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(54) Method for a segmented inverse gamma correction for a plasma display panel

Verfahren zur segmentierten invertierten Gammakorrektur für eine Plasmaanzeigetafel

Procédé segmenté pour correction inverse de gamma pour un panneau d'affichage à plasma

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(73) Proprietor: **CPT Technology (Group) Co., Ltd.**
Mawei district
Fuzhou
Fujian (CN)

(72) Inventors:
- **Shiuh-Bin, Kao**
  Taipei (TW)
- **Liang-Kuei, Hsu**
  Taipei (TW)
- **Kuang-Lang, Chen**
  Taipei (TW)

(74) Representative: **Becker Kurig Straus**
Patentanwälte
Bavariastrasse 7
80336 München (DE)

(56) References cited:
EP-A- 0 831 643 **EP-A- 0 947 975**
JP-A- 6 311 394 **JP-A- 8 317 250**

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to PDPs (plasma display panels) and more particularly to a method of effecting various anti compensation processes on segmented gray level of input image on PDP, thereby significantly improving image quality of PDP.

BACKGROUND OF THE INVENTION

[0002] The brightness of a typical color television (TV) may be expressed in following equation (1) in terms of input voltage by utilizing the physical characteristic of cathode ray tube (CRT) of color TV:

$$\text{brightness} = k_1 \times (V_{INPUT}/V_{MAX})^{\gamma} \qquad (1)$$

where γ = 2.2, k_1 is a variable representing gray level of color TV (e.g., k_1 = 256 if gray level of color TV is 256), V_{INPUT} is input voltage varied as gray level of color TV, and V_{MAX} is a maximum voltage required for showing a maximum gray level of color TV. Hence, the relationship of input gray level (voltage) versus output brightness of color TV may be plotted as a curve (FIG. 1b). Conventionally, prior to sending a video signal (e.g., NTSC or HDTV), a Gamma (γ) compensation process (called compensation process hereinafter) is performed on the original video signal by utilizing above physical characteristic thereof. That is, a compensation process is performed with respect to γ in equation (1). As such, the relationship of input brightness versus output gray level (voltage) of color TV may be plotted as a curve (FIG. 1a). In one example of γ = 0.45 (i.e., obtained from 1/2.2), the video signal received by color TV is converted into image for showing on screen of CRT of color TV. Hence, the relationship of input brightness versus output brightness of color TV may be plotted as a straight line (FIG. 1c). As a result, a high quality image is shown on the typical color TV without distortion.

[0003] As to recently available PDPs (plasma display panels) brightness of respective discharge unit on panel thereof is controlled by discharge number. Hence, brightness may be expressed in following equation (2) in terms of discharge number as below (i.e., a straight line):

$$\text{brightness} = k_2 \times \text{discharge number} \qquad (2)$$

where k_2 is a variable representing brightness in a discharge number of a pixel of plasma display panel (e.g., k_2 = 1 if brightness of one discharge of PDP is equal to 1 cd/m^2). In view of this, the higher discharge number the brighter of PDP. This is similar to the effect that the larger input voltage the brighter of a typical color TV.

[0004] Referring to FIGS. 2a, 2b and 2c, a compensation process is performed on received video signal by PDP by substituting γ = 0.45 into equation (1) by similarly utilizing the physical characteristic of typical color TV. As such, the relationship of input brightness versus output gray level (voltage) of PDP may be plotted as a curve (FIG. 2a). Further, the relationship of input gray level (voltage) versus output brightness of PDP may be plotted as a straight line (FIG. 2b). Furthermore, video signal received by PDP is converted into image for showing on screen of PDP. Hence, the relationship of input brightness versus output brightness of PDP may be plotted as a curve (FIG. 2c) by similarly substituting γ = 0.45 into equation (1). As a result, a distorted image with poor contrast is shown on PDP.

[0005] Typically, an anti compensation process is performed for solving above drawbacks. In detail, in one example, an anti compensation process is performed on received video signal by PDP by substituting γ = 2.2 into equation (1). As such, in PDP the relationship of input gray level (voltage) versus output gray level may be plotted as a curve (FIG. 3b). In another example, an anti compensation process is performed on received video signal by PDP by substituting γ = 0.45 into equation (1). Hence, in PDP the relationship of input brightness versus output gray level (voltage) may be plotted as a curve (FIG. 3a). As to image shown on PDP, the relationship of input gray level (voltage) versus output brightness of PDP may be plotted as a straight line (FIG. 3c). By combining FIGS. 3a, 3b and 3c, in PDP the relationship of input brightness versus output brightness may be plotted as a straight line (FIG. 3d). In other words, a linear relationship exists between image shown on PDP and received video signal. As a result, a high quality image is shown on PDP without distortion.

[0006] As to current PDPs, signal input/output and processing are done by a digital technique. Moreover, in most cases gray level of PDP is expressed as a power of 2. For example, in PDP eight bits are needed for representing 256 gray levels. Typically, in performing a compensation process an analog-to-digital conversion is performed on video signal prior to substituting γ = 0.45 into equation (1). Then an anti compensation process is performed by substituting γ = 2.2 into equation (1) for effecting an inverse transform on video signal. Finally, an image is shown on PDP. However, the previous improvement technique has a disadvantage. That is, a non-integer number (e.g., decimal) can not be expressed by a digital signal. Hence, the decimal has to be converted into an integer. In the case of the original video signal having 256 gray levels, the number of gray level is reduced to 184 after first being processed in a analog-to-digital conversion and subsequently by substituting γ = 2.2 into equation (1) for performing an anti compensation process thereafter. In another case that the original video signal having a gray level in the range of 0 to 40, the number of gray level is reduced to 5 (e.g., gray level 0, 1, 2, 3, and 4) after an inverse transform is performed by substituting γ = 2.2 into equation (1) (see Table I below.)

TABLE I

gray level of original video signal	gray level after γ = 2.2 conversion	gray level after γ = 2.0 conversion	gray level after γ = 1.8 conversion	gray level after γ = 1.6 conversion
0-20	0	0-1	0-2	0-4
21-28	1	1-3	2-4	4-7
29-33	2	3-4	5-6	7-9
34-38	3	4-5	6-8	10-12
39-42	4	5-6	8-9	12-14
43-46	5	7-8	10-11	14-16
...	...	...	...	...
47-61	6-10	8-14	12-19	14-25
Total gray level = 62	Total gray level = 11	Total gray level = 15	Total gray level = 20	Total gray level = 26

[0007] Hence, a problem of insufficient gray level of video signal is occurred in the range of low gray level after such anti compensation process. And in turn a false contour is occurred in the range of low gray level. Consequently, a poor contrast is occurred in the range of high gray level due to extremely low gray level (or brightness) gradient. As a result, a difference between two gray levels is undistinguishable visually.

[0008] JP 6 311394 A discloses a circuit to improve the picture quality by setting a gamma correction characteristic of a video signal to a characteristic in response to a pattern so as to apply gamma correction proper to the content of a video signal. An arithmetic operation section receiving plural parameters from a pattern discrimination section uses the parameters to make arithmetic operation. A gamma correction curve required for a video image is decided through the arithmetic operation. The gamma correction curve decided in this way differs from the plural parameters, that is the pattern of the video signal and portions A, C form a cubic curve and a portion B forms a straight line. Then the required gamma correction characteristic obtained by the arithmetic operation section is written in a RAM via a control section. The RAM to which the gamma correction characteristic is written acts like an input output converter and the video signal inputted via the A/D converter is converted and outputted according to the gamma characteristic. Then the written gamma characteristic is revised based on the result of the arithmetic operation by the arithmetic operation section.

[0009] JP 8 317250 A discloses a device for increasing the practical contrast to display a picture with a stereoscopic effect by raising a minimum level and a maximum level of an input signal within an output level range and increasing the gamma value of input/ output characteristics corresponding to the vicinity of APL at the time of using a display device, where the display gradation is limited, to display the picture which has APL varied. An input video signal is digitized and is converted to a desired video signal characteristic by an input/output characteristic conversion part consisting of a RAM or the like and is displayed on a display part. Meanwhile, a luminance signal is obtained from the video signal by a matrix circuit, and APL is calculated for each field or frame by an APL calculation part, and a histogram is calculated in a histogram calculation part. The dynamic range and gamma characteristic most suitable for the input video signal are calculated from these data in accordance with procedures of a dynamic range processing part and a gamma characteristic processing part by a control part, and the conversion characteristic is set to the input/output characteristic conversion part.

SUMMARY OF THE INVENTION

[0010] It is thus an object of the present invention to provide a process of effecting a gamma compensation on the video signal of an input image to be displayed on a plasma display panel, as recited in the appended claim.
[0011] The above and other objects, features and advantages of the present invention will become apparent from the following detailed description taken with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1a is a graph showing a relationship of input brightness versus output gray level (voltage) of a conventional color TV;
FIG. 1b is a graph showing a relationship of input gray level (voltage) versus output brightness of the conventional color TV;
FIG. 1c is a graph showing a relationship of input brightness versus output brightness of the conventional color TV;
FIG. 2a is a graph showing a relationship of input brightness versus output gray level (voltage) of a conventional plasma display panel (PDP);
FIG. 2b is a graph showing a relationship of input gray level (voltage) versus output brightness of the conventional PDP;
FIG. 2c is a graph showing a relationship of input brightness versus output brightness of the conventional PDP;
FIG. 3a is a graph showing a relationship of input brightness versus output gray level (voltage) of the conventional PDP after an anti compensation process is performed thereon;
FIG. 3b is a graph showing a relationship of input gray level (voltage) versus output gray level of the conventional PDP after the anti compensation process is performed thereon;
FIG. 3c is a graph showing a relationship of input gray level (voltage) versus output brightness of the conventional PDP after the anti compensation process is performed thereon;
FIG. 3d is a graph showing a relationship of input brightness versus output brightness of the conventional PDP after the anti compensation process is performed thereon;
FIG. 4 is a graph showing a relationship of input gray level versus output gray level gradient after performing a method of effecting various anti compensation processes on segmented gray level of input image on PDP according to the invention where three Gamma values are used;
FIG. 5 is a graph similar to FIG. 4 showing a relationship of input gray level versus output gray level where single Gamma and segmented Gamma curves are plotted for comparison; and
FIG. 6 is a graph similar to FIG. 4 showing a relationship of input gray level versus output brightness where single Gamma and segmented Gamma curves are plotted for comparison.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] Referring to FIGS. 4 to 6, where a method according to the invention is illustrated by respective graphs. Before the method performs an anti compensation process on video signal received by PDP, (i.e., a compensation process is performed on the video signal with respect to $\gamma = 0.45$ in equation (1)), a processing is performed on the video signal for dividing it into three segments based on gray level thereof. Then various anti compensation processes are performed on the video signal in respective segment so as to increase the number of gray level of video signal in the range of low gray level and increase gray level (or brightness) gradient of video signal in the range of high gray level. As a result, image quality of PDP is greatly improved. Further, a false contour is not easily occurred in the range of low gray level. Consequently, a sharp contrast is occurred in the range of high gray level. As an end, a difference between two gray levels in the range of high gray level is distinguishable visually, resulting in an enhanced image brightness.
[0014] The gray level of an image shown on a typical color TV may be varied depending on input voltage by utilizing the physical characteristic of CRT of color TV. Further, gray level of an output image is related to that of an input video signal. Hence, an output gray level of a typical color TV may be expressed in following equation (3) by deriving itself from equation (1):

$$\text{output gray level} = C_1 \times (\text{input gray level}/C_1\text{-}1)^{\gamma} \qquad (3)$$

where C_1 is a variable representing a maximum gray level of typical color TV. For example, the number of gray level thereof is 256, i.e., in the range of 0 to 255. Hence, gray level is 0 if input voltage is a minimum and gray level is 255 if input voltage is a maximum. As such, C_1-1 = gray level of maximum gray level = 255 and input gray level is a gray level of input video signal.

[0015] As stated above, a compensation process is performed on the video signal with respect to γ = 0.45 in equation (1)). Thereafter, an anti compensation process is performed on the received video signal for obtaining an improved image brightness on PDP. As a result, brightness of an input image of PDP may be expressed in terms of an output gray level. Similarly, an output gray level of PDP may be expressed in following equation (4) by deriving itself from equation (1):

$$\text{output gray level} = C_2 \times (\text{input gray level}/C_2\text{-}1)^{\gamma} \qquad (4)$$

where C_2 is a variable representing a gray level of PDP. For example, the number of gray level thereof is 256, i.e., C_2 = 256 in the range of 0 to 255. Hence, a maximum gray level is 255, i.e., C_2-1 = 255. In following cases that a plurality of γ having values smaller than 2.2 (e.g., 2.0, 1.8, and 1.6) are substituted into γ in equation (4) for obtaining respective output gray level. It is found that the smaller the γ the higher the output gray level in the range of low gray level. This may be best illustrated in Table II below.

TABLE II

gray level of original video signal	gray level after γ = 2.2 conversion
0-14	0
15-24	1
25-31	2
32-36	3
37-40	4
41-44	5
45-48	6
49-51	7
52-54	8
55-57	9
58-59	10
...	...
255	255
Total gray level =256	Total gray level = 184

[0016] As to the higher gray level in the range of low gray level, it means that a false contour is not easily occurred. Further, gradient of PDP may be expressed in following equation (5) by differentiating equation (3):

$$\text{gradient} = C_1/255 \times \gamma \times (\text{input gray level}/C_1\text{-}1)^{\gamma\text{-}1} \qquad (5)$$

[0017] In view of equation (5), it is found that there is a substantially linear relationship between brightness of PDP and output gray level. Hence, the contrast of image becomes poorer as gradient of output image of PDP becomes smaller. In other words, the contrast of image becomes sharper as gradient of output image of PDP becomes larger. In following cases that a plurality of γ s having values larger than 2.2 (e.g., 2.4 and 2.6) are substituted into γ in equation (5) for obtaining respective output gray level. It is found that the larger the γ the higher the output gray level in the range of high gray level (FIG. 4). This means that the contrast of image becomes sharper. That is, a gray level difference in the range of high gray level of output image is easier to distinguish visually.

[0018] Above fact is obtained and utilized by the invention in which before the method of the invention performs an anti compensation process on the video signal received by PDP, (i.e., a compensation process is performed on the video signal with respect to γ = 0.45 in equation (1)), a processing is performed on the video signal for dividing it into three segments based on gray level thereof. Then a plurality of anti compensation processes are performed on the video signal in respective segment with respect to various γ s. A smaller γ is used in the anti compensation process with respect to video signal in the range of low gray level for increasing the number of gray level therein. As a result, a false contour is not easily occurred in the range of low gray level. In contrast, a larger γ is used in the anti compensation process with respect to video signal in the range of high gray level for increasing the number of gray level therein. As a result, a sharp contrast of image is obtained, thereby greatly improving the image quality of PDP.

[0019] In one embodiment of the invention, a maximum brightness of a PDP is 500 cd/m^2 if gray level thereof is 256. Also, an anti compensation process on video signal received by PDP is already performed with respect to γ = 0.45 in equation (1). Thus when video signal is received by PDP a control circuit of PDP will be enabled to divide video signal into three segments based on gray level thereof. Then a plurality of anti compensation processes are performed on the video signal in respective segment with respect to various γ s. A γ smaller than 2.2 (e.g., γ = 1.6) is used in the anti compensation process with respect to video signal in the range of low gray level for increasing the number of gray level therein. Similarly, a γ = 2.2 is used in the anti compensation process with respect to video signal in the range of intermediate gray level. A γ larger than 2.2 (e.g., γ = 2.6) is used in the anti compensation process with respect to video signal in the range of high gray level. After the invention performing above anti compensation processes, as to output image of PDP, the number of gray level in the range of low gray level is increased and gradient in the range of high gray level is also increased. As a result, a false contour is not easily occurred in the range of low gray level. Further, a sharp contrast of output image is obtained in the range of high gray level, thereby greatly improving the image quality of PDP.

[0020] While the invention has been described by means of specific embodiments, numerous modifications and variations could be made thereto by those skilled in the art without departing from the scope of the invention set forth in the claims.

Claims

1. A process of effecting a gamma compensation on the video signal of an input image to be displayed on a plasma display panel, said process comprising the steps of:

dividing the range of grey levels in said video signal into three segments , the first segment covering grey levels from a first grey level up to a second grey level larger than said first grey level, the second segment covering grey levels up to said first grey level, and said third segment covering grey levels above said second grey level;
performing a first gamma compensation on said video signal for grey levels within said first segment with respect to a first gamma value;
performing a second gamma compensation on said video signal for grey levels within said second segment with respect to a second gamma value smaller than said first gamma value; and performing a third gamma compensation on said video signal for grey levels within said third segment with respect to a third gamma value, the process being **characterized in that** said third gamma value is larger than said first gamma value.

2. The process of claim 1, wherein said first gamma compensation has been performed on said video signal received by said PDP according to the following equation:

$$\text{brightness} = k_1 \times (V_{INPUT}/V_{MAX})^{\gamma}$$

where γ =2.2, k_1 is a variable representing a gray level of said video signal, V_{INPUT} is an input voltage, and V_{MAX} is a maximum voltage for showing said maximum gray level of said video signal.

3. The process of claim 2, wherein said second gamma value is smaller than 2.2.

4. The process of claim 2, wherein said first gamma value is equal to 2.2.

5. The process of claim 2, wherein said third gamma value is larger than 2.2.

6. The process of claim 1, wherein in the steps of performing said gamma compensations, each respective one of said first, second, and third gamma compensations is performed.

Patentansprüche

1. Verfahren zum Bewirken einer Gammakompensation des Videosignals eines Eingabebildes, das auf einem Plasmabildschirm angezeigt werden soll, wobei das Verfahren die Schritte umfasst:

   Trennen der Bandbreite an Graustufen in dem Videosignal in Drei Segmente, wobei das erste Segment Graustufen abdeckt, die von einer ersten Graustufe bis zu einer zweiten Graustufe reichen, die größer ist als die erste Graustufe, wobei das zweite Segment Graustufen abdeckt, die bis zu der ersten Graustufe reichen, und wobei das dritte Segment Graustufen oberhalb der zweiten Graustufe abdeckt;
   Durchführen einer ersten Gammakompensation an dem Videosignal für Graustufen innerhalb des ersten Segments mit Bezug auf einen ersten Gammawert;
   Durchführen einer zweiten Gammakompensation an dem Videosignal für Graustufen innerhalb des zweiten Segments mit Bezug auf einen zweiten Gammawert, der kleiner ist als der erste Gammawert; und
   Durchführen einer dritten Gammakompensation an dem Videosignal für Graustufen innerhalb des dritten Segments mit Bezug auf einen dritten Gammawert, wobei das Verfahren **dadurch gekennzeichnet ist, dass** der dritte Gammawert größer ist als der erste Gammawert.

2. Verfahren gemäß Anspruch 1, wobei die erste Gammakompensation an dem Videosignal durchgeführt wurde, das von dem PDP, gemäß der folgenden Gleichung empfangen wurde:

$$\text{Helligkeit} = k_1 \text{ x } (V_{INPUT}/V_{MAX})^{\gamma}$$

   wobei γ=2,2 ist, k_1 eine Variable ist, die eine Graustufe des Videosignals repräsentiert, V_{INPUT} eine Eingabespannung ist und V_{MAX} eine Maximalspannung ist, um die maximale Graustufe des Videosignals zu zeigen.

3. Verfahren gemäß Anspruch 2, wobei der zweite Gammawert kleiner als 2,2 ist.

4. Verfahren gemäß Anspruch 2, wobei der erste Gammawert gleich 2,2 ist.

5. Verfahren gemäß Anspruch 2, wobei der dritte Gammawert größer als 2,2 ist.

6. Verfahren gemäß Anspruch 1, wobei in den Schritten des Durchführens der Gammakompensationen jede der ersten, zweiten und dritten Gammakompensation durchgeführt wird.

Revendications

1. Procédé d'exécution d'une compensation gamma sur le signal vidéo d'une image d'entrée à afficher sur un panneau d'affichage plasma, ledit procédé comprenant les étapes de :

   la division de la plage de niveaux de gris dans ledit signal vidéo en trois segments, le premier segment couvrant des niveaux de gris d'un premier niveau de gris jusqu'à un deuxième niveau de gris supérieur au dit premier niveau de gris, le deuxième segment couvrant des niveaux de gris jusqu'au dit premier niveau de gris, et ledit troisième segment couvrant des niveaux de gris au-dessus dudit deuxième niveau de gris ;
   l'exécution d'une première compensation gamma sur ledit signal vidéo pour des niveaux de gris à l'intérieur dudit premier segment par rapport à une première valeur gamma ;
   l'exécution d'une deuxième compensation gamma sur ledit signal vidéo pour des niveaux de gris à l'intérieur dudit deuxième segment par rapport à une deuxième valeur gamma inférieure à ladite première valeur gamma ;
   et l'exécution d'une troisième compensation gamma sur ledit signal vidéo pour des niveaux de gris à l'intérieur dudit troisième segment par rapport à une troisième valeur gamma, le procédé étant **caractérisé en ce que** ladite troisième valeur gamma est supérieure à ladite première valeur gamma.

2. Procédé selon la revendication 1, dans lequel ladite première compensation gamma est exécutée sur ledit signal vidéo reçu par ledit PDP selon l'équation suivante :

$$\text{luminosité} = k_1 \times (V_{INPUT}/V_{MAX})^{\gamma}$$

où γ = 2,2, k_1 est une variable représentant un niveau de gris dudit signal vidéo, V_{INPUT} est une tension d'entrée, et V_{MAX} est une tension maximale pour représenter ledit niveau de gris maximal dudit signal vidéo.

3. Procédé selon la revendication 2, dans lequel ladite deuxième valeur gamma est inférieure à 2,2.

4. Procédé selon la revendication 2, dans lequel ladite première valeur gamma est égale à 2,2.

5. Procédé selon la revendication 2, dans lequel ladite troisième valeur gamma est supérieure à 2,2.

6. Procédé selon la revendication 1, dans lequel, aux étapes d'exécution desdites compensations gamma, chacune respective desdites première, deuxième et troisième compensations gamma est exécutée.

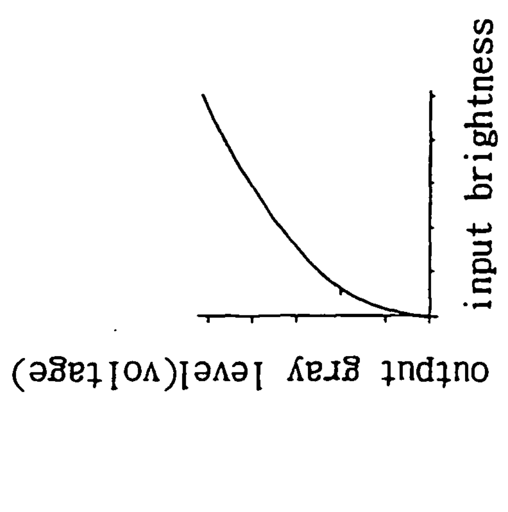

FIG. 1a (Prior Art)

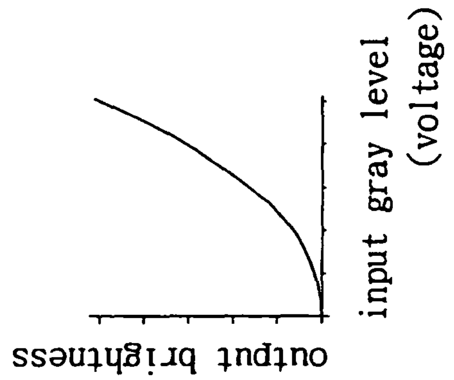

FIG. 1b (Prior Art)

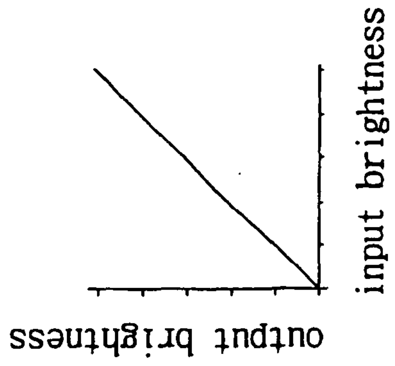

FIG. 1c (Prior Art)

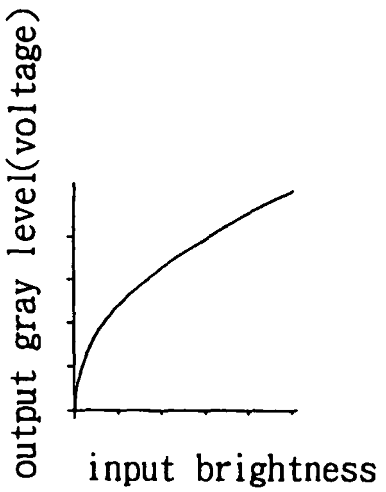

FIG. 2a
(Prior Art)

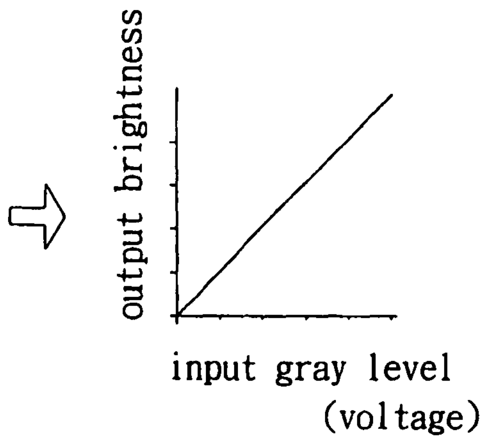

FIG. 2b
(Prior Art)

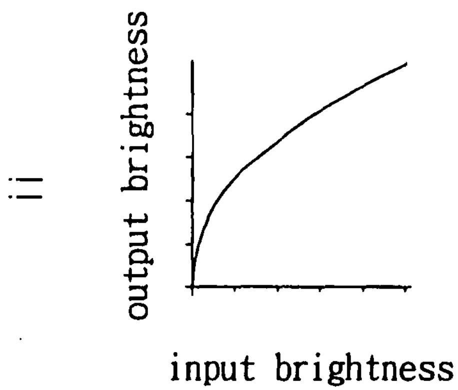

FIG. 2c
(Prior Art)

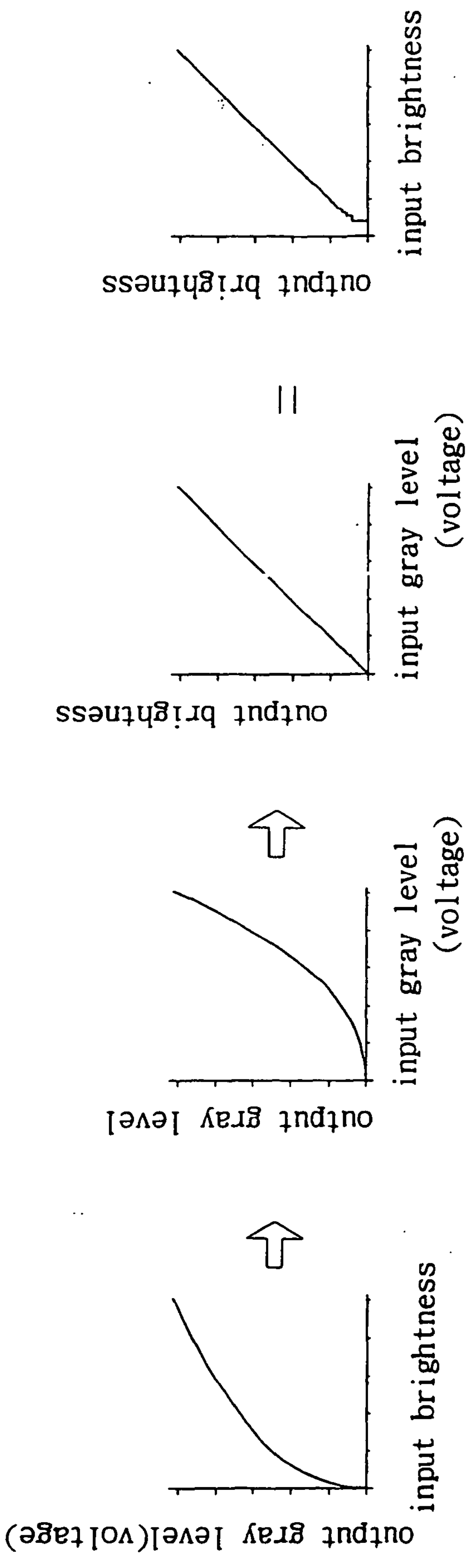

FIG. 3a (Prior Art)

FIG. 3b (Prior Art)

FIG. 3c (Prior Art)

FIG. 3d (Prior Art)

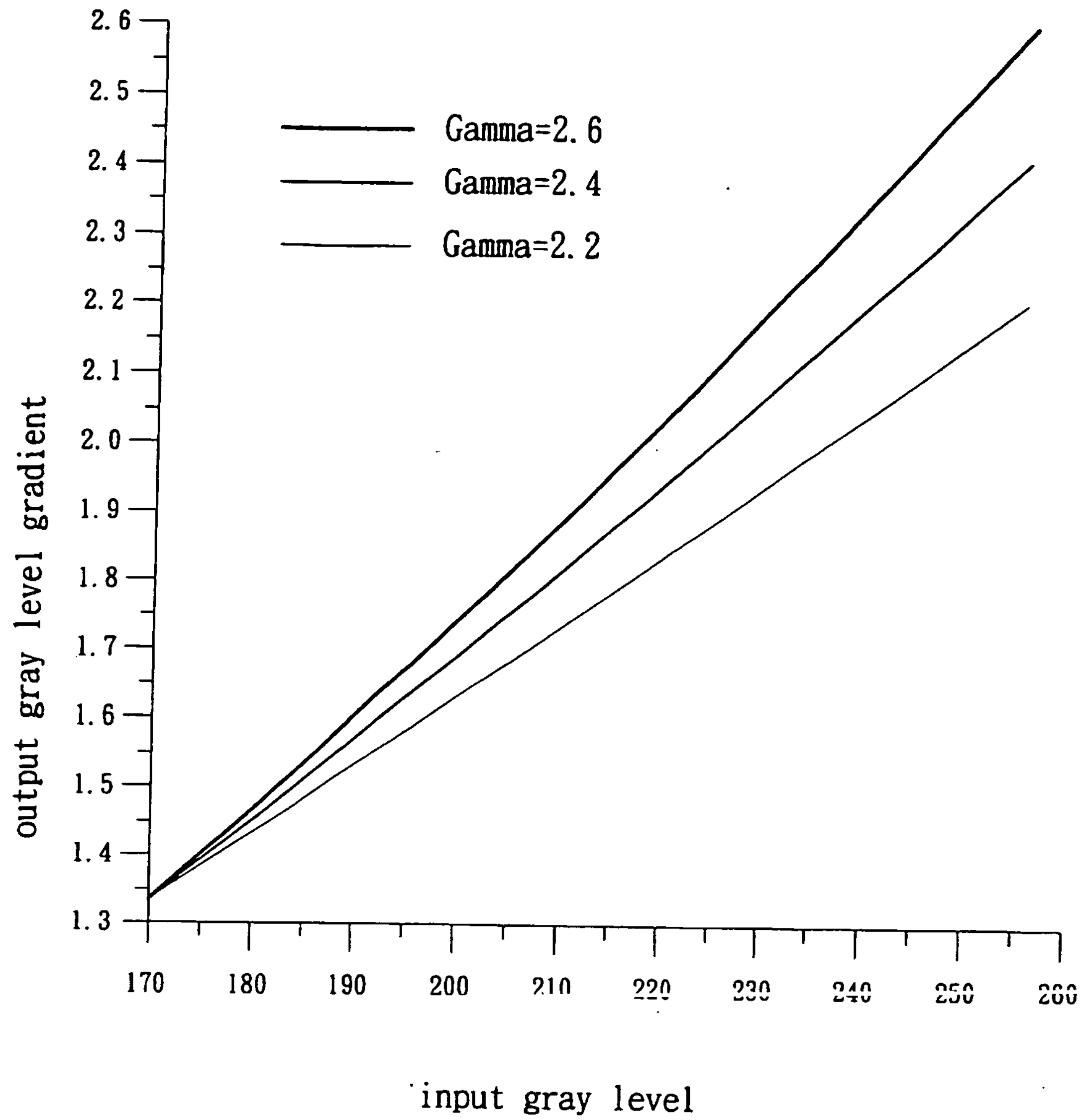
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
output gray level gradient
Gamma=2.6
Gamma=2.4
Gamma=2.2
170
180
190
200
210
220
230
240
250
260
input gray level

FIG. 4

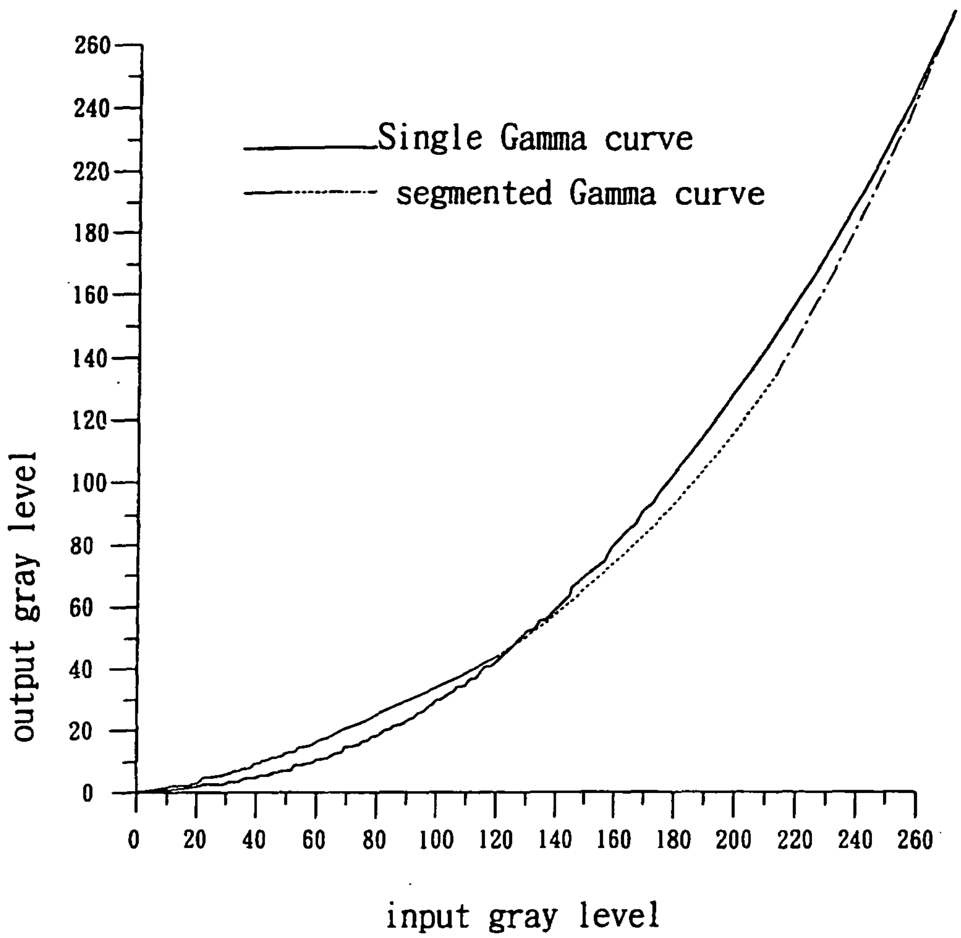
Single Gamma curve
segmented Gamma curve
output gray level
input gray level
0
20
40
60
80
100
120
140
160
180
220
240
260
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 5

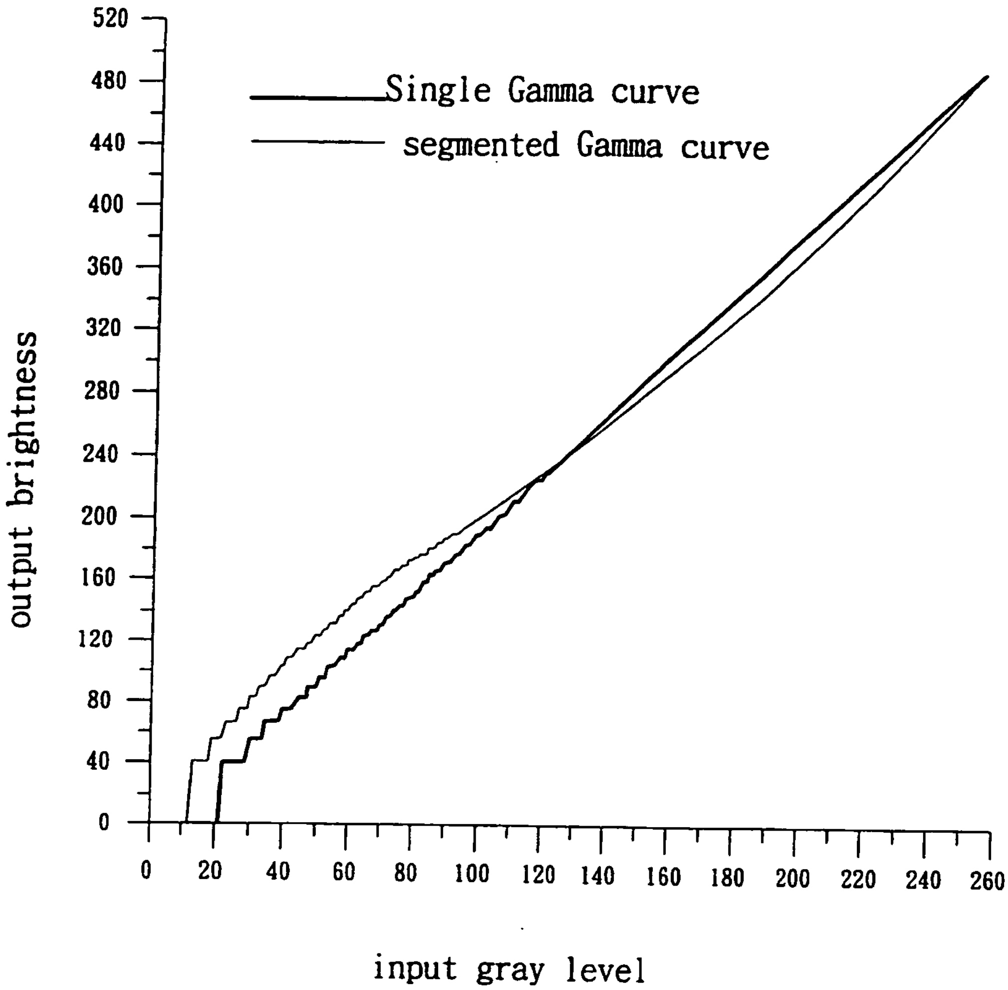
Single Gamma curve
segmented Gamma curve
output brightness
input gray level
0
40
80
120
160
200
240
280
320
360
400
440
480
520
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6311394 A **[0008]**
- JP 8317250 A **[0009]**