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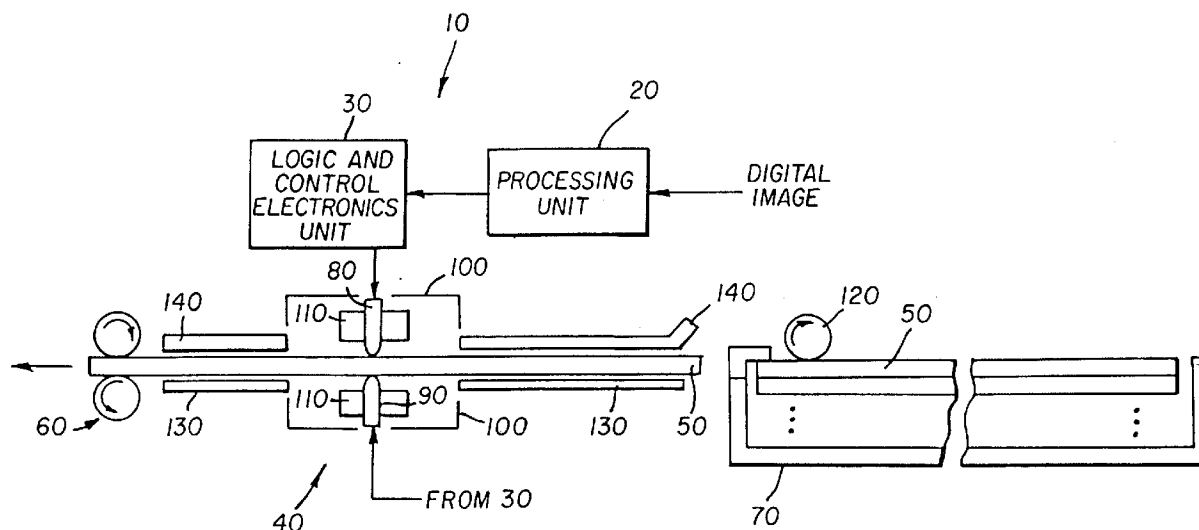
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(54) Forming images on receivers having field-driven particles

(57) An electronic printing apparatus stores a digitized image and includes a receptacle for receiving one or more receivers, each receiver including field-driven particles in a matrix that can change reflective density in response to an applied electric field. The receiver is transported to an image forming position where an array of electrodes for selectively applying electric fields at the

image forming position across the receiver and electronic circuitry coupled to the array for selectively applying voltages to the array so that fields are applied at the image forming position to field-driven particles at particular locations on the receiver corresponding to pixels in the stored image so that the electrodes produce an image in the receiver corresponding to the stored image.

**FIG. 1****EP 0 940 261 A1**

Description

[0001] This invention relates to an electronic printing apparatus for producing images on a receiver having electric field-driven particles.

[0002] There are several types of electric field-driven particles in the field of non-emissive displays. One class is the so-called electrophoretic particle that is based on the principle of movement of charged particles in an electric field. In an electrophoretic receiver, the charged particles containing different reflective optical densities can be moved by an electric field to or away from the viewing side of the receiver, which produces a contrast in the optical density. Another class of electric field-driven particles are particles carrying an electric dipole. Each pole of the particle is associated with a different optical densities (bi-chromatic). The electric dipole can be aligned by a pair of electrodes in two directions, which orient each of the two polar surfaces to the viewing direction. The different optical densities on the two halves of the particles thus produces a contrast in the optical densities.

[0003] To produce a high quality image it is essential to form a plurality of image pixels by varying the electric field on a pixel wise basis. The electric fields can be produced by a plurality pairs of electrodes embodied in the receiver as disclosed in US-A-3,612,758. A shortcoming is that this solution requires the incorporation of electrodes in the receiver, increasing the receiver complexity.

[0004] It is an object of the present invention to provide an electronic printing apparatus for producing images on a receiver having electric field-driven particles.

[0005] Another object of the present invention is to reduce the complexity of the receiver.

[0006] These objects are achieved by an electronic printing apparatus, comprising:

- a) means for storing a digitized image;
- b) a receptacle for receiving one or more receivers, each receiver including field-driven particles in a matrix that can change reflective density in response to an applied electric field;
- c) means for transporting a receiver to an image forming position;
- d) an array of electrodes for selectively applying electric fields at the image forming position across the receiver; and
- e) electronic control means coupled to the array for selectively applying voltages to the array so that fields are applied at the image forming position to field-driven particles at particular locations on the receiver corresponding to pixels in the stored image sothat the electrodes produce an image in the receiver corresponding to the stored image.

[0007] An advantage of the present invention is that by using an externally applied electric field to eliminate

the need of electrodes in the receiver.

[0008] An additional advantage is that the display content on the receiver can be changed by electronic printing apparatus.

[0009] Another feature of the invention is that the print head is compatible with a wide range of printing resolution.

FIG. 1 shows the electronic printing apparatus 10 in accordance to the present invention;

FIG. 2 shows a top view of the structure around the print head 40; and

FIG. 3a and 3b show a cross sectional view of the receiver 50 of FIG. 1.

[0010] FIG. 1 shows the electronic printing apparatus 10 in accordance to the present invention. The electronic printing apparatus 10 includes a processing unit 20, a logic and control electronics unit 30, a print head 40, a receiver 50 that comprises electric field-driven particles in a matrix (see FIG. 3), a receiver transport 60, and a receptacle 70. The print head 40 includes an array of pairs of top electrode 80 and bottom electrode 90 corresponding to each pixel of the image forming position on the receiver 50. The array of electrodes is contained in an electrode structure 110. The electrode structure 110 is formed using polystyrene as an insulating material. It is known that other insulating materials including ceramics and plastics can be used. An electric voltage is applied by logic and control electronics unit 30 across the pair of electrodes at each pixel location to produce the desired optical density at that pixel. An electrically grounded shield 100 is provided to shield print head 40 from external electric fields. The electrically grounded shield 100 isolates the print heads and fields applied at the image forming position. A top view of the print head 40 is shown in FIG. 2.

[0011] The receiver 50 is shown to be picked by a retard roller 120 from the receptacle 70. Other receiver feed mechanisms are also compatible with the present invention: for example, the receiver can be fed by single sheet or by a receiver roll equipped with cutter. The term "receptacle" will be understood to mean a device for receiving one or more receivers including a receiver tray, a receiver roll holder, a single sheet feed slot and so forth. During the printing process, the receiver 50 is supported by the platen 130 and guided by the guiding plate 140, and is transported by the receiver transport 60.

[0012] FIG. 2 shows a top view of the structure around the print head 40. For clarity reasons, only selected components are shown. The receiver 50 is shown to be transported under the print head 40 by the receiver transport 60. The print head 40 is shown to include a plurality of top electrodes 80, each corresponding to one pixel. The top electrodes 80 are located within holes in the electrode structure 110. The bottom electrodes 90 of FIG. 1 are also disposed in an electrode structure 110. The electrodes are distributed in a linear fashion to form

a linear array as shown in FIG. 2 to minimize electric field fringing effects between adjacent pixels printed on the receiver 50. Different printing resolutions are achievable across the receiver 50 by the different arrangements of the top electrodes 80, including different electrode spacings. The printing resolution down the receiver 50 can also be changed by controlling the receiver transport speed by the receiver transport 60 or the rate of printing by controlling the logic and control electronics unit 30.

[0013] FIG. 3a and 3b show a cross sectional view of the receiver 50 of FIG. 1. The receiver 50 is shown to comprise a plurality of electric field-driven particles 200. The electric field-driven particles 200 are exemplified by bi-chromatic particles, that is, half of the particle is white and the other half is of a different color density such as black, yellow, magenta, cyan, red, green, blue, and so forth. The bi-chromatic particles are electrically bi-polar. Each of the color surfaces (for example white and black) is aligned with one pole of the dipole direction. The stable electric field-driven particles 200 are suspended in a fluid 210 such as oil which are together encapsulated in a microcapsule 220. The microcapsules 220 are immersed in matrix 230. An electric field induced in the microcapsule 220 align the electric field-driven particles 200 to a low energy direction in which the dipole opposes the electric field. When the field is removed the particles state remains unchanged. FIG. 3a shows the electric field-driven particle 200 in the white state as a result of field previously imposed by a negative top electrode 80 of FIG. 1 and positive bottom electrode 90 of FIG. 1. FIG. 3b shows the electric field-driven particle 200 in the black state as a result of field previously imposed by a positive top electrode 80 of FIG. 1 and negative bottom electrode 90 of FIG. 1. The receiver 50 shown here is less complex than the prior art receiver structures comprising field-driven particles and addressing electrodes.

[0014] The field-driven particles can include many different types, for example, the bi-chromatic dipolar particles and electrophoretic particles. In this regard, the following disclosures are herein incorporated in the present invention. Details of the fabrication of the bi-chromatic dipolar particles and their addressing configuration are disclosed in US-A-4,143,103; US-A-5,344,594; and US-A-5,604,027, and in "A Newly Developed Electrical Twisting Ball Display" by Saitoh and others p249-253, Proceedings of the SID, Vol. 23/4, 1982, the disclosure of these references are incorporated herein by reference. Another type of field-driven particle is disclosed in PCT Patent Application WO 97/04398. It is understood that the present invention is compatible with many other types of field-driven particles that can display different color densities under the influence of an applied electrical field.

[0015] Referring to FIG. 1, an electronic printing apparatus 10 in accordance with the present invention is shown. A user sends a digital image to a processing unit 20. Processing unit 20 receives the digital image and

stores it in an internal memory. It will be understood that the term "digital image" can include only a portion of the finally produced image in the receiver, for example, a line of the image. In such a situation, an input line buffer could be used in the processing unit 20. All processes are controlled by processing unit 20 via which works with logic and control electronics unit 30. The logic and control electronics unit 30 addresses electrodes to provide electric fields as will be subsequently described. A receiver 50 is picked from a receptacle 70 by a retard roller 120. The receiver 50 is advanced until the leading edge engages receiver transport 60. Retard roller 120 produces a retard tension against receiver transport 60 which controls receiver 50 motion. As the receiver 50 is transported past the image forming position between the array of pair of electrodes, each pixel of the digital image produced by an electric field applied by the pair of the electrodes, top electrode 80 and bottom electrode 90. Each pair of electrodes are driven in a complementary fashion, bottom electrode 90 presents a voltage of opposite polarity to the voltage produced by top electrode 80, each voltage referred to ground. Each pixel location is driven according to the input digital image to produce the desired optical density as described in FIGS. 3a and 3b. The pixel is selected from the digital image to adjust for the relative location of each electrode pair and transport motion. The receiver transport 60 advances the receiver 50 a displacement which corresponds to a pixel pitch. The next set of pixels are written according to the current position. The process is repeated until the entire image is formed. The retard roller 120 disengages as the process continues and the receiver transport 60 continues to control receiver 50 motion. The receiver transport 60 moves the receiver 50 out of the electronic printing apparatus 10 to eject the print. The receiver transport 60 and the retard roller 120 are close to the image forming position under the electrodes 80 and 90, this improves control over the receiver motion and improves print quality.

[0016] The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

PARTS LIST

[0017]

- 10 electronic printing apparatus
- 20 processing unit
- 30 logic and control electronics unit
- 40 print head
- 50 receiver
- 60 receiver transport
- 70 receptacle
- 80 top electrode
- 90 bottom electrode

100	electrically grounded shield	
110	electrode structure	
120	retard roller	
130	platen	
140	guiding plate	5
200	electric field-driven particle	
210	fluid	
220	microcapsule	
230	matrix	10

Claims

1. An electronic printing apparatus, comprising:
 - a) means for storing a digitized image;
 - b) a receptacle for receiving one or more receivers, each receiver including field-driven particles in a matrix that can change reflective density in response to an applied electric field;
 - c) means for transporting a receiver to an image forming position;
 - d) an array of electrodes for selectively applying electric fields at the image forming position across the receiver; and
 - e) electronic control means coupled to the array for selectively applying voltages to the array so that fields are applied at the image forming position to field-driven particles at particular locations on the receiver corresponding to pixels in the stored image so that the electrodes produce an image in the receiver corresponding to the stored image.
2. The electronic printing apparatus of claim 1 wherein the array is a linear array of spaced electrodes.
3. The electronic printing apparatus of claim 1 further including an electric shield for isolating the fields applied at the image forming position.
4. The electronic printing apparatus of claim 1 wherein the electronic control means further includes logic and control means responsive to the stored digital image for controlling the operation of the transport means and the application of voltages to the array to cause images to be applied a line at a time to the receiver.

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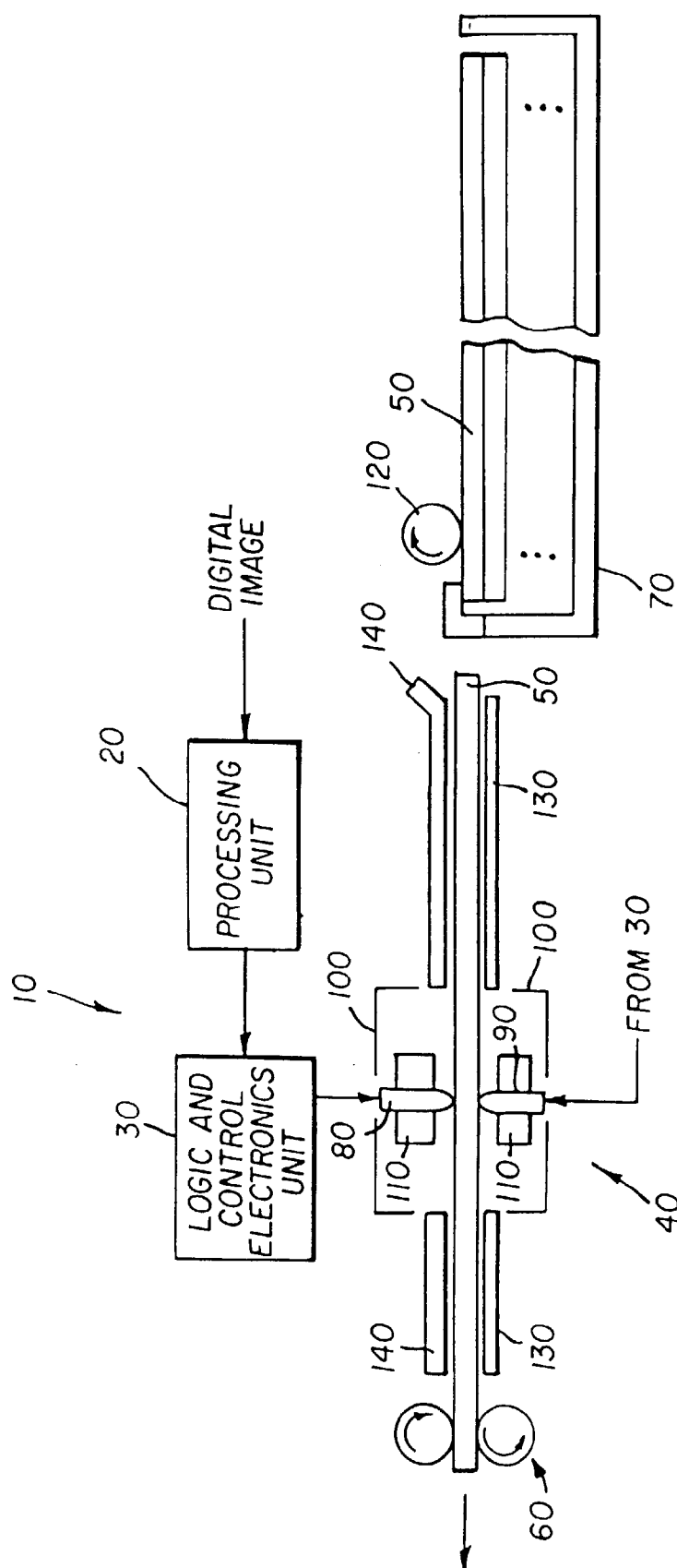
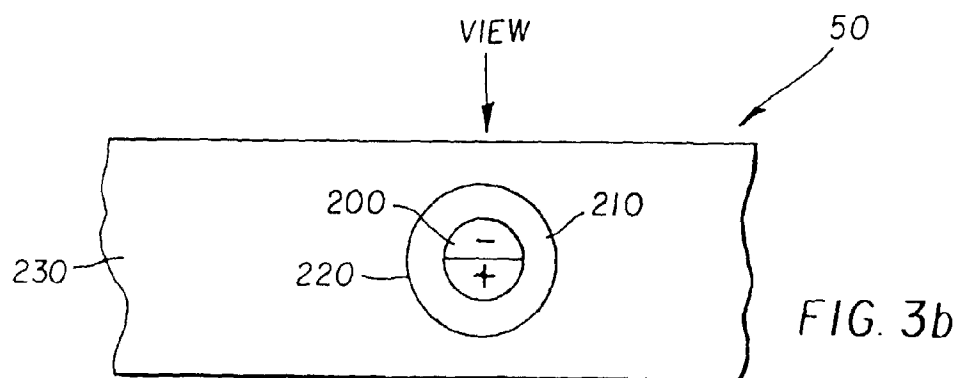
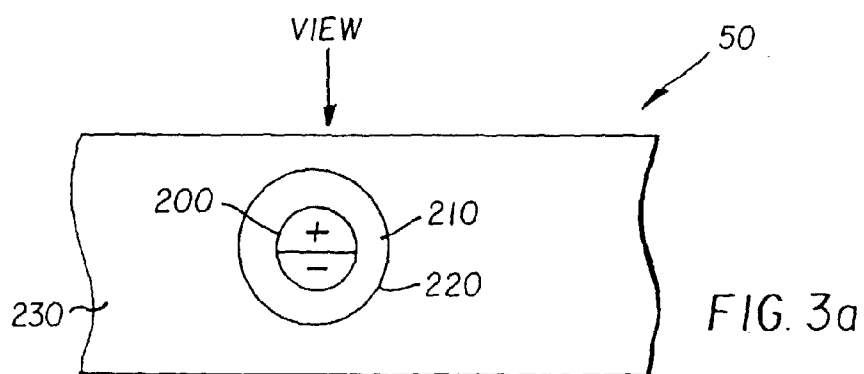
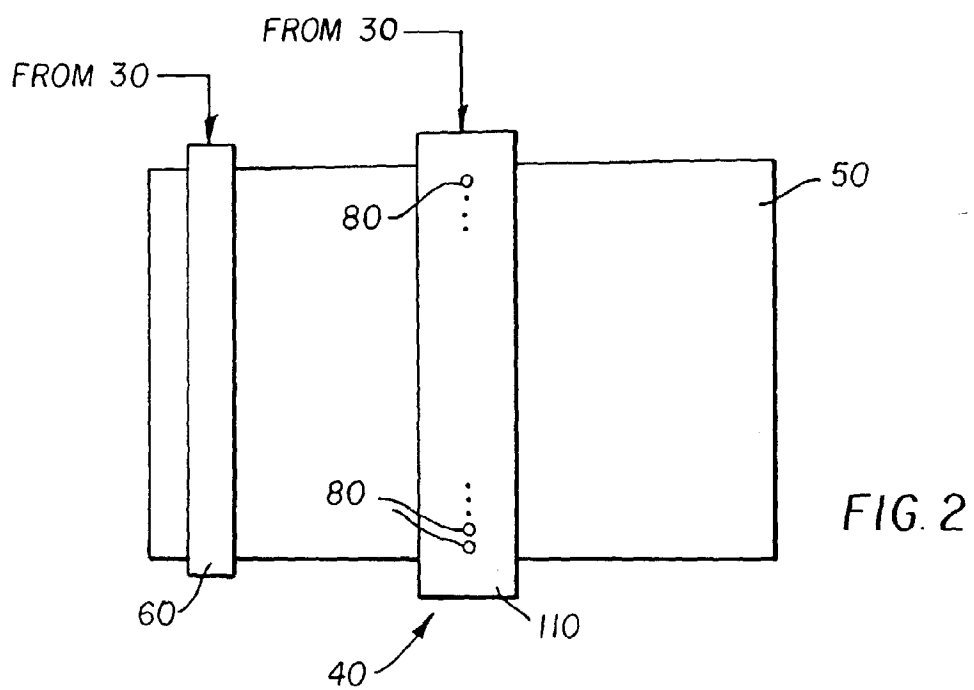


FIG. 1





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EUROPEAN SEARCH REPORT

Application Number
EP 99 20 0500

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 5 723 204 A (STEFIK MARK J) 3 March 1998	1,2,4	B41J2/385
Y	* the whole document *	3	
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Y	US 4 977 416 A (BIBL ANDREAS ET AL) 11 December 1990 * column 5, line 34 - column 6, line 27; figures 1-3 *	3	
A	US 5 659 374 A (MCCORMACK BRIAN C ET AL) 19 August 1997 * column 1, line 20 - line 58 * * column 5, line 23 - line 50; figure 5 *	1,2,4	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B41J G09F
Place of search		Date of completion of the search	Examiner
THE HAGUE		29 June 1999	De Groot, R
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 20 0500

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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