INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

World Intellectual Property Organization

International Bureau

International Publication Date 3 November 2016 (03.11.2016)

(51) International Patent Classification:
G02F 1/1333 (2006.01)  G06F 3/041 (2006.01)

(21) International Application Number:
PCT/US2010/029882

(22) International Filing Date:
28 April 2016 (28.04.2016)

(25) Filing Language: English
(26) Publication Language: English

(30) Priority Data:

(71) Applicant: WICUE, INC. [US/US]: 10692 Gascoigne Dr., Cupertino, California 95014 (US).

(72) Inventor: Li, Fenghua; 10692 Gascoigne Dr., Cupertino, California 95014 (US).

(74) Agents: ZHANG, Yiming et al; Perkins Coie LLP - PAO, P.O. Box 1247, Seattle, Washington 98111-1247 (US).


Published:
— with international search report (Art. 21(3))
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: LIQUID CRYSTAL WRITING DEVICE

FIG. 2A

(57) Abstract: Embodiments are disclosed for selectively and partially erasing images from a liquid crystal writing device. A liquid crystal writing device according to some embodiments includes a transparent top layer, a liquid crystal layer including a plurality of liquid crystal cells beneath the transparent top layer, a matrix of electrodes, and a control circuitry. The liquid crystal layer displays an image by switching cells to a reflective state. The writing device detects a mechanical pressure applied on a pressed area. The mechanical pressure indicating a command to erase at least a portion of the image from the pressed area. The control circuitry instructs one or more electrodes from the matrix to apply an erase voltage signal to a portion the liquid crystal cells that correspond to the pressed area, wherein the erase voltage signal switches the portion of the liquid crystal cells to the scattering state.
LIQUID CRYSTAL WRITING DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 62/154,054 entitled "Liquid Crystal Writing Device With Selectively Erase Function," filed April 28, 2015.

BACKGROUND

Bistable liquid crystal displays are utilized as display devices due to low power consumption. After the display content is shown on the display, a bistable liquid crystal display does not need voltage to hold the display content until it is switched to the new display content. For example, U.S. Pat. No. 6,104,448 discloses a cholesteric liquid crystal mixing with polymer has bistability including both a light scattering focal conic texture and a light reflective planar texture, in which the chiral dopant has a pitch length reflecting light in the visible spectrum and the polymer network is distributed uniformly holding the liquid crystal domains.
BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1 is an illustration of a liquid crystal (LC) writing device with a partial erase function.

[0004] FIG. 2A is an illustration of a liquid crystal writing device having multiple layers.

[0005] FIG. 2B is an illustration of the patterned electrodes of a liquid crystal writing device.

[0006] FIG. 3 is an illustration of an LC writing device including infrared (IR) touch components.

[0007] FIG. 4 is an illustration of an LC writing device with a display function.

[0008] FIG. 5A is an illustration of setting up and exchanging information for a conference call using the writing devices.

[0009] FIG. 5B is an illustration of a conference system including writing devices and TV displays.

[0010] FIG. 6 is an illustration of an electronic blackboard system including large LC writing boards.

[0011] FIG. 7 is a high-level block diagram illustrating an example of a hardware architecture of a computing device that performs disclosed processes, in various embodiments.
DETAILED DESCRIPTION

[0012] The disclosed embodiments introduce a liquid crystal (LC) writing apparatus with a selective erase function. The LC writing apparatus can obtain operating commands from user and determine if it is partial or full erase command.

If the command is a partial erase command, the LC writing apparatus then applies pre-determined erasing voltage onto the target erase area between first electrode and second electrode that correspond to the target erase area. Thus, the target erase area will be applied with corresponding electric field to erase the displayed marks that have been written on the target erase area. In some embodiments, the partial erase effect on writing device can be integrated with capacitive touch components inside the liquid crystal cell.

[0013] In some embodiments, the liquid crystal writing device can be integrated with recording function. The liquid crystal writing device includes a first conductive layer, an active liquid crystal layer (with or without polymer), and a second conductive layer that has a dark background. The device can further include capacitive touch sensor that is located at each of the conductive layer sandwiching the liquid crystal layer. A user of the device can write on the flexible pressure-sensitive liquid crystal writing device by applying mechanical stress on the surface of the writing device. The device can record the writing by tracing the written information into digital images using the capacitive touch sensor and saving the digital images into memory.

[0014] In some embodiments, the device can also have display functions so that the previous writings and drawings or any graphics and text can be displayed again on the writing surface for reading and editing. The graphics content retrieved from memory or external devices can be displayed on the writing device directly. In some embodiments, remotely utilizing two or more sets of these liquid crystal writing devices, users in different locations in a conference can remotely write and edit together on the same written content displayed on separate writing devices.

[0015] FIG. 1 is an illustration of a liquid crystal writing device with a partial erase function. The liquid crystal writing device can erase partially or selectively any content displayed on the device. For example, as shown in FIG. 1, a user wrote "How to make Wicue Board partial erase" on the writing device. The writing device displays the words accordingly. Then the user may need to change the writing or
correct any error, e.g., changing a particular letter. The user can use a finger to erase a target portion of the writing or drawing (indicated by the dashed lines in FIG. 1), without other portions of the writing or drawing being affected.

[0016] In some embodiments, the liquid crystal writing device can be a high-brightness liquid crystal writing tablet with a large size up to 1.2 meter by 4 meter. The writing device can be manufactured using a reliable, fast and effective roll-to-roll method at low cost and at large width with a good uniformity. The writing device offers a perfect replacement of blackboard in classroom and whiteboard in meeting room, which has clear advantages over conventional LC writing device technologies that have relatively low brightness due to the existence of polymer. Usually the polymer will make the reflectance of choiesteric LC weaker because the surface anchoring of polymer domain aligns choiesteric liquid crystal helix into different orientation. The liquid crystal writing device as illustrated in FIG. 1 can avoid the effect from polymer and still can be manufactured using roll-to-roll production method. The writing device can provide a writing space having a large size and is an eco-friendy writing tablet for teachers to avoid the chalk dust and eliminate the usage of costly dry erase markers for the whiteboards.

[0017] In some embodiments, a black ink can be coated onto the bottom substrate or the substrate material of the device can be black flexible polyethylene terephthalate (PET) in order to create a high contrast writing trace appearance. An application of a mechanical stress from any hard tip to the choiesteric liquid crystal layer can change the liquid crystal cells from a light-scattering focal conic (FC) texture to a light-reflective planar (P) texture. A short electrical pulse with enough voltage (also referred to as erase voltage level) to the liquid crystal layers sandwiched between two conductive layers returns the reflective planar texture back into initial light scattering focal conic texture. The erase voltage level can depend on various factors of the liquid crystal cells including, e.g., thickness of the liquid crystal cells. In some embodiments, the erase voltage level can be from 5 volts to 40 volts. In order to switch from P-state to FC-state, the erase voltage pulse reaches a high voltage level (e.g., 40 volts) first. Then the voltage level gradually decreases to zero within a time period. Such a time period can last for, e.g., tens or hundreds of milliseconds.
In some embodiments, the liquid crystal writing surface can be integrated with recording function, so that the user can save the writing into digital images in various formats, such as PDF, JPG, etc. The liquid crystal writing surface can be also integrated with display function, so that the user can read the previously written information or other graphics/text from their mobile device or internal memory on the writing device. The writing device displays the information so that the user can edit or discuss based on the displayed content. In some other embodiments, remotely utilizing two or more sets of these liquid crystal writing devices, users in different locations in a conference can remotely write and edit together on the same written content displayed on separate writing devices.

FIG. 2A is an illustration of a liquid crystal writing device having multiple layers. The bistable liquid crystal writing device can have, e.g., a partial erase function, a save function and a display function. Pressure-generated writing image is displayed on the writing device because mechanical stress can make the choiesteric liquid crystal molecules change orientation from focal-conic (FC) scattering state (dark) into planar (P) color reflective state (bright). The reflective writing color can be from the ambient light. A strong ambient light can enhance the brightness of the written content on the writing board. In some embodiments, the reflective color is green to make the LC blackboard appear bright to user. Furthermore, the human eye has a better sensitivity for the green color. The writing device can include flexible PET substrates, such that a user writing on the writing board feels like writing with a regular pen or a dry erase marker.

To realize the partial erase function, the liquid crystal writing apparatus 200, as shown in FIG. 2A, includes choiesteric liquid crystal (with or without polymer) layer 204 sandwiched by first 203 and second conductive layer 205. The LC layer 204 can be, e.g., 5-20 micron thick and the reflective color could be controlled by the concentration of the chiral dopant. Each of the first and second conductive layers 203 and 205 includes patterned electrodes. The conductive layers 203 and 205 can include ITO or polymer conductive layer, or other flexible materials, such as nano Ag wire or metal mesh.

The top substrate 201 is a transparent and flexible PET film. A user of the writing device can use a finger 207 (or pens, stylus, other objects) to write on the
top substrate 201. The PET film can be coated with anti-glare coating for less surface reflection and hard-coating for durability.

[0022] The layer 206 below the second conductive layer 205 can be a flexible PET transparent substrate. The bottom substrate 202 can be either coated with black ink, or include a non-transparent black PET film. Although the writing device illustrated in FIG. 2A includes black PET film, writing devices according to various embodiments can include films of any arbitrary colors.

[0023] FIG. 2B is an illustration of the patterned electrodes of a liquid crystal writing device. In each of the first and second conductive layers 203 and 205, the patterned electrodes can have straight-line shapes and are parallel to each other. In other words, each of the two conductive layers has separated and parallel electrode lines. Each electrode line includes multiple electrodes. Then the electrode lines of the first conductive layers 203 are arranged to be orthogonally perpendicular to the electrode lines of the second conductive layer 205. Thus, the perpendicular electrode lines of the first and second conductive layers form a matrix of small pixels. The pixels can have square shapes.

[0024] The pixel size for the pixels can depend on the resolution requirement of the partial erase function. For example, a pixel size of a few square millimeters may be enough for teachers to correct the writing errors on the board. The pixels provide in-cell touch function for the purpose to provide the location information for the partial erase. For example, a passive matrix display integrated circuit (IC) controller can be connected to the electrodes within the LC writing layer in order to enable the selective erase function. In some alternative embodiments, the writing device itself does not need to include an in-cell touch component, but rely on an external touch device to determine the location of targeted erase area information.

[0025] A user can use fingers (or other devices such as pen or stylus) to write directly on the liquid crystal board device and erase contents selectively. The writing device can collect the interactive touch information using various types of technologies. For example, the writing device can use electromagnetic resonance (EMR) technology. A metal pen is used to generate magnetic field when electric current passing through. When the mental pen moves on the writing board of the device, a location of the pen tip can be detected based on electromagnetic conversion principle, and is recorded as precise coordinate records. However, one
drawback of the EMR touch technology is the high cost of materials and required special electronic pen, making it inconvenient to use. [0026] The writing device 200 can include an in-cell type touch. The capacitive touch component includes etched electrode from internal conductive layer of the LC cell. In other words, the touch function is integrated into the liquid crystal sandwiched cell. Such a design has a few advantages, such as thin form factor, low cost and good use experience. The electrode can be made, e.g., from a traditional patterned indium tin oxide (ITO) or other conductive materials, etched into lines using a wet etch or laser etching. The neighboring electrode lines usually are fully separated so that there is no electrical contact between the neighboring electrode lines. The separated electrode lines help making sharp boundaries among erase target areas. However, etching can be expensive and usually cannot be made into roll-to-roll manufacturing. Furthermore, bonding each of single electrode is time-consuming and lots of failure can happen because the ITO lines are easy to be broken when the ITO film is coated on the flexible PET substrate. [0027] In some embodiments, partially separated small electrodes can be utilized to create partial erase. There are several approaches to create partial-separation ITO lines. FIG. 3 is an illustration of an LC writing device including infrared (IR) touch components. As shown in FIG. 3, electrodes 301 and 302 (and electrodes 303 and 304) do not need to be 100% separated. The electrodes can actually have some contact and can provide more control capability. For example, ITO line-width with partial separation can be less than 10 microns. This makes bonding FPC connectors with a lot of flexibility. This partial separation of ITO line usually is operated by controlling the voltage and frequencies, which has a few advantages: 1) Roll-to-roll production with a low cost is possible; 2) partial erase area size is programmable. [0028] Power supply of the writing device (e.g. battery) continuously provides a small touch current running through the electrodes to scan the capacitance level of the electrode matrix. In some embodiments, the voltage level of the small touch current can be, e.g., 3-5 volts. Once an erase signal is received (e.g., a user pressing a button or switch triggering the erase function), the writing device detects the erase touch pressure to a portion of the writing layer based on the change of the capacitance level of the electrodes corresponding to that portion. The electronic
system of the writing device obtains the location information based on the electrodes with changed capacitance levels.

Accordingly, a display chip of the writing device applies proper voltage to the targeted electrodes to erase the writing on the portion of the writing layer. In other words, in the electrode passive-matrix, the display chip controls the electrodes relating with the specific area and implements the partial erase function to erase writing on certain areas. A similar algorism is applicable to save the writing traces digitally.

This device can be built for electronically capturing an image on a writing board, storing the image in a memory card and then downloading the captured image back onto mobile devices. FC-state or P-state can be detected by measuring the capacitance of electrodes of the targeted pixels. The optical state of FC-state or P-state is determined by the orientation arrangement of molecules of liquid crystals. On the other hand, the capacitance measured at applied low voltage of FC-state or P-state is also determined by the arrangement of molecules of liquid crystals. Therefore, measuring the capacitance of liquid crystals before and after writing can be the method to erase or save the writing image by checking the optical state of F-state or P-state at certain area.

In some embodiments, the capacitance of the electrodes sandwiching a LC cell at P-state can be about 3nF at 3V. The capacitance of the electrodes sandwiching a LC cell at FC-state can be about 5nF at 3V. The capacitance levels are different for the P-state and FC-state, because of the different liquid crystal molecule orientation for P-state and FC-state. The different liquid crystal molecule orientation cause different dielectric constants for those two states.

Based on the different capacitance levels of the electrode pairs, the writing device can identify the LC cells at P-state and the LC cells at FC-state. The writing device can assume that the LC cells at P-state present the foreground color (i.e. image content) and the LC cells at FC-state present the background color. Thus, based on the locations of the LC cells at P-state and FC-state, the writing device can capture the image based on the capacitance levels.

In some embodiments, as shown in FIG. 3, the writing device includes an external infra-red (IR) touch unit which includes a matching combination of infrared transmitter and infrared receiving unit connected and fixed to liquid crystal
writing board. The infrared transmitter includes multiple splicing of electrical infrared emission units, and the linear array of infrared emission heads. The IR touch design can be standardized in production, increasing efficiency and reducing costs. [0034] FIG. 4 is an illustration of an LC writing device with a display function.

First step is to read the drawings from the memory or external device. A user can control the communication unit 404 and connect via Bluetooth or WiFi to a mobile device 405 (e.g., a phone or tablet) or integrated external display device. The user can select and display information (e.g., previously written electronic notes) from the memory or external mobile device on the writing board 400. The writing board acts as an external display of the mobile device 405. In some other embodiments, the mobile device can also act as an external display of the writing unit 406. [0035] During the operation of the display function, there may not be an external mechanical pressure applied on the surface of the writing device to mechanically switch the liquid crystal cells from FC-state to P~state. Instead, the writing device will apply a display voltage pulse to some of the liquid crystal cells for electronically switching from FC-state to P~state. In some embodiments, the display voltage pulse has a voltage level of 25-50 volts. After the pulse of 25-50 volts, the voltage level applied by the electrodes immediately drops to zero volts. [0036] In some embodiments, the writing device can use a direct addressing method for driving the display. According to the direct addressing method, electrode segment is directly connected and controlled individually by the peripheral electronics. The segments are arranged in a way such that the electrodes can produce the desired display image (or writing). The most common arrangement is the 7-segments arrangement, which is commonly used in alphanumeric displays, such as calculators and watches. In this method, no multiplexing is available and this is the reason for only being used in low information content applications. In the direct method, the smallest controllable component for the image production is called segment instead of pixel. [0037] As the size of displays and the size of the information content increases, there is a need for more image elements. The solution to this problem was the modification of the segments arrangement into a pixels matrix with M rows and N columns. In this method, each pixel cannot be controlled individually and a
multiplexing addressing approach is to be realized. The new multiplexed addressing method was the passive matrix (PM).

[0038] The passive matrix is a one-line-at-a-time driving method. During the programming time, a pulse from the row peripheral driver activates all the pixels of the programming line and at the same time, the data voltage is delivered to the storage capacitor and the liquid crystal through the peripheral column driver. Passive matrix is the addressing method with the minimum number of interconnections. For example, for an M rows and N columns array, the direct method needs MxN interconnections while the passive matrix method needs M+N interconnections. Furthermore, passive matrix is a simple and the cost-efficient method.

[0039] In some embodiments, the disclosed writing device can be utilized in a conference meeting system. The conference meeting system establishes a connection to each participant of a teleconference. FIG. 5A is an illustration of setting up and exchanging information for a conference call using the writing devices.

[0040] A meeting room in London has a conference meeting system including a LC writing board 501. A meeting room in New York has a conference meeting system including a LC writing board 502. Both 501 and 502 has function of save, selective erase and display writings. The presenter in London can write information "A" on the board 501. In real time or in near real time, the board 502 receives and displays the information "A" accordingly. Similarly, another presenter in New York can write information "B" on the board 502. In real time or in near real time, the board 501 receives and displays the information "B" accordingly.

[0041] Furthermore, in some embodiments, the LC writing device 510 that is in a conference meeting in London can remotely control the second LC writing device 502 in New York. The method sends images captured by a touch screen remotely. The method receives images captured by a touch screen of the second device. The method sends a command through a communication channel of a real-time communication session between writing boards and to perform an operation that modifies the writing images remotely in different location.

[0042] FIG. 5B is an illustration of a conference system including writing devices and TV displays. The liquid crystal writing device 501 and 502 can provide
the save and selective erase functions, while the TV displays 503 and 504 can provide the display functions. The liquid crystal writing device 501 and 502 and the TV display 503 and 504 can communicate remotely through a communication channel so that the write and display functions can be controlled remotely.

[0043] FIG. 6 is an illustration of an electronic blackboard system including large LC writing boards. The system 600 can be a standardized blackboard system that can be used in various applications, e.g., conference or classroom. The system 600 includes two large LC writing blackboard 601 and 604 can slide freely from left to right, or vice versa. In some other embodiments, the system can include more LC writing boards behind boards 601 and 604 in order to provide an even larger writing area. The system 600 includes a smart LCD TV 603, which includes built-in computer and is placed in the middle of the system 600 (or anywhere behind the LC writing board). The system 600 further includes the frame 602 that can be made of metal material, such as steel, in order to provide reliable support for the whole blackboard system.

[0044] Users of the system 600 can write mainly on LC writing boards 601 and 604. The LC writing boards 601 and 604 can have built-in save functions. Any writing on boards 601 and 604 can be saved into infernal memory card through the built-in PCB board for 600. The LC writing boards 601 and 604 can also have built-in partial erase functions. The display function can be provided by the smart LCD TV 603.

[0045] FIG. 7 is a high-level block diagram illustrating an example of a hardware architecture of a computing device 700 that performs the above process, in various embodiments. The computing device 700 executes some or all of the processor executable process steps that are described below in detail. In various embodiments, the computing device 700 includes a processor subsystem that includes one or more processors 702. Processor 702 may be or may include, one or more programmable general-purpose or special-purpose microprocessors, digital signal processors (DSPs), programmable controllers, application specific integrated circuits (ASICs), programmable logic devices (PLDs), or the like, or a combination of such hardware based devices.

[0046] The computing device 700 can further include a memory 704, a network adapter 710, a cluster access adapter 712 and a storage adapter 714, ail
interconnected by an interconnect 708. Interconnect 708 may include, for example, a system bus, a Peripheral Component Interconnect (PCI) bus, a HyperTransport or industry standard architecture (ISA) bus, a small computer system interface (SCSI) bus, a universal serial bus (USB), or an Institute of Electrical and Electronics Engineers (IEEE) standard 1394 bus (sometimes referred to as "Firewire") or any other data communication system.

[0047] The cluster access adapter 712 includes one or more ports adapted to couple the computing device 700 to other devices. In the illustrated embodiment, Ethernet can be used as the clustering protocol and interconnect media, although other types of protocols and interconnects may be utilized within the cluster architecture described herein.

[0048] The computing device 700 can be embodied as a single- or multi-processor system executing an operating system 706 that can implement a high-level module, e.g., a manager, to logically organize the information as a hierarchical structure of named directories, files and special types of files called virtual disks at the storage devices. The computing device 700 can further include graphical processing unit(s) for graphical processing tasks or processing non-graphical tasks in parallel.

[0049] The memory 704 can comprise storage locations that are addressable by the processor(s) 702 and adapters 710, 712, and 714 for storing processor executable code and data structures. The processor 702 and adapters 710, 712, and 714 may, in turn, comprise processing elements and/or logic circuitry configured to execute the software code and manipulate the data structures. The operating system 706, portions of which are typically resident in memory and executed by the processor(s) 702, functionally organizes the computing device 700 by (among other things) configuring the processor(s) 702 to invoke. It will be apparent to those skilled in the art that other processing and memory implementations, including various computer readable storage media, may be used for storing and executing program instructions pertaining to the technology.

[0050] The network adapter 710 can include multiple ports to couple the computing device 700 to one or more clients over point-to-point links, wide area networks, virtual private networks implemented over a public network (e.g., the Internet) or a shared local area network. The network adapter 710 thus can include
the mechanical, electrical and signaling circuitry needed to connect the computing
device 700 to the network. Illustratively, the network can be embodied as an
Ethernet network or a Fibre Channel (FC) network. A client can communicate with
the computing device over the network by exchanging discrete frames or packets of
data according to pre-defined protocols, e.g., TCP/IP.

[0051] The storage adapter 714 can cooperate with the operating system 706
to access information requested by a client. The information may be stored on any
type of attached array of writable storage media, e.g., magnetic disk or tape, optical
disk (e.g., CD-ROM or DVD), flash memory, solid-state disk (SSD), electronic
random access memory (RAM), micro-electro mechanical and/or any other similar
media adapted to store information, including data and parity information. The
storage adapter 714 can include multiple ports having input/output (I/O) interface
circuitry that couples to the disks over an I/O interconnect arrangement, e.g., a
conventional high-performance, Fibre Channel (FC) link topology. In various
embodiments, the cluster adapter 712 and the storage adapter 714 can be
implemented as one adapter configured to connect to a switching fabric, e.g., a
storage network switch, in order to communicate with other devices and the mass
storage devices.

EXAMPLES OF CERTAIN EMBODIMENTS

[0052] Certain embodiments of the technology introduced herein are
summarized in the following numbered examples:

[0053] 1. An electronic writing device, comprising: a transparent top layer; a
liquid crystal layer including a plurality of liquid crystal cells beneath the transparent
top layer, the liquid crystal layer configured to display an image by switching one or
more of the liquid crystal cells from a scattering state to a reflective state; a matrix of
electrodes configured to supply voltage signals to the liquid crystal cells; and a
control circuitry configured to receive an erase command, the erase command
indicating that a touched area of the transparent top layer is touched and instructing
to erase at least a portion of the image from the touched area; wherein the control
circuitry is further configured to instruct one or more electrodes from the matrix to
apply an erase voltage signal to a portion of the liquid crystal cells that correspond to
the touched area, wherein the erase voltage signal switches the portion of the liquid
crystal cells to the scattering state.
2. The electronic writing device of example 1, wherein the liquid crystal cells of the scattering state present background of the image, and the liquid crystal cells of the reflective state present content of the image, and wherein the electronic writing device erases the portion of the image using the erase voltage signals that switches the corresponding portion of the liquid crystal cells to the scattering state.

3. The electronic writing device of example 1, wherein the matrix of electrodes comprises: a first conductive layer on top of the liquid crystal layer, the first conductive layer including a plurality of first electrode lines extending in parallel along a first direction; and a second conductive layer on top of the liquid crystal layer, the second conductive layer including a plurality of second electrode lines extending in parallel along a second direction, the second direction being perpendicular to the first direction; wherein the perpendicular first and second electrode lines form the matrix of electrodes.

4. The electronic writing device of example 3, wherein the matrix of electrodes detects the mechanical pressure applied on the touched area by detecting a change of capacitance levels between the first and second conductive layer for electrodes that correspond to the touched area.

5. The electronic writing device of example 4, wherein the control circuitry determines a location of the touched area by identifying the electrodes having the change of capacitance levels.

8. The electronic writing device of example 1, wherein in response to that the mechanical pressure is continuously applied to different touched areas, the control circuitry continuously instructs electrodes from the matrix to apply erase voltage signals to liquid crystal cells that correspond to the touched areas.

7. The electronic writing device of example 3, wherein the first electrode lines of the first conductive layer are either fully separated from each other or partially separated, and the second electrode lines of the second conductive layer are either fully separated from each other or partially separated.

8. The electronic writing device of example 3, wherein during operation of the electronic writing device, the first and second conductive layers monitor capacitance levels of the liquid crystal cells based on fluctuation of currents running through the first and second electrode lines; and wherein the control circuitry is
configured to locate the touched area for image erasure by identifying electrodes with changing capacitance levels.

[0061] 9. The electronic writing device of example 1, wherein the control circuitry is configured to receive a write command, a partial erase command, or a full erase command; wherein in response to the write command, a mechanical pressure applied on a pressed area causes the liquid crystal cells of the pressed area switching from a scattering state to a reflective state due to mechanical stress on liquid crystal molecules within the liquid crystal cells; in response to the partial erase command, the erase voltage signal applied to the liquid crystal cells corresponding to the touched area causes the liquid crystal cells of the touched area switching from a scattering state to a reflective state; and in response to the full erase command, the control circuitry instructs all electrodes from the matrix to apply an erase voltage signal to all of the liquid crystal cells, wherein the erase voltage signal switches the liquid crystal cells to the scattering state.

[0062] 10. The electronic writing device of example 9, further comprising: one or more buttons or switches for generating the write command, the partial erase command, or the full erase command.

[0063] 11. The electronic writing device of example 1, further comprising: a data storage for storing data of the image displayed by the liquid crystal layer; and a record circuitry configured to: detect cell state information regarding whether each of the liquid crystal cells is in the scattering state or the reflective state, convert the cell state information into the data of the image based on whether each cell is in the scattering state or the reflective state, and store the data of the image into the data storage.

[0064] 12. The electronic writing device of example 11, wherein the record circuitry detects whether a particular liquid crystal cell is in the scattering state or the reflective state by measuring a capacitance level between a pair of electrodes placed on top of and beneath the particular liquid crystal cell.

[0065] 13. The electronic writing device of example 1, further comprising: a data interface for retrieving data of a display image; and wherein the control circuitry is configured to instruct one or more electrodes from the matrix to apply a display voltage signal to a portion of the liquid crystal cells, wherein the display voltage
signal switches the portion of the liquid crystal cells to the reflective state for displaying the display image.

[0066] 14. A method for selectively erasing images from a liquid crystal writing device, comprising: receiving a command for partially erasing an image being displayed on the liquid crystal writing device, the liquid crystal writing device including a plurality the liquid crystal cells for displaying images; detecting that a touched area of the liquid crystal writing device is touched by an external object;

identifying a portion of the liquid crystal cells that correspond to a location of the touched area; and applying an erase voltage pulse to the portion of the liquid crystal cells to switch states of the cells such that a portion of the image displayed on the touched area is erased.

[0067] 15. The method of example 14, wherein the location of the touched area is identified by monitoring capacitance levels of electrode pairs for each liquid crystal cell, and the erase voltage pulse is applied to the liquid crystal cells via the electrode pairs for the touched area.

[0068] 16. The method of example 14, wherein the location of the touched area is identified by a touch panel of the liquid crystal writing device using infrared touch sensing, resistive touch sensing, capacitive touch sensing, or electo-magnetic resonance touch sensing.

[0069] 17. The method of example 14, further comprising: receiving a command for recording the image being displayed on the liquid crystal writing device; identifying liquid crystal cells that are in a reflected state and are presenting content of the image, by sensing capacitance levels of electrode pairs for each liquid crystal cell; generating data of the image based on the locations of the identified liquid crystal cells on a display surface of the liquid crystal writing device; and storing the data of the image in a storage component of the liquid crystal writing device or transmitting the data of the image via a communication interface of the liquid crystal writing device.

[0070] 18. The method of example 14, further comprising: receiving a command for displaying an image; retrieving data of the image; identifying liquid crystal cells that have locations corresponding to the foreground content of the image; applying a display voltage pulse to the identified liquid crystal cells through electrode pairs for
the identified liquid crystal cells to switch states of the cells to a reflected state such that the image is displayed on the liquid crystal writing device.

19. A liquid crystal writing apparatus for selectively erasing displayed content, comprising: means for displaying an image using liquid crystal cells of the liquid crystal writing apparatus; means for receiving a mechanical pressure applied to the liquid crystal writing apparatus; means for detecting a location of a pressed area due to the mechanical pressure; and means for selectively applying an erase voltage pulse to liquid crystal cells corresponding to the pressed area for partially erasing the image from the pressed area of a display of the liquid crystal writing apparatus.

20. The liquid crystal writing apparatus of example 19, further comprising: means for establishing a communication channel with a second liquid crystal writing apparatus for a remote conference; means for synchronizing images being displayed on the liquid crystal writing apparatus and the second liquid crystal writing apparatus, when new content is written on either the liquid crystal writing apparatus or the second liquid crystal writing apparatus, or when content is partially erased from either the liquid crystal writing apparatus or the second liquid crystal writing apparatus.

Any or all of the features and functions described above can be combined with each other, except to the extent it may be otherwise stated above or to the extent that any such embodiments may be incompatible by virtue of their function or structure, as will be apparent to persons of ordinary skill in the art. Unless contrary to physical possibility, it is envisioned that (i) the methods/steps described herein may be performed in any sequence and/or in any combination, and that (ii) the components of respective embodiments may be combined in any manner.

Although the subject matter has been described in language specific to structural features and/or acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as examples of implementing the claims and other equivalent features and acts are intended to be within the scope of the claims.
CLAIMS

I/We claim:

1. An electronic writing device, comprising:
   a transparent top layer;
   a liquid crystal layer including a plurality of liquid crystal cells beneath the transparent top layer, the liquid crystal layer configured to display an image by switching one or more of the liquid crystal cells from a scattering state to a reflective state;
   a matrix of electrodes configured to supply voltage signals to the liquid crystal cells; and
   a control circuitry configured to receive an erase command, the erase command indicating that a touched area of the transparent top layer is touched and instructing to erase at least a portion of the image from the touched area;

   wherein the control circuitry is further configured to instruct one or more electrodes from the matrix to apply an erase voltage signal to a portion of the liquid crystal cells that correspond to the touched area, wherein the erase voltage signal switches the portion of the liquid crystal cells to the scattering state.

2. The electronic writing device of claim 1, wherein the liquid crystal cells of the scattering state present background of the image, and the liquid crystal cells of the reflective state present content of the image, and wherein the electronic writing device erases the portion of the image using the erase voltage signals that switches the corresponding portion of the liquid crystal cells to the scattering state.

3. The electronic writing device of claim 1, wherein the matrix of electrodes comprises:
   a first conductive layer on top of the liquid crystal layer, the first conductive layer including a plurality of first electrode lines extending in parallel along a first direction; and
   a second conductive layer on top of the liquid crystal layer, the second conductive layer including a plurality of second electrode lines extending in parallel along a second direction, the second direction being perpendicular to the first direction;
wherein the perpendicular first and second electrode lines form the matrix of electrodes.

4. The electronic writing device of claim 3, wherein the matrix of electrodes detects the mechanical pressure applied on the touched area by detecting a change of capacitance levels between the first and second conductive layer for electrodes that correspond to the touched area.

5. The electronic writing device of claim 4, wherein the control circuitry determines a location of the touched area by identifying the electrodes having the change of capacitance levels.

6. The electronic writing device of claim 1, wherein in response to that the mechanical pressure is continuously applied to different touched areas, the control circuitry continuously instructs electrodes from the matrix to apply erase voltage signals to liquid crystal cells that correspond to the touched areas.

7. The electronic writing device of claim 3, wherein the first electrode lines of the first conductive layer are either fully separated from each other or partially separated, and the second electrode lines of the second conductive layer are either fully separated from each other or partially separated.

8. The electronic writing device of claim 3, wherein during operation of the electronic writing device, the first and second conductive layers monitor capacitance levels of the liquid crystal cells based on fluctuation of currents running through the first and second electrode lines; and

   wherein the control circuitry is configured to locate the touched area for image erasure by identifying electrodes with changing capacitance levels.

9. The electronic writing device of claim 1, wherein the control circuitry is configured to receive a write command, a partial erase command, or a full erase command; wherein
in response to the write command, a mechanical pressure applied on a pressed area causes the liquid crystal cells of the pressed area switching from a scattering state to a reflective state due to mechanical stress on liquid crystal molecules within the liquid crystal cells;

in response to the partial erase command, the erase voltage signal applied to the liquid crystal cells corresponding to the touched area causes the liquid crystal cells of the touched area switching from a scattering state to a reflective state; and

in response to the full erase command, the control circuitry instructs all electrodes from the matrix to apply an erase voltage signal to all of the liquid crystal cells, wherein the erase voltage signal switches the liquid crystal cells to the scattering state.

10. The electronic writing device of claim 9, further comprising:

one or more buttons or switches for generating the write command, the partial erase command, or the full erase command.

11. The electronic writing device of claim 1, further comprising:

a data storage for storing data of the image displayed by the liquid crystal layer; and

a record circuitry configured to:

detect cell state information regarding whether each of the liquid crystal cells is in the scattering state or the reflective state,

convert the cell state information into the data of the image based on whether each cell is in the scattering state or the reflective state, and

store the data of the image into the data storage.

12. The electronic writing device of claim 11, wherein the record circuitry detects whether a particular liquid crystal cell is in the scattering state or the reflective state by measuring a capacitance level between a pair of electrodes placed on top of and beneath the particular liquid crystal cell.

13. The electronic writing device of claim 1, further comprising:

a data interface for retrieving data of a display image; and
wherein the control circuitry is configured to instruct one or more electrodes from the matrix to apply a display voltage signal to a portion of the liquid crystal cells, wherein the display voltage signal switches the portion of the liquid crystal cells to the reflective state for displaying the display image.

14. A method for selectively erasing images from a liquid crystal writing device, comprising:

- receiving a command for partially erasing an image being displayed on the liquid crystal writing device, the liquid crystal writing device including a plurality the liquid crystal cells for displaying images;
- detecting that a touched area of the liquid crystal writing device is touched by an external object;
- identifying a portion of the liquid crystal cells that correspond to a location of the touched area; and
- applying an erase voltage pulse to the portion of the liquid crystal cells to switch states of the cells such that a portion of the image displayed on the touched area is erased.

15. The method of claim 14, wherein the location of the touched area is identified by monitoring capacitance levels of electrode pairs for each liquid crystal cell, and the erase voltage pulse is applied to the liquid crystal cells via the electrode pairs for the touched area.

16. The method of claim 14, wherein the location of the touched area is identified by a touch panel of the liquid crystal writing device using infrared touch sensing, resistive touch sensing, capacitive touch sensing, or electo-magnetic resonance touch sensing.

17. The method of claim 14, further comprising:

- receiving a command for recording the image being displayed on the liquid crystal writing device;
identifying liquid crystal cells that are in a reflected state and are presenting content of the image, by sensing capacitance levels of electrode pairs for each liquid crystal cell;

generating data of the image based on the locations of the identified liquid crystal cells on a display surface of the liquid crystal writing device; and

storing the data of the image in a storage component of the liquid crystal writing device or transmitting the data of the image via a communication interface of the liquid crystal writing device.

18. The method of claim 14, further comprising:

receiving a command for displaying an image;

retrieving data of the image;

identifying liquid crystal cells that have locations corresponding to the foreground content of the image;

applying a display voltage pulse to the identified liquid crystal cells through electrode pairs for the identified liquid crystal cells to switch states of the cells to a reflected state such that the image is displayed on the liquid crystal writing device.

19. A liquid crystal writing apparatus for selectively erasing displayed content,

comprising:

means for displaying an image using liquid crystal cells of the liquid crystal writing apparatus;

means for receiving a mechanical pressure applied to the liquid crystal writing apparatus;

means for detecting a location of a pressed area due to the mechanical pressure; and

means for selectively applying an erase voltage pulse to liquid crystal cells corresponding to the pressed area for partially erasing the image from the pressed area of a display of the liquid crystal writing apparatus.

20. The liquid crystal writing apparatus of claim 19, further comprising:

means for establishing a communication channel with a second liquid crystal writing apparatus for a remote conference;
means for synchronizing images being displaying on the liquid crystal writing apparatus and the second liquid crystal writing apparatus, when new content is written on either the liquid crystal writing apparatus or the second liquid crystal writing apparatus, or when content is partially erased from either the liquid crystal writing apparatus or the second liquid crystal writing apparatus.
How to make Wicue Board partial erase
FIG. 5A

501
Write (A)
Display (B)
Save
Selective
Erase

502
Write (A)
Display (B)
Save
Selective
Erase

London

New York
FIG. 5B

London

New York
A. CLASSIFICATION OF SUBJECT MATTER

G02F 1/1333(2006.01)i, G06F 3/041(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02F 1/1333; G06F 3/044; G02F 1/1335; G06F 3/045; G06F 3/041

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: liquid crystal cell, electrode, circuit, touched area, voltage, erase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 2009-0096942 AI (TOD L. SCHNEIDER et a1.) 16 Apr i1 2009 See paragraphs [0007H0026] , [0040H0058] , [0068H0095] ; claims 1, 5, 12; and figures 1-2 .</td>
<td>1-20</td>
</tr>
<tr>
<td>Y</td>
<td>US 2013-0100074 AI (BARNESANDNOBLE.COM LLC.) 25 Apr i1 2013 See paragraphs [0019]- [0052] ; claims 1, 10; and figure 9 .</td>
<td>1-20</td>
</tr>
<tr>
<td>Y</td>
<td>US 2012-0268420 AI (DUANE MARIKA et a1 .) 25 Oct ober 2012 See paragraphs [0035]- [0050] ; claims 2-4, 12; and figure 2 .</td>
<td>11-13 ,17-18</td>
</tr>
<tr>
<td>A</td>
<td>US 2003-0071958 AI (BAO-GANG WU et a1.) 17 Apr i1 2003 See paragraphs [0043]- [0053] ; claim V, and figures 1-2 .</td>
<td>1-20</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

latest document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
18 August 2016 (18.08.2016)

Date of mailing of the international search report
19 August 2016 (19.08.2016)

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongda-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer
LEE, Dong Yun

Telephone No. +82-42-481-8734

Form PCT/ISA/210 (second sheet) (January 2015)
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>JP 2015-181000 A</td>
<td>15/10/2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 5847705 B2</td>
<td>27/01/2016</td>
</tr>
<tr>
<td></td>
<td></td>
<td>KR 10-1396373 Bl</td>
<td>19/05/2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TW 2009/12717 A</td>
<td>16/03/2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2009-0038111 Al</td>
<td>05/02/2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2010-0265214 Al</td>
<td>21/10/2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 8139039 B2</td>
<td>20/03/2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 8228301 B2</td>
<td>24/07/2012</td>
</tr>
<tr>
<td></td>
<td>wo 2009-018240 A2</td>
<td>05/02/2009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wo 2009-018399 A2</td>
<td>05/02/2009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wo 2009-018399 A3</td>
<td>30/04/2009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wo 2010-138568 A2</td>
<td>02/12/2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wo 2010-138568 A3</td>
<td>02/12/2010</td>
<td></td>
</tr>
<tr>
<td>US 2013--0100074 Al</td>
<td>25/04/2013</td>
<td>TW 201329796 A</td>
<td>16/07/2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 9134849 B2</td>
<td>15/09/2015</td>
</tr>
<tr>
<td></td>
<td>wo 2013-063241 Al</td>
<td>02/05/2013</td>
<td></td>
</tr>
<tr>
<td>US 2012--0268420 Al</td>
<td>25/10/2012</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2001-0022632 Al</td>
<td>20/09/2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 6982432 B2</td>
<td>03/01/2006</td>
</tr>
<tr>
<td>US 2003--0071958 Al</td>
<td>17/04/2003</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>