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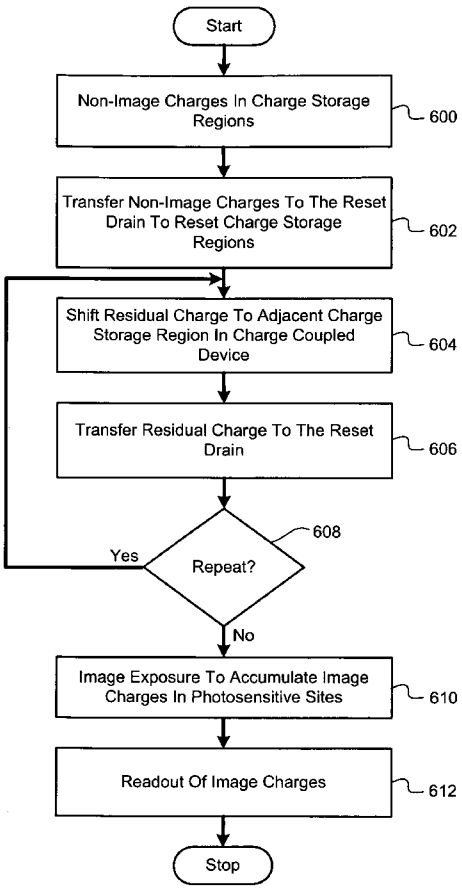

FIG. 6

(57) Abstract: One or more charge storage regions in a charge- coupled device (CCD) shift register can contain residual charge that did not transfer to a reset drain during a reset operation. (602) An image sensor drains the residual charge from each charge storage region by shifting the residual charge to an adjacent charge storage region (604) and resetting the CCD shift register one more time (606). The process of resetting the CCD shift register, shifting the residual non- image charge to an adjacent charge storage region, and resetting the CCD shift register again can be repeated any number of times.

WO 2009/137079 A1

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DRAINING RESIDUAL CHARGE FROM (CCD) SHIFT REGISTERS

TECHNICAL FIELD

The invention relates generally to the field of image sensors, and more particularly to charge-coupled device (CCD) image sensors. Still more particularly, the invention relates to a system and method for draining residual charge from CCD shift registers in image sensors having reset drains.

BACKGROUND OF THE INVENTION

CCD image sensors capture images through photosensitive sites that generate charge in response to the intensity of light striking the photosensitive sites. **FIG. 1** is a top view of a CCD image sensor in accordance with the prior art. Pixel array 100 includes rows and columns of pixels 102. Each pixel includes a photosensitive site (not shown) that generates charge in response to incident light striking the photosensitive site. To read the accumulated charges out of pixel array 100, a vertical CCD shift register (not shown) is either positioned adjacent to, or contained within, each column of photosensitive sites to receive and shift the accumulated charges to horizontal CCD shift register 104. The charges are shifted through the vertical CCD shift register in a row-by-row or in parallel process. Horizontal CCD shift register 104 receives the charges from the vertical CCD shift registers and sequentially shifts each row of accumulated charges to output amplifier 106 in a pixel-by-pixel or serial manner.

The CCD shift registers are emptied of all non-image related charges, such as dark current, prior to image exposure and readout of the accumulated image-related charges. This is known as a reset or flush operation. Resetting the CCD shift registers prior to image capture allows an image sensor to output an accurate representation of a captured image. **FIGS. 2(a)-2(b)** are graphical illustrations of a reset operation in a CCD shift register in accordance with the prior art. Non-image or unwanted charges 200 collect in CCD charge

storage regions 202, 204, 206, 208, 210, as shown in **FIG. 2(a)**. A reset operation is performed to cause non-image charges 200 to transfer from charge storage regions 202, 204, 206, 208, 210 to a reset drain (not shown). **FIG. 2(b)** depicts charge storage regions 202, 204, 206, 208, 210 after the reset operation.

Unfortunately, some residual non-image charge 212 remains in charge storage region 206 after the reset operation. Manufacturing defects typically cause non-image charge 200 in charge storage region 206 to transfer incompletely to the reset drain. For example, misalignment of gates, defects in the semiconductor substrate, and added or missing materials can result in residual charge remaining in a charge storage region of a CCD after a reset operation. When residual non-image charge 212 remains in one or more charge storage regions of a CCD, an image sensor does not produce an accurate representation of a captured image.

SUMMARY OF THE INVENTION

After a first reset operation is performed on one or more CCD shift registers in an image sensor, any residual non-image charge that remains in one or more charge storage regions is shifted to an adjacent charge storage region and the CCD shift register is reset a second time. The charge can be shifted forward or backward within the CCD to an immediately adjacent charge storage region or to a charge storage region located two or more charge storage regions away from the initial charge storage region. The process of resetting one or more CCD shift registers, shifting any residual charge to an adjacent charge storage region, and resetting the one or more CCD shift registers again can be repeated any number of times. A timing generator generates the clocking signal or signals used to shift charge through the one or more CCD shift registers. The timing generator also generates the signal or signals used to reset the one or more CCD shift registers multiple times. The one or more CCD shift registers can be vertical CCD shift registers included in a pixel array or horizontal CCD shift registers that receive charge from the vertical CCD shift registers and sequentially shift charge to an

output amplifier or other readout circuitry.

These and other aspects, objects, features and advantages of the present invention will be more clearly understood and appreciated from a review of the following detailed description of embodiments in accordance with the invention and the appended claims, and by reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of a CCD image sensor in accordance with the prior art;

FIGS. 2(a)-2(b) are graphical illustrations of a reset operation in a CCD shift register in accordance with the prior art;

FIG. 3 is a top view of an image sensor in an embodiment in accordance with the invention;

FIG. 4 is a simplified block diagram of one column 306 in pixel array 308 shown in **FIG. 3** in an embodiment in accordance with the invention;

FIG. 5 is a simplified block diagram of horizontal CCD shift register 310 and drain 316 shown in **FIG. 3** in an embodiment in accordance with the invention;

FIG. 6 is a flowchart of a method for draining residual non-image charge from a charge-coupled device shift register in an embodiment in accordance with the invention;

FIGS. 7(a)-7(d) are graphical illustrations of the method shown in **FIG. 6** using the timing depicted in **Fig. 8**;

FIG. 8 is an exemplary timing diagram for a reset operation in a charge-coupled device shift register in an embodiment in accordance with the invention; and

FIG. 9 is a block diagram of an imaging system that can use an image sensor that implements the method shown in **FIG. 6** in an embodiment in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following Detailed Description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration an exemplary embodiment in which the invention may be practiced. In this regard, directional terminology, such as "top," "bottom," "front," "back," "leading," "trailing," "forward," "backward," etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting.

Throughout the specification and claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise. The meaning of "a," "an," and "the" includes plural reference, the meaning of "in" includes "in" and "on." The term "connected" means either a direct electrical connection between the items connected or an indirect connection through one or more passive or active intermediary devices. The term "circuit" means either a single component or a multiplicity of components, either active or passive, that are connected together to provide a desired function. The term "signal" means at least one current, voltage, or data signal. Referring to the drawings, like numbers indicate like parts throughout the views.

Referring now to **FIG. 3**, there is shown a top view of an image sensor in an embodiment in accordance with the invention. Image sensor 300 includes pixels 302 that are arranged in rows 304 and columns 306 to form pixel array 308. Pixel array 308 can have any number of pixels, such as, for example, 1280 columns by 960 rows of pixels. Image sensor 300 is implemented as a charge-coupled device (CCD) image sensor in an embodiment in accordance with the invention.

Each pixel 302 includes a photosensitive site (not shown) that generates charge in response to the amount of incident light striking the photosensitive site. During readout of pixel array 308, charge is either transferred from each photosensitive site to an adjacent charge storage region in a vertical

CCD shift register (not shown), or maintained within the same photosensitive site when the CCD shift register itself is the photosensitive site. Each column 306 includes a vertical CCD shift register that shifts charge vertically from charge storage region to charge storage region in parallel with the other vertical CCD shift registers in pixel array 308. Since all of the vertical CCD shift registers in pixel array 308 shift charge in parallel, the vertical CCD shift registers are also known by those skilled in the art as parallel shift registers. Charge is transferred from each vertical CCD shift registers to a corresponding reset drain or drains prior to an image capture or readout operation

Charge is then transferred from the vertical CCD shift registers to horizontal CCD shift register 310 and sequentially output to amplifier 312. Horizontal CCD shift register 310 is also known by those skilled in the art as a sequential or serial shift register. Timing generator 314 generates the signals needed to shift charge through the vertical CCD shift registers and horizontal CCD shift register 310. Charge is transferred from horizontal CCD shift register 310 to reset drain 316 prior to an image capture or readout operation.

Although **FIG. 3** depicts one horizontal CCD shift register 310, other embodiments in accordance with the invention are not limited to this structure. Two or more horizontal CCD shift registers can be included in an image sensor in other embodiments in accordance with the invention.

FIG. 4 is a simplified block diagram of one column 306 in pixel array 308 shown in **FIG. 3** in an embodiment in accordance with the invention. Each column 306 includes a column 400 of charge storage regions 402, 404, 406, 408, 410, reset drain 412, and transfer mechanism 414 positioned between charge storage regions 402, 404, 406, 408, 410 and reset drain 412. Transfer mechanism 414 is used to transfer charge from each charge storage region 402, 404, 406, 408, 410 to reset drain 412. In the embodiment shown in **FIG. 4**, reset drain 412 is a common reset drain used by all of the charge storage regions 402, 404, 406, 408, 410 in column 400, and transfer mechanism 414 is a series of transfer gates 416, 418, 420, 422, 424 positioned adjacent respective charge storage regions 402, 404,

406, 408, 410.

Those skilled in the art will recognize that reset drain 412 and transfer mechanism 414 can be implemented differently in other embodiments in accordance with the invention. For example, reset drain 412 can be implemented vertically rather than laterally to the charge storage regions such as commonly found in CCD architectures with vertical overflow drains. Additionally, transfer mechanism 414 can be configured as a vertical charge potential barrier to a vertically located reset drain. In this case, the potential barrier is formed by selective substrate doping and can be selectively removed by voltage modulation of the drain bias.

Column 400 of charge storage regions 402, 404, 406, 408, 410 is implemented as a vertical CCD shift register with each charge storage region 402, 404, 406, 408, 410 operating as both a photosensitive site and a charge storage region used to shift charge through the vertical CCD shift register in an embodiment in accordance with the invention. Other embodiments in accordance with the invention can configure column 400 of charge storage regions 402, 404, 406, 408, 410 differently. By way of example only, column 400 of charge storage regions 402, 404, 406, 408, 410 can be implemented as only charge storage regions of a vertical CCD shift register with each charge storage region positioned adjacent a photosensitive site.

One or more clocking signals that are generated by timing generator 314 in **FIG. 3** are input on signal line 426 to shift charge from one charge storage region to an adjacent charge storage region. A transfer mechanism enable signal (TM), also generated by timing generator 314 (**FIG. 3**), is input on signal line 428 to enable transfer gates 416, 418, 420, 422, 424 and cause charge to transfer from respective charge storage regions 402, 404, 406, 408, 410 to reset drain 412.

Although only five charge storage regions 402, 404, 406, 408, 410 and five transfer gates 416, 418, 420, 422, 424 are shown in **FIG. 4**, those skilled in the art will appreciate that an image sensor can include any number of charge storage regions and transfer gates. Typically, in practice, there is at least one

charge storage region in a vertical CCD shift register for each photosensitive site in the pixel array. Moreover, each vertical CCD shift register can use one or more phases to shift charge through the vertical CCD shift register in other embodiments in accordance with the invention.

Referring now to **FIG. 5**, there is shown a simplified block diagram of horizontal CCD shift register 310 and drain 316 shown in **FIG. 3** in an embodiment in accordance with the invention. Horizontal CCD shift register 310 includes a series of charge storage regions 500, 502, 504, 506, 508. Transfer mechanism 510 is positioned between charge storage regions 500, 502, 504, 506, 508 and reset drain 316. Transfer mechanism 510 transfers charge from each charge storage region 500, 502, 504, 506, 508 to reset drain 316. In the embodiment shown in **FIG. 5**, reset drain 316 is a common reset drain used by all of the charge storage regions 500, 502, 504, 506, 508 in horizontal CCD shift register 310, and transfer mechanism 510 is a series of transfer gates 512, 514, 516, 518, 520 positioned adjacent respective charge storage regions 500, 502, 504, 506, 508. Reset drain 316 and transfer mechanism 510 can be implemented differently in other embodiments in accordance with the invention.

One or more clocking signals generated by timing generator 314 in **FIG. 3** are input on signal line 522 to shift charge from one charge storage region to an adjacent charge storage region in horizontal CCD shift register 310. A transfer mechanism enable signal (TM), also generated by timing generator 314 (**FIG. 3**), is input on signal line 524 to enable transfer gates 512, 514, 516, 518, 520 and cause charge to transfer from respective charge storage regions 500, 502, 504, 506, 508 to reset drain 316.

Although only five charge storage regions 500, 502, 504, 506, 508 and five transfer gates 512, 514, 516, 518, 520 are shown in **FIG. 5**, those skilled in the art will appreciate that an image sensor can include any number of charge storage regions and transfer gates. Typically, in practice, there is at least one charge storage region in one or more horizontal CCD shift registers for each column in the pixel array. Moreover, each horizontal CCD shift register can use one or more phases to shift charge through the horizontal CCD shift register in

other embodiments in accordance with the invention.

FIG. 6 is a flowchart of a method for draining residual non-image charge from a charge-coupled device shift register in an embodiment in accordance with the invention. The method of **FIG. 6** will be described in conjunction with the illustrations in **FIGS. 7(a)-7(d)**. Initially unwanted or non-image charges, such as, for example, dark current charges, collect in the charge storage regions, as shown in block 600. **FIG. 7(a)** depicts non-image charges 700 in respective charge storage regions 702, 704, 706, 708, 710. Charge storage regions 702, 704, 706, 708, 710 can be located in either a vertical CCD shift register or a horizontal CCD shift register. Image charges or non-image charges are shifted through the charge storage regions 702, 704, 706, 708, 710 in the direction indicated by arrow 712.

Returning to **FIG. 6**, the non-image charges are then transferred to the reset drain, as shown in block 602. This step is known as a reset operation, and can be performed at various times during the operation of an image sensor. Typically, one such time is prior to image capture and readout where the photosensitive sites are reset to a predetermined charge level. One example of a predetermined charge level is a no signal or zero charge level.

FIG. 7(b) illustrates charge storage regions 702, 704, 706, 708, 710 after the reset operation has been performed. Charge storage regions 702, 704, 708, 710 are empty, while some residual non-image charge 714 remains in charge storage region 706. Residual charge 714 represents unwanted charge that remains in a charge storage region after a reset operation.

Referring now to block 604 in **FIG. 6**, any residual non-image charge that remains in one or more charge storage regions is then shifted to an adjacent charge storage region in the CCD. **FIG. 7(c)** depicts residual non-image charge 714 shifted forward (i.e., in the direction of arrow 712) from charge storage region 706 to charge storage region 704. Although residual non-image charge 714 is depicted as shifting forward to the immediately adjacent charge storage region 704, embodiments in accordance with the invention are not limited

to this implementation. Residual non-image charge 714 can be shifted forward two or more charge storage regions, such as, for example, from charge storage region 706 to charge storage region 702.

After the residual non-image charge is shifted to an adjacent charge storage region, another reset operation is performed to transfer the residual non-image charge to the reset drain (block 606 in **FIG. 6**). **FIG. 7(d)** illustrates charge storage regions 702, 704, 706, 708, 710 after the second reset of charge storage regions 702, 704, 706, 708, 710. By shifting residual non-image charge 714 from a charge storage region that is not able to efficiently transfer charge to a reset drain (e.g., charge storage region 706) to an adjacent charge storage region that is able to efficiently transfer charge to the reset drain (e.g., charge storage region 704), residual non-image charge 714 is transferred to the reset drain during the second reset of charge storage regions 702, 704, 706, 708, 710.

Returning to **FIG. 6**, a determination is made at block 608 as to whether or not the method is to return to block 604. In one embodiment in accordance with the invention, only one reset-shift-reset operation is performed. Other embodiments in accordance with the invention can perform two or more reset-shift-reset operations.

If the method is to return to block 604, blocks 604, 606, and 608 are repeated for a given number of times or until the charge storage regions are empty of all, or nearly all, residual non-image charge. Although **FIG. 7(d)** depicts charge storage regions 702, 704, 706, 708, 710 as empty of charges, embodiments in accordance with the invention are not limited to this condition. Resetting a CCD shift register, shifting the residual non-image charge to an adjacent charge storage region, and then resetting the CCD shift register again can be repeated until one or more charge storage regions are substantially, but not completely, empty of non-image charges. By way of example only, the amount of time needed to completely empty all charge storage regions of charges may be too long, so the steps of resetting, shifting residual charge, and resetting are performed a predetermined number of times in some embodiments in accordance with the invention. The predetermined number of times may be determined, for example,

through statistical analysis or testing of the image sensor to determine the number of reset operations that result in an acceptable amount of residual non-image charges remaining in one or more charge storage regions.

Referring again to block 608, the method passes to block 610 when the process does not repeat. At block 610, an image is captured by the pixel array and the photosensitive sites accumulate image charges. When the image exposure time period ends, the image charges are read out of the pixel array (block 612).

Referring now to **FIG. 8**, there is shown an exemplary timing diagram for a reset operation in a charge-coupled device shift register in an embodiment in accordance with the invention. Initially, at time t_0, one or more charge storage regions contains non-image charges and the signal "clock" is clocking the charge storage regions to shift charge through a CCD. The clock signal is input on signal line 426 in the embodiment shown in **FIG. 4** and on signal line 522 in the embodiment shown in **FIG. 5**.

At time t_1, a reset operation is performed when the transfer mechanism enable signal (TM) is enabled, thereby causing the non-image charges to transfer to the reset drain. The TM signal is input on signal line 428 in the embodiment shown in **FIG. 4** and on signal line 524 in the embodiment shown in **FIG. 5**.

Any residual non-image charge that remains in one or more charge storage regions is then shifted to an adjacent charge storage region at time t_2. In the embodiment of **FIG. 8**, this is accomplished by maintaining signal TM in an enabled state while the charge storage regions are clocked. At time t_3, another reset operation occurs and causes the residual non-image charge that has been shifted to the adjacent charge storage region to transfer to the reset drain.

Embodiments in accordance with the invention are not limited to the timing diagram illustrated in **FIG. 8**. Other forms of timing can be used in other embodiments in accordance with the invention. For example, the TM signal may be cycled on and off in synchronization with the clocking signal or signals input on signal line 426 (**FIG. 4**) and signal line 522 (**FIG. 5**).

FIG. 9 is a block diagram of an imaging system that can use an

image sensor that implements the method shown in **FIG. 6** in an embodiment in accordance with the invention. Imaging system 900 includes digital camera phone 902 and computing device 904. Digital camera phone 902 is only one example of an image capture device that can use an image sensor that implements embodiments in accordance with the invention. Other types of image capture devices, such as, for example, digital still cameras and digital video camcorders can use one or more image sensors that implement embodiments in accordance with the invention.

Digital camera phone 902 is a portable, handheld, battery-operated device in an embodiment in accordance with the invention. Digital camera phone 902 produces digital images that are stored in memory 906, which can be, for example, an internal Flash EPROM memory or a removable memory card. Other types of digital image storage media, such as magnetic hard drives, magnetic tape, or optical disks, can alternatively be used to implement memory 906.

Digital camera phone 902 uses lens 908 to focus light from a scene (not shown) onto pixel array 910 of image sensor 912. Pixel array 910 provides color image information using the Bayer color filter pattern in an embodiment in accordance with the invention. Pixel array 910 is controlled by timing generator 914, which also controls flash 916 in order to illuminate the scene when the ambient illumination is low.

The analog output signals output from the pixel array 910 are amplified and converted to digital data by analog-to-digital (A/D) converter circuit 918. The digital data are stored in buffer memory 920 and subsequently processed by processor 922. Processor 922 is controlled by the firmware stored in firmware memory 924, which can be flash EPROM memory. Processor 922 includes real-time clock 926, which keeps the date and time even when digital camera phone 902 and processor 922 are in a low power state. The processed digital image files are stored in memory 906. Memory 906 can also store other types of data, such as, for example, music files (e.g. MP3 files), ring tones, phone numbers, calendars, and to-do lists.

In one embodiment in accordance with the invention, digital

camera phone 902 captures still images. Processor 922 performs color interpolation followed by color and tone correction, in order to produce rendered sRGB image data. The rendered sRGB image data are then compressed and stored as an image file in memory 906. By way of example only, the image data can be compressed pursuant to the JPEG format, which uses the known "Exif" image format. This format includes an Exif application segment that stores particular image metadata using various TIFF tags. Separate TIFF tags can be used, for example, to store the date and time the picture was captured, the lens f/number and other camera settings, and to store image captions.

Processor 922 produces different image sizes that are selected by the user in an embodiment in accordance with the invention. One such size is the low-resolution "thumbnail" size image. Generating thumbnail-size images is described in commonly assigned U.S. Patent No. 5,164,831, entitled "Electronic Still Camera Providing Multi-Format Storage Of Full And Reduced Resolution Images" to Kuchta, et al.. The thumbnail image is stored in RAM memory 928 and supplied to display 930, which can be, for example, an active matrix LCD or organic light emitting diode (OLED). Generating thumbnail size images allows the captured images to be reviewed quickly on color display 930.

In another embodiment in accordance with the invention, digital camera phone 902 produces and stores video clips. A video clip with a lower resolution video image frame is produced by summing multiple pixels of pixel array 910 together (e.g. summing pixels of the same color within each 4 column x 4 row area of the pixel array 910). The video image frames are read from pixel array 910 at regular intervals, for example, using a 19 frame per second readout rate.

Audio codec 932 is connected to processor 920 and receives an audio signal from microphone (Mic) 934. Audio codec 932 also provides an audio signal to speaker 936. These components are used both for telephone conversations and to record and playback an audio track, along with a video sequence or still image.

Speaker 936 is also used to inform the user of an incoming phone

call in an embodiment in accordance with the invention. This can be done using a standard ring tone stored in firmware memory 924, or by using a custom ring-tone downloaded from mobile phone network 938 and stored in memory 906. In addition, a vibration device (not shown) can be used to provide a silent (e.g. non-audible) notification of an incoming phone call.

Processor 922 is connected to wireless modem 940, which enables digital camera phone 902 to transmit and receive information via radio frequency (RF) channel 942. Wireless modem 940 communicates with mobile phone network 938 using another RF link (not shown), such as a 3GSM network. Mobile phone network 938 communicates with photo service provider 944, which stores digital images uploaded from digital camera phone 902. Other devices, including computing device 904, access these images via the Internet 946. Mobile phone network 938 also connects to a standard telephone network (not shown) in order to provide normal telephone service in an embodiment in accordance with the invention.

A graphical user interface (not shown) is displayed on display 930 and controlled by user controls 948. User controls 948 include dedicated push buttons (e.g. a telephone keypad) to dial a phone number, a control to set the mode (e.g. "phone" mode, "calendar" mode" "camera" mode), a joystick controller that includes 4-way control (up, down, left, right) and a push-button center "OK" or "select" switch, in embodiments in accordance with the invention.

Dock 950 recharges the batteries (not shown) in digital camera phone 902. Dock 950 connects digital camera phone 902 to computing device 904 via dock interface 952. Dock interface 952 is implemented as wired interface, such as a USB interface, in an embodiment in accordance with the invention. Alternatively, in other embodiments in accordance with the invention, dock interface 952 is implemented as a wireless interface, such as a Bluetooth or an IEEE 802.11b wireless interface. Dock interface 952 is used to download images from memory 906 to computing device 904. Dock interface 952 is also used to transfer calendar information from computing device 904 to memory 906 in

digital camera phone 902.

The invention has been described in detail with particular reference to embodiments in accordance with the invention, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. For example, **FIG. 7** describes the image and residual non-image charges shifting uni-directionally, or in the direction depicted by arrow 712. Other embodiments in accordance with the invention, however, can shift charge bi-directionally, thereby allowing the image charges, non-image charges, or the residual non-image charges to be shifted forward or backward within a CCD shift register.

PARTS LIST

100	pixel array
102	pixel
104	horizontal charge-coupled device shift register
106	amplifier
200	charge
202	charge storage region
204	charge storage region
206	charge storage region
208	charge storage region
210	charge storage region
212	residual non-image charge
300	image sensor
302	pixel
304	row
306	column
308	pixel array
310	horizontal charge-coupled device shift register
312	amplifier
314	timing generator
316	reset drain
400	column
402	charge storage region
404	charge storage region
406	charge storage region
408	charge storage region
410	charge storage region
412	reset drain
414	transfer mechanism
416	transfer gate
418	transfer gate
420	transfer gate
422	transfer gate
424	transfer gate

426	signal line
428	signal line
500	charge storage region
502	charge storage region
504	charge storage region
506	charge storage region
508	charge storage region
510	transfer mechanism
512	transfer gate
514	transfer gate
516	transfer gate
518	transfer gate
520	transfer gate
522	signal line
524	signal line
700	charge
702	charge storage region
704	charge storage region
706	charge storage region
708	charge storage region
710	charge storage region
712	direction of charge shift
714	residual charge
900	imaging system
902	camera phone
904	computing device
906	memory
908	lens
910	image sensor array
912	active pixel sensor
914	timing generator
916	flash
918	analog-to-digital converter
920	buffer memory
922	digital processor
924	firmware memory

926	clock
928	RAM memory
930	display
932	audio codec
934	microphone
936	speaker
938	mobile phone network
940	wireless modem
942	RF channel
944	photo service provider
946	internet
948	user controls
950	dock
952	dock interface

CLAIMS:

1. An image sensor, comprising:

a charge-coupled device (CCD) shift register having a plurality of charge storage regions;

a reset drain;

a transfer mechanism positioned between the CCD shift register and the reset drain to transfer charge from each charge storage region to the reset drain; and

a timing generator for enabling a first reset of the plurality of charge storage regions such that non-image charges in the plurality of charge storage regions are transferred to the reset drain, and after the first reset is performed, for generating clock signals to shift any residual non-image charge remaining in at least one charge storage region to a respective adjacent charge storage region and then enabling a second reset to transfer the residual non-image charge to the reset drain.

2. The image sensor of claim 1, wherein the transfer mechanism includes a plurality of transfer gates with each transfer gate adjacent a charge storage region.

3. The image sensor of claim 2, wherein the CCD shift register comprises a horizontal CCD shift register.

4. The image sensor of claim 2, wherein the CCD shift register comprises a vertical CCD shift register, and wherein the vertical CCD shift register, the reset drain, and the plurality of transfer gates are included in a column of pixels within a pixel array.

5. The image sensor of claim 1, wherein the reset drain comprises a common reset drain that receives charge from all of the charge storage regions in the CCD shift register.

6. The image sensor of claim 1, wherein the image sensor is disposed in an image capture device.

7. In an image sensor, a method for draining residual non-image charge from a charge-coupled device (CCD) shift register to a reset drain, wherein the CCD shift register includes a plurality of charge storage regions, the method comprising the steps of:

(a) transferring non-image charge from the CCD shift register to the reset drain;

(b) shifting any residual non-image charge remaining in at least one of the charge-storage regions in the CCD shift register to a respective adjacent charge-storage region; and

(c) transferring the residual non-image charge in the adjacent charge-storage region to the reset drain.

8. The method of claim 7, further comprising the step of (d) repeating steps (b) and (c) for a given number of times.

9. The method of claim 7, wherein the step of transferring non-image charge from the CCD shift register to the reset drain comprises transferring non-image charge from the CCD shift register to a common reset drain.

10. In an image sensor, a method for draining residual non-image charge from a charge-coupled device (CCD) shift register to a reset drain, where the CCD shift register includes a plurality of charge storage regions, the method comprising the steps of:

(a) enabling a transfer mechanism;

(b) transferring non-image charge from the CCD shift register to the reset drain;

(c) shifting any residual non-image charge remaining in at least one charge storage region in the CCD shift register to a respective adjacent charge storage region; and

(d) transferring the residual non-image charge in the adjacent charge storage region to the reset drain.

11. The method of claim 10, further comprising the step of disabling the transfer mechanism.

12. The method of claim 11, further comprising the step of repeating steps (c) and (d) for a given number of times prior to disabling the transfer mechanism.

13. The method of claim 12, wherein the transfer mechanism remains enabled while steps (c) and (d) are repeated.

14. The method of claim 10, wherein the step of enabling a transfer mechanism comprises enabling a plurality of transfer gates where each transfer gate is adjacent a charge storage region.

15. The method of claim 10, wherein the step of transferring non-image charge from the CCD shift register to the reset drain comprises transferring non-image charge from the CCD shift register to a common reset drain.

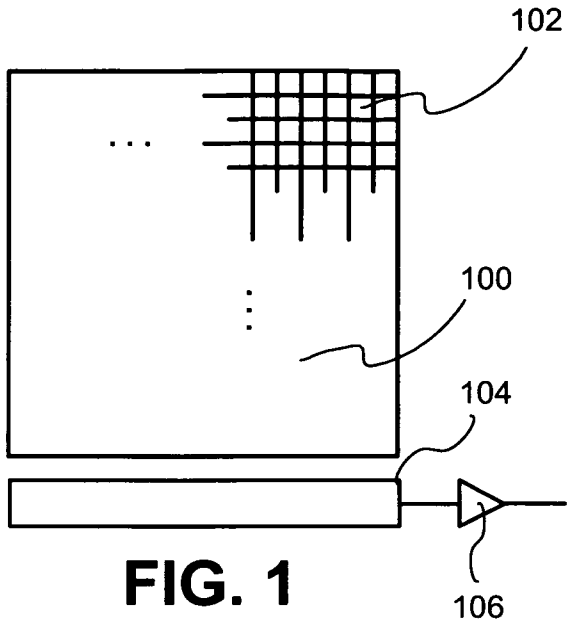


FIG. 1
(Prior Art)

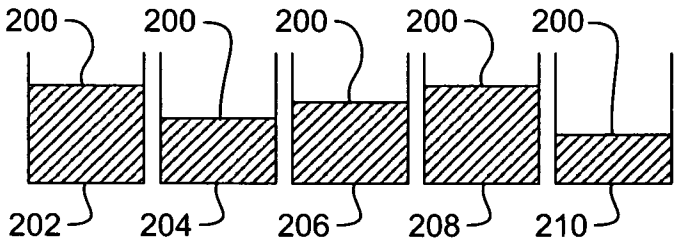


FIG. 2(a)
(Prior Art)

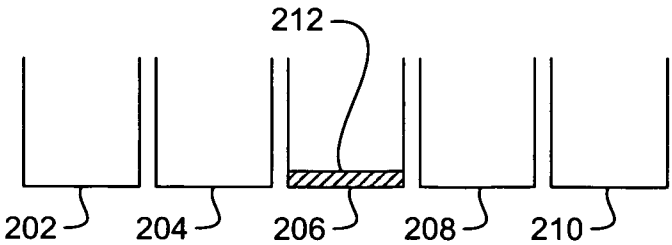


FIG. 2(b)
(Prior Art)

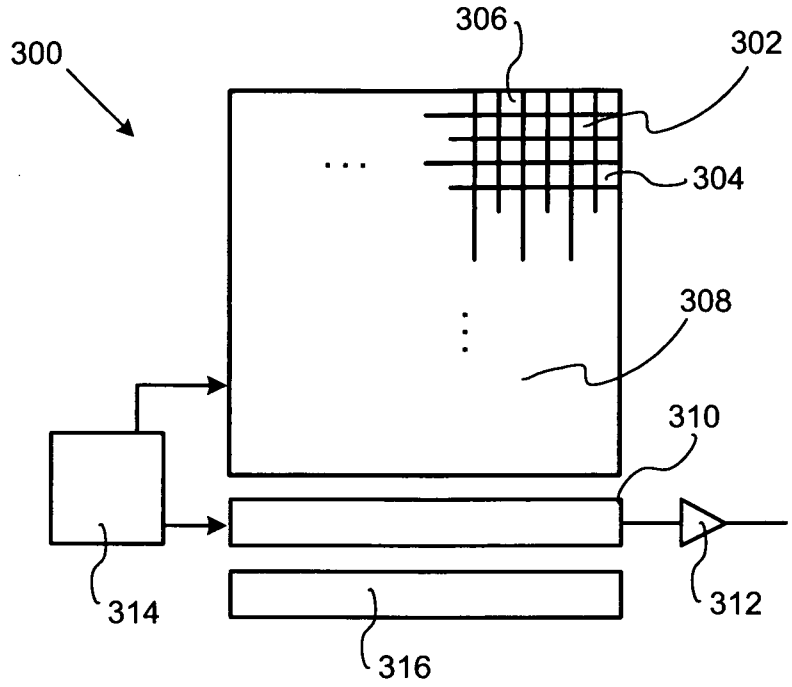
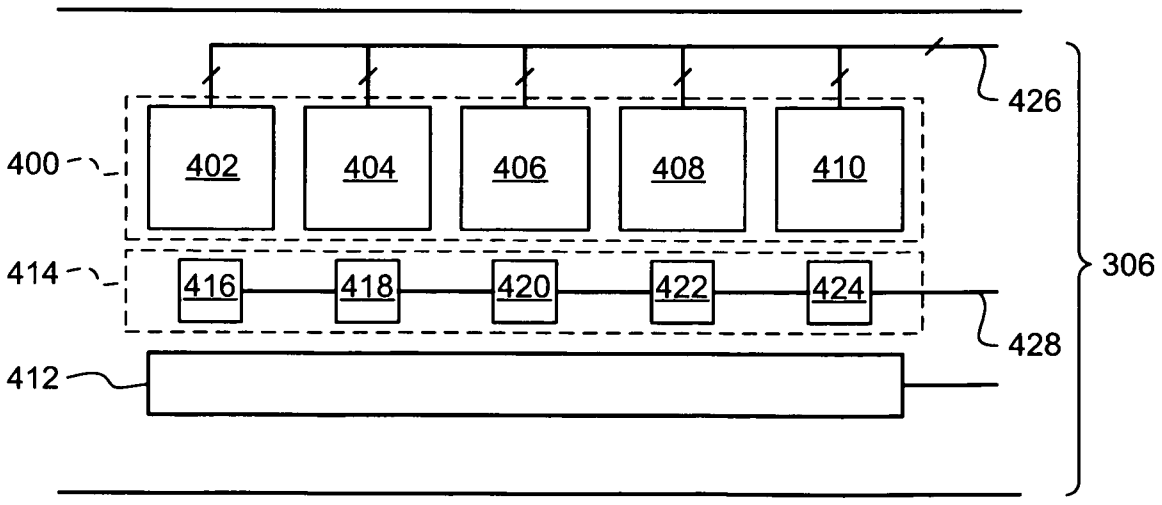

300
306
302
304
308
310
312
314
316

FIG. 3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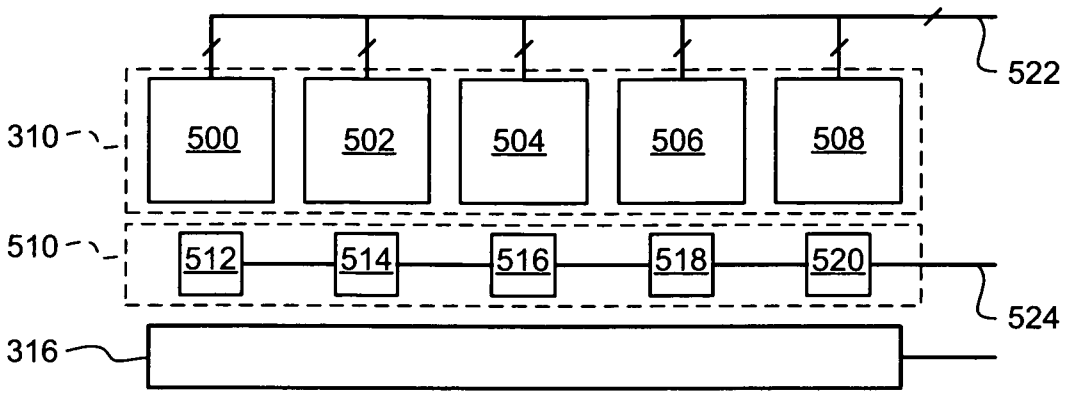
400
402
404
406
408
410
414
416
418
420
422
424
428
412
306

FIG. 4


522
310
500
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504
506
508
510
512
514
516
518
520
524
316

FIG. 5

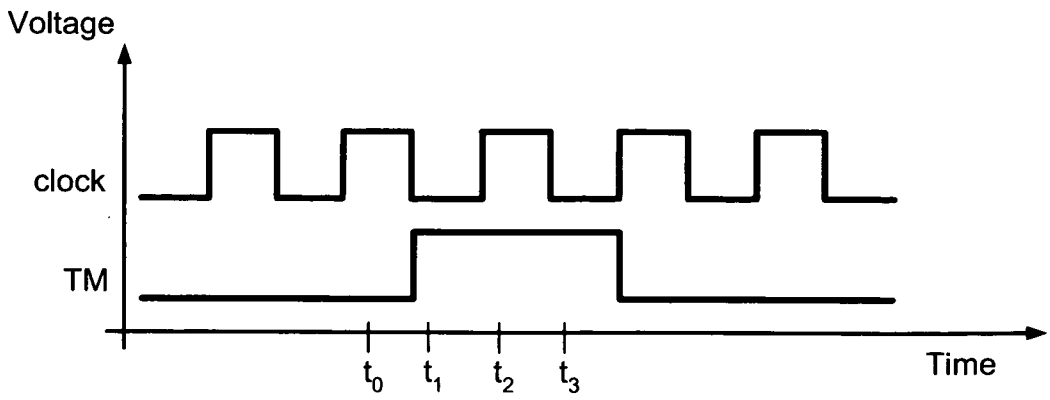
Voltage
clock
TM
t_0
t_1
t_2
t_3
Time

FIG. 8

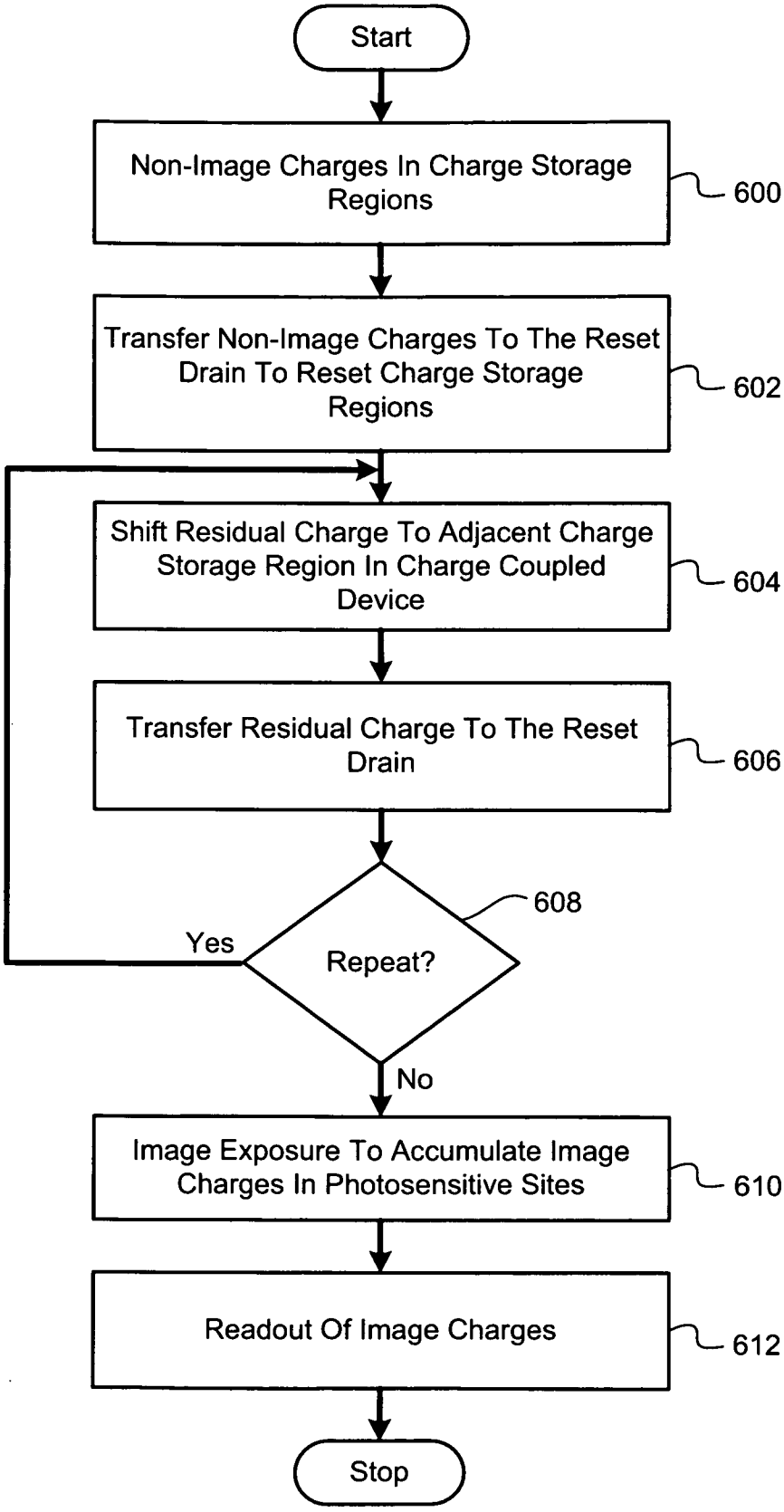
Start
Non-Image Charges In Charge Storage Regions
600
Transfer Non-Image Charges To The Reset Drain To Reset Charge Storage Regions
602
Shift Residual Charge To Adjacent Charge Storage Region In Charge Coupled Device
604
Transfer Residual Charge To The Reset Drain
606
608
Repeat?
Yes
No
Image Exposure To Accumulate Image Charges In Photosensitive Sites
610
Readout Of Image Charges
612
Stop

FIG. 6

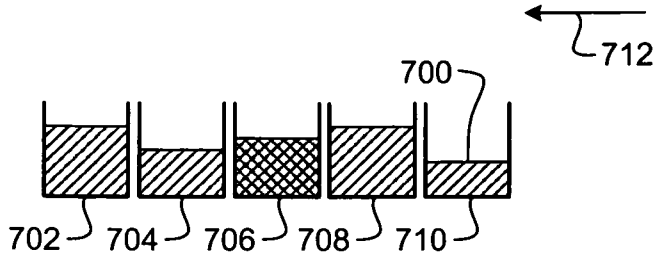

FIG. 7(a)

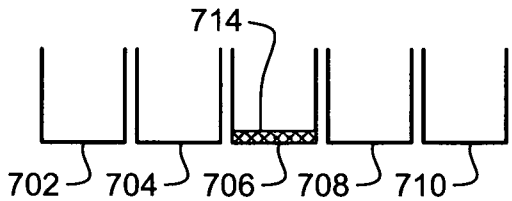

FIG. 7(b)

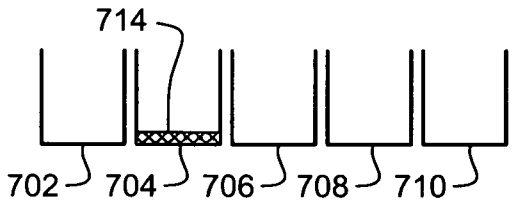

FIG. 7(c)

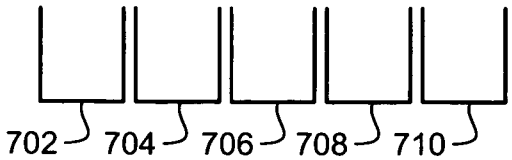

FIG. 7(d)

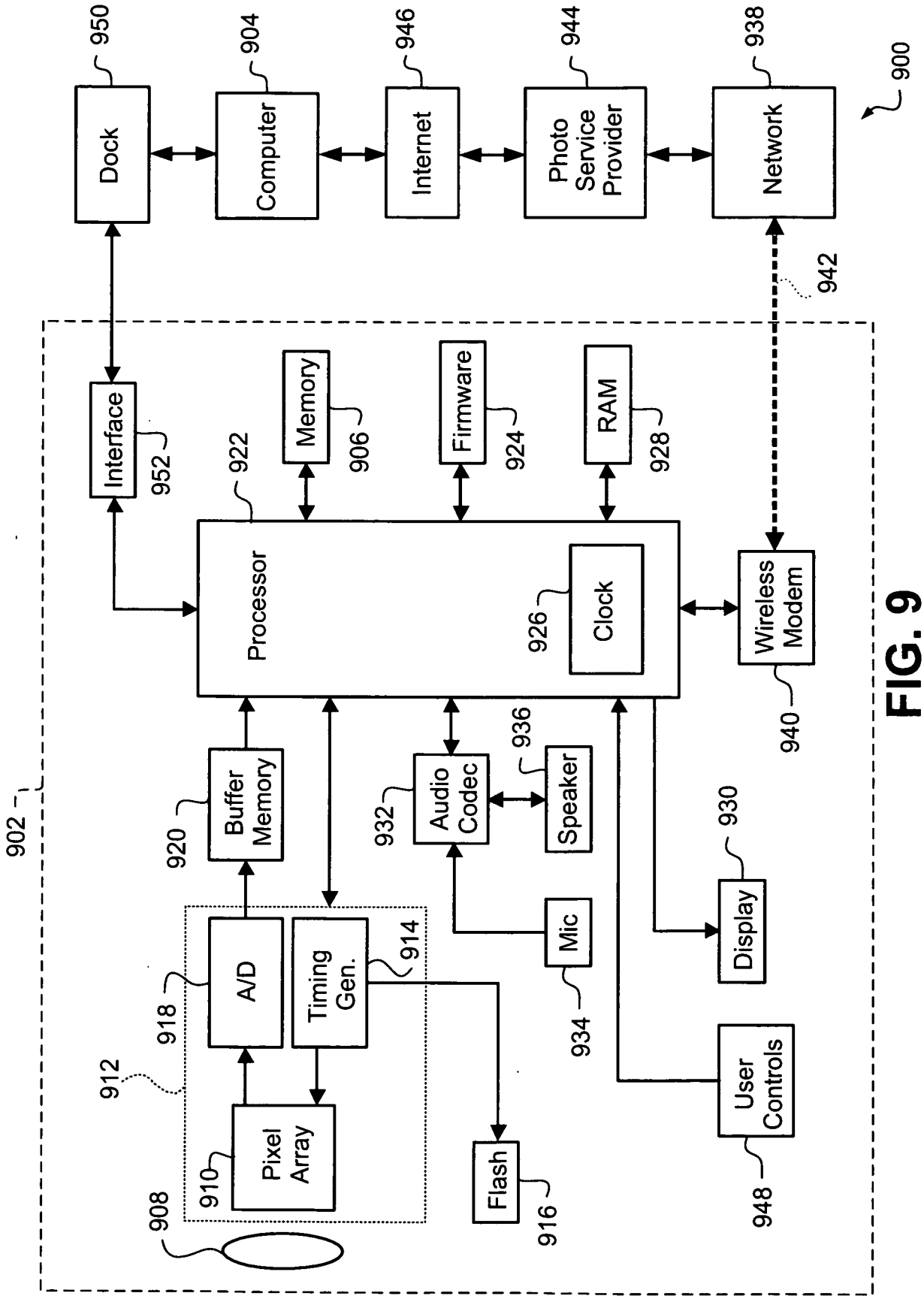
950
Dock
904
Computer
946
Internet
944
Photo Service Provider
938
Network
900
942
902
Interface
952
922
Processor
Memory
906
Firmware
924
RAM
928
926
Clock
Wireless Modem
940
936
Audio Codec
932
Speaker
Buffer Memory
920
930
Display
Mic
934
A/D
918
Timing Gen.
914
912
Pixel Array
910
908
Flash
916
User Controls
948

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/002843

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L27/148

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 614 225 A (KONINKL PHILIPS ELECTRONICS NV [NL]) 7 September 1994 (1994-09-07) column 7, line 10 - column 8, line 16 column 8, lines 42-47 column 10, lines 29-24 figure 4 -----	1-15
X	US 6 040 859 A (TAKAHASHI TATSUYA [JP]) 21 March 2000 (2000-03-21) column 3, line 57 - column 4, line 59 column 5, lines 58-64 column 7, lines 12-29 figures 3,5,6,9 -----	1-6

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 August 2009	04/09/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Markmann, Markus

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/002843

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 593 303 A (DYCK RUDOLPH H [US] ET AL) 3 June 1986 (1986-06-03) column 4, lines 15-36 figures 3a,3b	1-6
X	EP 1 137 071 A (EASTMAN KODAK CO [US]) 26 September 2001 (2001-09-26) paragraphs [0012], [0013] figure 4	1-6
X	US 2006/044432 A1 (STEVENS ERIC G [US] ET AL) 2 March 2006 (2006-03-02) paragraphs [0014], [0015] figures 1-6	1-6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2009/002843

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		DE 69410147 T2	03-12-1998
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		WO 2006026434 A1	09-03-2006