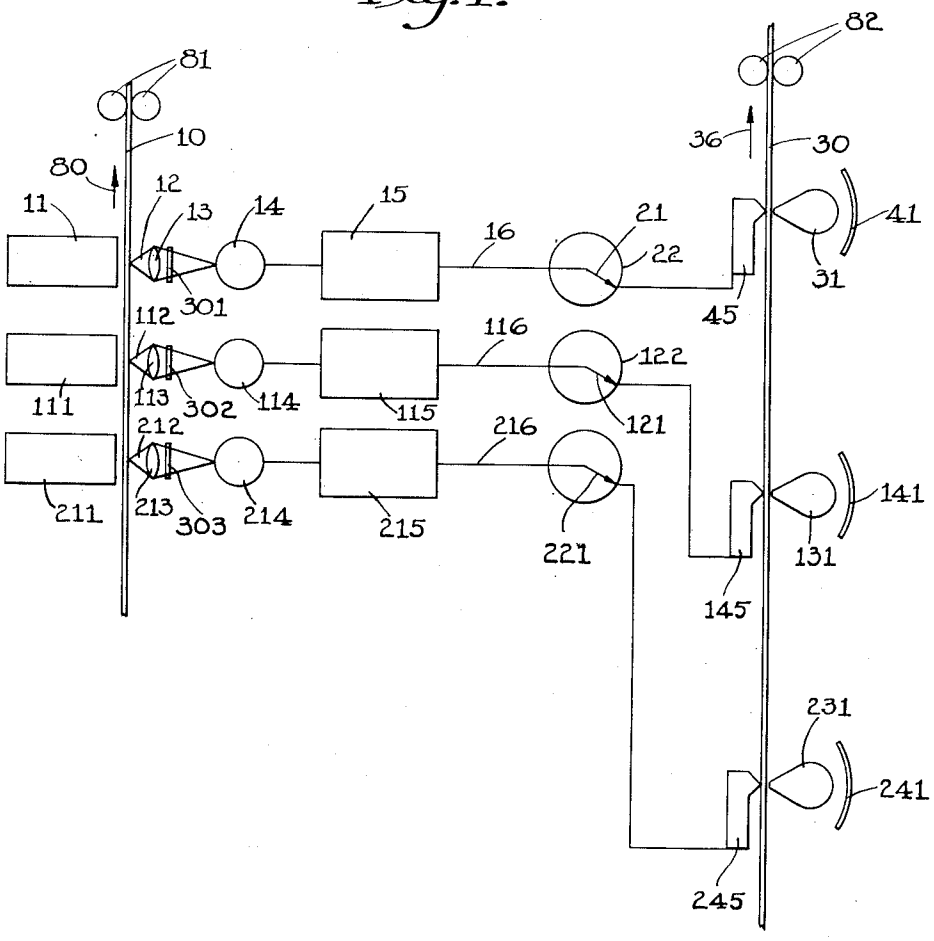
Feb. 5, 1952 P. J. GOOD 2,584,695

ELECTROSTATIC REPRODUCTION PROCESS AND APPARATUS

Filed Aug. 14, 1947 2 SHEETS—SHEET 1

Fig. 1.



INVENTOR,
Paul J. Good
BY Charles Shepard
Attorney

Feb. 5, 1952 P. J. GOOD 2,584,695

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Fig. 2.

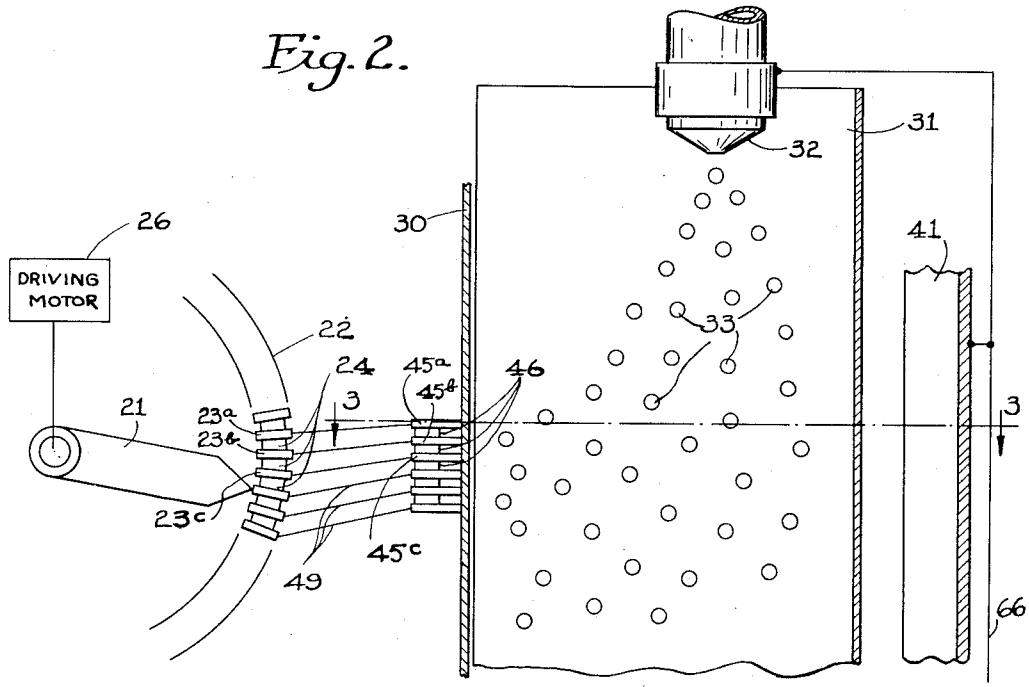
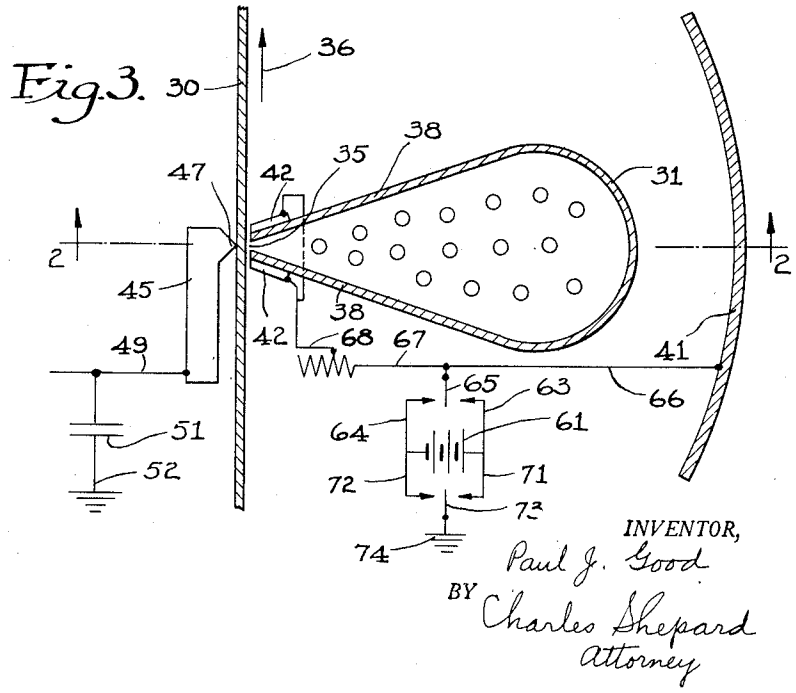


Fig. 3.



INVENTOR,
Paul J. Good
BY Charles Shepard
Attorney

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ELECTROSTATIC REPRODUCTION PROCESS AND APPARATUS

Paul J. Good, Webster, N. Y., assignor, by mesne assignments, to Bell & Howell Company, Chicago, Ill., a corporation of Illinois

Application August 14, 1947, Serial No. 768,654

17 Claims. (Cl. 178—5.2)

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This invention relates to the production of images or facsimiles by the use of electrostatic phenomena, rather than photochemical phenomena or reactions. It may be referred to conveniently as electrostatic photography, as distinguished from the conventional photochemical type of photography.

Broadly, the utilization of electrostatic phenomena in producing images or facsimiles is already known. See, for example, the United States patents to Carlson, No. 2,221,776, granted November 19, 1940; No. 2,277,013, granted March 17, 1942; No. 2,297,691, granted October 6, 1942; and No. 2,357,809, granted September 12, 1944. See also an article entited "Electrophotography" by Nicholas Langer, which appeared in "Radio-Electronic Engineering" (supplement to "Radio News") for July 1944, volume III, pages 22, 23, 40, and 41. However, the prior processes and prior apparatus are far from satisfactory and leave much to be desired.

An object of the present invention is the provision of a simple, effective, and efficient process or method for the production of visible prints or reproductions by the use of electrostatic phenomena without requiring the use of photochemical phenomena.

Another object of the invention is the provision of a method and an apparatus wherein the print forming or image forming steps do not require the immediate presence of any light sensitive or photo-sensitive material, so that these steps may be carried out under illuminated conditions, without requiring the use of a dark room or a dark chamber.

Another object is the provision of a novel method and apparatus whereby a conventional electronic scanning unit may be used to control the making of a print or reproduction on paper or other suitable sheet material, without requiring any photochemical reaction or any light sensitive material other than that in the conventional scanning unit.

A further object is the provision of an electrostatic reproducing method and apparatus so designed and constructed that prints or reproductions in full color may be obtained, as well as black and white prints and reproductions.

These and other objects are accomplished by the method herein described and by the construction disclosed as an illustrative embodiment of the invention in the following description and in the accompanying drawings forming a part hereof, in which

Fig. 1 is a diagrammatic view illustrating the apparatus as a whole;

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Fig. 2 is a diagrammatic vertical section through a portion of the apparatus, the section being taken approximately on the line 2—2 of Fig. 3; and

Fig. 3 is a diagrammatic horizontal section taken substantially on the line 3—3 of Fig. 2.

The same reference numerals throughout the several views indicate the same parts.

According to the method of the present invention, a conventional photocell scanning unit is used for scanning the original subject to be reproduced, as the subject is moved past the scanning unit. The electronic impulses coming from this scanning unit are used to produce electrostatic fields behind a suitable base material (such as paper or film) while the base material is moved past a chamber containing electrostatically charged particles or droplets of a colored liquid or dye solution, which particles or droplets will then be attracted to or repelled from the base material in accordance with the electrostatic charges produced behind the base material by the operation of the scanning unit. This results in the deposit on the base material of varying amounts of the colored liquid or dye, in proportion to the electrostatic charges, which in turn are in proportion to the light falling on the scanning unit from the original subject which is to be reproduced, so that a reproduction of the original subject is made. Since the deposit of the colored liquid or dye on the base material is controlled entirely by electronic phenomena and is entirely independent of any photochemical reaction or any light sensitive material except the scanning unit itself (which may be at a considerable distance from the dye-depositing part of the apparatus) it follows that the step of depositing the dye or colored liquid can be carried out under full illumination as well as in darkness, and consequently the reproduction can be observed while it is being made, with consequent ability to vary the density or make any other desired corrections as the process proceeds, without the necessity of waiting until the complete reproduction is finished, then finding it unsatisfactory, and having to do it all over again.

If only a single scanning unit and associated single dye-depositing unit are employed, the reproduction will be, of course, a single color reproduction of the original subject; for example, a black and white print. It is, however, within the scope of the present invention to provide a plurality of scanning units scanning the original subject through different colored filters, each scanning unit being connected to its own indi-

vidual dye-depositing unit which deposits a dye of a color corresponding to the filter used with its associated scanning unit. If, for example, three scanning units are used, scanning the original subject through three filters corresponding to the three primary colors, then in effect three color separation prints are made, and if the deposit of dye of the three colors is made on the same piece of base material, each deposit being properly registered with the others, the result will be a reproduction in full colors of the original subject.

Referring now to the apparatus disclosed diagrammatically in the drawings, there is shown at 10 the original subject to be reproduced, which may be in the form, for example, of a document, a photographic print, or any other suitable subject. At 11 there is indicated diagrammatically the light projecting unit of a conventional electronic scanning device, throwing light upon the original subject 10, which light is then projected in a beam 12 passing through a lens 13 to the photocell 14, the output of which is suitably amplified by the amplifier indicated diagrammatically at 15 and the amplified output is then conducted by a wire 16 to a contact arm 21 which is rotated in synchronism with the travel of the scanning beam by driving means 26 so as to pass over successive contacts on a commutator 22, the commutator having a great multiplicity of contacts 23 some of which are individually designated at 23*a*, 23*b*, 23*c*, etc., and which are separated from each other by insulating separators 24. The parts 11 to 15, inclusive, are intended merely to indicate diagrammatically any suitable known form of scanning unit, the details of which are well understood in the art. The scanning unit may utilize either a reflected beam or a transmitted beam. All such details are immaterial to the present invention.

The base on which the reproduction or print is to be made is indicated at 30, and may be a sheet of paper, film, or any other suitable known form of base material. On one side of the base 30 there is a dye chamber 31 having at its top a spray nozzle 32 from which a great quantity of minute particles or droplets of a liquid dye solution or colored liquid are sprayed into the chamber 31, so as to form practically a mist or fog of such particles or droplets filling the chamber 31. Some of such particles or droplets constituting the mist or fog are indicated diagrammatically at 33, although it must be understood that the size of these particles is greatly exaggerated in the drawings, the actual size thereof being extremely minute.

The chamber 31 is preferably closed on all sides except for a narrow exit slit 35 in very close proximity to the base sheet 30 and extending transversely to the direction of movement of the sheet 30. Preferably this slit 35 extends vertically and the sheet 30 is moved horizontally past the slit 35 in the direction of the arrow 36, the sheet being positioned in a vertical plane as it passes the slit. The side walls of the chamber 31 converge or taper towards the slit 35 as indicated at 38.

Behind the chamber 31, that is, on the side thereof opposite from the base sheet 30, there is a metallic electrode 41 of substantial area, preferably curved approximately cylindrically and placed with its concave side towards the base 30. Focusing electrodes 42 of metal are also provided, arranged on opposite sides of the slit 35, lying against the outer faces of the converging side walls 38. The walls of the chamber 31 itself may conveniently be of non-metallic or dielectric material.

On the opposite side of the base sheet 30 from the chamber 31, and in direct alinement with the slit 35, there is a great quantity of tiny electrodes, each one connected to one of the contact members 23 of the commutator 22. The electrodes are indicated in general at 45 and certain of the individual electrodes are designated 45*a*, 45*b*, 45*c*, etc. Insulating spacers 46 are placed between successive electrodes. The electrodes are preferably thin, flat metal plates of the shape best shown in Fig. 3, each electrode having a fairly sharp point or nose 47 (formed conveniently at a right angle or 90° corner) lying close to and practically in contact with the rear face of the sheet 30, at a point directly opposite the slit 35 in the chamber 31. This nose or point 47 and its location relative to the base 30 and slit 35 are the important features of each electrode, the rest of the area of the electrode being of a shape and size dictated by convenience in making the electrodes, assembling them, and forming the necessary electrical connections to them. The body of the electrodes are assembled in a pile or stack with the noses or points 47 alined with each other in a vertical row so that all of the noses 47 of all of the electrodes are in alinement with each other and with the slit 35 (that is, directly opposite the slit), the stack of electrodes being built up to a sufficient height to extend across the entire vertical width of the base sheet 30, or at least that part of the width thereof on which the reproduction or facsimile is to be made. Each of these electrodes 45 is connected individually to one of the commutator contacts 23 by means of a wire 49, the electrode 45*a* being connected to the commutator contact 23*a*, the electrode 45*b* being connected to the commutator contact 23*b*, and so on. Also, each individual electrode is connected to one side of its own individual stabilizing capacitator or condenser 51, the other side of all the capacitators or condensers being grounded as at 52.

Other electrical parts of the apparatus include a source of direct current potential, such as the battery 61, one side of which is grounded and the other side of which is connected to the spray nozzle 32, the electrode 41, and the focusing electrodes 42. In order to enable either negative or positive facsimiles or reproductions to be obtained, as desired, it is convenient to arrange the battery 61 so that either the negative or positive side thereof may be connected at will to the spray nozzle and the electrodes 41 and 42, and the other side thereof may be grounded. This may be done, for example, by providing a wire 63 leading from the positive side of the battery 61 and the wire 64 leading from the negative side, and a switch 65 which may be connected at will to either the wire 63 or the wire 64. From the switch 65 a wire 66 leads to the electrode 41 and to the spray nozzle 32, and another wire 67 leads to the electrodes 42. A potentiometer 68 may be inserted in the wire 67 so as to vary the voltage impressed on the focusing electrodes 42. The battery is also provided with wires 71 and 72 leading from the positive and negative sides, respectively, to a switch 73 which is grounded at 74. It is seen that if the switch 65 is placed in contact with the wire 63, the positive side of the battery will be connected to the spray nozzle 32, the electrode 41, and the focusing electrodes 42. The switch 73 should

then be placed in contact with the wire 72 so that the negative side of the battery will be grounded. By reversing the switches 65 and 73, the negative side of the battery can be connected to the spray nozzle and the electrodes, the positive side being grounded.

In operation, the original subject 10 to be copied is moved in the direction of the arrow 80 by any suitable feeding means such as feed rolls 81, and the base material or sheet 30 on which the reproduction is to be made is moved at the same rate in the direction of the arrow 36 by any suitable feeding means such as the feed rolls 82 which are synchronized with the feed means 81. As is well understood, the scanning mechanism 11, 12, 13, 14 scans different portions of the original subject 10 in a direction transverse to the direction of feeding movement indicated by the arrow 80. That is, as the subject moves in the direction of the arrow 80 the scanning takes place across the width of the subject 10, the scanning movement being very rapid and the feeding movement being relatively slow, so that the successive lines along which the original is scanned, in a crosswise direction, are quite close to each other in the direction of travel of the subject. All of this is well understood in the scanning art.

The commutator brush 21 is driven by the motor 26 in synchronism with the shift of the scanning beam across the width of the original subject 10 in such manner that when the scanning beam is starting at the top of one transverse scanning line across the subject, the commutator brush or contact 21 is in contact with the commutator element 23 which is connected to the top one of the electrodes 45 in the pack or stack of electrodes. As the scanning beam passes progressively along the scanning line across the width of the subject 10, the commutator brush 21 progressively moves to make contact successively with other contact elements 23 which are connected to other electrodes 45, in such manner that when the scanning beam reaches the bottom end of the scanning line, the contact element 21 is electrically connected to the electrode 45 at the bottom of the stack or pack of electrodes. Then the scanning beam quickly returns to the top and again starts scanning along the next scanning line, from top to bottom across the width of the original 10, and the commutator brush 21 moves along to the next contact member 23 which now is the one connected to the top electrode 45.

Let it be assumed that the electrical impulses coming from the scanning mechanism to the commutator brush 21 are of negative potential when the scanning beam is scanning the dark parts of the original subject 10. As is well understood in the scanning art, the potential of the electrical impulses will be in proportion to the amount of darkness or light on the original, so that the white areas of the original will produce no potential in the commutator brush 21, the darkest areas of the original will produce the highest negative potential in the commutator brush 21, and areas of intermediate darkness will produce intermediate negative potentials in the commutator brush 21. Now if it is desired to produce a positive print or facsimile reproduction in which the light areas of the original will be reproduced as light areas on the reproduction and the dark areas of the original will be reproduced as dark areas on the reproduction, the switch 65 should be connected to the positive side of the battery 61 and the negative side of the battery should be grounded. Accordingly, each of the atomized droplets or particles issuing from the spray nozzle 32 will ge given a positive electrostatic charge by reason of the positive potential existing on the spray nozzle. The positive charge on the electrode 41 will tend to drive all of the positively charged particles constituting the fog or mist in the chamber 31, in a direction away from the electrode 41 and toward the slit 35. The positive charge on the focusing electrodes 42 will also tend to repel the positively charged droplets, to a slight extent, just enough to prevent any of the droplets from passing through the slot 35 unless they are helped along by the attraction of a negative charge on the nose or point 47 of one of the electrodes 45. When the scanning beam is focused on a white area of the original subject, there will be no negative potential transmitted to the corresponding one of the electrodes 45, and consequently no coloring matter will come through the slot 35 at this time. Where the scanning beam is focused upon a black part of the original subject 10, the highest negative potential will be applied to the corresponding one of the electrodes 45, and the maximum quantity of positively charged droplets or particles 33 of the coloring material will be drawn through the slot 35 at a point opposite the negatively charged electrode 45 and will fall upon the base material 30. Where the scanning beam falls upon a gray part of the original subject, a negative potential of less than the maximum potential will be impressed upon the corresponding one of the electrodes 45, and consequently some of the positively charged coloring matter 33 will be drawn through the slot 35 and fall upon the base sheet 30 opposite the point of the negatively charged electrode, but a smaller quantity of coloring matter will be drawn than if the higher negative potential corresponding to a black part of the original had been impressed on the electrode 45. Thus the amount of coloring matter which is deposited on the base 30 will be proportional to the negative potential output of the scanning unit which, in turn, is proportional to the tones of the original subject 10. Hence a positive reproduction of the original subject is made.

The definition achieved in the reproduction will depend partly upon the width of the slot 35 and partly upon the size and spacing of the individual electrodes 45. Better definition is achieved by using a greater number of electrodes 45, spaced closer together. The number and spacing of the electrodes produces a result somewhat analogous to the size of the screen mesh used in making a half tone reproduction. That is, the closer the spacing of the individual electrodes 45 and the smaller each of these electrodes is, the better is the definition in the finished print, just as in making a half tone reproduction, better definition is achieved in using a finer screen. Reasonably good results are obtained by making each electrode 45 approximately .01 inch thick, and spacing the electrodes from each other by means of insulating layers 46 which are not over .01 inch thick, the slot 35 through which the coloring matter is applied having a width of the order of about .01 inch.

The overall darkness or lightness of the print can be controlled to some extent by varying the potential of the focusing electrodes 42 by suitable adjustment of the potentiometer 68. The higher the potential impressed upon the focusing electrodes 42, the more difficult it will be for the droplets of coloring matter to pass these electrodes when attracted by one of the electrodes 45, and so a smaller quantity of the coloring

droplets will be deposited upon the base **30**, resulting in a lighter colored or "thinner" print. When the potential on the electrodes **42** is reduced while still maintaining sufficient potential thereon to focus the droplets to pass centrally between these electrodes and through the slot **35**, it will be easier for the charged droplets **33** to pass through this slot towards the attraction of one of the electrodes **45**, with the result that a greater quantity of the coloring matter will be deposited on the base **30**, and a darker or more dense print or reproduction will be produced.

It was assumed above that the negative impulses emanating from the scanning unit corresponded to the dark parts of the original subject, and that a positive print or reproduction was to be made; consequently the parts **32**, **41**, and **42** were charged positively. If it is desired to produce a negative or reverse print rather than a positive one, then the switches **65** and **73** are simply reversed, so that the parts **32**, **41**, and **42** will be charged negatively rather than positively, and the droplets **33** will likewise be charged negatively. Under these circumstances, the least deposit of droplets will be made on the base sheet **30** in those areas corresponding to the darkest areas of the original subject, and the greatest deposit of droplets will be made on the base sheet in those areas corresponding to the lightest areas of the original, so that a negative or reversed reproduction or facsimile is produced. Likewise, if the scanning unit is designed with a reverse potential from that assumed above, so that the output has a maximum positive potential when the darkest areas are being scanned, then impressing a negative potential on the parts **32**, **41**, and **42** will result in making a positive print, and impressing a positive potential on these parts will result in making a negative reproduction of the original.

Where only a single scanning unit is employed to scan the original subject **10**, the reproduction must be in a single tone or color, and ordinarily this will be a black and white reproduction, using black dye or coloring matter for the droplets **33**. Droplets of some other color such as red or blue could be used and the result would be a monochrome reproduction in red tones or blue tones of the original subject **10**.

If full color reproduction is desired this can be easily achieved by using three separate scanning units and color applying units, each of which is identical with the others except as to the color filters employed and the color of dye or coloring matter used in the chamber **31**. For example, referring to Fig. 1, the first scanning unit is indicated as before by the parts **11** to **15**, inclusive, and the color applying unit it indicated by the parts **21** to **45**, inclusive. The second scanning unit is similarly indicated by the parts **111** to **115**, inclusive, and the color applying unit is indicated by the parts **121** to **145**, inclusive. The third scanning unit is correspondingly indicated by the numerals **211** to **215**, inclusive, while the third color applying unit is indicated by the numerals **221** to **245**, inclusive. Separate color filters are used in connection with the separate scanning units, and separate colors are used in the color chambers of the coloring applying units. For example, the first scanning unit has the light beam projected through a red filter **301**, and a red dye solution or a red colored liquid is used in making the fog of droplets in the chamber **31** of the first color applying unit. A green filter **302** is used in the light beam of the second scanning unit **111**, etc., and a green dye solution or a green colored liquid is used to form the droplets in the chamber **131** of the second color applying unit. A blue filter **303** is used in the light beam of the third scanning unit and a blue dye solution or blue colored liquid is used to form the droplets in the chamber **231** of the third color applying unit. The original subject **10** passes successively past the three scanning units, and the base material **30** passes successively past the three color applying units each of which is synchronized with its associated scanning unit, and the units are properly synchronized or correlated with each other. With this arrangement, a full color reproduction of the original may be made. The electronic impulses sent by the first scanning unit will correspond to the red color values of the original, and the first reproducing unit will apply red color to the base **30** in proportion to the red color values of the original. Similarly, the second scanning unit will be responsive only to the green color values of the original and the second reproducing unit will apply green color proportional thereto on the base **30**. Likewise, the third scanning unit will be responsive only to the blue color values of the original and the third reproducing unit will apply blue color to the base **30**. The net result, if each color deposit is properly registered with the others, will be a full color reproduction of the original **10** in the natural colors thereof.

The wires **16**, **116**, and **216** may be of any desired length, so that the reproducing units may be separated from the scanning units by any desired distance, whether it be a few feet or many miles. The synchronization of the subject feeding means **81** with the reproduction feeding means **82**, and the synchronization of the driving motor **26** with the line scanning movements of the scanning beam, are accomplished by techniques well understood in the art of wire transmission of pictures and facsimiles.

It is seen from the foregoing disclosure that the above mentioned objects of the invention are admirably fulfilled. It is to be understood that the foregoing disclosure is given by way of illustrative example only, rather than by way of limitation, and that without departing from the invention, the details may be varied within the scope of the appended claims.

What is claimed is:

1. The method of making a graphic reproduction of a subject which comprises scanning the subject along successive scanning lines, translating varying tones at different points along each scanning line into electrostatic charges of varying potential, providing a base sheet on which to make the reproduction, impressing said electrostatic charges successively at different points along a reproducing line on one side of the base sheet and providing a supply of minute particles of coloring material with electrostatic charges of opposite sign on the opposite side of said base sheet along said reproducing line so that said particles will be attracted toward said impressed electrostatic charges in proportion to the varying potentials thereof and will thereby come into contact with said base sheet and form markings thereon.

2. The method of making a graphic reproduction of a subject which comprises advancing the subject past a scanning station, concomitantly advancing a base sheet past a reproducing station, providing a supply of electrostatically charged minute particles of coloring material in

proximity to one surface of said base sheet at said reproducing station along a line transverse to the direction of advance of said base sheet, scanning said subject along a scanning line at said scanning station transverse to the direction of advance of said subject, translating varying tone values of said subject along said scanning line into electric currents of varying potential, and impressing said varying potential along said reproducing line in proximity to the opposite surface of said base sheet from said particles of coloring material, to form electrostatic charges to attract said charged particles of coloring material to said base sheet in accordance with the varying tone values of the subject.

3. The method of making a graphic reproduction of a subject which comprises advancing the subject past a scanning station, concomitantly advancing a base sheet past a reproducing station, providing a supply of electrostatically charged minute particles of coloring material in proximity to one surface of said base sheet at said reproducing station along a line transverse to the direction of advance of said base sheet, scanning said subject along a scanning line transverse to the direction of advance of the subject, translating varying tone values at successive points along the scanning line into varying electrostatic charges, and impressing said varying electrostatic charges at corresponding successive points along said reproducing line and in proximity to the opposite surface of said base sheet from said particles of coloring material, so that said varying electrostatic charges will attract said particles of coloring material to said base sheet in accordance with the varying tone values of the subject.

4. The method of making a graphic reproduction in a plurality of colors of a subject containing a plurality of colors, which comprises advancing the subject past a plurality of scanning stations, concomitantly advancing a base sheet past a plurality of reproducing stations, providing a supply of electrostatically charged minute particles of coloring material in proximity to one face of said base sheet at each of said reproducing stations, said particles at one reproducing station being of one color and said particles at another reproducing station being of another color, scanning said subject at one of said scanning stations in response to color values of the subject corresponding to the color of said particles at one of said reproducing stations, to produce electrostatic charges of varying potential in accordance with varying tones of said color values of the subject, impressing said electrostatic charges in proximity to the opposite surface of said base sheet from said particles of coloring material at the corresponding reproducing station to attract said particles of coloring material to the base sheet in accordance with said varying tones of the subject, correspondingly scanning the subject at another scanning station in response to color values of the subject corresponding to the color of said particles at another reproducing station, to produce electrostatic charges of varying potential in accordance with the varying tones of said other color values of the subject, and correspondingly impressing said electrostatic charges in proximity to said opposite surface of said base sheet at said other reproducing station.

5. The method of making a graphic reproduction in full colors of a subject containing a plurality of colors, which comprises advancing the subject past a plurality of scanning stations, concomitantly advancing a base sheet past a corresponding plurality of reproducing stations, scanning said subject at each scanning station along a scanning line transverse to the direction of advance of the subject, the scanning at each scanning station being responsive to color values different from those to which the scanning at the other scanning stations is responsive, translating varying tone values at successive points along each scanning line into varying electrostatic charges, impressing the varying electrostatic charges from each of the scanning stations at corresponding successive points along a reproducing line transverse to the direction of advance of the base sheet at a corresponding one of the reproducing stations, in proximity to one surface of the base sheet, and providing at each of the reproducing stations a supply of electrostatically charged minute particles of coloring material along the reproducing line and in proximity to the opposite surface of the base sheet from that at which the electrostatic charges are impressed, said particles of coloring material at each reproducing station being of a color corresponding to the color to which the scanning operation is responsive at the corresponding scanning station, so that the varying electrostatic charges at each reproducing station will attract particles of coloring material to the base sheet in accordance with the varying tone values of the corresponding color of the subject.

6. Apparatus for making a graphic reproduction of a subject, including means for scanning the subject along successive scanning lines, means for translating varying tones at different points along each scanning line into electrostatic charges of varying potential, means for impressing said electrostatic charges successively at different points along a reproducing line on one side of a base sheet, and means for providing a supply of minute particles of coloring material with electrostatic charges of opposite sign on the opposite side of said base sheet along said reproducing line so that said particles will be attracted toward said impressed electrostatic charges in proportion to the varying potential thereof and will thereby come into contact with said base sheet and form markings thereon.

7. Means for making a graphic reproduction of a subject, including means for advancing the subject past a scanning station, means for concomitantly advancing a base sheet past a reproducing station, means providing a supply of electrostatically charged minute particles of coloring material in proximity to one surface of said base sheet at said reproducing station, and means for producing electrostatic charges in proximity to the opposite surface of said base sheet at said reproducing station and in accordance with varying tone values of that portion of the subject which is at the scanning station, to attract said charged particles of coloring material to said base sheet.

8. Apparatus for making a graphic reproduction on a base sheet, including means for advancing a base sheet, a chamber in close proximity to one surface of said base sheet, said chamber having a narrow opening in close proximity to said surface of said base sheet and extending in a direction transverse to the direction of advance of the base sheet, means for producing a supply of electrostatically charged minute particles of coloring material in said cham-

ber, and a multiplicity of electrodes closely adjacent the opposite surface of said base sheet from said chamber, said electrodes being successively arranged in close relationship to each other along a line corresponding to the line of said narrow opening of said chamber.

9. A construction as described in claim 8, further including a repulsion electrode associated with said chamber at the opposite side thereof from said narrow opening.

10. A construction as described in claim 8, further including a pair of focusing electrodes associated with said chamber at opposite sides of said narrow opening.

11. A construction as described in claim 8, in which said means for producing a supply of electrostatically charged particles includes a nozzle through which said coloring material is introduced into said chamber, and means for impressing an electrostatic charge on said nozzle.

12. Apparatus for making graphic reproductions of subjects, including means for advancing a subject past a scanning station, means for scanning said subject along successive scanning lines each extending in a direction transverse to the direction of advance of the subject and for translating varying tone values at successive points along each scanning line into electric currents of varying potential, a commutator including a multiplicity of contact elements and a commutator brush element adapted to travel successively over and make successive contact with said contact elements, means for driving said commutator brush element in synchronism with the scanning movements of said scanning means, means for impressing said currents of varying potential on said commutator brush element so that as said brush element moves over said contact elements said currents will be successively impressed on successive contact elements, a multiplicity of relatively small electrodes closely spaced along a reproducing line, an electrical connection between each electrode and a separate one of said contact elements, means for advancing sheet material past said line of electrodes with one face of the sheet material in close proximity to the electrodes, and a chamber on the opposite face of the sheet material from said electrodes for supplying electrostatically charged minute particles of coloring material in position to be attracted by varying electrostatic charges on said electrodes and thereby to contact with said sheet material.

13. Apparatus for making a graphic reproduction of a subject in a plurality of colors, including means for advancing a subject, scanning means responsive to one color for scanning said subject along successive scanning lines each extending transverse to the direction of advance of the subject and for translating varying tone values along each scanning line into electric currents of varying potential, other scanning means responsive to another color for similarly scanning said subject and translating the varying tone values into electric currents of varying potential, a plurality of sets of electrodes, each set including a multiplicity of electrodes closely spaced along a reproducing line transverse to a direction of advancing movement of a piece of sheet material on which the reproduction is to be made, means for impressing the varying electric currents from the first scanning means on successive electrodes of said first set, means for impressing the varying electric currents from another scanning means on successive electrodes of another set, means for advancing a piece of sheet material on which the reproduction is to be made, in synchronism with the advance of the subject and with one face of said sheet material successively passing in close proximity to both sets of electrodes, means adjacent the opposite face of the sheet material for supplying electrostatically charged minute particles of coloring material of a color corresponding to the color to which said first scanning means is responsive, in position to be attracted by electrostatic charges of opposite sign on the electrodes of the first set, and means adjacent said opposite face of said sheet material for supplying electrostatically charged minute particles of coloring material of a color corresponding to the color to which another scanning means is responsive, in position to be attracted to said opposite face of said sheet material by electrostatic charges on the electrodes of said second set.

14. Apparatus as described in claim 12, further including a multiplicity of electric capacitators, an electrical connection between each electrode and one side of a separate one of said capacitators, and electrical connections grounding the other side of each capacitator.

15. Apparatus as described in claim 12, further including a repulsion electrode associated with said chamber adjacent the side thereof remote from said sheet material, to tend to repel said charged particles of coloring material toward said sheet material.

16. Apparatus as described in claim 15, further including a source of both negative and positive electric potential, and means for connecting said repulsion electrode at will to either negative or positive potential.

17. The method of making a graphic representation on a base sheet which includes the steps of providing a fog-like supply of tiny droplets of marking liquid in proximity to one face of the base sheet to be marked, moving said base sheet past said supply of droplets in one direction, making said droplets accessible to the base sheet along a restricted line transverse to the direction of movement of the base sheet while shielding the rest of the area of the base sheet from said droplets, impressing an electrostatic potential of one sign on said droplets, and impressing electrostatic potentials of opposite sign progressively at a multiplicity of successive points along said restricted line and on the opposite face of said base sheet from said droplets, to tend to draw droplets to said base sheet in differential amounts varying with the electrostatic potentials impressed at said opposite face of said base sheet.

PAUL J. GOOD.

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1,709,926	Weaver	Apr. 23, 1929
1,817,098	Ranger	Aug. 4, 1931
1,941,001	Hansell	Dec. 26, 1933
1,957,646	Hinton	May 8, 1934
2,143,376	Hansell	Jan. 10, 1939
2,272,638	Hardy	Feb. 10, 1942
2,278,940	Murphy	Apr. 7, 1942
2,413,706	Gunderson	Jan. 7, 1947
2,461,515	Bronwell	Feb. 15, 1949