# DYNAMIC RETARDATION OF THE RATE OF IMAGE RETENTION IN LIGHT-EMISSIVE DISPLAY MONITORS

by

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## ABSTRACT

A system for reducing or preventing burn-in of static images in an emissive optical display includes a display monitor, an executive circuit, a memory, a timer, and an interface circuit. This system prevents differential aging between static image areas and non-static image areas on a display screen. It is especially useful for plasma and organic light-emitting diode displays. A memory at a given excitation level for longer than a predetermined time, the executive circuit causes that pixel's excitation level to either become equal to the average or moving average of all pixels in the display, or to become equal to a value representative of a neighboring, non-static pixel. The result is a substantially equal average rate of aging for all pixels in the display.

## BACKGROUND

This concept relates to video display monitors, and in particular to monitors using light generating means which degrade with use, such as plasma and organic light-emitting diode displays, and the like.

### Cathode-Ray Tube Displays

In the past, cathode ray picture tubes (CRTs) were well known to suffer from image retention of unchanging or "static" images. This is due to aging of the internal phosphor coating as it is repeatedly struck by the electron beam sweeping in a raster fashion across the screen. For example, computer games with non-moving portions of images have tended to cause "aging", "wear", "ghosting" or "etching" of the static portion of the image in the screen. When different images are subsequently viewed on an etched screen, ghosting from previous images is seen along with the desired images. Damage to such screens is generally permanent and it substantially reduces the quality of other video material such as moving pictures.

## Plasma Video Displays—Figs. 1 and 2

Plasma video displays in wide use today suffer from the same deficiency as older CRTs. A static image, i.e. one of unchanging color and intensity, that remains on the display screen for only a period of hours can permanently damage such a display by aging light and dark picture elements (pixels) at different rates. Static images left for shorter times exhibit transient ghosting and are also annoying.

Typical static images are shown in Figs. 1 and 2 below. They can include part or all of the screen. These are also called “inactive” image areas. The remainder of the screen comprises pixels that change rapidly enough to avoid damage to the screen. These non-static image areas are also called “active” image areas.

In Fig. 1, a display screen 100 is shown within the broken lines. Screen 100 typically mounts on a wall (not shown) or stands on a pedestal (not shown). An image area or raster 105 fills less than all of screen 100. Blank regions or bands 110 on either side of image 105 are typically maintained at a black or dark grey level of illumination. Screen 100 can have this appearance with both live television and recorded images.

Pixels in image areas 110 are generally not activated, and therefore emit no light. These unused pixels exhibit no aging. Pixels in region 105 emit light and therefore age with time. When a full-screen image is later displayed, pixels in areas 110 are perceptibly brighter for the same level of excitation when compared with pixels in area 105. The result is that the center part of the image is generally dimmer than that in outer bands 110.

Fig. 2 shows a display 200 with a full-screen, moving image 205, and a commercial logo mark 210. Mark 210 is generally displayed in television images. In this example, mark 210 comprises letters within a circle, and typically appears as a static image in white or bold colors. In some cases, it appears translucent. If mark 210 is left on screen 200 for a period of minutes to hours, pixels in this region will age faster on average than those in the remainder of screen 200. Thus when mark 210 is removed, as would occur when changing television channels, pixels at the location of mark 210 will be slightly darker than those in the remainder of screen 200. As a result a ghost of mark 210 is left on screen 200.

If allowed to remain for long periods of time, static image areas such as 110 and 210 can permanently damage an emissive display.

Plasma video displays utilize minute electrical discharges in a gas to create light of ultraviolet wavelengths, which in turn excites red, green, and blue phosphors. All phosphors exhibit a decrease in light output with use. Over time, at equal excitation, the phosphors in the more-used pixels emit less light than those in the less-used pixels. Thus pixels in a portion of the screen which is generally dark will exhibit less aging than pixels in a region of the screen which is generally light. Ghosting, or a difference in brightness, becomes visible when a new image is displayed over a previously burned-in area.

## Repair and Damage Avoidance

Various means are used to reduce the damage caused by static images. Operating the screen with a gray or white image for a period of time ages all pixels at the same rate. This averages the degradation due to ghost images and makes them less visible. These procedures partially repair damage caused by static images.

Another well-known technique is used in an attempt to avoid damage before it occurs. The image is slowly moved around on the screen, resulting in more equal usage, and therefore more equal aging, of pixels in the region where the motion occurs.

While the above repair and damage-avoidance methods reduce screen damage due to static images, neither is able to cause all pixels in the screen to age at or near the same rate. Thus neither method is fully effective in preventing or eliminating burn-in.

## Other Emissive Display Technologies

Other light-emissive display technologies suffer from the same problem as CRTs and plasma displays. For example, both crystalline and organic light-emitting diodes experience a reduction in light output over time. Displays using them are thus subject to uneven output caused by ghosting.

Accordingly, one object of the present system is to greatly reduce or eliminate differential aging of pixels in light-emissive display screens, including plasma, and crystalline and organic light-emitting diodes, among others. Other objects are to provide a system and method which can be applied to any light-emissive display, which is inexpensive, easily mass-produced, and can be supplied either as a retrofit to existing displays or incorporated into new display panels.

An image analysis and adjustment system is provided which analyzes video images on a real-time basis. The system acts as a filter which adjusts the performance of individual pixels in static image areas in a way which reduces or eliminates image burn-in by ensuring that all pixels age at about the same rate.

## FIGURES

Fig. 1 shows a prior-art light-emissive display screen partially filled with an image.

Fig. 2 shows a prior-art light-emissive display screen with a logo mark.

Fig. 3 is a block diagram of a generalized, prior-art display system.

Fig. 4 is a block diagram showing the monitor section of Fig. 3.

Fig. 5 is a block diagram showing operation of one part a preferred embodiment of the present system.

Fig. 6 is a detailed view of the system of Fig. 5.

Fig. 7 is a flow chart showing operation of the system of Fig. 5.

Fig. 8 is a logo.

## BACKGROUND—The Prior Art—Figs. 3 and 4

Numerous video formats are in use today. Most of these fall into two main types: interlaced scan video and progressive scan video. The well-known interlaced video format displays alternate fields, each containing half the lines (i.e. every other line) in an image. Two alternate fields comprise a full video frame. In the U.S., a full interlaced video frame is displayed in 1/30 second. In many places outside the U.S., a full interlaced video frame is displayed in 1/25 second.

The progressive video format displays all scan lines sequentially in one frame time. In the U.S., a full progressive video frame is displayed in 1/30 or 1/60 second. In many places outside the U.S., a full progressive frame is displayed in 1/25 or 1/50 second. Many modern high-definition television sets and DVD players use progressive video scanning.

The block diagram of Fig. 3 shows a generalized hardware arrangement capable of displaying either video format. Although the discussion below focuses primarily on the video component of the programming, inclusion of an audio signal is assumed, even if that audio signal is zero.

A monitor assembly 300, indicated by dashed lines, is designed to accept and display images represented by digital signals. Monitor 300 presents audio and video information to an audience (not shown) at block 330. The signals applied to monitor 300 are supplied by a digital signal source 305, or by an analog signal source 310 in conjunction with a digital encoder 315. Switch 320 permits selection of the source for monitor 300. Switch 320 is merely symbolic. Instead of switch 320, electronic switches of various types and even connector assemblies are often used.

Analog audio-visual signal sources exemplified by block 310 are well-known. They include the demodulated output of television tuners, analog VCR and DVD outputs, and the like. Their output formats include S-Video, analog RGB, and composite video, among others.

The digital signals presented to monitor 300 are known by the various designations indicated, i.e. 1080i, 1080p, 720p, 480p, 480i, and so forth. Definitions of these terms are contained in standards published by the Society of Motion Picture and Television Engineers (SMPTE), of White Plains NY 10607, USA, the Advanced Television Systems Committee (ATSC) of Washington DC 20006, USA, and others. The designations indicate the vertical resolution of video information, i.e. 480 vertical lines, etc. They also indicate whether the video information comprises interlaced or progressive scans of the video image, as noted by “p” or “i”. The standards further include the image aspect ratio, audio signal definitions, whether the video data depth is 8 or 10 bits, etc.

The digital signals represent streaming rasterized video and audio. The streaming data are broken into linear sequences of known length. This is done using coding representative of the start and end of a line. A full frame image comprises predetermined numbers of visible image lines and not-normally-visible “overhead” lines. Overhead lines contain data of various kinds in support of the present programming. For example, the 720p protocol includes 720 lines of image data and 30 overhead lines, for a total of 750 lines per frame.

Image lines contain image data for each individually illuminated pixel in a row. Each scan line in the image is preceded by a “Start of Active Video” (SAV) binary code, and followed by an “End of Active Video” (EAV) code. After SAV, a predetermined number of samples follows, with each sample containing image data for one pixel. The 720p protocol includes 1280 RGB samples per active line. After EAV and before the next SAV, each line further includes additional overhead data.

The image data associated with each line contain either 8 or 10 bit representations of color and intensity for each pixel. Color and intensity values are typically coded as Red, Green, and Blue values (R,G,B), or Y, $C_B$, $C_R$ luminance and chrominance values. These values are mapped into new, related values by a well-known gamma correction function. The gamma correction corrects color and intensity differences introduced by monitor 300. After gamma correction, the image seen by the viewer is nearly the same as the original transmitted or recorded image.

Audio-video presentation block 330 comprises the visible screen 200 (Fig. 2), loudspeakers (not shown), and their associated drivers (not shown). The drivers include semiconductor memory (not shown) and circuitry that actuates the loudspeakers and individual pixels on the screen.

For purposes of the present discussion, the use of R, G, and B values will be assumed, although the Y, $C_B$, $C_R$ values could be used as well.

In Fig. 4, a video signal of one of the types discussed containing all image information is delivered to an interface circuit 325′. Circuit 325′ decomposes the video signal into its component parts. A signal representative of information about the red components, including location and intensity for each red pixel on the display screen, is delivered to a red memory array or “plane” 410. Similarly green information is delivered to green memory plane 411, and blue to blue memory plane 412. Planes 410, 411, and 412 are simply locations in a semiconductor memory which can store a full field of image information for all pixels of one of the three component colors—red, green, and blue (R, G, and B). Alternatively, other circuitry such as output driver latches can be substituted for memory planes 410, 411, and 412, in well-known fashion.

A memory location for each pixel relays the intensity value of that pixel to a pixel driver for that pixel location. Red, green, and blue pixel drivers are identified by reference numerals 415, 416, and 417, respectively. The intensity of each pixel is generally represented by an 8- or 10-bit, binary number.

A viewing screen (100 in Fig. 1, or 200 in Fig. 2) contains an array of light-generating pixels of three types (420, 421, and 422) that are arranged to emit the three respective colors R, G, and B).

Each driver (415, 416, 417) applies a voltage, proportional to the above binary number, to its related pixels (420, 421, 422) on the viewing screen at the proper time to reproduce the originally transmitted image, in well-known fashion. I.e., each pixel emits a predetermined level of red, green, or blue light (425, 426, 427) according to its placement on the display screen. The original image is thus reproduced.

### The PlasmaGuardian—Description—Figs. 5 and 6

Display screens operate in a variety of ambient lighting conditions. In a brightly lit room, a manual adjustment or an automatic sensor causes the display screen to operate at a relatively high light intensity. In a dimly lit room, the same adjustment or sensor will cause the screen to operate at a relatively low light intensity. The average image intensity is not known a-priori; therefore it must be taken into account, as explained below. Similarly, the gamma correction has different values for each color (R, G, B) and for each screen. This is also taken into account, as explained below.

The preferred embodiment incorporates at least three principal functions. A first function evaluates the average or moving average intensity of each color plane of the image being displayed. This average can be taken over smaller or larger areas of the screen, and shorter or longer periods, as required.

A second function determines the period of time, or interval, over which any one pixel is emitting at a constant output level, from near zero to full output intensity.

A third function determines which pixels are static and adjusts their intensity to the previously-calculated average or moving average value for all pixels.

One implementation of circuitry which satisfies the above requirements is shown in Figs. 5 and 6. In order to simplify the present discussion, only the red channel is discussed here, however the R, G, and B channels all operate in the same fashion.

A red executive circuit, block 500, receives its input from signal interface circuit 325′, described above. The red executive circuit is preferably a microprocessor, application-specific integrated circuit, field-programmable gate array or other circuit capable of performing calculations, storing and retrieving information, and having timing capability. Red executive memory 505 stores values received from executive 500 and provides timing information to executive 500 on demand. Executive 500 presents red intensity values to red memory plane 410 through its output connection 510. Executive 500 receives all synchronization signals, i.e. vertical synchronization, horizontal timing, etc., required for its operation from interface circuit 325′ (Fig. 4).

Fig. 6 is similar to Fig. 5, except for detail shown within each functional block. Memory 505 has locations, A1…MN, corresponding to memory locations A1…MN in red memory plane 410. These same locations correspond to drivers for pixels A1…MN in red drivers block 415, and to actual pixel locations A1…MN in red pixels block 420. Pixel locations A are all on the first, upper, line of image 100 (Fig. 1). They progress from left to right and are numbered sequentially, i.e. A1, A2, …AN. Lines are numbered sequentially from top to bottom, i.e. A…M. N and M are the numbers of the last pixels in the horizontal rows and vertical columns and thus are also the resolutions of the image, respectively. E.g., pixel D240 is the 240$^{th}$ pixel across in the fourth row down. Pixel MN is the last pixel in the bottom row.

Executive memory 505 has an additional memory location associated with each pixel. This location, identified in Fig. 6 as TA1, …TMN, stores timing information. The values in TA1, …TMN are incremented once each frame, for example. Alternatively they may be incremented less frequently, if required.

Memory locations X1, …XN in executive memory 505 are auxiliary storage locations. They are used for storing the results of calculations, as described below.

In an 8-bit video system with 1280 x 720 pixels, the size of memory 505 is approximately 2 megabytes. In a 10-bit system, the size of memory 505 is about 3 megabytes. In a 720p system, with 1280 x 720 pixels horizontally and vertically, respectively, there are 30 lines devoted to “overhead” time. Thus, with a 60 Hz frame rate, the time available for calculation of averages during overhead is 666 microseconds. Various schemes, such as calculating averages every other frame, can reduce the computing power required for calculations.

**The PlasmaGuardian—Operation—Figs. 5-7**

Executive circuit 500 receives the video signal from block 325′ (Fig. 4). Executive 500 notes the present value of red intensity and the present time for each red pixel. As each pixel’s information becomes available from interface circuit 325′, executive 500 saves this value at the equivalent location in its associated executive memory 505. The time at which each pixel’s data is saved is also noted and saved as T1…TMN.

When time is available, usually during “overhead” lines between image data, executive 500 reads the image data value at each location in memory, sums these, and calculates the average intensity of all the red (R) locations in the frame. The average intensity value is stored in auxiliary memory location X1. The average can be either the average of each frame intensity, or it can be a moving average over more than one frame. The moving average is preferable, for reasons that will be explained below.

With each new image frame, executive 500 compares the incoming data for each pixel with the data previously stored in memory, for example $A1_{NEW}$ and $A1_{OLD}$. If the two values are equal, or are equal to within a predetermined error, the value in TA1 is checked. Allowing for a predetermined amount of error reduces the sensitivity of the present system to noise. Intensity values which vary by two or three bits, for example, can be assumed to be equal for purposes of the calculations described here.

Non-static image case: If the time value in TA1 is less than a predetermined time, say one minute, executive 500 passes $A1_{NEW}$ along to R memory plane 410 unchanged.

Static image case: If the time value in TA1 is greater than or equal to the predetermined time, executive 500 modifies the value $A1_{NEW}$ before passing it on to R memory plane 410. $A1_{NEW}$ is suddenly, or gradually over the period of a predetermined number of frames, made equal to the moving average calculated above. $A1_{NEW}$, as modified, is then passed along to R memory plane 410. The value of $A1_{OLD}$ in memory 505 remains unchanged in this case. Whether this change is sudden or gradual is optional. A gradual change, the moving average, is less noticeable, and hence potentially less irritating to viewers.

Non-static image following static image case: If the values of $A1_{NEW}$ and $A1_{OLD}$ differ by more than a predetermined error, the image component at pixel A1 is no longer static. In this case, $A1_{NEW}$ is passed via output 510 to memory 410, The value of $A1_{OLD}$ in location A1 of memory 505 is set equal to the new $A1_{NEW}$ value, and the time value in TA1 is reset to zero.

The results of these operations are:

(1) A static R pixel retains its original value for a predetermined period of time, one minute in the present example.

(2) After one minute has elapsed, the R pixel gradually assumes an intensity value that is equal to the moving average of intensity in the R image plane. This pixel tracks the average intensity in the R image plane until a new and different intensity value, greater than a predetermined error amount, is received from interface circuit 325′.

(3) When a different new value is received, the pixel immediately reverts to non-static status and assumes the current video intensity value.

This process is duplicated in the G and B image planes. The entire process is repeated with each new video frame.

When this process is extended to all three color planes, the result is a "graying" of static image areas, with these areas assuming the average intensity of the entire screen. Thus the color in the "gray" areas assumes the moving average of all colors in the screen. This is not particularly distracting to the viewer.

This process ensures that all pixels in the screen age at very nearly the same rate, i.e. pixels in static image areas age at a rate commensurate with pixels in active image areas. Ghosting due to static image areas is thus prevented.

## Flowchart

Fig. 7 is a flowchart that depicts logic operation, representative of firmware, in one of the color planes. Simultaneous and identical operation of all three planes is assumed.

A startup procedure (blocks 700-720) commences when monitor 300 (Fig. 3) is first activated (block 700). An initial frame is presented to block 330 (Fig. 3) and executive (Figs. 5 and 6) 500 passes all pixel values to memory plane 410 (Fig. 7, block 705). Executive 500 also stores all pixel intensity values in memory 505 (block 710), and resets all pixel timers (block 715). The average intensity value and the average count, representative of the number of pixels included in the average intensity, stored in memory 505 are reset to zero (block 720). The values in plane 410 are passed to pixel drivers 415, and finally appear as pixels 420, as described above. This concludes the initialization procedure. It is not normally repeated until the next time monitor 300 is newly activated.

The following procedure continues indefinitely until monitor 300 is deactivated. It is preferably repeated by executive 500 for each new frame. (Alternatively, it can be repeated for every second, tenth, hundredth, etc. frame.) Executive 500 waits to detect SAV (described above in connection with Figs. 3 and 4) (block 725).

Pixels are numbered from top-to-bottom and left-to-right, as described above. In a 1280 x 720 screen, there are 921,600 active imaging pixels. Executive 500 is arranged to count only active image pixels, not overhead data locations.

Upon detection of SAV, executive 500 compares the new and old pixel intensity values for the current pixel (blocks 730 and 735). If the new intensity value is not equal to the old value, the current pixel is not displaying a static image component. Executive 500 resets the current pixel timer (block 740). If the current pixel is not the last one in the present frame (block 745), executive 500 then increments the pixel count (block750) and returns to block 730 to continue evaluating pixel conditions.

If the current pixel is the last one in the current frame, executive 500 resets the pixel count (760) and waits for the next SAV (block 725).

If, on the other hand, the current (new) pixel intensity value is equal to the old value (block 735), executive 500 increments the current pixel timer (block 765). Executive 500 then checks to see if the value of the current pixel timer is greater than the predetermined time threshold allowed for static images (block 770). If this is not the case, executive 500 adds the current intensity value to a register in memory 505 used for accumulating intensities for later calculation of the average intensity (block 775). It also increments the count of active pixels which will be used in calculating the active intensity average. These data are stored in the previously mentioned "X" registers in memory 505. Logic flow then proceeds to block 745, as above.

If the value of the current pixel timer is greater than or equal to the predetermined time threshold allowed for static images, this pixel's intensity is static. Executive 500 then sets the value of $R_{NEW}$ for this pixel to the screen average value, or to the moving average of the screen average value (block 780). Then the pixel count is incremented by one (block 790) and the next pixel is processed (block 730).

### Gradual Intensity Change of Static Pixels—Alternative Method

Instead of using a moving average to change the intensity of the static pixels gradually, the following formula can be used. Static areas are made gray by replacing their $R_{NEW}$ values by an $R_{NEW}$ value according to the following formula. t represents the present time. $t_{initial}$ is the time at which the present pixel was determined to be static.

$$R_{NEW,\ Modified} = [(t - t_{initial})(R_{NEW\ FINAL} - R_{NEW\ INITIAL})]/t$$

$R_{NEW\ FINAL}$ is the average screen intensity value, and $R_{NEW\ INITIAL}$ is the initial intensity value of the static pixel. The values for the green and blue pixel planes are calculated the same way as for the red plane. Variations on the above equation can be used to cause a faster or slower rate of equilibration of the pixel intensity with the screen average.

## Special Case—Dither Around Average Intensity Values

Instead of setting the intensity of static pixels to the average screen intensity value for each color, the intensity of static pixels can be dithered around the average value. This produces a scintillating effect in static image areas which may be more pleasing than the exact moving average value. For example, if the average screen value of red excitation is 200, then the value of $R_{NEW}$ is set to 205 for a first frame, then 195 for a second frame, and so forth. The deviation from the average value can be predetermined, or be determined randomly by executive 500. Similarly the deviation in the green and blue planes can be dithered by the same amount, or by randomly determined, differing amounts. The rate of dithering can be once per frame, once per ten frames, or any other suitable rate.

Dithering can be done stepwise in a single frame, i.e. 195 to 205 for an average of 200, or it can be done continuously over a number of frames. If it is done continuously, the dither values can move from 195 through 205 and back again in a sinusoidal or other fashion.

## Special Case—All Pixels Static

In the following special case, all pixels are static to within a predetermined amount of error. (As described above, some error is tolerated to avoid the effects of noise.) Such a situation occurs when a test pattern image (not shown) is presented, for example. Instead of setting all pixels to the present average intensity, it is advantageous to reduce the intensity of all pixels to zero.

When executive 500 determines that most or all pixels are static, it decreases their intensity values to zero or near zero. As above, when any pixel is determined to be active, its timer is reset and the active intensity value is passed through to memory plane 410. In turn, this immediately causes that pixel to be displayed at its original intensity.

In this special case, the display monitor is apparently not in use. When this is true, it is optionally desirable to set the audio component of the programming to zero also. This is done by ancillary circuitry (not shown) that is notified when all three of the red, green, and blue executives (500) blank their respective planes.

In certain cases, a screen saver is appropriate to use when all pixels are static. The operation of a screen saver can be coupled with the operation of the present system. Such a screen saver energizes all pixels at the same average level, however this can be an average over a period of time in order to permit displaying of changing images. In the case of a computer monitor a keystroke or pointing device movement disables the screen saver and returns the monitor to normal operation.

## First Alternative System—Description and Operation—Fig. 8

The prior embodiment works globally to energize the static pixels in a screen to the average or moving average level of the non-static pixels. It is well-suited to protecting large areas from ghosting damage.

The first alternative embodiment works locally to derive excitation levels for static pixels by mapping intensities of proximate pixels into regions of static pixels. This embodiment works best for relatively small static regions such as logo 210 (Fig. 2).

Fig. 8 shows a portion of a screen 800 containing a static logo 805. The portion of screen 800 is 20 x 20 pixels in extent in this example. Pixel rows are labeled A through T. Pixel columns are labeled 1 through 20.

In this embodiment, the following sequence of events occurs. Executive 500 (Fig. 5) senses a first static pixel D8. This sensing is done the same way as described above in connection with the first embodiment. The static RGB intensity values of pixel D8 are $R_{OLD}$, $G_{OLD}$, and $B_{OLD}$. Executive 500 (Fig. 8) then calculates a vector 810 of random length and direction from pixel D8 to a non-static pixel, B6 for example. Non-static pixels are easily recognized. They have zero or reset values in their individual timers within memory 505 (Fig. 6). Executive 500 simply tests for zero or reset values to find non-static pixels. The R, G, and B intensity values of pixel B6 are then mapped into, i.e. replace, the current values $R_{NEW}$, $G_{NEW}$, $B_{NEW}$. The old values are left unchanged until their new counterparts change, as explained above in connection with the first embodiment. Since vector 810 is of random length and direction, it is free to change with each new frame on screen 800. Therefore, a new value, representative of the local screen excitation, will be presented to each static location within logo 805 with each new frame. Alternatively, this value can be changed every other frame, or every tenth, hundredth frame, etc. The length of vector 810 is variable, and predetermined limits can be established for its length and preferred direction.

An alternative to the above random vector provides a non-random vector for selection of a non-static pixel to be mapped into the location of a static pixel. This vector can point to the nearest non-static pixel, the horizontally nearest, the vertically nearest, etc. non-static pixel. Instead of the nearest non-static pixel, the next-nearest can be used. Instead of horizontal or vertical, another predetermined direction can be used. The appearance of logo 905 changes only after the time threshold for ghosting damage.

In some cases logo 905 will disappear if the nearest non-static pixels are used. If dithering is applied to the modified static intensity values, as described above in connection with the preferred embodiment, then logo 905 will change in appearance, but it will not disappear altogether.

Dithering is especially useful in the case of computer monitors. Computer programs such as Windows, sold by Microsoft Corporation of Redmond, WA, USA, employ icons which are typically static. Without dithering, these icons will become “gray” and their text will be unreadable. With dithering, the icons will change appearance after the threshold time for screen damage, but they and their text will still be visible.

## Second Alternative System—Description and Operation

The second alternative embodiment is a combination of the preferred and first alternative embodiments.

Executive 500 (Figs. 5 and 6) evaluates the spatial extent of static areas. For static areas larger than a predetermined size in each of the x-and y-directions, the preferred embodiment is applied, i.e. in each color plane, static pixels assume the average or moving average value of intensity of all pixels in that plane. For static areas smaller than or equal to the predetermined size, the first alternative embodiment is applied, i.e. static pixels assume the intensity values of nearby non-static pixels within each color plane. This action employs the embodiment best suited within all static areas.

## SUMMARY

Thus it is seen that we have provided an improved method for preventing ghosting injury to an emissive display screen which ages with use. The method requires only a minor addition to the memory and circuitry in the display electronics. It acts to prevent damage to the screen, rather than to attempt to repair damage after it occurs.

While the above description contains many specificities, it will be apparent that the PlasmaGuardian is not limited to these and can be practiced with the use of additional hardware and combinations of the various components described. For example, in the event that the parameters chosen for monitor operation do not completely eliminate ghosting, addition of the prior-art methods of exciting all pixels simultaneously can still improve operation of the display.

The system and method described above can be applied at any point in the signal path from the initial image prior to transmission, to the final stage before the pixel drivers. Thus a retrofit can be provided for existing displays by simply interposing the monitor circuitry with its associated software anywhere within the video signal path.

The monitor system described can be used for any type of display and advertising signs, and any type of screen which ages with use—plasma, CRT, organic light-emitting diode, and so forth.

The adjustment of the drive level can be abrupt or gradual. The time for action of the monitor circuitry can be less than or greater than one minute. Other criteria can be used to determine the best sequence of events. For example, the average of drive levels in all pixel planes can be used instead of the average of excitation in a single plane. The average can be determined over a limited region surrounding a given pixel, and so forth.

While the present system employs elements that are well-known to those skilled in the arts of computer software and hardware design, it combines these elements in a novel way which produces a new result not heretofore discovered.

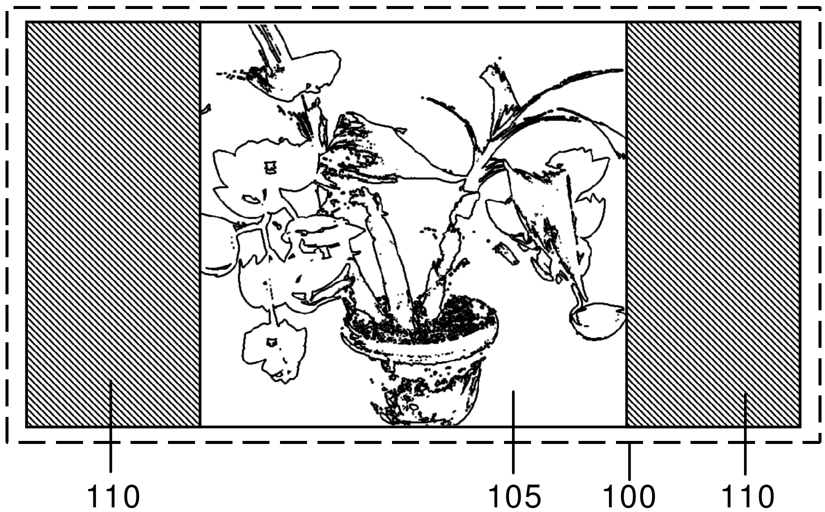



Fig. 1--Prior Art

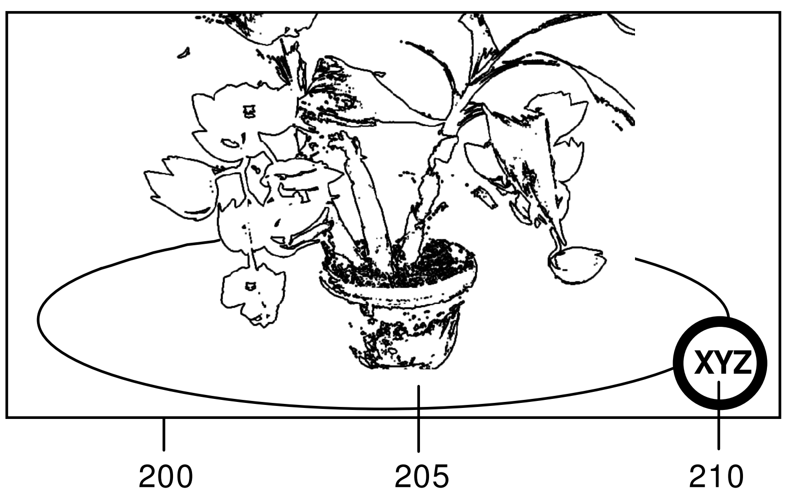



Fig. 2--Prior Art

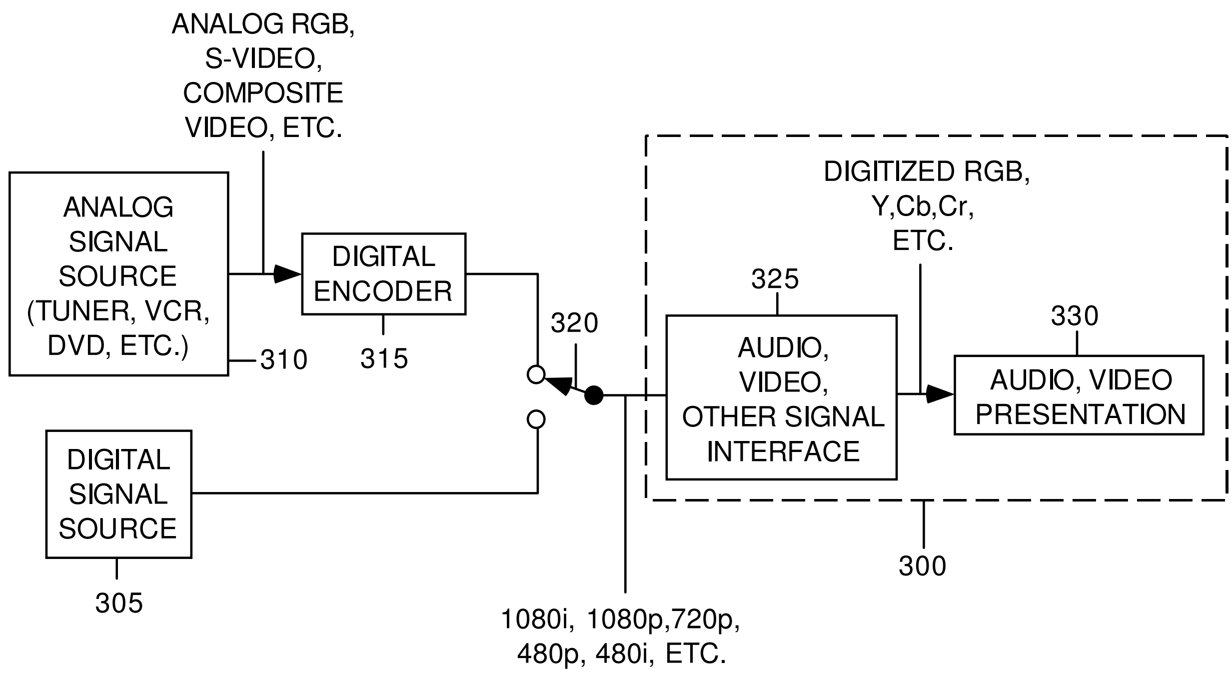



Fig. 3--Prior Art

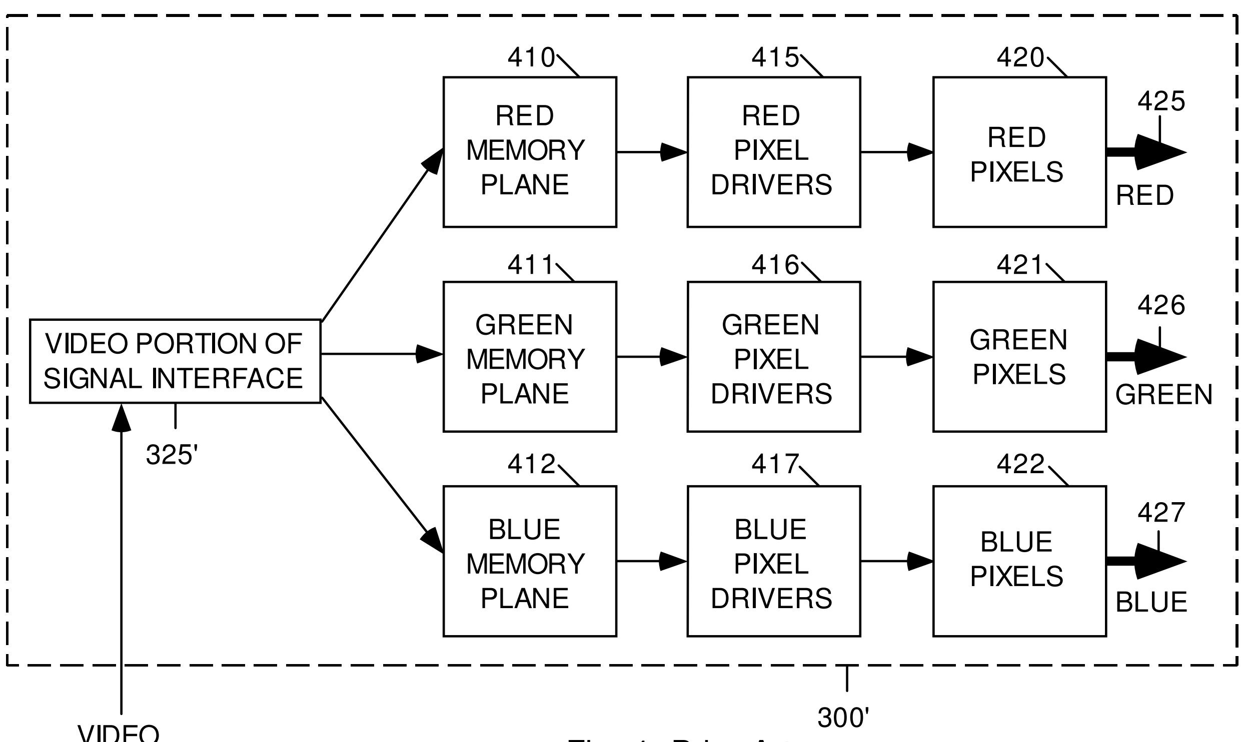
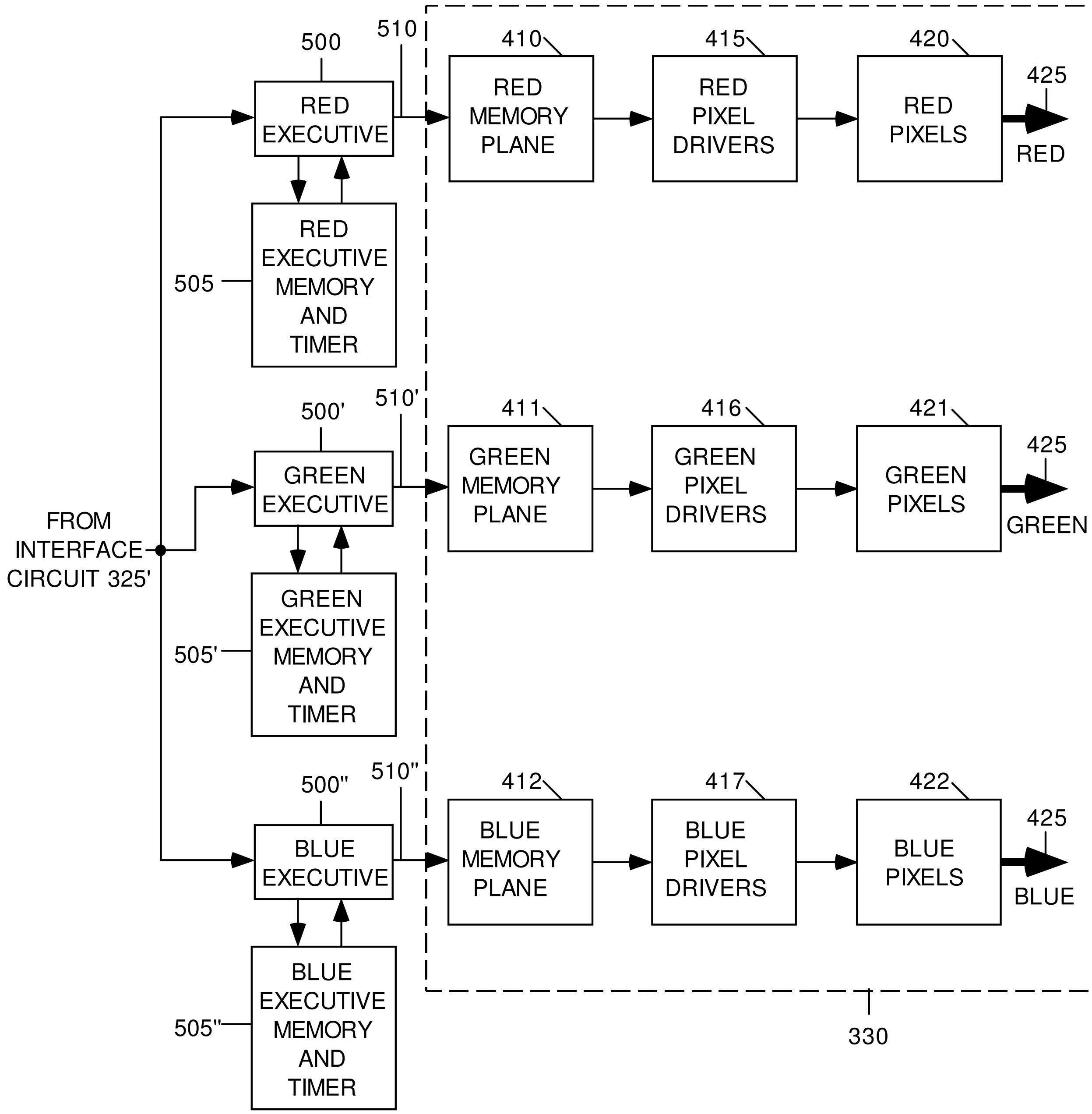



Fig. 4--Prior Art



500
510
410
415
420
RED EXECUTIVE
RED MEMORY PLANE
RED PIXEL DRIVERS
RED PIXELS
425
RED
RED EXECUTIVE MEMORY AND TIMER
505
500'
510'
411
416
421
GREEN EXECUTIVE
GREEN MEMORY PLANE
GREEN PIXEL DRIVERS
GREEN PIXELS
425
GREEN
FROM INTERFACE CIRCUIT 325'
GREEN EXECUTIVE MEMORY AND TIMER
505'
500"
510"
412
417
422
BLUE EXECUTIVE
BLUE MEMORY PLANE
BLUE PIXEL DRIVERS
BLUE PIXELS
425
BLUE
BLUE EXECUTIVE MEMORY AND TIMER
505"
330


Fig. 5

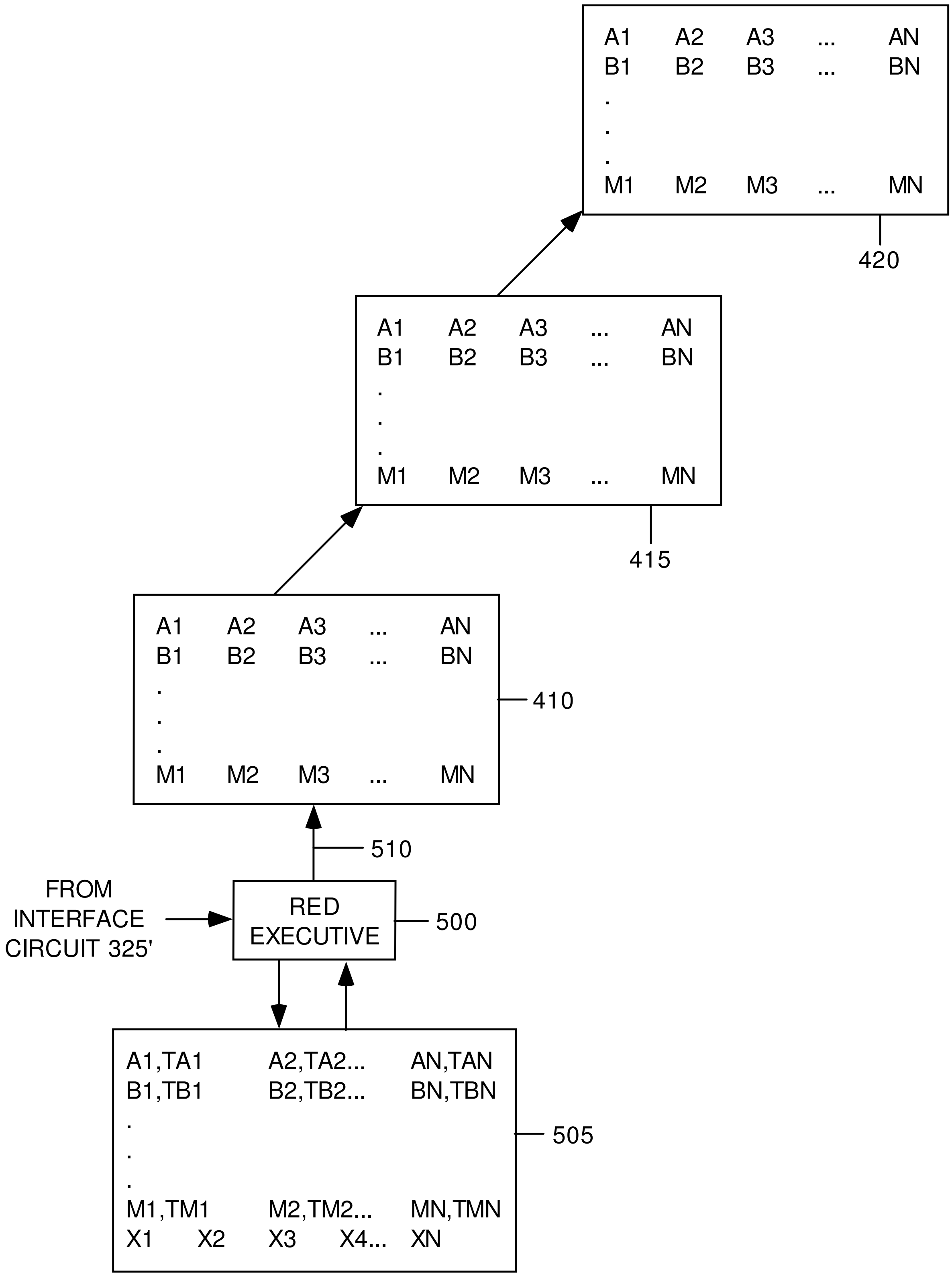

A1 A2 A3 ... AN
B1 B2 B3 ... BN
. . .
M1 M2 M3 ... MN
420
A1 A2 A3 ... AN
B1 B2 B3 ... BN
. . .
M1 M2 M3 ... MN
415
A1 A2 A3 ... AN
B1 B2 B3 ... BN
. . .
M1 M2 M3 ... MN
410
510
FROM INTERFACE CIRCUIT 325'
RED EXECUTIVE
500
A1,TA1 A2,TA2... AN,TAN
B1,TB1 B2,TB2... BN,TBN
. . .
M1,TM1 M2,TM2... MN,TMN
X1 X2 X3 X4... XN
505

Fig. 6

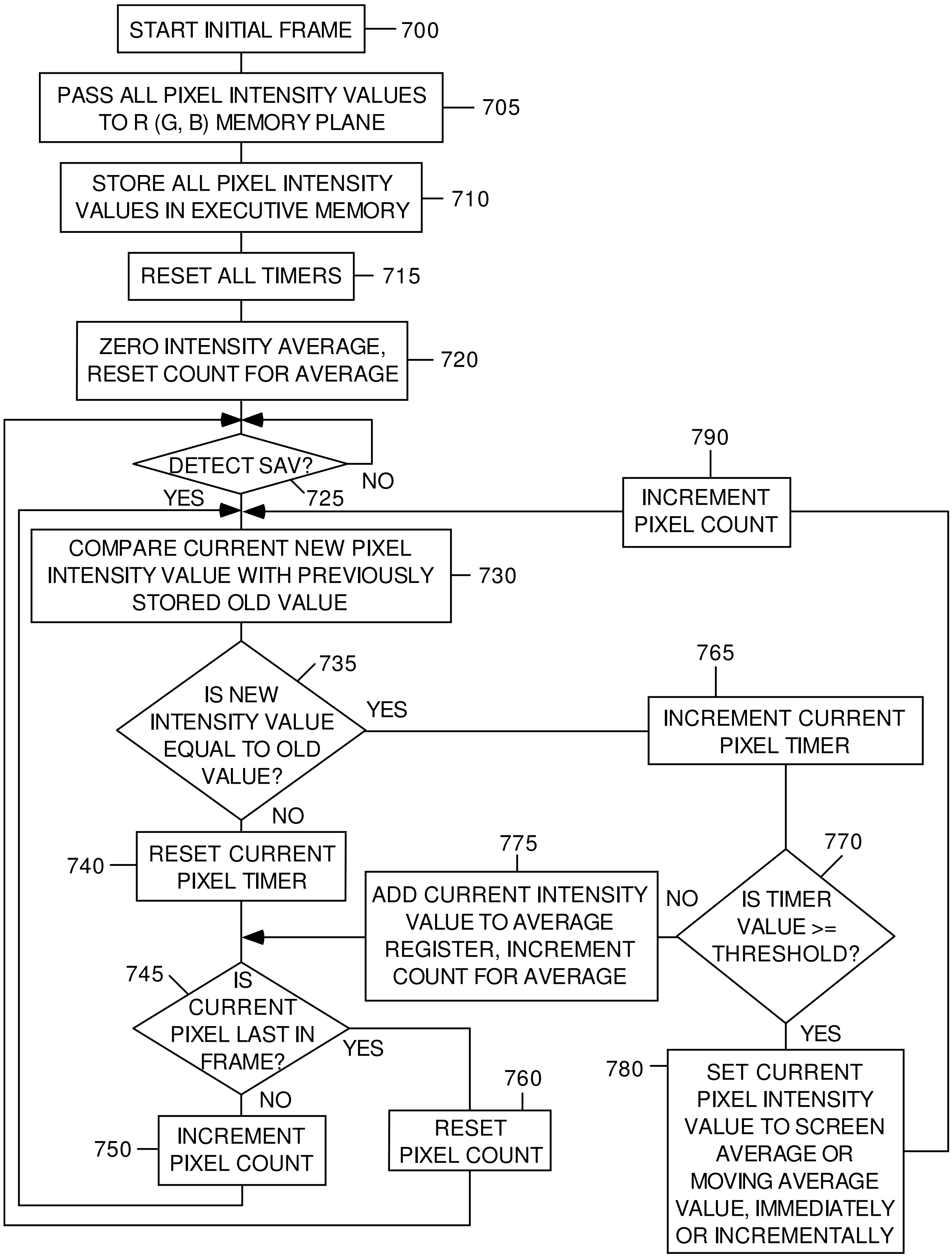

START INITIAL FRAME
700
PASS ALL PIXEL INTENSITY VALUES TO R (G, B) MEMORY PLANE
705
STORE ALL PIXEL INTENSITY VALUES IN EXECUTIVE MEMORY
710
RESET ALL TIMERS
715
ZERO INTENSITY AVERAGE, RESET COUNT FOR AVERAGE
720
DETECT SAV?
NO
YES
725
790
INCREMENT PIXEL COUNT
COMPARE CURRENT NEW PIXEL INTENSITY VALUE WITH PREVIOUSLY STORED OLD VALUE
730
735
IS NEW INTENSITY VALUE EQUAL TO OLD VALUE?
YES
765
INCREMENT CURRENT PIXEL TIMER
NO
740
RESET CURRENT PIXEL TIMER
775
ADD CURRENT INTENSITY VALUE TO AVERAGE REGISTER, INCREMENT COUNT FOR AVERAGE
NO
770
IS TIMER VALUE >= THRESHOLD?
745
IS CURRENT PIXEL LAST IN FRAME?
YES
760
RESET PIXEL COUNT
NO
750
INCREMENT PIXEL COUNT
YES
780
SET CURRENT PIXEL INTENSITY VALUE TO SCREEN AVERAGE OR MOVING AVERAGE VALUE, IMMEDIATELY OR INCREMENTALLY

Fig. 7

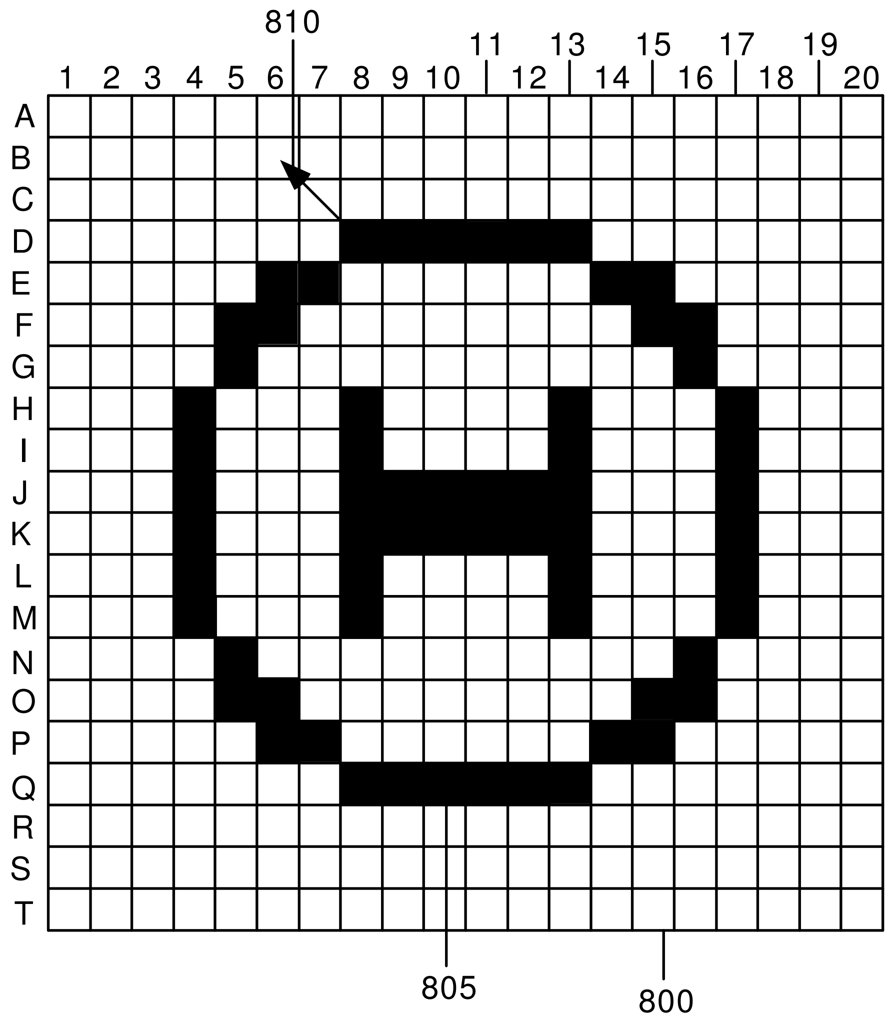

810
11 13 15 17 19
1 2 3 4 5 6 7 8 9 10 12 14 16 18 20
A B C D E F G H I J K L M N O P Q R S T
805
800

Fig. 8