

May 26, 1964

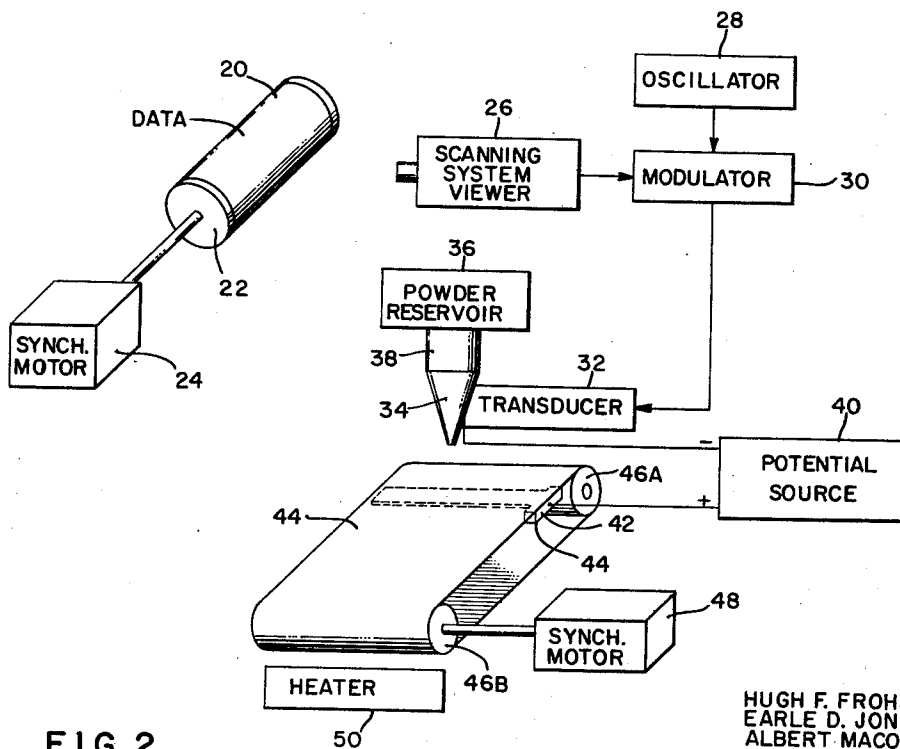
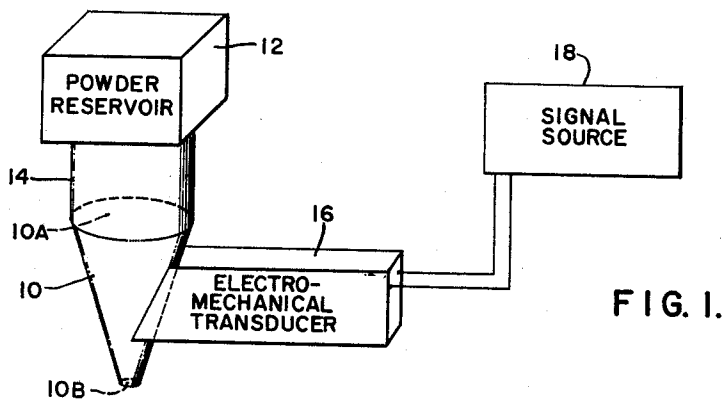
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3,134,849

MEANS FOR SEQUENTIALLY DEPOSITING TONER POWDER

Filed Aug. 9, 1961

2 Sheets-Sheet 1



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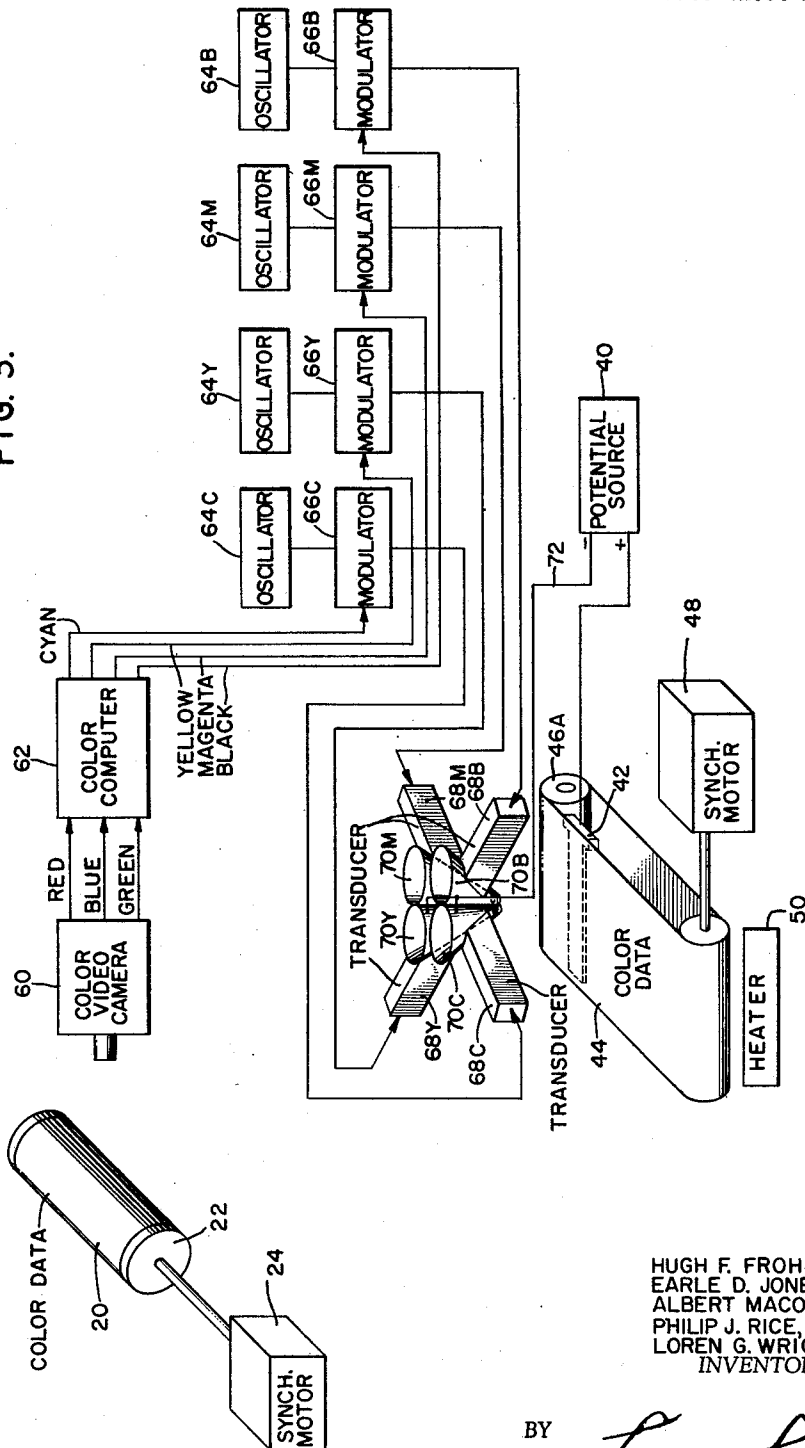
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2 Sheets-Sheet 2

FIG. 3.



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MEANS FOR SEQUENTIALLY DEPOSITING TONER POWDER

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Filed Aug. 9, 1961, Ser. No. 130,338

17 Claims. (Cl. 178-5.2)

This invention relates to writing, using electrostatic techniques, and, more particularly, to improvements therein.

The basic system used in electrostatic writing is first to establish an electric field through which a writing medium is passed. Thereafter, toner powder, or pigmented powder, is introduced into the field through one of the electrodes, which is transferred by operation of the field and the charge on the powder to be deposited upon the writing medium. The powder can thereafter be fixed to the writing medium by techniques which are determined by the nature of the powder and the writing medium. In order to deposit the toner on the writing medium in a manner which conveys intelligence, a number of different techniques have been employed, one of which has been to introduce the toner into the electric field through a screen which has areas thereof masked off in a predetermined pattern. When, however, it is desired to employ an electrostatic-writing technique wherein the operation of writing is to occur substantially concurrently with the operation of scanning an original using, for example, the well-known facsimile-scanning techniques, problems arise. It is difficult to stop and start the electrostatic-writing process or to control the writing process with variations in the scanning signal. This is especially true if it is desired to write electrostatically simultaneously in the same colors as the original.

An object of this invention is the provision of a novel writing transducer for electrostatic writing.

It is another object of this invention to provide an electrostatic-writing transducer suitable for duplication of copy being simultaneously scanned.

Another object of this invention is the provision of an electrostatic-writing system which duplicates an original being scanned in color.

Yet another object of the present invention is the provision of a novel method and means for writing using electrostatic techniques.

These and other objects of the invention are achieved in an arrangement wherein an electrostatic-writing transducer comprises a refillable container for the toner or powder employed for electrostatic writing. This container is conductive and is connected to a high-voltage power supply to constitute one electrode for establishing an electric field. A second backplate, or electrode, is positioned opposite the container and is connected to the high-voltage power supply to establish an electric field between it and the container. Suitable writing material, or output copy, passes through the electric field established between the container and the backplate. The container has a small opening perforated therein, through which powder can pass into the electric field, to be attracted to the backplate. However, the opening is of such size that the powder will not pass therethrough unless the container is vibrated. Means such as an electromechanical transducer are provided for vibrating the container controllably in response to signals received from a scanning device. In accordance with this invention, the powder will not pass through the opening in the container, except in the presence of the control vibration. For writing in color, signals representative of each color

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in the original are generated by a suitable scanning device. A separate electromechanical transducer, to which each separate color signal is applied, is provided for each color, as is a separate container, which is vibrated by the electromechanical transducer. The openings of the containers are juxtapositioned to combine the powder emitted therethrough in a single powder cloud.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a drawing of an electrostatic writing transducer in accordance with this invention;

FIGURE 2 is a drawing of an embodiment of the invention suitable for electrostatic writing in a single color; and

FIGURE 3 is a drawing of an embodiment of the invention suitable for electrostatic writing in color.

Referring now to FIGURE 1, there may be seen a drawing in accordance with this invention of an electrostatic-writing transducer. Effectively, it comprises a container 10, which is made of a conductive material so that it can serve as an electrode for establishing an electric field. A preferred shape for the container is that of a nozzle or frustum of a cone. This container has two openings, one 10A at the top, through which a pigmented powder is passed from a reservoir 12 through a tube 14; the second opening 10B is at the bottom, and pigmented powder is emitted through it into an electric field. The second opening is made so small that no pigment powder or toner powder will pass through it, despite any external forces, unless the container 10 is vibrated. The amount of toner powder passing through the opening 10B is determined by the amplitude of vibration of the container 10. The size of the opening 10A is not critical. There is a wide range of aperture sizes between the size at which the powder falls through the aperture regardless of vibrations and the size at which powder will not pass through. By way of example, in an embodiment of the invention which was built and operated, the aperture size was $\frac{1}{32}$ " diameter.

For vibrating the container 10, any suitable electromechanical transducer 16 may be employed which is driven from a signal source 18. The transducer may be attached to the container in a suitable manner to effectuate the required vibration. The transducer may be any of the types well known in the art, such as a crystal of either the piezoelectric or ferroelectric type, a magnetostrictive device, or an electromagnetic motor such as the voice coil of a loudspeaker. A preferred transducer is a ceramic crystal. The signal source 18 can comprise any suitable device which generates signals suitable for driving the type of electromechanical transducer employed from scanning signals derived by scanning original copy.

FIGURE 2 is a drawing of an electrostatic-writing system in accordance with this invention. Input copy 20, containing data to be reproduced, is wrapped around a drum 22. The drum is rotatably driven by a synchronous motor 24. A suitable scanning system 26 looks at the input copy 20 as it is being rotated and provides an output, consisting of video signals representative of the data.

The scanning arrangement described thus far is well known in the facsimile art, for example. In accordance with this invention, however, the output signals of the scanning system, together with oscillations from an oscillator 28, are applied to a modulator circuit 30, which produces as its output amplitude-modulated oscillation signals. These are applied to an electromechanical trans-

ducer 32, which vibrates a container 34 responsive thereto. Pigment powder is provided to the container 34 from a reservoir 36 through a tube 38.

A source of potential 40 is connected to the container 34 and to a backplate 42, to establish an electric field therebetween. A document 44, on which the data which is scanned is to be written, is spaced through the electric field. The document 44 is either in the form of a loop supported by two spaced rollers 46A, 46B, or may be attached to a belt which is supported by these rollers to be moved through the electric field. Such rotation is made synchronous with the rotation of the scanning drum 22 by employing a motor 48 which is driven synchronously with the motor 24. Not shown, but well understood by those skilled in facsimile art, is the means required to effectuate synchronous transverse motion of the scanning system viewer and the document 44 along with the rotational motions to effectuate complete scanning of both the original and the copy. This has been omitted to maintain the clarity and simplicity of this explanation.

The transducer 32 vibrates the container 34 with an amplitude determined by the signals from the scanning system viewer 26. In the absence of signals therefrom, no powder is emitted into the electric field between the container 34 and the backplate 42. Otherwise, powder is emitted in a quantity determined by signal amplitude and transferred by the electric field to the document 44. The size of the reproduced data can be varied by varying the speed of the synchronous motor 48 relative to the motor 24. Effectively, the emitter powder travels in a straight-line path and covers what may be considered as an elemental region of the document 44, corresponding to the element being scanned by the scanning-system viewer. A suitable frequency for the oscillator is one in the sonic or supersonic region. In an embodiment of the invention which was built using a ceramic crystal, a frequency of 20 kilocycles was used. The modulator circuit 30 may be any suitable amplitude-modulator circuit well known in the radio field, for example.

The pigment powder, or toner powder, which is deposited on the document 44 may be any of the types employed in xerography or printing. Such powder may be fixed by using heat. A heater 50 is positioned adjacent the path of the document to accomplish this purpose.

FIGURE 3 shows an embodiment of the invention whereby a four-color reproduction may be obtained. In FIGURE 3, similar-functioning apparatus bears the same reference numbers as are used in FIGURE 2. The copy 20 on the drum 22 is scanned by a video color camera 60, which looks at elements of the copy on the drum and produces as its output three primary color-video signals representative of the element being viewed. Suitable apparatus for scanning the copy on the drum element by element and producing color signals representative thereof are well known, being described, for example, in an article by G. S. Allen, vol. 6, 1958, pages 125-140, in the *Journal of Photographic Sciences*. The article is entitled "Electronic Scanning Methods for Color Printing." The color-video signals are applied to a color computer 62, which determines which of the three signals is the smallest, uses this to provide a black-representative signal, and subtracts this signal from the other two signals to determine how much of the other two colors is to be printed on the black color, providing output signals representative thereof. The computer then converts the three color-representative video signals to three complementary color signals, respectively cyan, yellow, and magenta, which, as is well known, are required for printing where copy is viewed by its light reflectance rather than by its light transmission. The color computer also has circuitry for performing electronic masking. Such color computers are well known in the printing art, suitable ones being described in Patents Nos. 2,968,214, 2,972,012, 2,976,348, and 2,976,349, for example. An oscillator, respectively 64C, 64Y, 64M, and 64B, is provided for each color sig-

nal from the computer. These oscillators produce output oscillations, as does oscillator 28, which may be in the sonic or ultrasonic range. The frequency of oscillation of the oscillators need not be the same, but can vary to accommodate differences in the subsequent equipment and/or toner powder used. Such differences may be differences in transducers, mass of the containers, etc. None of these are critical and are readily determined.

Associated with each oscillator is a modulator 66C, 66Y, 66M, and 66B, which, as modulator 30, constitutes an amplifier of the oscillations whose gain is controlled by the respective cyan, yellow, magenta, and black video-signal outputs of the color computer. The respective outputs of the modulators 66C, 66Y, 66M, and 66B are respectively applied to electromechanical transducers 68C, 68Y, 68M, 68B to cause them to vibrate, responsive to these outputs, the respective containers 70C, 60Y, 70M, and 70B. These containers are each identical with the container 10 in FIGURE 1 or 34 in FIGURE 2. The associated powder reservoirs and pipes are not shown, to preserve clarity in the drawing. However, into each container there is fed a toner powder having the color represented by the signal by which the container is being vibrated.

It is to be noted that the containers are electrically connected by a lead 72 to the high-voltage potential source 40, to which the backplate 42 is connected. Furthermore, the containers are all supported so that the powder emitted by each one will mingle with the powder of the others in the same region of the electric field. This mingling results in the color on the copy 44 being a composite of the powder colors and thus rendering a substantially faithful copy of the colors of the original.

The operation of the system should be clear. Any copy which it is desired to reproduce is placed upon the drum 20, and a writing medium 44, upon which it is desired to reproduce the data on the input copy, is supported for synchronous movement with the copy, below the containers. The apparatus is started; the camera 60 scans the elemental area of the input copy and provides three color signals representative of each area. The color computer converts these three color signals into their complementary colors and also generates a signal corresponding to black therefrom. These four signals are employed to control the modulators which amplify the oscillations. These oscillations are employed to drive a separate electromechanical transducer for each color. Each one of these transducers converts the electrical oscillations to mechanical oscillations. These mechanical oscillations are used to shake or vibrate a nozzle-shaped container, a different one of which is attached to a different one of the ceramic transducers. Pigment powder is fed into each one of the nozzles from a separate reservoir containing powder or toner with the desired color. A connection is made between the reservoir and the nozzle with a flexible tubing. The ends of the nozzles are brought together to effectively cover a unit area. The nozzles are made one electrode of an electric field. The openings of the nozzles are positioned so that effectively the powder which is vibrated out of the nozzles by operation of the transducers superimposes upon the writing medium passing underneath the nozzles. By controlling the speed of the synchronous motor 32, it is possible to enlarge the size of the image which is written upon the output copy.

The powder output of the containers is determined not only by the presence of an oscillation or vibration, but also by the amplitude of that vibration. That is, the higher the amplitude of the signal driving the ceramic transducer, the greater the amplitude of vibration and the more powder is emitted through the nozzle. Thus, the electrostatic writing transducer can afford a rather faithful reproduction, not only of the color but also of the brightness of the original image.

There has been shown and described herein a novel and useful electrostatic transducer and writing system af-

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fording reproduction of an original copy in color using element-by-element scanning techniques. Although the shape of the container has been indicated as that of a truncated cone or nozzle, it is to be understood that this exemplifies the preferred shape and is not to be construed as a limitation upon the invention. Any shape for a container which has the requisite input and output apertures and which is capable of being vibrated by the transducer to emit a pigment powder responsive to such vibration is to be considered within the scope of this invention.

We claim:

1. An electrostatic-writing transducer comprising a container for pigment powder, said container having conductive walls and having one opening through which pigment powder can be introduced into said container and a second opening for removing pigment powder from said container, said second opening being sufficiently small to prevent passage of pigment powder unless said container is vibrated, and means connected to said container for controllably vibrating said container at various predetermined amplitudes to vary the amount of powder passing through said second opening accordingly.

2. An electrostatic-writing transducer as recited in claim 1 wherein said means connected to said container for controllably vibrating said container at various predetermined amplitudes includes an electromechanical transducer, a source of signals for controlling said electromechanical transducer, and means for applying signals from said source to said electromechanical transducer to cause it to vibrate responsive thereto.

3. An electrostatic-writing transducer as recited in claim 1 wherein said container has substantially the shape of a truncated cone.

4. An electrostatic-writing transducer comprising a container for pigment powder, said container having conductive walls and having one opening through which pigment powder can be introduced into said container and a second opening for removing pigment powder from said container, said second opening having dimensions on the order of those requiring that the container be vibrated to pass pigment powder therethrough, and a crystal connected to said container, said crystal having the property that an electrical signal applied thereto is converted to mechanical motion of said crystal.

5. An electrostatic-writing transducer comprising a container for pigment powder made of conductive material, said container having substantially the shape of a truncated cone having a larger opening at the base and a smaller opening at the apex, means for introducing pigment powder into said larger opening, said smaller opening having dimensions requiring that said container be vibrated to pass pigment powder therethrough, a ceramic crystal attached to the side of said cone, and means for applying signals to said crystal to cause said crystal to vibrate responsive thereto to vibrate said cone therewith.

6. An electrostatic-writing system comprising means for establishing an electric field including spaced electrodes, and means for applying an electric potential to said spaced electrodes, one of said spaced electrodes comprising a conductive body having an aperture therethrough, means for applying pigment powder to said aperture to introduce said pigment powder into said electric field, said aperture having dimensions requiring the vibration of said electrode to pass pigment powder therethrough, an electromechanical transducer connected to said one of said electrodes for vibrating said one of said electrodes, means for generating predetermined signals representative of desired copy, means for applying said predetermined signals to said transducer for causing it to vibrate said one of said electrodes responsive thereto, and means for passing a writing medium through said electric field to receive the pigment powder introduced into said field whereby said desired copy is reproduced on said writing medium.

7. An electrostatic-writing system as recited in claim 6

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wherein said one of said spaced electrodes comprises a container for pigment powder made of conductive material and having substantially the shape of a truncated cone with a larger opening at the base into which pigment powder is introduced and a smaller opening at the apex through which pigment powder is introduced into said electric field.

8. An electrostatic-writing system as recited in claim 6 wherein said means for generating predetermined signals representative of desired copy includes means for generating control signals representative of desired copy, means for generating electrical oscillations at a predetermined frequency, modulator means to which said control signals and oscillations are applied for controlling the amplitude of said oscillations responsive to said control signals, and means for applying the output of said modulator means to said electromechanical transducer to cause it to vibrate responsive thereto.

9. In an electrostatic-writing system of the type wherein spaced electrodes are provided for establishing an electric field therebetween, and a cloud of pigment powder is introduced into said electric field through an aperture in one of said electrodes to be deposited on a writing medium being passed transversely through said field, the improvement comprising making the dimensions of said aperture such that pigment powder does not pass through said aperture unless said electrode is vibrated, means for vibrating said electrode connected thereto, means for generating predetermined signals, and means for controlling the amplitude of the vibrations provided by said means for vibrating responsive to said predetermined signals.

10. In an electrostatic-writing system for reproducing data on a writing medium from an original document, said system being of the type wherein spaced electrodes are provided for establishing an electric field therebetween, and a cloud of pigment powder is introduced into said electric field through an aperture in one of said electrodes to be deposited on a writing medium being passed transversely through said field, the improvement comprising making said one of said electrodes out of a plurality of containers of pigment powder, there being as many containers as there are colors desired to be written on said writing medium, each container having a first aperture into which pigment powder can be introduced and a second aperture through which powder passes into said electric field, said second aperture having dimensions requiring the vibration of said container to pass pigment powder therethrough, a separate means for vibrating each container connected respectively to each container, means for deriving separate signals representative of each color in an original desired to be reproduced on said writing medium, and means for applying said separate signals respectively to said separate means for vibrating to control the amplitude of vibration of said respective containers responsive thereto.

11. In an electrostatic-writing system as recited in claim 10 wherein each said container has substantially the shape of a truncated cone and there is a means to support said cones with their second apertures adjacent one another to emit pigment powder in substantially the same region of said electric field.

12. In an electrostatic-writing system as recited in claim 11 wherein each said means for vibrating comprises an electromechanical transducer connected to each said cone, and said means for deriving separate signals representative of each color includes means for generating oscillations at a predetermined frequency, and means for amplitude modulating said oscillations responsive to the brightness of a color in said original.

13. A system for electrostatically producing on a writing medium a copy of data on an original document comprising means for scanning said original document for producing signals representing the data on said original document, means for producing oscillations at a desired frequency, modulator means to which said signals and

said oscillations are applied for amplitude modulating said oscillations responsive to said signals, means for establishing an electric field including spaced electrodes, and a source of potential connected to said electrodes, means for passing said writing medium transversely through said electric field, pigment powder, means for introducing said pigment powder into said electric field through one of said electrodes to be deposited on said writing medium, and means for controlling the amount of powder introduced into said field through said electrode responsive to the output of said modulator means.

14. A system as recited in claim 13 wherein said one of said electrodes through which pigment powder is introduced into said field has walls defining an opening through which pigment powder is passed into said electric field, said opening being dimensioned not to pass said pigment powder unless said electrode is vibrated, means for vibrating said electrode, and means for applying the output of said modulator means to said means for vibrating to control the amplitude of vibration responsive thereto.

15. A system as recited in claim 13 wherein said one of said electrodes through which pigment powder is introduced into said field comprises a container having a first opening through which pigment powder enters said container and a second opening through which pigment powder is introduced into said electric field, said second opening being dimensioned not to pass said pigment powder unless said container is vibrated, said means for controlling the amount of powder introduced into said field through said electrode comprising an electromechanical transducer attached to said container, and means for applying the output of said modulator means to said transducer to control the vibrations of said container by said transducer therewith.

16. A system for electrostatically producing on a writing medium a copy of data on an original document comprising means for scanning said original document for producing separate signals representing separate color

characteristics of the data on said writing medium, a separate oscillator associated with each color, a separate modulator associated with each color, means for applying the separate signals and the outputs of the separate oscillator to each of the respective separate modulators associated with the same colors to produce separate oscillations modulated by said respective separate signals, means for establishing an electric field including spaced electrodes, and a source of potential connected to said electrodes, means for passing said writing medium transversely through said electric field, one of said spaced electrodes comprising a separate container for and associated with each color, each said container having a first opening through which a pigment powder having the associated color may be passed into said container and a second opening through which pigment powder is introduced into said electric field, each said second opening being dimensioned not to pass pigment powder unless said container is vibrated, a separate electromechanical transducer connected to each said container, and means for applying the respective outputs of each said modulator to each transducer attached to a container associated with the same color as said modulator to vibrate said container responsive to said modulator output.

17. A system as recited in claim 16 wherein each said container is shaped substantially as a frustum of a cone, means supporting each said container so that the pigment powder emitted by their respective second openings is mixed together in said electric field, and said electromechanical transducer comprises a ceramic crystal.

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