consumption of developer can be reduced and even substantially eliminated if that which was utilized for development is restored to the system.

Now in accordance with the invention a xerographic plate can have an image developed and subsequently be cleaned in a liquid immersion development system that by the novelty of its combination is rendered completely automatic and adapted for continuous recycling of a xerographic plate. When the ingredients utilized in developing are subsequently restored to the system, substantially no consumption of material occurs and the system is operative indefinitely at a very minimum of cost.

It is therefore the principal object of the invention to improve method and apparatus for liquid development of electrostatic latent images on a xerographic plate.

It is a further object of the invention to provide method and apparatus for developing an image on a xerographic plate in a liquid development system that is self-contained and adapted for automatic recycling operation.

It is a further object of the invention to provide method and apparatus for developing electrostatic latent images on a xerographic plate with a developer liquid while maintaining a like liquid at a substantially lower concentration of developer for cleaning purposes.

These and other objects are attained in one embodiment of the invention by means of a self-contained liquid conduit system in which a xerographic plate is supported for development in contact with a developer liquid that is circulated past a plate on its support means. After the developed image on the plate has been utilized externally, the plate is returned to the system for cleaning that is achieved by circulating clear liquid past the xerographic plate while the plate is simultaneously being brushed to remove the developer. The apparatus includes at least two liquid containing reservoirs, the liquid in one having substantially less developer therein than the other. By means of a separating device in the conduit system, ratios of developer content in the two liquids are maintained. By controlled valving, either liquid may be circulated from its respective reservoir.

Embodiments of the invention are disclosed in the accompanying drawings in which:

FIG. 1 is a schematic isometric partially broken and illustrating an operable system employing the method and apparatus of the invention;

FIG. 2 is a schematic side sectional view illustrating a continuous automatic apparatus employing the method and apparatus of the invention; and

FIG. 3 is a schematic side sectional view illustrating an alternative continuous automatic apparatus employing the method and apparatus of the invention.

Referring to FIG. 1 there is illustrated a developing system in accordance with the invention that includes a liquid conveying conduit system generally designated 10, for containing a liquid of high electrical resistance 12, which may be of a hydrocarbon such as kerosene, benzene, etc. as disclosed in the above-cited Mayer patent and which is circulated by pump 11 through the system in the direction indicated by the arrows.

At a suitable location within the conduit system, and desirably at the highest level of circulation, there is provided an opening 13. A xerographic plate 18 is adapted to seat in a recess of support member 19 whereby the photoconductive surface of the plate is supported in contact with or immersed in the liquid of the system. A cover plate 16, hinged at 17, is adapted to rest on a gas-

ket member 14 arranged around the opening. A number of spring clamps 15 adjacent to the gasket secure the cover plate against the gasket and over the xerographic plate which is thereby maintained in liquid-tight operative relation to the system. During periods of plate absence, the cover plate may be secured in a like manner whereby evaporation of liquid from the system is prevented.

Spaced opposite the opening there may optionally be included to facilitate solid area development, an electrically biased development electrode (not shown) such as disclosed in copending application Ser. No. 531,280, filed August 29, 1955, in the name of Ricker, now Patent No. 3,001,842.

For containing the liquids there is provided at least two reservoirs 24 and 25 arranged to permit the flow of liquid, selectively from each or simultaneously from both. One reservoir contains liquid having a relatively low concentration of developer particles and which liquid is hereinafter referred to as "clear" liquid and the other of which contains liquid of relatively high developer concentration and which is hereinafter referred to as "developer" liquid. For purposes of discussion, reservoir 24 will be regarded as containing clear liquid and reservoir 25 as containing developer liquid. Included in reservoir 25 is a motor operated agitator 29 that is operatively effective to stir the developer in the liquid.

On the outlet side of each reservoir there is provided a valve 26 and 27 to selectively isolate reservoirs 24 and 25 respectively from the conduit system in accordance with the sequence of use of the respective liquids. The valves may be of a commercially available type and optionally may be adjustable for proportioning flow of liquids simultaneously from both reservoirs in response to a suitable regulating device to maintain desired developer concentration in the liquid being circulated. To maintain maximum liquid level in reservoir 24 an overflow 20 is provided therefrom to reservoir 25, while the maximum level in 25 is maintained below the inlet of the overflow by a float control 21 that, through a relay, actuates the motor of circulating pump 22. Pump 22 when actuated circulates developer liquid through pipe loop 23 containing a unidirectional flowcheck 28 and by recirculating the liquid effects redistribution of quantities between reservoirs as will be understood from the discussion below. Alternatively, between the reservoirs there may be included an equalizing connection (not shown) by which relative liquid levels are maintained and which may include a strainer or the like of small enough mesh to prevent circulation of developer particles between reservoirs.

In order to maintain a differential of developer concentration between the liquids in the reservoirs there is provided an electrostatic separator 40 having at least two electrode plates 41 and 42 spaced apart and charged to opposite polarities by being connected to opposite poles of a source of D.C. potential 43. The separator includes two outlet legs 44 and 45 disposed over or connected to reservoirs 24 and 25 respectively and that may include proportional restricting devices such as an orifice, whereby liquid passing through the separator passes to each of the reservoirs substantially in proportion to their rate of respective liquid consumption per cycle. Since developer particles in the liquid are pre-selected whereby to acquire an electrostatic charge of opposite polarity to the polarity of the xerographic plate image to which they are to be attracted, unconsumed developer particles in the separator are attracted toward the separator plate charged oppositely thereto and for the purpose of illustration will be considered as in suspension migrating toward positive plate 41 rather than negative plate 42. By this means a predominance of developer particles are attracted toward leg 45 and flow into reservoir 25. Although absolute developer separation between reservoirs might be desirable it has not been found necessary,

but rather it has been found desirable to establish a suitable equilibrium of concentration which is maintained at a constant satisfactory level.

A xerographic plate bearing an image to be developed is brought to the system under an absence of light and placed within opening 13 as aforesaid. Valve 27 is opened and developer liquid is then circulated by pump 11 for a predetermined period of time under manual or automatic control such as an automatic timer (not shown) in the pump motor circuit. After development the plate is removed for external utilization whereat the developed image may be optically scanned or the like. Thereafter the plate is returned for cleaning.

To clean a xerographic plate, valve 26 is opened while valve 27 is closed and clear liquid is circulated via pump 11 through the system from reservoir 24. To facilitate plate cleaning there is provided an immersed brushing unit 50 that includes a brush 51 having soft fiber bristles and operable while rotating to be moved on a track 52 back and forth across the xerographic plate simultaneously with the flow of clear liquid. By this means, developer is brushed into the circulating clear liquid from which developer therein is appropriately separated by means of separator 40 as described above. The developer ingredients removed on cleaning are thereby restored to the system, and a development cycle is completed without a significant consumption of material. Obviously, however, some loss of material will occur while the plate is being subjected to utilization means, even if limited to slight evaporation losses.

An immersed brushing unit 55, in separator 40, is periodically operative to rotate while moving over a track 56 and is effective to remove collected developer from plate 41 wherefrom the developer may be washed into liquid entering reservoir 25.

Suitable shutoff valves 57 and 58 may be provided for system isolation where desired and may be utilized for example, in the position illustrated, to prevent draining, or for isolating the development zone in the vicinity of opening 13 during removal and insertion of a xerographic plate.

To operate the apparatus of FIG. 1, a xerographic plate 18 having a previously formed electrostatic latent image thereon is secured over opening 13 in operative relation to the developing system. Thereafter, developer liquid taken from reservoir 25 is circulated for a predetermined time period, which may be in the order of a few seconds, past the xerographic plate to effect development of the image thereon. As the liquid is circulated, spent developer fluid flows through separator 40 in which the developer particles are caused to drift toward output leg 45 connected to reservoir 25 while the liquid divides proportionally as aforesaid between legs 44 and 45. After development, the plate is removed for utilization of the image after which it is returned to the system for cleaning. Thereafter a wash liquid relatively clear of developer and taken from reservoir 24 is circulated while brushing unit 50 is operative to facilitate cleaning. The previously clear liquid passes to the separator 40 and is again analyzed into clear and developer-laden fractions. After cleaning the plate is removed and may be reused externally for forming another electrostatic latent image.

Reference is now had to FIG. 2 in which an automatic apparatus utilizing the method of the invention is illustrated. The apparatus is housed in a light-tight housing 62 in which an endless flexible xerographic plate 63 comprising a photoconductive layer on a flexible conductive backing is continuously advanced over suitable guide rolls, one of which is driven by a motor M-1. In contrast to the apparatus of FIG. 1 in which a xerographic plate is held stationary, it will be noticed that in the apparatus of FIG. 2 the xerographic plate is arranged in an endless web and continuously advanced sequentially into contact with liquids employed to effect development and subsequent plate cleaning.

5

As the plate advances a uniform electrostatic charge is first applied on its surface by a corona generating device 64 which may be of a type disclosed in U.S. Patent 2,836,725 and which is energized from a suitable potential source 65. On further advancement the charged plate is exposed to a light image of activating radiation, as for example, from a cathode ray tube or the like 66 aligned optically with objective lens 67. The image formed on the surface of the cathode ray tube is projected onto the charged plate surface resulting in an electrostatic latent image that is subsequently to be made visible by development. As the plate continues to advance it moves over a skewed guide roll 68 whereon the plate is directed into a developer liquid 69 contained in a reservoir 70 wherein development of the electrostatic latent image on the plate is effected. Where the source of activating radiation is a cathode ray tube having a white image on a dark background, it may be preferred to effect reversal development i.e., to use developer particles in the liquid that are repelled by the non-image areas of the plate to the image areas thereon resulting in a dark image on a clear background. As the plate emerges from reservoir 70 containing the developed image, it again passes over guide roll 68 without overlapping the entering plate portion and exits through a restricted slot 71 in a light shield 72.

The plate bearing the developed image passes a projection station designated 80 whereat the image is suitably illuminated by lamps 81 and 82, and the image reflected by a mirror 83 into a lens 84, from which it is projected at increased magnification ratio onto a projection screen 85 for viewing by an audience of any convenient size. The developed image is thereafter removed from the plate as the plate passes through a clear washing liquid 86 contained in a reservoir 87 while being brushed by brushes 88. After cleaning the plate is recycled.

To maintain liquid 69 and 86 with proper ratio of developer concentration, liquid is removed from each reservoir in regulated proportions and circulated via pump 93 to a separator unit 40 from which the liquid is returned to the respective reservoirs in a manner similarly as described in FIG. 1. To maintain liquid levels within the reservoirs the proportion of liquid removed from each is controlled by a differential level control 94 having floats 95 floating in stillwells 96 and 97. The floats operate the level control to effect a compensating adjustment on a suitable mixing valve 98. By this means a greater proportion of liquid is removed from the reservoir having the highest liquid level.

Referring to FIG. 3 there is illustrated an alternative embodiment of automatic apparatus utilizing the method of the invention in which following development, the image is transferred to a secondary support surface 101 at a transfer station generally designated 102. Any transfer means known in the art may be employed. In the illustrated embodiment, a web of secondary support material is drawn from a supply reel 103 over guide roll 104 whereafter the web contacts the xerographic plate 63 in the vicinity of a corona generating device 105, which may be similar to corona generator 64 described above and that functions to electrostatically attract the developed image from the plate onto the support material. Thereafter the support material containing the transferred image advances through a suitable fusing device 106 which may for example be a heat fuser of the type disclosed in U.S. Patent 2,852,651 wherein the image is permanently affixed to the surface of the web. After fusing the web is drawn through an exit slot 108 onto a takeup reel 107 or alternatively may be cut into predetermined lengths and stacked.

Because developer particles on transfer are being consumed without being restored to the developing system, that which is consumed is replenished from a suitable dispensing unit 109 containing developer particles 110 that are dispensed in metered amounts to developer liquid 69.

6

The dispenser is operative in response to a regulatory control (not shown) set to effect dispensing substantially in proportion to the rate of consumption. Setting of the regulatory control may be automatic or manual. Where required for extended operation, make-up liquid can be made available to the system.

Whereas FIGS. 2 and 3 have been described with separate utilization functions for the developed image these functions could readily be combined in the manner disclosed in copending application, Ser. No. 103,345, filed on April 17, 1961, being the same date as the application hereof, in the name of Daniel Rubin. In a combined apparatus a transfer station 102 could be installed in FIG. 2 following the projection station 80 preceding the cleaning of the xerographic plate in clear liquid 86. A suitable dispenser 109 would then be required similarly as in FIG. 3. In this manner, both a projected image and a permanent copy will be produced. The advantages of such a combined arrangement would be dependent on the subject matter for which the system were being employed to effect visible reproduction.

By the apparatus thus described there is disclosed novel liquid developing apparatus for developing an electrostatic image on a xerographic plate in a system that is uniquely self-contained and having the ability to separate developer in the liquid in which it is contained to produce clear liquid for flushing and cleaning purposes and to reconstitute the developer liquid for development purposes.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus comprising in combination means to support a xerographic plate, at least two reservoirs for containment of a liquid of high electrical resistance in which electroscopic developing material can be contained, means to selectively contact a xerographic plate on its support means with a quantity of liquid contained in each of said reservoirs and return an excess of said liquid quantity through a common return to the reservoirs, and developing material separating means connected in the common return to said reservoirs to maintain the liquid in at least one of said reservoirs with a high concentration of developing material adapted to effect development of an electrostatic latent image on a xerographic plate by depositing developing material thereon while maintaining the liquid in another of said reservoirs with a substantially lower concentration of developing material adapted to remove developer deposited on a plate by the highly concentrated liquid.

2. Apparatus comprising in combination a circuited liquid conduit system, means to support a xerographic plate in contact with liquid within said conduit system, means to circulate within said conduit system a liquid of high electrical resistance capable of having electroscopic developing material contained therein, means to effect for a pre-determined time period circulation of developer-contained liquid into contact with a xerographic plate on its support means to effect development of an electrostatic latent image by the deposition of developer particles, and means operative after said last-recited means to effect for a second predetermined time period circulation of liquid that contains substantially less developer than the first circulated liquid into contact with a xerographic plate on its support means to flush developer therefrom deposited by said first circulated liquid.

3. Apparatus comprising in combination means to support a xerographic plate, at least two reservoirs for containing liquid having high electrical resistance and capable of having an electroscopic developing material contained therein, said reservoirs being interconnected in a circulat-

7

ing system, at least one of said reservoirs containing liquid having substantially more developing material than the liquid in another of said reservoirs and capable of developing an electrostatic latent image on a xerographic plate, means to selectively circulate liquid contained in each of said reservoirs into contact past a xerographic plate on its support means and return to both of said reservoirs through a common return and developing material separator means operatively connected in the common return of said circulating system and effective after liquid contact with the plate to direct developing material primarily to the liquid in the reservoir containing substantially more developing material whereby a substantially uniform developer concentration is maintained therein.

4. Apparatus including in combination means to support a xerographic plate on which an electrostatic latent image has been previously formed, means to immerse the plate on its support means into a reservoir containing a liquid of high electrical resistance having electroscopic developing material for effecting development of the electrostatic latent image on the plate, means to utilize the developed image, means operatively arranged after utilization to immerse the plate in a second reservoir containing a like-liquid as said first-recited liquid but having substantially less developing material and adapted to effect removal of developer contained on a plate, and developer particle separator means operatively connected to both of said reservoirs to effect removal of developer material from the like liquid to the first recited developer liquid.

8

5. The apparatus of claim 4 in which the separator means includes an electrostatic separator.

6. Apparatus comprising in combination a circuited liquid conduit system including, means to support a xerographic plate in liquid contact within said conduit system, means to circulate within said conduit system a liquid of high electrical resistance capable of having an electroscopic developing material contained therein adapted to effect development of an electrostatic latent image on a xerographic plate by depositing developing material thereon, at least two reservoirs containing liquid to be circulated and to which excess circulated liquid is returned in a common return by said circulating means, at least one of said reservoirs containing liquid having substantially more developing material contained therein than the liquid in another of said reservoirs, developing material separating means connected in the common return to said reservoirs and adapted to maintain a substantially constant ratio of developing material contained in the liquids in said reservoirs, and means to combine liquid to be circulated from said reservoirs in predetermined proportions.

References Cited in the file of this patent

UNITED STATES PATENTS

2,430,015	Hatton et al.	Nov. 4, 1947
2,877,133	Mayer	Mar. 10, 1959
2,887,087	Jones	May 19, 1959
2,937,390	Bolton et al.	May 24, 1960
2,991,754	Johnson	July 11, 1961
3,001,888	Metcalf et al.	Sept. 26, 1961