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(54) An oled display with aging compensation

(57) An OLED display includes a plurality of light emitting elements divided into two or more groups, the light emitting elements having an output that changes with time or use; a current measuring device for sensing the total current used by the display to produce a current signal; and a controller for simultaneously activating all of the light emitting elements in a group and responsive to the current signal for calculating a correction signal for the light emitting elements in the group and applying the correction signal to input image signals to produce corrected input image signals that compensate for the changes in the output of the light emitting elements of the group.

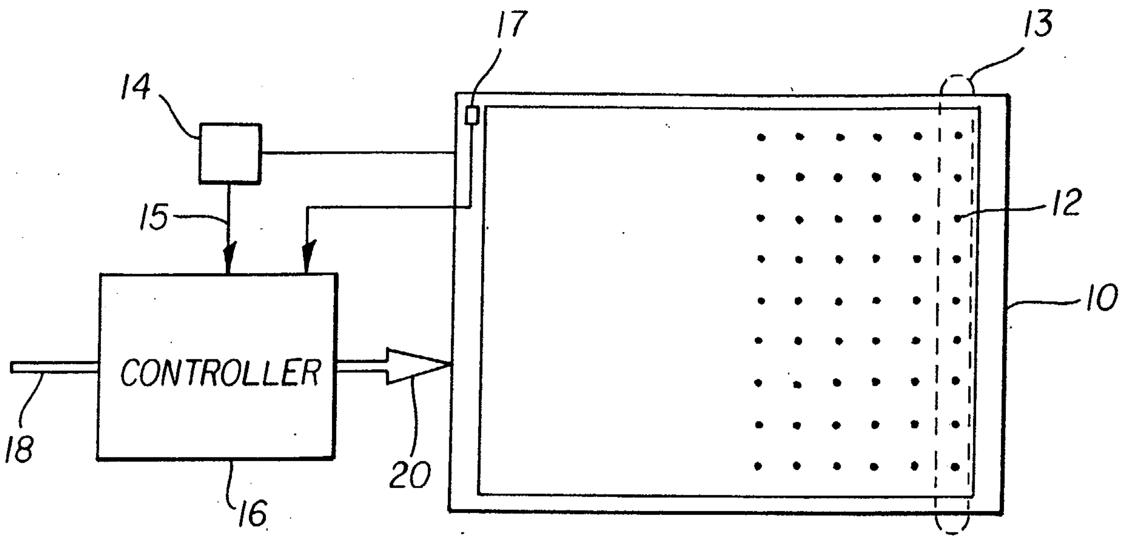

FIG. 1

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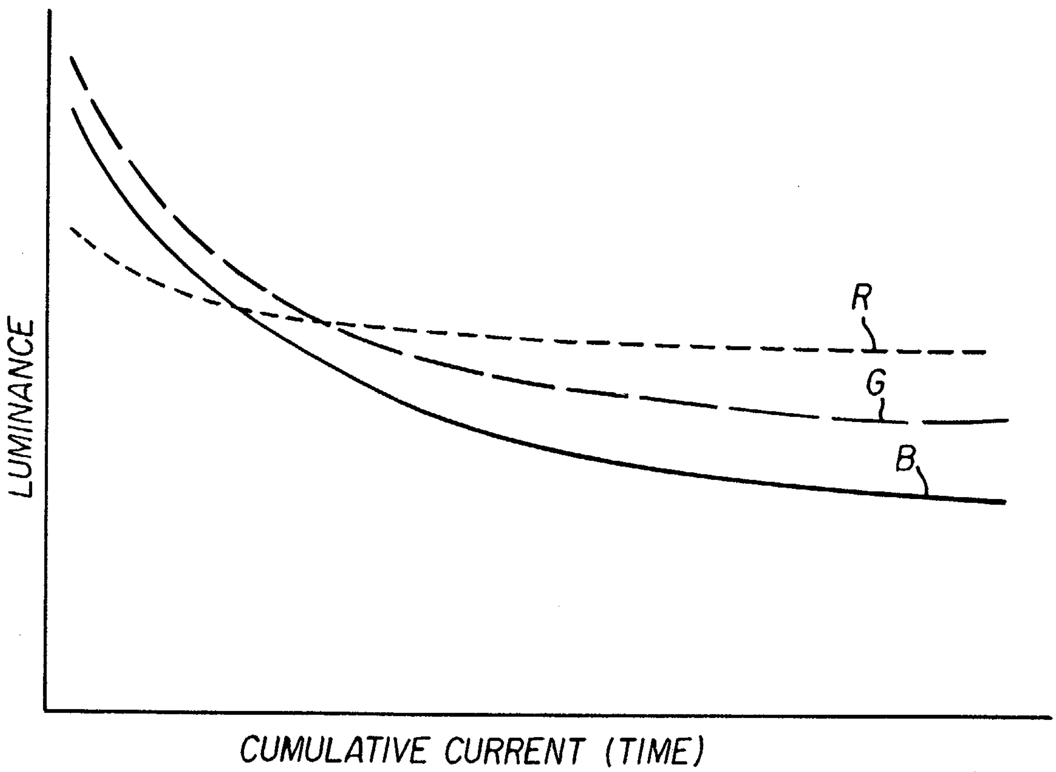

FIG. 2

Description

[0001] The present invention relates to solid-state OLED flat-panel display devices and more particularly to such display devices having means to compensate for the aging of the organic light emitting display.

[0002] Solid-state organic light emitting diode (OLED) image display devices are of great interest as a superior flat-panel display technology. These displays utilize current passing through thin films of organic material to generate light. The color of light emitted and the efficiency of the energy conversion from current to light are determined by the composition of the organic thin-film material. Different organic materials emit different colors of light. However, as the display is used, the organic materials in the device age and become less efficient at emitting light. This reduces the lifetime of the display. The differing organic materials may age at different rates, causing differential color aging and a display whose white point varies as the display is used.

[0003] The rate at which the display ages is related to the amount of current that passes through the device and, hence, the amount of light that has been emitted from the display. One technique to compensate for this aging effect in polymer light emitting diodes is described in US 6,456,016 issued September 24, 2002 to Sundahl et al. This approach relies on a controlled reduction of current provided at an early stage of device use followed by a second stage in which the display output is gradually decreased. This solution requires that the operating time of the device be tracked by a timer within the controller which then provides a compensating amount of current. Moreover, once a display has been in use, the controller must remain associated with that display to avoid errors in device operating time.

[0004] This technique has the disadvantage of not representing the performance of small-molecule organic light emitting diode devices well. Moreover, the time of use of the display must be accumulated, requiring timing, calculation, and storage circuitry in the controller. Also, this technique does not accommodate differences in behavior of the display at varying levels of brightness and temperature and cannot accommodate differential aging rates of the different organic materials.

[0005] US 6,414,661 B1 issued July 2, 2002 to Shen et al. describes a method and associated system that compensates for long-term variations in the light-emitting efficiency of individual organic light emitting diodes (OLEDs) in an OLED display device, by calculating and predicting the decay in light output efficiency of each pixel based on the accumulated drive current applied to the pixel and derives a correction coefficient that is applied to the next drive current for each pixel. This technique requires the measurement and accumulation of drive current applied to each pixel, requiring a stored memory that must be continuously updated as the display is used, requiring complex and extensive circuitry.

[0006] US Patent Application 2002/0167474 A1 by Everitt, published November 14, 2002, describes a pulse width modulation driver for an organic light emitting diode display. One embodiment of a video display comprises a voltage driver for providing a selected voltage to drive an organic light emitting diode in a video display. The voltage driver may receive voltage information from a correction table that accounts for aging, column resistance, row resistance, and other diode characteristics. In one embodiment of the invention, the correction tables are calculated prior to and/or during normal circuit operation. Since the OLED output light level is assumed to be linear with respect to OLED current, the correction scheme is based on sending a known current through the OLED diode for a duration sufficiently long to allow the transients to settle out and then measuring the corresponding voltage with an analog to digital converter (A/D) residing on the column driver. A calibration current source and the A/D can be switched to any column through a switching matrix. This design requires the use of integrated, calibrated current source and A/D converter, greatly increasing the complexity of the circuit design.

[0007] US 6,504,565 B1 issued January 7, 203 to Narita et al., describes a light-emitting device which includes a light-emitting element array formed by arranging a plurality of light-emitting elements, a driving unit for driving the light-emitting element array to emit light from each of the light-emitting elements, a memory unit for storing the number of light emissions for each light-emitting element of the light-emitting element array, and a control unit for controlling the driving unit based on the information stored in the memory unit so that the amount of light emitted from each light-emitting element is held constant. An exposure device employing the light-emitting device, and an image forming apparatus employing the exposure device are also disclosed. This design requires the use of a calculation unit responsive to each signal sent to each pixel to record usage, greatly increasing the complexity of the circuit design.

[0008] JP 2002278514 A by Numeo Koji, published September 27, 2002, describes a method in which a prescribed voltage is applied to organic EL elements by a current-measuring circuit and the current flows are measured; and a temperature measurement circuit estimates the temperature of the organic EL elements. A comparison is made with the voltage value applied to the elements, the flow of current values and the estimated temperature, the changes due to aging of similarly constituted elements determined beforehand, the changes due to aging in the current-luminance characteristics and the temperature at the time of the characteristics measurements for estimating the current-luminance characteristics of the elements. Then, the total sum of the amount of currents being supplied to the elements in the interval during which display data are displayed, is changed so as to obtain the luminance that is to be originally displayed, based on the estimated values of the current-luminance characteristics, the values of the current flowing in the elements, and the display data.

[0009] This design presumes a predictable relative use of pixels and does not accommodate differences in actual usage of groups of pixels or of individual pixels. Hence, accurate correction for color or spatial groups is likely to be inaccurate over time. Moreover, the integration of temperature and multiple current sensing circuits within the display is required. This integration is complex, reduces manufacturing yields, and takes up space within the display.

[0010] There is a need therefore for an improved aging compensation method for organic light emitting diode displays.

[0011] The need is met according to the present invention by providing a OLED display that includes a plurality of light emitting elements divided into two or more groups, the light emitting elements having an output that changes with time or use; a current measuring device for sensing the total current used by the display to produce a current signal; and a controller for simultaneously activating all of the light emitting elements in a group and responsive to the current signal for calculating a correction signal for the light emitting elements in the group and applying the correction signal to input image signals to produce corrected input image signals that compensate for the changes in the output of the light emitting elements of the group.

[0012] The advantages of this invention are an OLED display device that compensates for the aging of the organic materials in the display without requiring extensive or complex circuitry for accumulating a continuous measurement of display light emitting element use or time of operation.

Fig. 1 is a schematic diagram of an OLED display with feedback and control circuits according to the present invention;

Fig. 2 is a diagram illustrating the aging of OLED displays;

Fig. 3 is a flowchart illustrating the use of the present invention; and

Fig. 4 is a schematic diagram of a prior art OLED structure.

[0013] Referring to Fig. 1, one embodiment of the present invention includes an OLED display **10** having a plurality of light emitting elements **12** that are arranged in groups **13**; a current measuring device **14** for sensing the total current used by the display to produce a current signal on line **15**; and a controller **16** for driving the display. According to the present invention, the controller **16** includes means for simultaneously activating all of the light emitting elements in a group and responds to the current signal for calculating a correction signal for the light emitting elements in the group. The controller **16** applies the correction signal to input image signals **18** to produce corrected input image signals **20** that compensate for the changes in the output of the light emitting elements of the group. The current measuring device can comprise, for example, a resistor connected across the terminals of an operational amplifier as is known in the art.

[0014] In one embodiment, the display **10** is a color image display comprising an array of pixels, each pixel including a plurality of different colored light emitting elements (e.g. red, green and blue) that are individually controlled by the controller circuit **16** to display a color image. The colored light emitting elements may be formed by different organic light emitting materials that emit light of different colors, alternatively, they may all be formed by the same organic white light emitting materials with color filters over the individual elements to produce the different colors. In another embodiment, the light emitting elements are individual graphic elements within a display and may not be organized as an array. In either embodiment, the light emitting elements may have either passive- or active-matrix control and may either have a bottom-emitting or top-emitting architecture.

[0015] Referring to Fig. 2, a graph illustrating the typical light output of an OLED display device as current is passed through the OLEDs is shown. The three curves represent typical performance of the different light emitters emitting differently colored light (e.g. R,G,B representing red, green and blue light emitters, respectively) as represented by luminance output over time or cumulative current. As can be seen by the curves, the decay in luminance between the differently colored light emitters can be different. The differences can be due to different aging characteristics of materials used in the differently colored light emitters, or due to different usages of the differently colored light emitters. Hence, in conventional use, with no aging correction, the display will become less bright and the color, in particular the white point, of the display will shift.

[0016] The aging of the OLEDs is related to the cumulative current passed through the OLED resulting in reduced performance, also the aging of the OLED material results in an increase in the apparent resistance of the OLED that causes a decrease in the current passing through the OLED at a given voltage. The decrease in current is directly related to the decrease in luminance of the OLED at a given voltage. In addition to the OLED resistance changing with use, the light emitting efficiency of the organic materials is reduced.

[0017] A first model of the luminance decrease and its relationship to the decrease in current at a given voltage was generated by driving a display and measuring the change in current and luminance over time. The change in image signal necessary to cause the OLED display to output a nominal luminance for a given input image signal was then determined. These changes were then used to create a second model representing a correction value. By combining the first and second models, an integrated model was created that relates the change in current use by the display for a given input image signal to the change in signal value needed to correct the display output to the nominal luminance value desired. By controlling the signal applied to the OLED, an OLED display with a constant luminance output is achieved.

[0018] Referring to Fig. 3, the present invention operates as follows. Before a display device is used, a given input image signal is applied **30** to a group of light emitting elements, a measurement **32** of the current used by the display for the given input image signal is made. The given input image signal is typically a flat field of constant luminance across the group of light emitting elements in the display. This measurement may be taken once and assumed to apply to all similar devices or it may be taken for each individual display. In either case, the measurement is stored **34** in the controller circuit **16** and an initial correction signal set to 0. The process is repeated **35** for each group of light emitting elements. The display may then be put **36** into use. While in use, an input image signal is applied 38 to the controller **16**. The controller **16** corrects the input image signal for each group of light emitting elements to form **40** a corrected input image signal that is applied **42** to the display and the process repeats. Periodically a decision **44** is made to recalibrate the display. The display is removed from use **46**, the group image signals are re-applied **48** to each group of light emitting elements, and a measurement **50** of the display current taken again. The current measurements are then applied to the integrated model and corrected image signals calculated **52** and stored **54**. The process is repeated **56** for each group of light emitting elements. The display is then returned to use **36** so that as each new input image signal is applied **38**, the controller forms **40** a new corrected image signal and applies **42** the corrected image signal to the display.

[0019] Over time the OLED materials will age, the resistance of the OLEDs increase, the current used at the given input image signal will decrease and the correction signal will increase. At some point in time, the controller circuit **16** will no longer be able to provide an image signal correction that is large enough and the display will have reached the end of its lifetime and can no longer meet its brightness or color specification. However, the display will continue to operate as its performance declines, thus providing a graceful degradation. Moreover, the time at which the display can no longer meet its specification can be signaled to a user of the display when a maximum correction is calculated, providing useful feedback on the performance of the display.

[0020] The present invention can be constructed simply, requiring only (in addition to a conventional display controller) a current measurement circuit, a transformation means for the model to perform the image signal correction (for example a lookup table or amplifier), and a calculation circuit to determine the correction for the given image signal. No current accumulation or time information is necessary. Although the display must be periodically removed from use to perform the correction, the period may be quite large, for example days or tens of hours of use.

[0021] The present invention can be used to correct for changes in color of a color display. As noted in reference to Fig. 2, as current passes through the various light emitting elements in the pixels, the materials for each color emitter will age differently. By creating groups comprising all of the light emitting elements of a given color, and measuring the current used by the display for that group, a correction for the light emitting elements of the given color can be calculated. A separate model may be applied for each color, thus maintaining a consistent color for the display device. In this case, the given input image signals may be flat, uniform fields for each individual color corresponding to the OLED materials that emit the corresponding color. This technique will work for both displays that rely on emitters of different colors, or on a single, white emitter together with color filter arrays arranged to provide colored light emitting elements. In the latter case, the correction curves representing the loss of efficiency for each color are identical. However, the use of the colors may not be the same, so that a separate correction for each color is still necessary to maintain a constant luminance and display white point.

[0022] The present invention may be extended to include complex relationships between the corrected image signal, the measured current, and the aging of the materials. Multiple input image signals may be used corresponding to a variety of display outputs. For example, a different input image signal may correspond to each display output brightness level. When periodically calculating the correction signals, a separate correction signal may be obtained for each display output brightness level by using different given input image signals. A separate correction signal is then employed for each display output brightness level required. As before, this can be done for each light emitting element grouping, for example different light emitting element color groups. Hence, the correction signals may correct for each display output brightness level of the display for each color as each material ages.

[0023] The groups of light emitting elements and input image signals used to calculate the correction signals for the display device may also be spatially specific as well as color specific. For example, the given input image signal may exercise only a subset, or even one light emitting element. In this way, the correction signals may apply to specific light emitting elements so that if a subset of light emitting elements age more rapidly, for example, if they are used more heavily (as an icon in a graphic user interface might), they may be corrected differently from other light emitting elements. Therefore, the present invention may correct for the aging of specific light emitting elements or groups of spatially distinct light emitting elements, and/or groups of colored light emitting elements. It is only necessary that a correction model be empirically derived for aging of each type of light emitting element or group of light emitting elements and that a periodic correction signal calculation be performed by driving the group of light emitting elements to be corrected.

[0024] The correction calculation process may be performed periodically during use, at power-up or power-down. The correction calculation process may take only a few milliseconds so that the effect on any user is limited. Alternatively, the correction calculation process may be performed in response to a user signal supplied to the controller.

[0025] OLED displays dissipate significant amounts of heat and become quite hot when used over long periods of time. Further experiments by applicant have determined that there is a strong relationship between temperature and current used by the display. Therefore, if the display has been in use for a period of time, the temperature of the display may need to be taken into account in calculating the correction signal. If it is assumed that the display has not been in use, or if the display is cooled, it may be assumed that the display is at a predetermined ambient temperature, for example room temperature. If the correction signal model was determined at that temperature, the temperature relationship may be ignored. If the display is calibrated at power-up and the correction signal model was determined at ambient temperature, this is a reasonable presumption in most cases. For example, mobile devices with a relatively frequent and short usage profile might not need temperature correction. Display applications for which the display is continuously on for longer periods, for example, monitors or televisions, might require temperature accommodation, or can be corrected on power-up to avoid display temperature issues.

[0026] If the display is calibrated at power-down, the display may be significantly hotter than the ambient temperature and it is preferred to accommodate the calibration by including the temperature effect. This can be done by measuring the temperature of the display, for example with a thermocouple placed on the substrate or cover of the device, or a temperature sensing element, such as a thermistor **17** (see Fig. 1), integrated into the electronics of the display. For displays that are constantly in use, the display is likely to be operated significantly above ambient temperature and the temperature can be taken into account for the display calibration.

[0027] To further reduce the possibility of complications resulting from inaccurate current readings or inadequately compensated display temperature, changes to the correction signals applied to the input image signals may be limited by the controller. Any change in correction can be limited in magnitude, for example to a 5% change. A calculated correction signal might also be restricted to be monotonically increasing, since the aging process does not reverse. Correction changes can also be averaged over time, for example an indicated correction change can be averaged with the previous value(s) to reduce variability. Alternatively, an actual correction can be made only after taking several readings, for example, every time the device is powered on, a corrections calculation is performed and a number of calculated correction signals (e.g. 10) are averaged to produce the actual correction signal that is applied to the device.

[0028] The corrected image signal may take a variety of forms depending on the OLED display device. For example, if analog voltage levels are used to specify the image signal, the correction will modify the voltages of the image signal. This can be done using amplifiers as is known in the art. In a second example, if digital values are used, for example corresponding to a charge deposited at an active-matrix light emitting element location, a lookup table may be used to convert the digital value to another digital value as is well known in the art. In a typical OLED display device, either digital or analog video signals are used to drive the display. The actual OLED may be either voltage- or current-driven depending on the circuit used to pass current through the OLED. Again, these techniques are well known in the art.

[0029] The correction signals used to modify the input image signal to form a corrected image signal may be used to implement a wide variety of display performance attributes over time. For example, the model used to supply correction signals to an input image signal may hold the average luminance or white point of the display constant. Alternatively, the correction signals used to create the corrected image signal may allow the average luminance to degrade more slowly than it would otherwise due to aging.

[0030] In a preferred embodiment, the invention is employed in a device that includes Organic Light Emitting Diodes (OLEDs) which are composed of small molecule or polymeric OLEDs as disclosed in but not limited to US 4,769,292, issued September 6, 1988 to Tang et al., and US 5,061,569, issued October 29, 1991 to VanSlyke et al. Many combinations and variations of organic light emitting displays can be used to fabricate such a device.

[0031] The present invention can be employed in most OLED device configurations. These include very simple structures comprising a single anode and cathode to more complex devices, such as passive matrix displays comprised of orthogonal arrays of anodes and cathodes to form light emitting elements, and active-matrix displays where each light emitting element is controlled independently, for example, with thin film transistors (TFTs).

[0032] There are numerous configurations of the organic layers wherein the present invention can be successfully practiced. A typical prior art structure is shown in Fig. 4 and is comprised of a substrate **101**, an anode **103**, a hole-injecting layer **105**, a hole-transporting layer **107**, a light-emitting layer **109**, an electron-transporting layer **111**, and a cathode **113**. These layers are described in detail below. Note that the substrate may alternatively be located adjacent to the cathode, or the substrate may actually constitute the anode or cathode. The organic layers between the anode and cathode are conveniently referred to as the organic EL element. The total combined thickness of the organic layers is preferably less than 500 nm.

[0033] The anode and cathode of the OLED are connected to a voltage/current source **250** through electrical conductors **260**. The OLED is operated by applying a potential between the anode and cathode such that the anode is at a more positive potential than the cathode. Holes are injected into the organic EL element from the anode and electrons are injected into the organic EL element at the anode. Enhanced device stability can sometimes be achieved when the OLED is operated in an AC mode where, for some time period in the cycle, the potential bias is reversed and no current flows. An example of an AC-driven OLED is described in US 5,552,678.

[0034] The OLED device of this invention is typically provided over a supporting substrate where either the cathode or anode can be in contact with the substrate. The electrode in contact with the substrate is conveniently referred to as the bottom electrode. Conventionally, the bottom electrode is the anode, but this invention is not limited to that configuration. The substrate can either be transmissive or opaque. In the case wherein the substrate is transmissive, a reflective or light absorbing layer is used to reflect the light through the cover or to absorb the light, thereby improving the contrast of the display. Substrates can include, but are not limited to, glass, plastic, semiconductor materials, silicon, ceramics, and circuit board materials. Of course it is necessary to provide a light-transparent top electrode.

[0035] When EL emission is viewed through anode 103, the anode should be transparent or substantially transparent to the emission of interest. Common transparent anode materials used in this invention are indium-tin oxide (ITO), indium-zinc oxide (IZO) and tin oxide, but other metal oxides can work including, but not limited to, aluminum- or indium-doped zinc oxide, magnesium-indium oxide, and nickel-tungsten oxide. In addition to these oxides, metal nitrides, such as gallium nitride, and metal selenides, such as zinc selenide, and metal sulfides, such as zinc sulfide, can be used as the anode. For applications where EL emission is viewed only through the cathode electrode, the transmissive characteristics of anode are immaterial and any conductive material can be used, transparent, opaque or reflective. Example conductors for this application include, but are not limited to, gold, iridium, molybdenum, palladium, and platinum. Typical anode materials, transmissive or otherwise, have a work function of 4.1 eV or greater. Desired anode materials are commonly deposited by any suitable means such as evaporation, sputtering, chemical vapor deposition, or electrochemical means. Anodes can be patterned using well-known photolithographic processes. Optionally, anodes may be polished prior to application of other layers to reduce surface roughness so as to minimize shorts or enhance reflectivity.

[0036] While not always necessary, it is often useful to provide a hole-injecting layer **105** between anode **103** and hole-transporting layer **107**. The hole-injecting material can serve to improve the film formation property of subsequent organic layers and to facilitate injection of holes into the hole-transporting layer. Suitable materials for use in the hole-injecting layer include, but are not limited to, porphyrinic compounds as described in US 4,720,432, plasma-deposited fluorocarbon polymers as described in US 6,208,075, and some aromatic amines, for example, m-MTDATA (4,4',4"-tris[(3-methylphenyl)phenylamino]triphenylamine). Alternative hole-injecting materials reportedly useful in organic EL devices are described in EP 0 891 121 A1 and EP 1 029 909 A1.

[0037] The hole-transporting layer **107** contains at least one hole-transporting compound such as an aromatic tertiary amine, where the latter is understood to be a compound containing at least one trivalent nitrogen atom that is bonded only to carbon atoms, at least one of which is a member of an aromatic ring. In one form the aromatic tertiary amine can be an arylamine, such as a monoarylamine, diarylamine, triarylamine, or a polymeric arylamine. Exemplary monomeric triarylamines are illustrated by Klupfel et al. US 3,180,730. Other suitable triarylamines substituted with one or more vinyl radicals and/or comprising at least one active hydrogen containing group are disclosed by Brantley et al US 3,567,450 and 3,658,520.

[0038] A more preferred class of aromatic tertiary amines are those which include at least two aromatic tertiary amine moieties as described in US 4,720,432 and 5,061,569. The hole-transporting layer can be formed of a single or a mixture of aromatic tertiary amine compounds. Illustrative of useful aromatic tertiary amines are the following:

1,1-Bis(4-di-p-tolylaminophenyl)cyclohexane
1,1-Bis(4-di-p-tolylaminophenyl)-4-phenylcyclohexane
4,4'-Bis(diphenylamino)quadriphenyl
Bis(4-dimethylamino-2-methylphenyl)-phenylmethane
N,N,N-Tri(p-tolyl)amine
4-(di-p-tolylamino)-4'-[4(di-p-tolylamino)-styryl]stilbene
N,N,N',N'-Tetra-p-tolyl-4-4'-diaminobiphenyl
N,N,N',N'-Tetraphenyl-4,4'-diaminobiphenyl
N,N,N',N'-tetra-1-naphthyl-4,4'-diaminobiphenyl
N,N,N',N'-tetra-2-naphthyl-4,4'-diaminobiphenyl
N-Phenylcarbazole
4,4'-Bis[N-(1-naphthyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]biphenyl
4,4"-Bis[N-(1-naphthyl)-N-phenylamino]p-terphe-

nyl
4,4'-Bis[N-(2-naphthyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(3-acenaphthenyl)-N-phenylamino]biphenyl
1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene
4,4'-Bis[N-(9-anthryl)-N-phenylamino]biphenyl
4,4"-Bis[N-(1-anthryl)-N-phenylamino]-p-terphenyl
4,4'-Bis[N-(2-phenanthryl)-N-phenylamino]biphenyl
4,4'-Bis[N-(8-fluoranthenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(2-pyrenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(2-naphthacenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(2-perylenyl)-N-phenylamino]biphenyl
4,4'-Bis[N-(1-coronenyl)-N-phenylamino]biphenyl
2,6-Bis(di-p-tolylamino)naphthalene
2,6-Bis[di-(1-naphthyl)amino]naphthalene
2,6-Bis[N-(1-naphthyl)-N-(2-naphthyl)amino]naphthalene
N,N,N',N'-Tetra(2-naphthyl)-4,4"-diamino-p-terphenyl
4,4'-Bis{N-phenyl-N-[4-(1-naphthyl)-phenyl]amino}biphenyl
4,4'-Bis[N-phenyl-N-(2-pyrenyl)amino]biphenyl
2,6-Bis[N,N-di(2-naphthyl)amine]fluorene
1,5-Bis[N-(1-naphthyl)-N-phenylamino]naphthalene
4,4',4"-tris[(3-methylphenyl)phenylamino]triphenylamine

[0039] Another class of useful hole-transporting materials includes polycyclic aromatic compounds as described in EP 1 009 041. Tertiary aromatic amines with more than two amine groups may be used including oligomeric materials. In addition, polymeric hole-transporting materials can be used such as poly(N-vinylcarbazole) (PVK), polythiophenes, polypyrrole, polyaniline, and copolymers such as poly(3,4-ethylenedioxythiophene) / poly(4-styrenesulfonate) also called PEDOT/PSS.

[0040] As more fully described in US 4,769,292 and 5,935,721, the light-emitting layer (LEL) **109** of the organic EL element includes a luminescent or fluorescent material where electroluminescence is produced as a result of electron-hole pair recombination in this region. The light-emitting layer can be comprised of a single material, but more commonly consists of a host material doped with a guest compound or compounds where light emission comes primarily from the dopant and can be of any color. The host materials in the light-emitting layer can be an electron-transporting material, as defined below, a hole-transporting material, as defined above, or another material or combination of materials that support hole-electron recombination. The dopant is usually chosen from highly fluorescent dyes, but phosphorescent compounds, e.g., transition metal complexes as described in WO 98/55561, WO 00/18851, WO 00/57676, and WO 00/70655 are also useful. Dopants are typically coated as 0.01 to 10 % by weight into the host material. Polymeric materials such as polyfluorenes and polyvinylarylenes (e.g., poly(p-phenylenevinylene), PPV) can also be used as the host material. In this case, small molecule dopants can be molecularly dispersed into the polymeric host, or the dopant could be added by copolymerizing a minor constituent into the host polymer.

[0041] An important relationship for choosing a dye as a dopant is a comparison of the bandgap potential which is defined as the energy difference between the highest occupied molecular orbital and the lowest unoccupied molecular orbital of the molecule. For efficient energy transfer from the host to the dopant molecule, a necessary condition is that the band gap of the dopant is smaller than that of the host material. For phosphorescent emitters it is also important that the host triplet energy level of the host be high enough to enable energy transfer from host to dopant.

[0042] Host and emitting molecules known to be of use include, but are not limited to, those disclosed in US 4,768,292; 5,141,671; 5,150,006; 5,151,629; 5,405,709; 5,484,922; 5,593,788; 5,645,948; 5,683,823; 5,755,999; 5,928,802; 5,935,720; 5,935,721; and 6,020,078. Metal complexes of 8-hydroxyquinoline (oxine) and similar derivatives constitute one class of useful host compounds capable of supporting electroluminescence. Illustrative of useful chelated oxinoid compounds are the following:

CO-1: Aluminum trisoxine [alias, tris(8-quinolinolato)aluminum(III)]
CO-2: Magnesium bisoxine [alias, bis(8-quinolinolato)magnesium(II)]
CO-3: Bis[benzo{f}-8-quinolinolato]zinc (II)
CO-4: Bis(2-methyl-8-quinolinolato)aluminum(III)-□-oxo-bis(2-methyl-8-quinolinolato) aluminum(III)
CO-5: Indium trisoxine [alias, tris(8-quinolinolato) indium]
CO-6: Aluminum tris(5-methyloxine) [alias, tris (5-methyl-8-quinolinolato) aluminum(III)]
CO-7: Lithium oxine [alias, (8-quinolinolato)lithium (I)]
CO-8: Gallium oxine [alias, tris(8-quinolinolato)gallium(III)]
CO-9: Zirconium oxine [alias, tetra(8-quinolinolato) zirconium(IV)]

[0043] Other classes of useful host materials include, but are not limited to: derivatives of anthracene, such as 9,10-di-(2-naphthyl)anthracene and derivatives thereof as described in US 5,935,721, distyrylarylene derivatives as described in US 5,121,029, and benzazole derivatives, for example, 2, 2', 2"-(1,3,5-phenylene)tris [1-phenyl-1H-benzimidazole]. Carbazole derivatives are particularly useful hosts for phosphorescent emitters.

[0044] Useful fluorescent dopants include, but are not limited to, derivatives of anthracene, tetracene, xanthene, perylene, rubrene, coumarin, rhodamine, and quinacridone, dicyanomethylenepyran compounds, thiopyran compounds, polymethine compounds, pyrilium and thiapyrilium compounds, fluorene derivatives, periflanthene derivatives, indenoperylene derivatives, bis (azinyl)amine boron compounds, bis(azinyl)methane compounds, and carbostyryl compounds.

[0045] Preferred thin film-forming materials for use in forming the electron-transporting layer **111** of the organic EL elements of this invention are metal chelated oxinoid compounds, including chelates of oxine itself (also commonly referred to as 8-quinolinol or 8-hydroxyquinoline). Such compounds help to inject and transport electrons, exhibit high levels of performance, and are readily fabricated in the form of thin films. Exemplary oxinoid compounds were listed previously.

[0046] Other electron-transporting materials include various butadiene derivatives as disclosed in US 4,356,429 and various heterocyclic optical brighteners as described in US 4,539,507. Benzazoles and triazines are also useful electron-transporting materials.

[0047] When light emission is viewed solely through the anode, the cathode 113 used in this invention can be comprised of nearly any conductive material. Desirable materials have good film-forming properties to ensure good contact with the underlying organic layer, promote electron injection at low voltage, and have good stability. Useful cathode materials often contain a low work function metal (< 4.0 eV) or metal alloy. One preferred cathode material is comprised of a Mg:Ag alloy wherein the percentage of silver is in the range of 1 to 20 %, as described in US 4,885,221. Another suitable class of cathode materials includes bilayers comprising a thin electron-injection layer (EIL) in contact with the organic layer (e.g., ETL) which is capped with a thicker layer of a conductive metal. Here, the EIL preferably includes a low work function metal or metal salt, and if so, the thicker capping layer does not need to have a low work function. One such cathode is comprised of a thin layer of LiF followed by a thicker layer of Al as described in US 5,677,572. Other useful cathode material sets include, but are not limited to, those disclosed in US 5,059,861, 5,059,862, and 6,140,763.

[0048] When light emission is viewed through the cathode, the cathode must be transparent or nearly transparent. For such applications, metals must be thin or one must use transparent conductive oxides, or a combination of these materials. Optically transparent cathodes have been described in more detail in US 4,885,211, US 5,247,190, JP 3,234,963, US 5,703,436, US 5,608,287, US 5,837,391, US 5,677,572, US 5,776,622, US 5,776,623, US 5,714,838, US 5,969,474, US 5,739,545, US 5,981,306, US 6,137,223, US 6,140,763, US 6,172,459, EP 1 076 368, US 6,278,236, and US 6,284,393. Cathode materials are typically deposited by evaporation, sputtering, or chemical vapor deposition. When needed, patterning can be achieved through many well known methods including, but not limited to, through-mask deposition, integral shadow masking, for example, as described in US 5,276,380 and EP 0 732 868, laser ablation, and selective chemical vapor deposition.

[0049] In some instances, layers **109** and **111** can optionally be collapsed into a single layer that serves the function of supporting both light emission and electron transportation. It also known in the art that emitting dopants may be added to the hole-transporting layer, which may serve as a host. Multiple dopants may be added to one or more layers in order to create a white-emitting OLED, for example, by combining blue- and yellow-emitting materials, cyan- and red-emitting materials, or red-, green-, and blue-emitting materials. White-emitting devices are described, for example, in EP 1 187 235, US 20020025419, EP 1 182 244, US 5,683,823, US 5,503,910, US 5,405,709, and US 5,283,182.

[0050] Additional layers such as electron or hole-blocking layers as taught in the art may be employed in devices of this invention. Hole-blocking layers are commonly used to improve efficiency of phosphorescent emitter devices, for example, as in US 20020015859.

[0051] This invention may be used in so-called stacked device architecture, for example, as taught in US 5,703,436 and US 6,337,492.

[0052] The organic materials mentioned above are suitably deposited through a vapor-phase method such as sublimation, but can be deposited from a fluid, for example, from a solvent with an optional binder to improve film formation. If the material is a polymer, solvent deposition is useful but other methods can be used, such as sputtering or thermal transfer from a donor sheet. The material to be deposited by sublimation can be vaporized from a sublimator "boat" often comprised of a tantalum material, e.g., as described in US 6,237,529, or can be first coated onto a donor sheet and then sublimed in closer proximity to the substrate. Layers with a mixture of materials can utilize separate sublimator boats or the materials can be pre-mixed and coated from a single boat or donor sheet. Patterned deposition can be achieved using shadow masks, integral shadow masks (US 5,294,870), spatially-defined thermal dye transfer from a donor sheet (US 5,688,551, 5,851,709 and 6,066,357) and inkjet method (US 6,066,357).

[0053] Most OLED devices are sensitive to moisture or oxygen, or both, so they are commonly sealed in an inert atmosphere such as nitrogen or argon, along with a desiccant such as alumina, bauxite, calcium sulfate, clays, silica gel, zeolites, alkaline metal oxides, alkaline earth metal oxides, sulfates, or metal halides and perchlorates. Methods for encapsulation and desiccation include, but are not limited to, those described in US 6,226,890. In addition, barrier layers such as SiOx, Teflon, and alternating inorganic/polymeric layers are known in the art for encapsulation.

[0054] OLED devices of this invention can employ various well-known optical effects in order to enhance its properties if desired. This includes optimizing layer thicknesses to yield maximum light transmission, providing dielectric mirror structures, replacing reflective electrodes with light-absorbing electrodes, providing anti glare or anti-reflection coatings over the display, providing a polarizing medium over the display, or providing colored, neutral density, or color conversion filters over the display. Filters, polarizers, and anti-glare or anti-reflection coatings may be specifically provided over the cover or an electrode protection layer beneath the cover.

Claims

1. An OLED display, comprising:

a) a plurality of light emitting elements divided into two or more groups, the light emitting elements having an output that changes with time or use;
b) a current measuring device for sensing the total current used by the display to produce a current signal; and
c) a controller for simultaneously activating all of the light emitting elements in a group and responsive to the current signal for calculating a correction signal for the light emitting elements in the group and applying the correction signal to input image signals to produce corrected input image signals that compensate for the changes in the output of the light emitting elements of the group.

2. The OLED display claimed in Claim 1, wherein the output of the light emitting elements change with temperature, and further comprising a temperature sensor and wherein the controller is also responsive to the temperature to calculate the correction signal.

3. The OLED display claimed in Claim 1, wherein the display is a color display including an array of pixels, each pixel comprising a plurality of differently colored light emitting elements, and wherein the groups of light emitting elements are defined by the colors of light emitting elements.

4. The OLED display claimed in Claim 1, wherein the groups of light emitting elements are defined by their location on the display.

5. The OLED display claimed in Claim 1, wherein the groups of light emitting elements are defined by individual light emitting elements.

6. The OLED display claimed in Claim 1, wherein the controller sequentially activates the groups of light emitting elements and compensates for the changes in each group.

7. The OLED display claimed in Claim 1, wherein the controller activates the light emitting elements in a group at a plurality of different input image signal levels to calculate the correction signal.

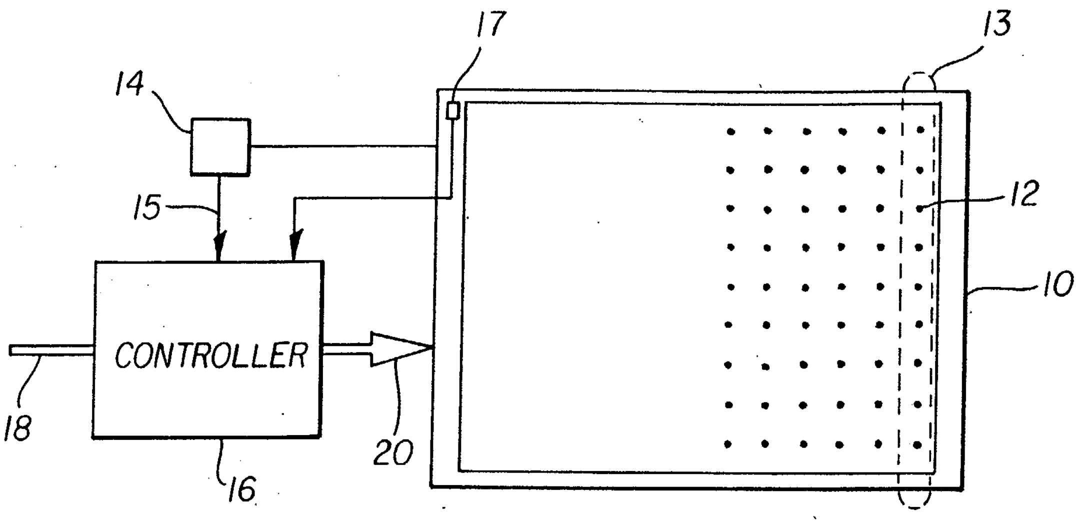

FIG. 1

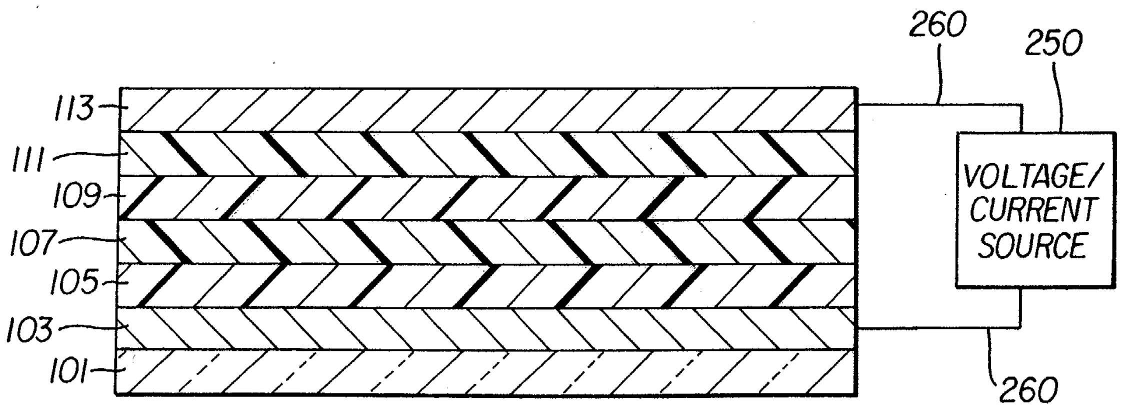

FIG. 4
(Prior Art)

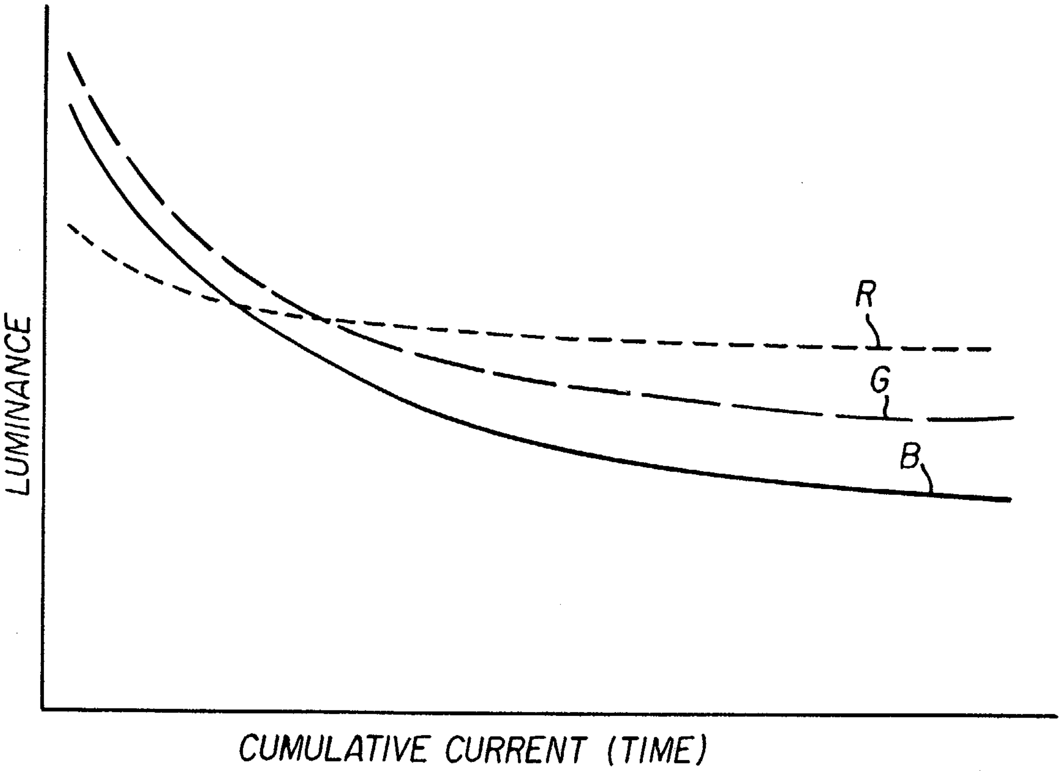

FIG. 2

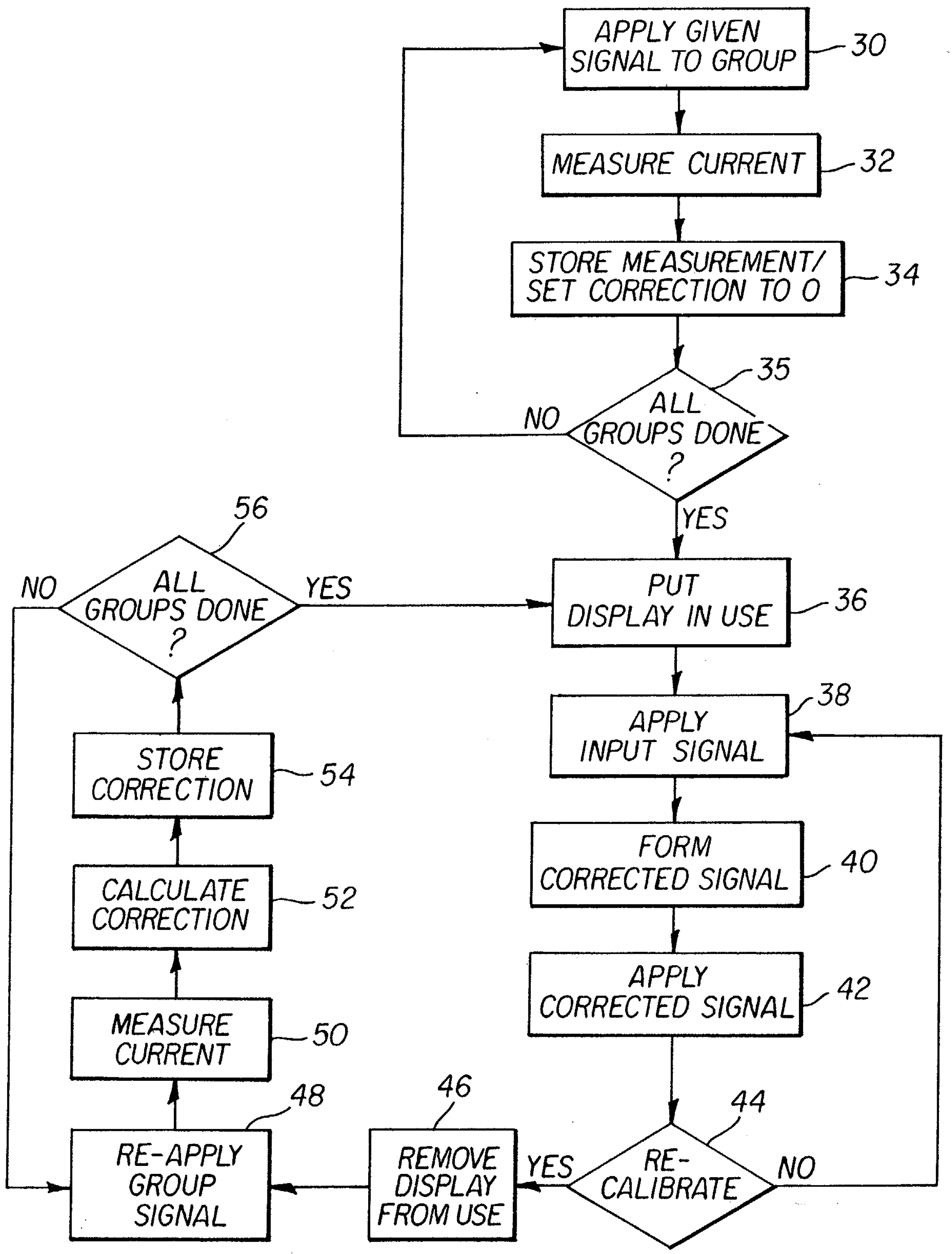
APPLY GIVEN SIGNAL TO GROUP
30
MEASURE CURRENT
32
STORE MEASUREMENT/ SET CORRECTION TO 0
34
ALL GROUPS DONE ?
35
NO
YES
PUT DISPLAY IN USE
36
APPLY INPUT SIGNAL
38
FORM CORRECTED SIGNAL
40
APPLY CORRECTED SIGNAL
42
RE-CALIBRATE
44
NO
YES
REMOVE DISPLAY FROM USE
46
RE-APPLY GROUP SIGNAL
48
MEASURE CURRENT
50
CALCULATE CORRECTION
52
STORE CORRECTION
54
ALL GROUPS DONE ?
56
NO
YES

FIG. 3

patsnap

专利名称(译)	具有老化补偿的oled显示器		
公开(公告)号	EP1443484A2	公开(公告)日	2004-08-04
申请号	EP2004075154	申请日	2004-01-19
[标]申请(专利权)人(译)	伊斯曼柯达公司		
申请(专利权)人(译)	伊士曼柯达公司		
当前申请(专利权)人(译)	全球OLED科技有限责任公司		
[标]发明人	COK RONALD S EASTMAN KODAK COMPANY ARNOLD ANDREW D EASTMAN KODAK COMPANY		
发明人	COK, RONALD S., EASTMAN KODAK COMPANY ARNOLD, ANDREW D. EASTMAN KODAK COMPANY		
IPC分类号	H05B33/08 G09G3/20 G09G3/30 G09G3/32 H01L51/50		
CPC分类号	G09G3/3208 G09G2320/0295 G09G2320/041 G09G2320/048 G09G2320/0693		
优先权	10/355922 2003-01-31 US		
其他公开文献	EP1443484A3		
外部链接	Espacenet		

摘要(译)

OLED显示器包括分成两组或更多组的多个发光元件，发光元件具有随时间变化或使用的输出;电流测量装置，用于检测显示器用于产生电流信号的总电流;控制器，用于同时激活一组中的所有发光元件并响应于该电流信号，用于计算该组中的发光元件的校正信号，并将该校正信号施加到输入图像信号，以产生校正的输入图像信号，补偿组中发光元件输出的变化。

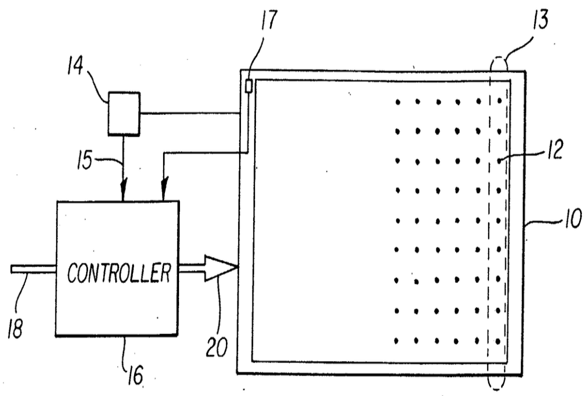

FIG. 1