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Disanto et al.

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[54] **ELECTROPHORETIC DISPLAY PANEL WITH ARC DRIVEN INDIVIDUAL PIXELS**

[75] Inventors: **Frank J. Disanto**, North Hills; **Denis A. Krusos**, Lloyd Harbor, both of N.Y.

[73] Assignee: **Copytele, Inc.**, Huntington Station, N.Y.

[21] Appl. No.: **18,111**

[22] Filed: **Feb. 17, 1993**

[51] **Int. Cl.**[6] **G09G 3/28**

[52] **U.S. Cl.** **345/107**; 313/484; 359/296

[58] **Field of Search** ..... 340/787, 788, 763, 771; 313/483, 484, 358, 585, ; 359/293, 294, 295, 296, 297; 345/107, 48, 60, 49

[56] **References Cited**

U.S. PATENT DOCUMENTS

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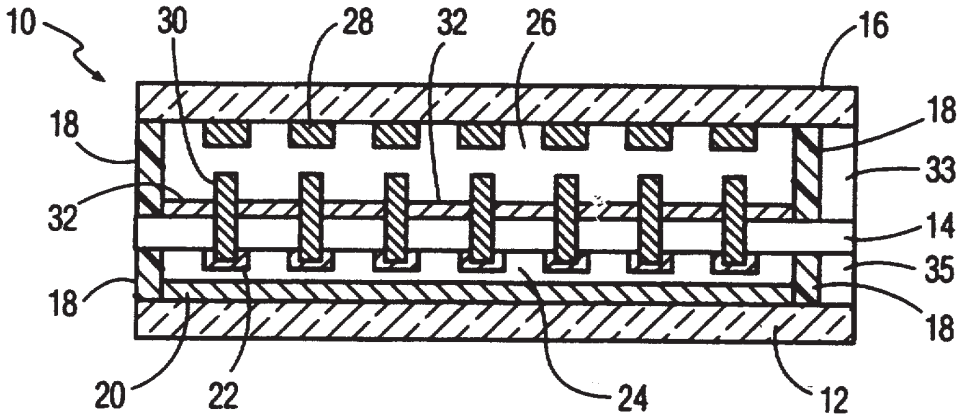
[57] **ABSTRACT**

An electrophoretic display includes a laminated triple pane construction with an electrophoretic fluid-containing envelope formed between the first and second panes and an ionizable gas-containing envelope between the second and third panes. A transparent reference electrode coats the first pane internal to the fluid envelope. A matrix of discrete pixels are disposed upon the second pane within the fluid envelope. Each pixel has a probe extending therefrom through the second pane and into the gas envelope. A plurality of row electrodes are disposed upon the second pane in the gas envelope in close proximity to corresponding rows of probes. A plurality of column electrodes disposed upon the third pane within the gas envelope perpendicular to the row lines establishes an addressable X–Y matrix. By impressing a sufficient voltage differential at selected intersections of the matrix, a local ionization of gas biases a proximate probe to the ionization potential. The probe potential is shared by the corresponding pixel, setting up an electrostatic field relative to the reference electrode for controlling the movement of pigment within the fluid. A capacitive effect is realized upon removal of ionization potential whereupon the gas deionizes leaving the pixel and probe to discharge slowly through the dielectric fluid.

17 Claims, 3 Drawing Sheets



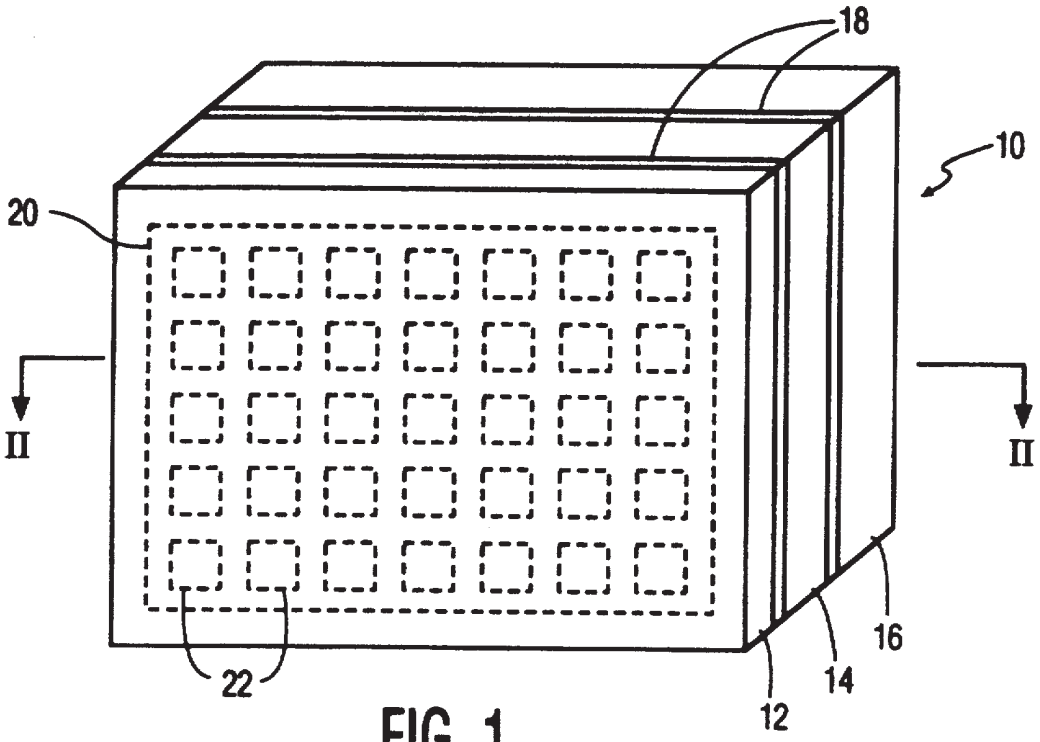


FIG. 1

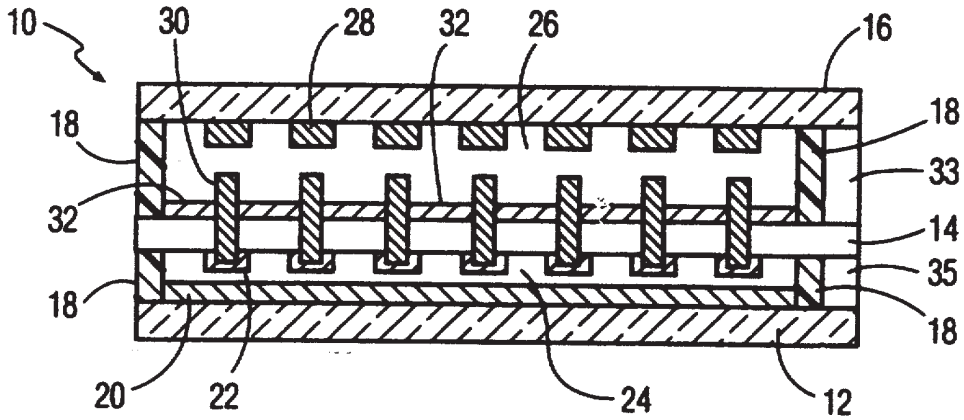


FIG. 2

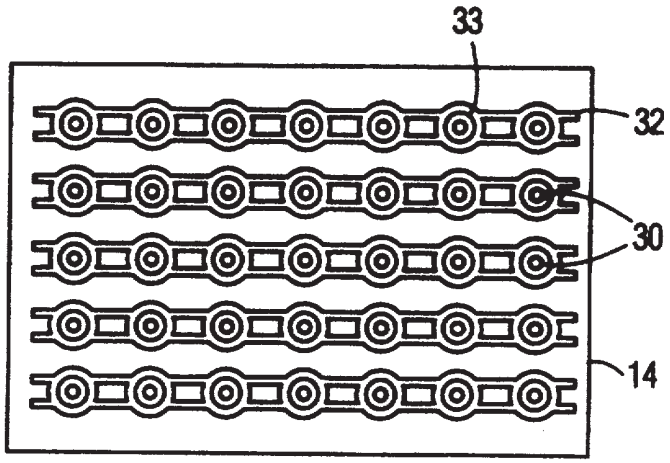


FIG. 3

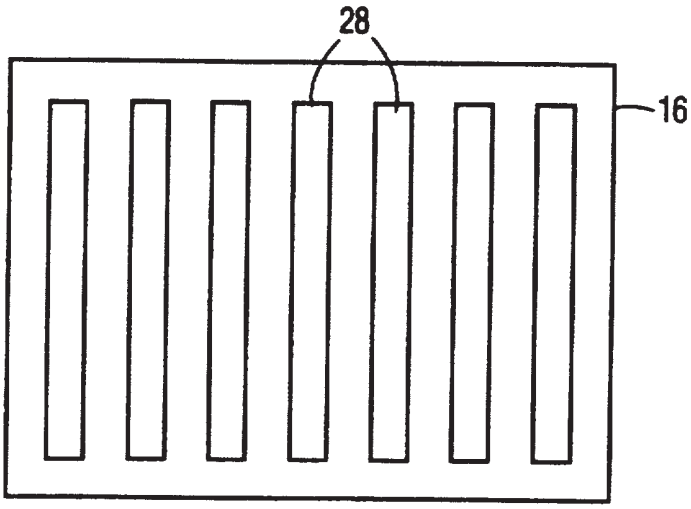


FIG. 4

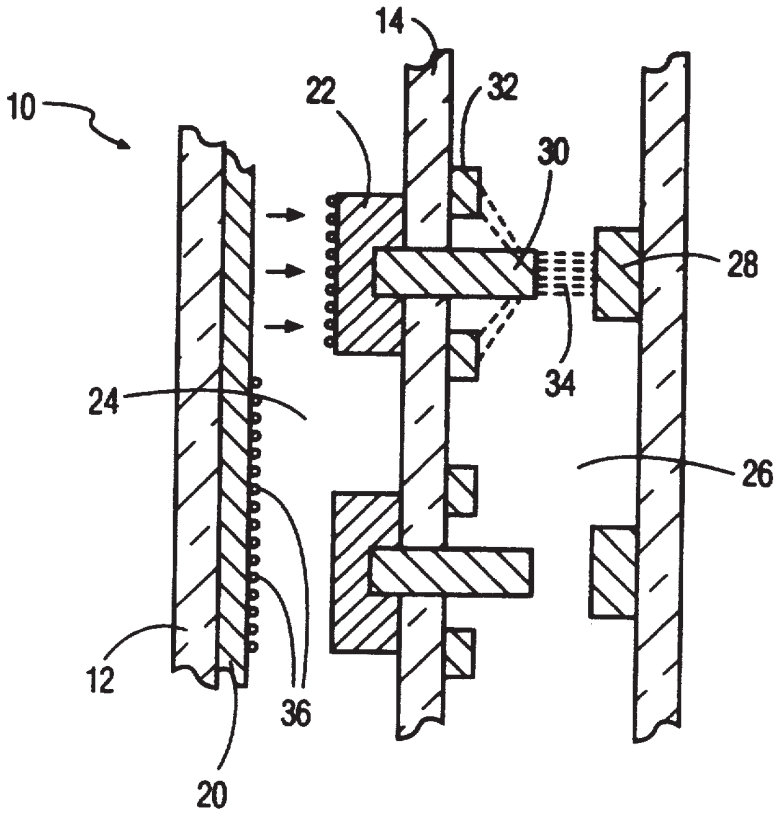


FIG. 5

ELECTROPHORETIC DISPLAY PANEL WITH ARC DRIVEN INDIVIDUAL PIXELS

FIELD OF THE INVENTION

The present invention relates to an electrophoretic display panel apparatus and, more particularly, to an electrophoretic display having independent pixel elements driven by an arc through an ionizable gas.

BACKGROUND OF THE INVENTION

Electrophoretic displays (EPIDS) are now well known. A variety of display types and features are taught in several patents issued in the names of the inventors herein, Frank J. DiSanto and Denis A. Krusos and assigned to the assignee herein, Copytele, Inc. of Huntington Station, N.Y. For example, U.S. Pat. Nos. 4,655,897 and 4,732,830, each entitled ELECTROPHORETIC DISPLAY PANELS AND ASSOCIATED METHODS describe the basic operation and construction of an electrophoretic display. U.S. Pat. No. 4,742,345, entitled ELECTROPHORETIC DISPLAY PANELS AND METHODS THEREFOR, describes a display having improved alignment and contrast. Many other patents regarding such displays are also assigned to Copytele, Inc.

The display panels shown in the above-mentioned patents operate upon the same basic principle, viz., if a suspension of electrically charged pigment particles in a dielectric fluid is subjected to an applied electrostatic field, the pigment particles will migrate through the fluid in response, to the electrostatic field. Given a substantially homogeneous suspension of particles having a pigment color different from that of the dielectric fluid, if the applied electrostatic field is localized it will cause a visually observable localized pigment particle migration. The localized pigment particle migration results either in a localized area of concentration or rarefaction of particles depending upon the polarity and direction of the electrostatic field and the charge on the pigment particles. The electrophoretic display apparatus taught in the foregoing U.S. Patents are "triode-type" displays having a plurality of independent, parallel, cathode row conductor elements or "lines" deposited in the horizontal on one surface of a glass viewing screen. A layer of insulating photoresist material deposited over the cathode elements and photoetched down to the cathode elements to yield a plurality of insulator strips positioned at right angles to the cathode elements, forms the substrate for a plurality of independent, parallel column or grid conductor elements or "lines" running in the vertical direction. A glass cap member forms a fluid-tight seal with the viewing window along the cap's peripheral edge for containing the fluid suspension and also; acts as a substrate for an anode plate deposited on the interior flat surface of the cap. When the cap is in place, the anode surface is in spaced parallel relation to both the cathode elements and the grid elements. Given a specific particulate suspension, the sign of the electrostatic charge which will attract and repel the pigment particles will be known. The cathode-element voltage, the anode voltage, and the grid element voltage can then be ascertained such that when a particular voltage is applied to the cathode and another voltage is applied to the grid, the area proximate their intersection will assume a net charge :sufficient to attract or repel pigment particles in suspension in the dielectric fluid. Since numerous cathode and grid lines are employed, there are numerous discrete intersection points which can be controlled by varying the voltage on the cathode and grid elements to cause localized visible regions of pigment concentration and rarefaction. Essentially then, the operating voltages on both cathode and grid must be able to assume at least two states corresponding to a logical one and a logical zero. Logical one for the cathode may either correspond to attraction or repulsion of pigment. Typically, the cathode and grid voltages are selected such that only when both are a logical one at a particular intersection point, will a sufficient electrostatic field be present at the intersection relative to the anode to cause the writing of a visual bit of information on the display through migration of pigment particles. The bit may be erased, e.g., upon a reversal of polarity and a logical zero-zero state occurring at the intersection coordinated with an erase voltage gradient between anode and cathode. In this manner, digitized data can be displayed on the electrophoretic display.

Besides the triode-type display, the applicant's herein have proposed a variety of EPID structures for utilizing the electrophoretic effect. For example, an alternative EPID construction is described in application Ser. No. 07/345,825, now U.S. Pat. No. 5,053,763, entitled DUAL ANODE FLAT PANEL-ELECTROPHORETIC DISPLAY APPARATUS, which relates to an electrophoretic display in which the cathode/grid matrix as found in triode-type displays is overlayed by a plurality of independent, separately addressable "local" anode lines. The local anode lines are deposited upon and aligned with the grid lines and are insulated therefrom by interstitial lines of photoresist. The local anode lines are in addition to the "remote" anode, which is the layer deposited upon the anode faceplate or cap as in triode displays. The dual anode structure aforesaid provides enhanced operation by eliminating unwanted variations in display brightness between frames, increasing the speed of the display and decreasing the anode voltage required during Write and Hold cycles, all as explained therein.

In general, it can be noted that a variety of EPID configurations have been proposed by the prior art. In the quest for better EPID's, improvements in resolution, speed of operation, simplicity of construction, reliability and economy continue to be sought.

An object of the present invention is to achieve an improved EPID structure and function.

SUMMARY OF THE INVENTION

The problems and disadvantages associated with conventional electrophoretic displays are overcome by the present invention which includes a first receptacle containing electrophoretic fluid and a second receptacle containing an ionizable gas. The first and second receptacles share a common barrier wall and a plurality of conductive pathways penetrate the barrier wall. A first end of the conductive pathways is disposed proximate the fluid while a second end is in contact with the gas. Apparatus is provided for ionizing the gas proximate selected conductive pathways to bias those selected pathways in order to induce movement of pigment in the fluid proximate the first end of the selected conductive pathways.

BRIEF DESCRIPTION OF THE FIGURES

For a better understanding of the present invention, reference is made to the following detailed description

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