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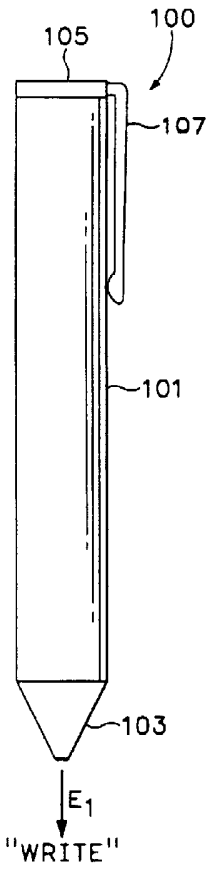
(54) Title: ELECTRONIC WRITING AND ERASING PENCIL

(57) Abstract: An electronic writing instrument for rewritable electronic writing surfaces. A self-powered, untethered, pencil-like instrument uses a perpendicular fringe field for changing the orientation of pixels composed of bistable, bichromal colorant elements. An appendix hereto describes bistable, bichromal, molecular colorant.



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(1) TITLE

ELECTRONIC WRITING AND ERASING PENCIL

(2) CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable.

(3) STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

(4) REFERENCE TO AN APPENDIX

The present application includes a hard copy appendix comprising pertinent specification pages and drawings of co-inventors' U.S. Pat. Appl. Ser. No. 09/844,862, filed April 27, 2001, by ZHANG, WILLIAMS and VINCENT for MOLECULAR MECHANICAL DEVICES WITH A BAND GAP CHANGE ACTIVATED BY AN ELECTRIC FIELD FOR OPTICAL SWITCHING APPLICATIONS as relates to subject matter claimed in accordance with the present invention.

(5) BACKGROUND OF THE INVENTION

(5.1) FIELD OF THE INVENTION

[0001] The present invention relates generally to an electronic writing and erasing device, and specifically to a handheld, pencil-like, electronic writing and erasing instrument adapted for use with a rewritable media, displays, and surfaces, particularly those using a nanotechnology-based display colorant.

(5.2) DESCRIPTION OF RELATED ART

[0002] There have been recent developments in the field of "electronic media." Commercially available mechanisms by Xerox Corporation with respect to its Gyricon[tm] sphere technology and E Ink Corporation with respect to its bichromal microcapsule technology are used to produce electronic images, improving resolution over conventional displays such as liquid crystal displays ("LCD"). See e.g., U.S. Patent No. 5,604,027 (Sheridon, assignee Xerox Corp.) and U.S. Patent No. 6,124,851 (Jacobson, assignee E Ink Corp.).

[0003] Assignee herein, Hewlett-Packard Company, has gone beyond these microcapsule-based colorant technologies by creating a bi-modal molecular colorant that is useful for rewritable media, displays, surfaces, and the like. In some embodiments, the molecules are also bistable, meaning that an electronic holding field is not necessary to maintain a particular state. The term "rewritable" as used herein should be understood to mean writable and erasable. In the main, the goal of such electronic, rewritable product development is to provide a means for producing electronic images that truly resembles hard copy in appearance and readability. The Appendix hereto provides a detailed description of one of the Hewlett-Packard inventions in this field of technology.

[0004] In general, electronic display and electronic media devices use conventional input mechanisms such as computer keyboards, computer adapted styli, computer mouse, Wacom[tm] cable-connected Deskpad and writing stylus, and the like, coupled to electrode arrays proximate the electronic media, or electronic media based

display, to image data into a readable format.

[0005] There is a need for a computer-free device to manually image and to annotate images produced electronically.

(6) BRIEF SUMMARY OF THE INVENTION

[0006] In its basic aspect, the present invention provides an electronic stylus apparatus including: a portable power source; connected to the power source, at least one electrode for producing a localized, emanating, electric field wherein the field is of a strength sufficient to reorient electronic picture elements formed of an electrically bistable colorant.

[0007] In another aspect, the present invention provides a method for electronic erasable writing, the method including: providing a surface having picture elements defined by a bistable, bichromal, colorant elements; and moving a portable, perpendicular electrical fringe field, tuned to changing orientation of the colorant elements, across said surface in a manner substantially identical to conventional handwriting.

[0008] In still another aspect, the present invention provides an erasable writing system including: an electronically writable-erasable surface having a layer of bistable, bichromal, colorant thereon; and a portable, electronic stylus adapted for writing and erasing said colorant.

[0009] The foregoing summary and list of advantages is not intended by the inventors to be an inclusive list of all the aspects, objects, advantages and features of

the present invention nor should any limitation on the scope of the invention be implied therefrom. This Summary is provided in accordance with the mandate of 37 C.F.R. 1.73 and M.P.E.P. 608.01(d) merely to apprise the public, and more especially those interested in the particular art to which the invention relates, of the nature of the invention in order to be of assistance in aiding ready understanding of the patent in future searches. Other objects, features and advantages of the present invention will become apparent upon consideration of the following explanation and the accompanying drawings, in which like reference designations represent like features throughout the drawings.

(7) BRIEF DESCRIPTION OF THE DRAWINGS

[0010] In accordance with 37 C.F.R. 1.84(u), in order to prevent confusion with FIGURES of the Appendix hereto, the drawings of this application use double capital letter suffices.

[0011] FIGURE 1AA is a schematic drawing in elevation view of a writing instrument according to the present invention, demonstrating an electrical writing field vector, "E1."

[0012] FIGURE 1BB is a schematic drawing in elevation view of the writing instrument of FIGURE 1AA, demonstrating an electrical erasing writing field vector, "E2".

[0013] FIGURE 1CC is an electrical schematic drawing for the present invention as shown in FIGURES 1AA and 1BB.

[0014] FIGURES 2AA, 2BB, and 2CC are schematic drawings in transparent elevation view of the present invention as shown in FIGURES 1AA, 1BB and 1CC, demonstrating writing features and methodology.

[0015] FIGURES 3AA, 3BB, and 3CC are schematic drawings in transparent elevation view of the present invention as shown in FIGURES 1AA, 1BB, 1CC, 2AA, 2BB, and 2CC, demonstrating erasing features and methodology.

[0016] FIGURE 4AA is an electrical schematic diagram associated with the present invention as shown in FIGURES 2AA, 2BB, 2CC, 3AA, 3BB and 3CC.

[0017] FIGURE 5AA is an illustration of the present invention in an electronic writing system embodiment.

[0018] The drawings referred to in this specification should be understood as not being drawn to scale except if specifically annotated.

(8) DETAILED DESCRIPTION OF THE INVENTION

[0019] Reference is made now in detail to a specific embodiment of the present invention, which illustrates the best mode presently contemplated by the inventors for practicing the invention. Alternative embodiments are also briefly described as applicable.

DEFINITIONS

[0020] The following terms and ideas are applicable to both the present discussion and the Appendix hereto.

[0021] The term "self-assembled" as used herein refers to a system that

naturally adopts some geometric pattern because of the identity of the components of the system; the system achieves at least a local minimum in its energy by adopting this configuration.

[0022] The term "singly configurable" means that a switch can change its state only once via an irreversible process such as an oxidation or reduction reaction; such a switch can be the basis of a programmable read-only memory (PROM), for example.

[0023] The term "reconfigurable" means that a switch can change its state multiple times via a reversible process such as an oxidation or reduction; in other words, the switch can be opened and closed multiple times, such as the memory bits in a random access memory (RAM) or a color pixel in a display.

[0024] The term "bistable" as applied to a molecule means a molecule having two relatively low energy states (local minima) separated by an energy (or activation) barrier. The molecule may be either irreversibly switched from one state to the other (singly configurable) or reversibly switched from one state to the other (reconfigurable). The term "multi-stable" refers to a molecule with more than two such low energy states, or local minima.

[0025] The term "bi-modal" for colorant molecules in accordance with the present invention may be designed to include the case of no, or low, activation barrier for fast but volatile switching. In this latter situation, bistability is not required, and the molecule is switched into one state by the electric field and relaxes back into its original state upon removal of the field; such molecules are referred to as "bi-modal".

In effect, these forms of the bimodal colorant molecules are "self-erasing". In contrast, in bistable colorant molecules the colorant molecule remains latched in its state upon removal of the field (non-volatile switch), and the presence of the activation barrier in that case requires application of an opposite field to switch the molecule back to its previous state. Also, "molecular colorant" as used hereinafter as one term to describe aspects of the present invention is to be distinguished from other chemical formulations, such as dyes, which act on a molecular level; in other words, "molecular colorant" used hereinafter signifies that the colorant molecules as described in the Appendix and their equivalents are employed in accordance with the present invention.

[0026] Micron-scale dimensions refers to dimensions that range from 1 micrometer to a few micrometers in size.

[0027] Sub-micron scale dimensions refers to dimensions that range from 1 micrometer down to 0.05 micrometers.

[0028] Nanometer scale dimensions refers to dimensions that range from 0.1 nanometers to 50 nanometers (0.05 micrometers).

[0029] Micron-scale and submicron-scale wires refers to rod or ribbon-shaped conductors or semiconductors with widths or diameters having the dimensions of 0.05 to 10 micrometers, heights that can range from a few tens of nanometers to a micrometer, and lengths of several micrometers and longer.

[0030] "HOMO" is the common chemical acronym for "highest occupied

molecular orbital", while "LUMO" is the common chemical acronym for "lowest unoccupied molecular orbital". HOMOs and LUMOs are responsible for electronic conduction in molecules and the energy difference between the HOMO and LUMO and other energetically nearby molecular orbitals is responsible for the color of the molecule.

[0031] An "optical switch," in the context of the present invention, involves changes in the electro-magnetic properties of the molecules, both within and outside that detectable by the human eye, e.g., ranging from the far infra-red (IR) to deep ultraviolet (UV). Optical switching includes changes in properties such as absorption, reflection, refraction, diffraction, and diffuse scattering of electro-magnetic radiation.

[0032] The term "transparency" is defined within the visible spectrum to mean that optically, light passing through the colorant is not impeded or altered except in the region in which the colorant spectrally absorbs. For example, if the molecular colorant does not absorb in the visible spectrum, then the colorant will appear to have water clear transparency.

[0033] The term "omni-ambient illumination viewability" is defined herein as the viewability under any ambient illumination condition to which the eye is responsive.

[0034] As a general proposition, "media" in the context of the present invention includes any surface, whether portable or fixed, that contains or is layered with a molecular colorant or a coating containing molecular colorant in accordance with the present invention wherein "bistable" molecules are employed; for example, both a

flexible sheet exhibiting all the characteristics of a piece of paper and a writable surface of an appliance (be it a refrigerator door or a computing appliance using the molecular colorant). "Display" (or "screen") in the context of the present invention includes any apparatus that employs "bimodal" molecules, but not necessarily bistable molecules. Because of the blurred line regarding where media type devices ends and display mechanisms begin, no limitation on the scope of the invention is intended nor should be implied from a designation of any particular embodiment as a "media" or as a "display."

[0035] As will become apparent from reading the Detailed Description and Appendix, "molecule" can be interpreted in accordance with the present invention to mean a solitary molecular device, e.g., an optical switch, or, depending on the context, may be a vast array of molecular-level devices, e.g., an array of individually addressable, pixel-sized, optical switches, which are in fact linked covalently as a single molecule in a self-assembling implementation. Thus, it can be recognized that some molecular systems comprise a super-molecule where selective domain changes of individual molecular devices forming the system are available. The term "molecular system" as used herein refers to both solitary molecular devices used systematically, such as in a regular array pixel pattern, and molecularly linked individual devices. No limitation on the scope of the invention is intended by interchangeably using these terms nor should any be implied.

[0036] Shown schematically in **FIGURES 1AA** and **1BB** is an electronic writing

and erasing instrument, or "e-pencil" hereinafter, 100 in accordance with the present invention. A barrel, or casing, 101 is formed in a shape and dimension suitable to handheld usage and may have the shape and feel of a conventional pencil. It includes a write tip 103 and erase head 105 that function on electronic rewritable surfaces just like a conventional pencil on conventional paper. It can optionally be provided with a clip 107 for convenient pocket or other holder carrying.

[0037] The write tip 103 provides a first polarity directed electric field (E_1) source. The erase head 105 provides an opposite polarity directed electric field (E_2) source. Optionally, switching mechanism (not shown) may be provided wherein the polarity at either of the pencil ends may be reversed such that the same end can provide the write or erase function or wherein both may be reversed to change the nib size for the function of interest, e.g., narrow erase to broad erase; see e.g., FIG. 4AA description hereinafter.

[0038] To describe at least one implementation of a molecular colorant used to create a rewritable surface upon which the present invention can be used, the reader is directed to the Appendix hereto. Moreover, the present invention will be useful with other electronically rewritable surfaces such as those made using Gyricon or E-Ink products.

[0039] Referring now also to **FIGURES 2AA** through **2CC**, the write tip 103 is used to create at least one picture-element (pixel) sized point or multi-pixel line in contact and translation across a rewritable surface. The preferred embodiment of the

e-pencil 100 is an untethered, handheld, battery-powered device. Batteries are depicted as two, exemplary, common AAA-sized batteries 201, 201' connected in series in a known manner. It will be recognized by those skilled in the art that other power pack mechanisms, such as AC-transformers can be used to power the e-pencil 100, providing the ability for greater or lesser power than a battery driven implementation. Moreover, field strength maintaining and surge protection mechanisms as would be known in the art may be employed with the present invention.

[0040] An electrical schematic is shown in **FIGURE 4AA** for a simplified embodiment where one tip electrode 403 is used for both writing and erasing. The batteries 201, 201' are represented as power source "V." The power source V is connected via a double pole, double throw switch 401 (shown in an OFF position) to the tip electrode 403 (analogous to FIG. 1AA, 1BB, elements 103 and 105 combined). The dashed-line arrow 405 represents the capability of switching the polarity of the voltage to the tip electrode 403.

[0041] In a more elaborate embodiment, as shown in FIGURES 2AA through 3CC, it may be desirable to have a writing tip 103 configured as an electrical point source and an erasing head 105 configured as a broader electrical area source just as a conventional pencil does.

[0042] Returning to FIGURES 2AA through 2CC and now also **FIGURES 3AA** through **3CC**, one embodiment of the e-pencil 100 has the electric field write tip 101

and the electric field erase head 105 appropriately connected in a known manner to a battery, or batteries, 201, 201'. The write tip 101 preferably includes a circular rod 107' and cylinder 107" electrode pair that are concentric and closely spaced. The write tip 103 is ideally housed within a conical end cap of the e-pencil 100, giving the appearance of a standard lead pencil. The electrode pair 107', 107" is electrically biased (±V as in FIG. 4AA) to produce a fringe field - represented in FIGS. 2CC and 3CC as semi-circular lines labeled "Perpendicular Fringe Field" (PFF) - having a principal field vector 203 that emanates along the axis of the e-pencil 100 from the central rod electrode 107', and substantially perpendicular to an erasable writing substrate 205, returning to the cylinder electrode 107". The writing substrate 205 has a layer 202 of colorant composed of bistable colorant pixels (see Appendix). The electrodes 107', 107" are biased so the principal field vector 203 from the write tip 101 orients, or otherwise switches, bistable colorant 202 (see Appendix) pixels exposed to the PFF to its writing image color.

[0043] Note that the drawn line width of the image produced by the writing tip 103 is dependent on the electrode geometry and may be varied with the bias voltage. The written lines may be "tunable," i.e, broadened in width by increasing the voltage (+V-) on the writing electrode 107. For example, a hand controlled switch 109 - e.g., a potentiometer added to FIG. 4AA between the power source V and electrode 403 - accessible along the barrel 101 of the pencil 100 may be used for this purpose. The writing tip 103 itself may be interchangeable with other line source nib embodiments

to simulate fine writing instruments such as fountain pens. Vector 203' represents a higher voltage, "broader" nib effect. More sophisticated, known manner, voltage control circuitry may be employed.

[0044] Only the principal field vector 203 writes the image. The field return lines are radially distributed between the rod and cylinder electrodes 107', 107", thereby diluting field intensity below the writing threshold. The writing tip electrodes 107', 107" may be made from most any conductive metal and may be further coated or plated to produce a good wear and low friction writing surface. The writing tip 103 may be gimbaled to allow correct contact and orientation of the writing tip with the media surface 202 while the e-pencil is held at an angle to the media surface.

[0045] The erase head 105 consists of an electrode pair 105', 105" with geometry suitable for producing a PFF having a more distributed principal field area. By comparison to the writing tip 103, the erase head 105 may consist of a larger area circular rod and cylinder electrode. Alternative geometries, such as a cross-shaped center electrode and conformal outer electrode as shown in FIG. 3BB can be designed to suit a particular implementation. The erase head electrode geometries are selected in these examples to mimic the approximate erase area of a standard lead pencil, but others may be employed. The erase head electrodes 105', 105" are biased to produce a principal field area or lines that orient, or otherwise switch, bistable colorant pixels contacted by the field to its transparent or media background color in the media area in contact with the erase head 105.

[0046] The writing tip's conical end cap and erase head are preferably assembled, e.g. threaded, at opposing ends of the barrel 101 that forms the casing for the e-pencil 100. This allows the batteries 201, 201' used to power the e-pencil to be contained and electrically connected within the barrel in a manner similar to a standard flashlight; in alternative embodiments (not shown) button-type or other commercially available batteries may be employed.

[0047] Standard step-up or step-down voltage components and circuitry may be added to drive the electrodes at voltages greater than or less than that provided by the batteries. Conventional electrical switch or switches (not shown) operable on the cylinder exterior may be used to activate the e-pencil, change writing or erasing line widths, or change the function of either the writing tip or erase head to its opposing function. In the latter case, the erase head may be biased to write broad lines for such things as area fills.

[0048] The electronic pencil and rewritable paper combination offer great benefit over a wide set of applications. The electronic pencil is nearly as simple in construction as a common flashlight and should have low manufacturing cost. The pencil uses very low current fields to write and erase and, therefore, should be very battery efficient. Standard note pads, such as Post-It™ Notes, used for reminders, to-do lists, grocery lists, phone messages and the like, may be substituted for by a more permanent, less messy, single rewritable sheet used in combination with the e-pencil. Such a sheet, for example, may have a magnetic backing for attachment to a

refrigerator, cabinet or interior car surface. The electronic erase feature eliminates the mess and residual image (stain) that often accompany similarly intended pencil and paper or white board and highlighting pen products; the electronic erase function provides a completely renewed writing surface.

[0049] In operation, to write on a surface having a pixel surface including a layer 202 of field-orientable, bistable, colorant (note that this can be any surface or media type upon which the colorant layer can be formed), the end-user moves the e-pencil 100 across the surface in the same manner as writing with a conventional pencil or pen. The perpendicular fringe field E1 (see FIGS. 1AA and 2CC) re-orients the pixels in the colorant layer, matching the strokes of the e-pencil 100. To erase writing produced in that manner, the end-user uses the reverse fringe field E2 (see FIGS. 1BB and 3CC), moving the "eraser" in the same manner as erasing with a conventional pencil or pen.

[0050] An exemplary embodiment writing system 500 in accordance with the present invention is shown in **FIGURE 5AA**. An electronic folio 501 includes a writing board, or similar support platform, 503 and, optionally, a security cover 505. An electronic media 507 having a writing surface including a bistable, bichromal colorant (such as formed of a layer of molecular devices as described in the Appendix hereto) is supported by the board 503. The end-user writes and erases to the electronic media 507 using the untethered, electronic stylus100 described hereinbefore.

[0051] The foregoing description of the preferred embodiment of the present

invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form or to exemplary embodiments disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in this art. Similarly, any process steps described might be interchangeable with other steps in order to achieve the same result. The embodiment was chosen and described in order to best explain the principles of the invention and its best mode practical application, thereby to enable others skilled in the art to understand the invention for various embodiments and with various modifications as are suited to the particular use or implementation contemplated. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents. Reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather means "one or more." Moreover, no element, component, nor method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the following claims. No claim element herein is to be construed under the provisions of 35 U.S.C. Sec. 112, sixth paragraph, unless the element is expressly recited using the phrase "means for. . ." and no process step herein is to be construed under those provisions unless the step or steps are expressly recited using the phrase "comprising the step(s) of. . .." What is claimed is:

(9) CLAIMS

1. An electronic stylus apparatus comprising:

a portable power source;

connected to the power source, at least one electrode for producing a localized, eminating, electric field wherein the field is of a strength sufficient to reorient electronic picture elements formed of an electrically bistable colorant.

2. The apparatus as set forth in claim 1 comprising:

connected between said power source and said electrode electronic circuitry for switching the polarity of said electric field.

3. The apparatus as set forth in claim 1 comprising:

connected between said power source and said electrode electronic circuitry for selectively varying the intensity of said electric field.

4. The apparatus as set forth in claim 1 comprising:

said at least one electrode is adapted for writing and erasing electrically bistable, bichromal, molecular colorant.

5. The apparatus as set forth in claim 1 comprising:

a hand-held cylindrical pencil shaped body wherein said power source and electrode are incorporated therein such that said apparatus is used in the manner of a conventional writing instrument.

6. The apparatus as set forth in claim 1 comprising:

electronic circuitry for maintaining a substantially constant electronic field output of the apparatus.

7. A method for electronic erasable writing, the method comprising:

providing a surface having picture elements defined by a bistable, bichromal, colorant elements; and

moving a portable, perpendicular electrical fringe field, tuned to changing orientation of the colorant elements, across said surface in a manner substantially identical to conventional handwriting.

8. The method as set forth in claim 7 comprising:

providing a writing-erasing instrument for producing said perpendicular fringe field such that said field is localized to eminating from a tip of said instrument.

9. The method as set forth in claim 7 comprising:

switching polarity of said perpendicular fringe field from a first polarity for writing

operations to a second polarity for erasing operations.

10. The method as set forth in claim 7 wherein the strength of the perpendicular fringe field is tunable such that the marking pixel width and erasing pixel width of said tip is adjustable.

11. The method as set forth in claim 7 wherein providing said surface includes using bistable, bichromal, molecular colorant.

12. An erasable writing system comprising:

an electronically writable-erasable surface having a layer of bistable, bichromal, colorant thereon; and

a poratable, electronic stylus adapted for writing and erasing said colorant.

13. The system as set forth in claim 12, said colorant comprising:

a molecular system, said system including electrochromic, switchable molecules, each of said molecules being selectively switchable between at least two optically distinguishable states, wherein said system is distributable on the substrate thereby forming an erasably writable surface.

14. The system as set forth in claim 13 comprising:

said molecules exhibit an electric field induced band gap change.

15. The system as set forth in claim 14 comprising:

said electric field induced band gap change occurs via a mechanism selected from a group including (1) molecular conformation change or an isomerization, (2) change of extended conjugation via chemical bonding change to change the band gap, and (3) molecular folding or stretching.

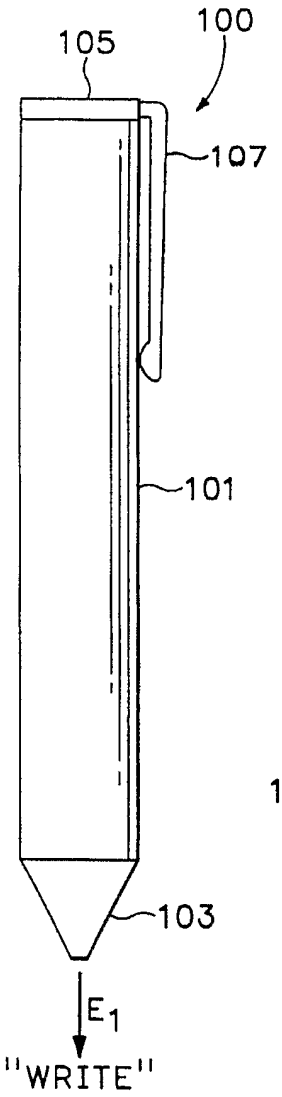

FIG.1AA

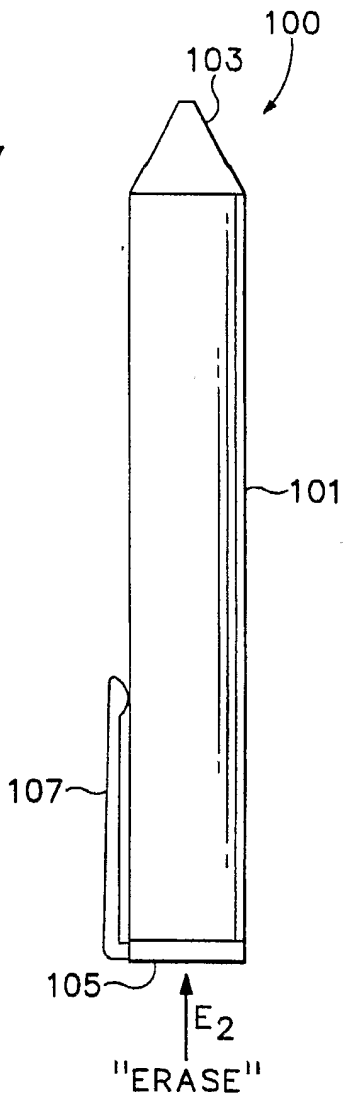

FIG.1BB

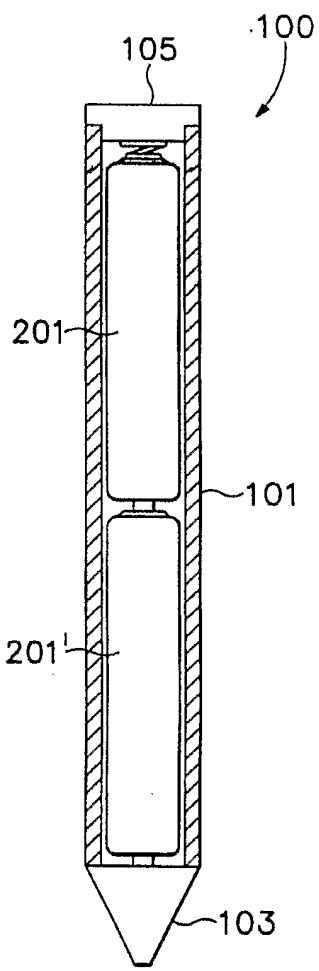

FIG.2AA

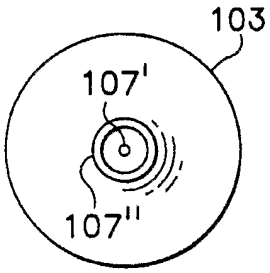

FIG.2BB

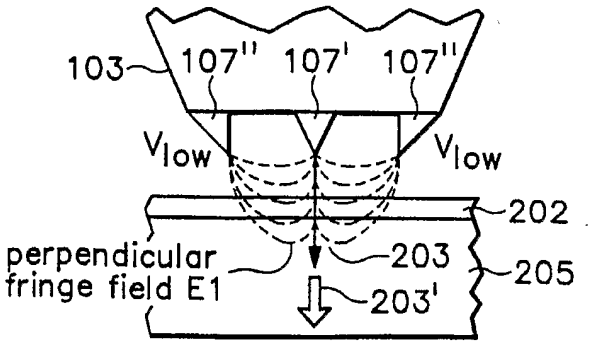

FIG.2CC

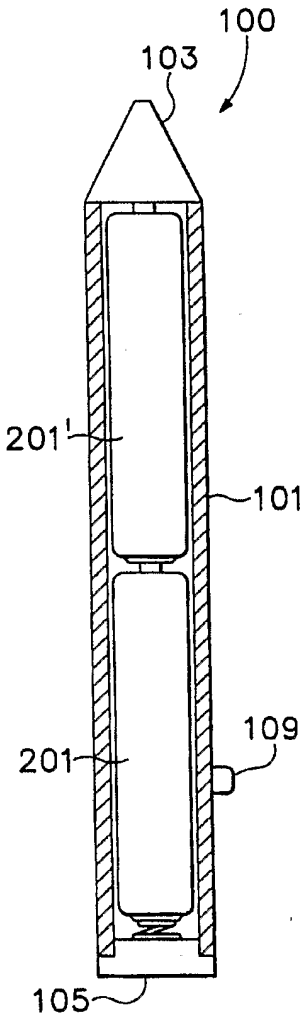

FIG.3AA

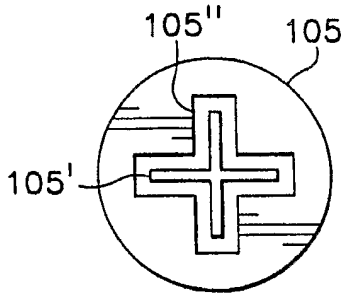

FIG.3BB

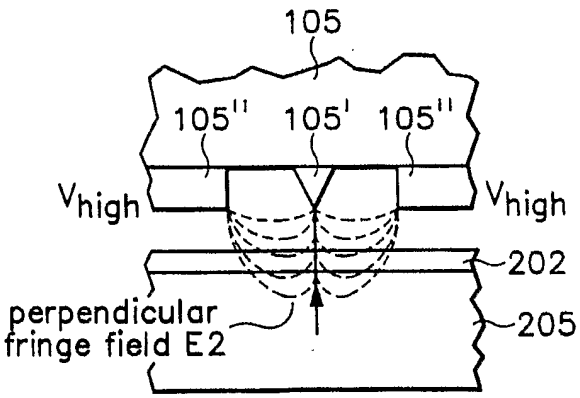

FIG.3CC

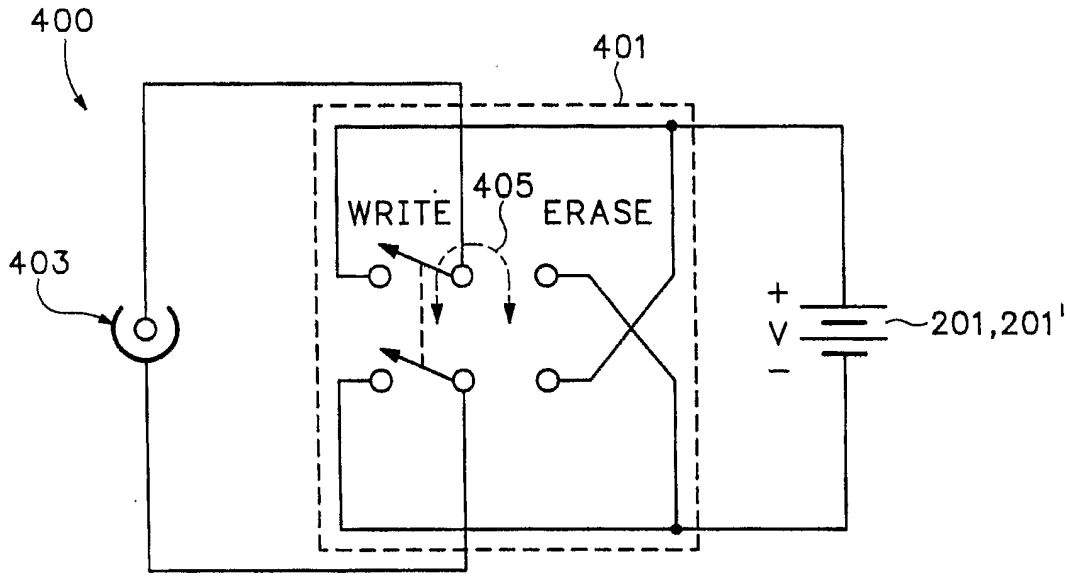

FIG.4AA

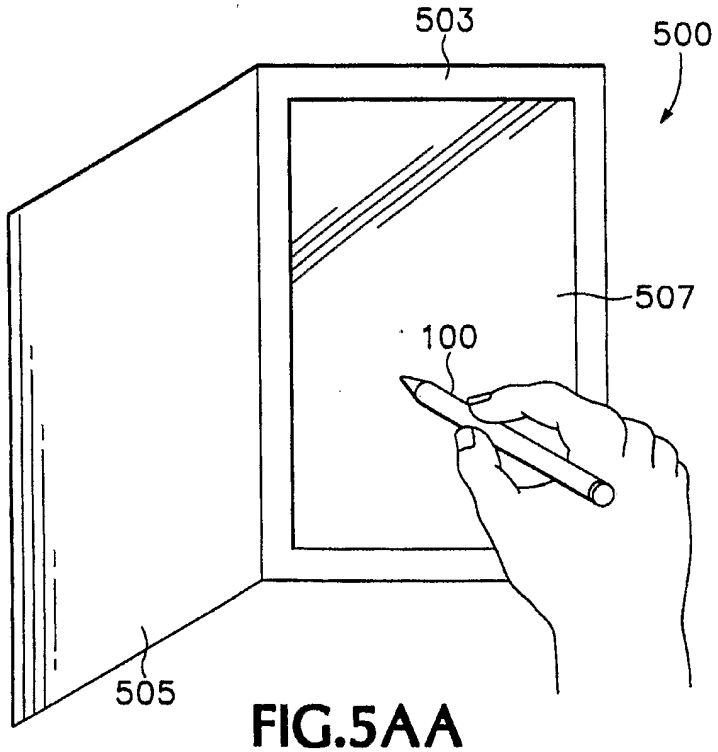

FIG.5AA

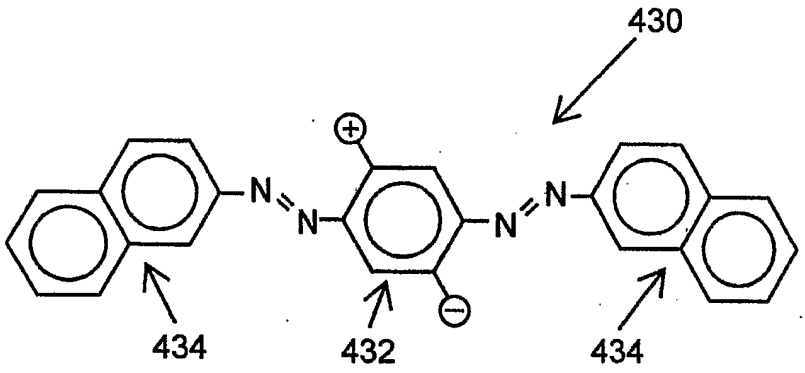

FIG. 5a

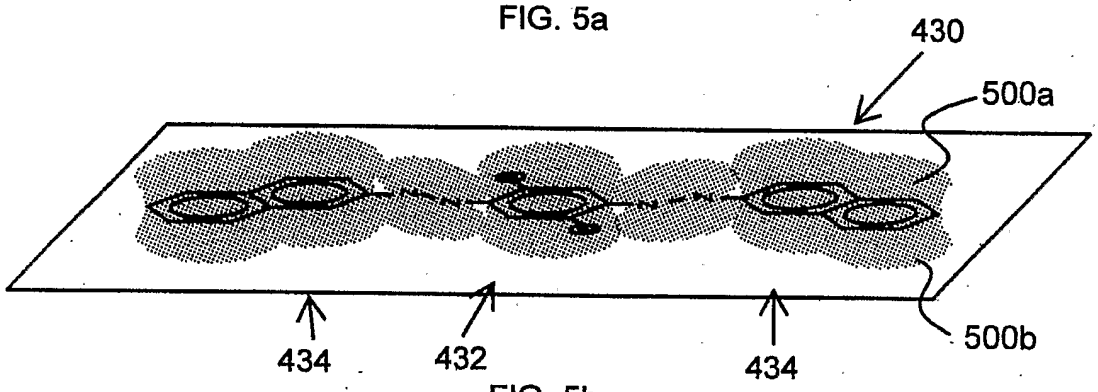

FIG. 5b

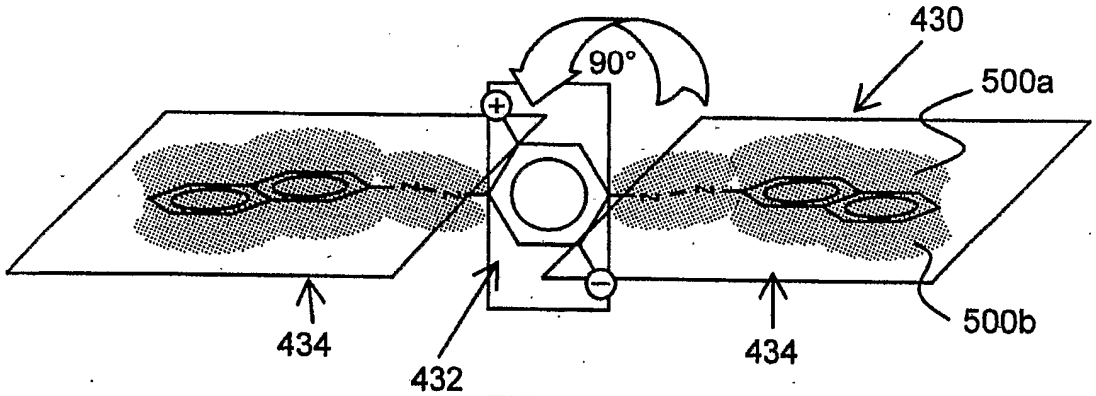

FIG. 5c

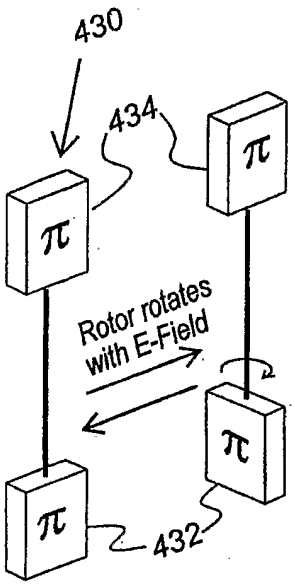

FIG. 4

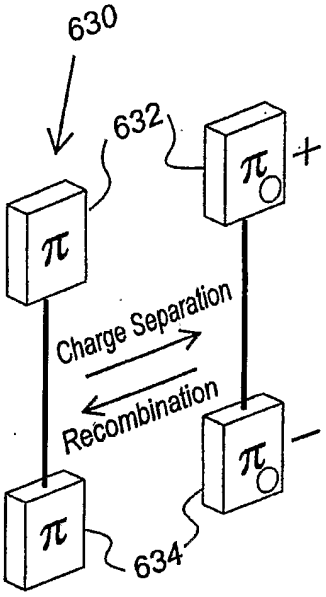

FIG. 6a

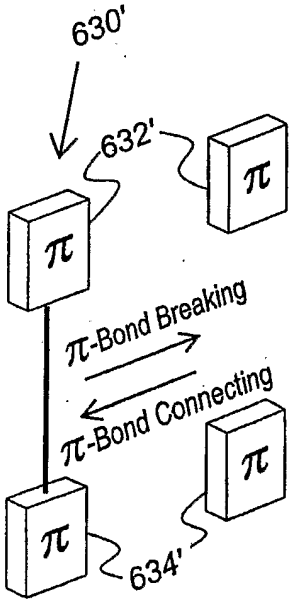

FIG. 6b

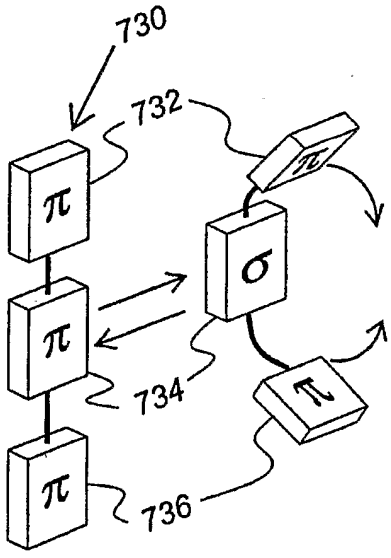

FIG. 7