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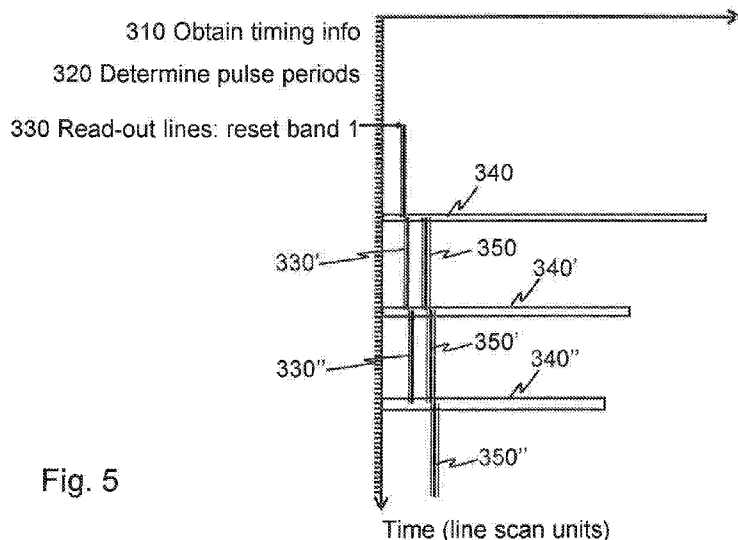


Fig. 5

(57) Abstract: An apparatus, method and computer program are disclosed that in an example embodiment provide separate flash light pulses (340, 340', 340'') for separately illuminating two or more bands of read-out lines of an image sensor during common exposure period of all read-out lines of each band. The flash light can be produced using a gas discharge flash using simmering triggering.

METHOD AND APPARATUS FOR PULSED FLASHLIGHT

TECHNICAL FIELD

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The present application generally relates to pulsed flashlight.

BACKGROUND

10 This section illustrates useful information for understanding the present application without admission of any technique described herein representative of the state of the art.

15 Digital cameras typically have a mechanical shutter or an electronic rolling shutter. In the latter case, whole picture is not exposing exactly simultaneously. This is caused by the operation of the most common image sensor, complementary metal-oxide semiconductor (CMOS) sensor. With CMOS sensor, lines of pixels are first initialized and after the exposure period read-out in the same order, e.g. top down. Therefore, vertical lines of objects that move sideways with relation to the image sensor became
20 skewed.

While the rolling shutter effect is most notable with digital cameras without any mechanical shutter, typically the mechanical shutters move vertically (over the shorter side of the image area). At very high change of illumination e.g. caused by a lightning,
25 different parts of the image area can be exposed very differently. Moreover, the speed of a mechanical shutter is finite, often in the range of 1/200 s. For higher speed, entry level single-lens reflex (SLR) cameras typically employ digital shutter only.

Flashlight is often used in photography to assist exposing images. For instance,
30 flashlight is used when more light is needed or when shorter exposure time is desired for stopping high-speed motion. Sometimes flash is also used for fill-in light to avoid undesired shadows when photographing an object against bright light. The amount of additional flashlight illumination must be balanced with backlight illumination of the object.

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Flashlights of portable electronic devices are usually xenon flash lights or light emitting diode (LED) based flash lights. A typical xenon flash light produces pulses of some microseconds using external triggering up to few milliseconds based on energy stored in a high power capacitor. A LED flash typically operates directly using the battery of the

portable electronic device and can produce illumination over longer periods. A flashgun of an SLR has its own power supply, e.g. an array of batteries and a rather efficient capacitor.

- 5 The xenon flash lights are normally found in dedicated cameras or high end camera phones, whereas the LED flash light is typical in entry-level devices thanks to its low production cost. A LED flash light needs no capacitor, either.

SUMMARY

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The inventors have studied the use of flashlights and made a number of findings.

With very high resolution image sensors, a relatively long time may be needed for reading the whole image sensor from a first line of an image to a last line. This time may
15 be up to tens of milliseconds. In consequence, to illuminate the whole camera field of view by exposing entire image sensor same time with a flash, the flash should be triggered on such a moment, when whole sensor exposure is happening simultaneously. This may yet be impossible with some high-resolution portable camera devices.

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Let us consider a scenario of a rolling shutter camera and a fast pulse high power flash. When flash is triggered, the flashlight illumination should last longer than the read-out-time. In return, fill-in-flash could be used in limited cases as otherwise either the flash cannot be triggered with short exposure times or the object close to the camera is
25 under-exposed, or the exposure time needs to be too long so that the background easily becomes over-exposed. On the other hand, if the exposure time of the image sensor is shorter than its read-out-time and a fast flash pulse is triggered, only part of the image is illuminated by the flash. For example, top part of the image may remain dark, when lower part is properly illuminated with the flash.

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While it is not known that these issues would have been identified in the prior art, there are different solutions that may coincidentally avoid them. For example, using a mechanical shutter and a xenon flash, all the pixels can be exposed using the flash light during a small proportion of the exposure time. By blocking light by the mechanical
35 shutter for the exposure time that exceeds the flash light period, each scan line of the image sensor can be exposed during exactly same period even if their reading subsequently takes place line by line. In result, the entire image area is homogenously exposed. On the other hand, some LED flashes produce flash pulses that last long enough to illuminate the image object over the entire exposure time thereby also

averting partial illumination of images. Also a high-power and high-speed flash gun of a digital SLR camera can sustain desired intensity of illumination over the entire exposure time (up to e.g. 1/200 s i.e. 5 ms) by producing an uninterrupted train of externally triggered high-power pulses that maintain constant flashlight illumination the intensity of which fluctuates by an amount that enables digital correction (e.g. 50 % of the maximum illumination power). That the SLR camera's flash gun can sustain a train of externally triggered flash pulses is enabled by a dedicated powerful capacitor and power source that may not fit in typical mobile phones, for example. Moreover, the sustained train of pulses may be long enough for fast SLR sensor read-out circuitries, but too short for some high resolution image sensor equipped portable devices such as camera phones with 40 million camera pixels in which radio interference compliance and / or cost factors may limit the speed of the read-out circuitries.

The external triggering is the most common one of the many ways to trigger a flashtube. Simmer voltage triggering (simmering in short) is one of the other alternatives. In simmering, the electrodes are electrified by a high voltage spark streamer that is maintained between the electrodes of the flashtube. Such triggering is mainly used in very fast rise time systems that discharge normally in about 1 μ s (e.g. for stop-motion photography).

It is also known that high current draw tends to create electric interference that may be damaging for reading and interpreting low voltage analog signals from the image sensor. It remains impossible or impractical with the known technical solutions to produce plural xenon flash light pulses in a portable device that has limited space for housing high capacity capacitor and limited battery power that is needed also for image processing. As such, fill-in flash with slow rolling shutter may be impossible to produce as such in good quality. Instead, multi-frame imaging can be used to capture images with different flash timing and combine a single frame using the illuminated parts of two or more images, provided that the imaging object and camera are stable over extended time needed for taking plural images by the image sensor.

Various aspects of examples of the invention are set out in the claims.

According to a first example aspect of the present invention, there is provided an apparatus, comprising:

an input configured to obtain flash pulse control information; and
a controller configured to receive the flash pulse control information and to accordingly control a flash unit to produce a plurality of pulses interspersed at desired times during exposure of a digital image.

The flash pulse control information may comprise an indication of a time at which each of the pulses should be produced.

- 5 The flash pulse control information may comprise an indication of an amount of illumination energy with which each of the pulses should be produced.

10 The flash pulse control information may comprise separate control information parts for different pulses to be produced. The time of receipt of each of the control information parts may be indicative of the time at which the pulse in question should be produced. The controller may be configured to cause producing each of the flash pulses immediately in response to receiving respective control information parts.

15 The apparatus may comprise an image sensor configured to take a digital image during the exposure time using flashlight produced by the flash unit.

20 The apparatus may comprise an image sensor control circuitry configured to reset the image sensor for beginning exposing a digital image. The image sensor control circuitry configured to read lines of pixels of the image sensor by read-out of pixel lines. The resetting may be performed sequentially by lines of pixels, line by line. The read-out of the lines of pixels may be performed sequentially by lines of pixels, line by line. The image sensor control circuitry may be configured to provide each line of pixels of the image sensor an equal exposure time by scanning the lines of pixels with same rate on resetting and reading the lines of pixels. The lines of pixels of the image sensor may be referred to as read-out lines.

The apparatus may comprise the flash unit.

30 The apparatus may be a battery operated apparatus. The apparatus may comprise a battery as a power supply.

The flash unit may be configured to produce the plurality of pulses by simmer voltage triggering.

35 The controller may be a processor. Alternatively, the controller may be a transistor such as an insulated gate bipolar transistor.

The flash unit may be a gas discharge flash unit. Alternatively, the flash unit may be a high power light emitting diode flash equipped with a super capacitor energy supply.

The flash unit may be controlled to emit light at least 500 or 1000 times brighter at the peak of the pulses than at the lowest light emission between the pulses.

- 5 The controller may be configured to identify from the flash pulse control information pulse beginning moments and to cause the flash unit to begin each pulse on a pulse beginning moment.

- 10 The flash pulse control information may comprise an indication of plural read-out events comprising for each band of read-out lines: a beginning time of resetting read-out lines; an end time of resetting read-out lines; a beginning time of reading read-out lines; and an end time of reading read-out lines.

- 15 The read-out of one band may begin as the reset of that band ends. Alternatively, the readout may begin after a common exposure period in which all the lines of pixels of the band are reset but not yet read-out. The common exposure period may be at most 1 to 10 % of the period of time taken from a read-out duration that is the duration from the start of the read-out of the first line of the band to the end of the read-out of the last line of the band. The pulses may be timed to occur at least partly during the common exposure period. The time taken from the beginning of resetting a first line of a band to the beginning of the read-out of the first line of the band may be referred to as exposure time. The exposure time may be substantially constant for all read-out lines.

- 25 The exposure time may exceed 5 ms. The exposure time may exceed 10 ms. The exposure time may exceed 20 ms. The exposure time may exceed 25 ms.

The exposure time may be less or equal to 100 ms. The exposure time may be less or equal to 50 ms.

- 30 Each of pulses may be configured to produce identical or corresponding energy. The plurality of pulses may comprise two pulses that last for identical durations. Alternatively, the different pulses may last for different times. Shorter pulses may be compensated by higher power so that the light energy from one pulse to next pulse or the end of the exposure time remains constant or substantially constant.

- 35 The pulses may be configured to cause identical or corresponding exposure for all or most of the lines of pixels of the image sensor.

The flash unit may comprise the gas discharge flash tube. The flash unit may comprise a xenon flash light. The flash unit may comprise a thyristor for initiating simmering in the flash unit.

- 5 The flash unit may be further configured for external triggering for producing a single flash pulse that is stronger than those that can be produced by the simmering.

10 The apparatus may be further configured to use the externally triggered single flash pulse when such a pulse is better suited for the photographing than one or more pulses produced by simmering.

The controller may be configured to control the flash unit according to the flash pulse control information to produce N pulses, wherein N is 2, 3, 4, 5, 6 or greater than 6.

- 15 The apparatus may be configured to adapt N depending on at least one of: ambient light level; desired exposure extent; image sensor sensitivity or ISO value; duration of read-out of read-out lines needed for taking the digital image; battery level of the apparatus; charging level of a capacitor that supplies power to the flash unit; and capacitance of a capacitor that supplies power to the flash unit.

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According to a second example aspect of the present invention, there is provided a method comprising:

obtaining flash pulse control information; and

- 25 controlling according to the flash pulse control information a flash unit to produce a plurality of pulses interspersed at desired times during exposure of a digital image.

According to a third example aspect of the present invention, there is provided a method comprising: providing separate flash light pulses for separately illuminating two or more bands of read-out lines of an image sensor during common exposure period of all read-out lines of each band. The method may further comprise receiving flash pulse control information and controlling the providing of the separate flash light pulses according to the flash pulse control information. The method may further comprise producing or causing of the producing the pulses using a gas discharge flash unit using simmering triggering.

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According to a fourth example aspect of the present invention, there is provided a computer program comprising computer executable program code configured to cause an apparatus perform, when executing the program code, the method of the second or third example aspect.

According to a fifth example aspect of the present invention, there is provided a memory medium comprising the computer program of the fourth example aspect.

- 5 According to a sixth example aspect of the present invention, there is provided an apparatus comprising means for executing the method of the second or third example aspect.

- 10 According to a seventh example aspect of the present invention, there is provided an apparatus comprising a memory storing the computer program of the fourth example aspect and a processor configured to execute the computer program.

- Any foregoing memory medium may comprise a digital data storage such as a data disc or diskette, optical storage, magnetic storage, holographic storage, opto-magnetic
15 storage, phase-change memory, resistive random access memory, magnetic random access memory, solid-electrolyte memory, ferroelectric random access memory, organic memory or polymer memory. The memory medium may be formed into a device without other substantial functions than storing memory or it may be formed as part of a device with other functions, including but not limited to a memory of a computer, a chip set, and
20 a sub assembly of an electronic device.

- Different non-binding example aspects and embodiments of the present invention have been illustrated in the foregoing. The embodiments in the foregoing are used merely to explain selected aspects or steps that may be utilized in implementations of the present
25 invention. Some embodiments may be presented only with reference to certain example aspects of the invention. It should be appreciated that corresponding embodiments may apply to other example aspects as well.

BRIEF DESCRIPTION OF THE DRAWINGS

- 30 For a more complete understanding of example embodiments of the present invention, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

- Fig. 1 shows an architectural overview of a system of an example embodiment of the
35 invention;

Fig. 2 shows a block diagram of an apparatus that could be used as the camera device in an example embodiment;

Fig. 3 shows an exemplary timing chart illustrating various events and intensities of pulses formed according to an example embodiment;

Fig. 4 shows an exemplary timing chart illustrating various events and intensities of pulses formed according to an example embodiment;

Fig. 5 shows an exemplary timing chart illustrating various events and intensities of pulses formed according to an example embodiment; and

5 Fig. 6 shows a process according to an example embodiment.

DETAILED DESCRIPTION OF THE DRAWINGS

10 An example embodiment of the present invention and its potential advantages are understood by referring to Figs. 1 through 3 of the drawings. In this document, like reference signs denote like parts or steps.

Fig. 1 shows an architectural overview of a system of an example embodiment of the invention. The system comprises a camera device 100 (such as a portable device e.g. a
15 mobile phone), an image object 110 and a backlight 120 such as the sun.

Fig. 2 shows a block diagram of an apparatus 200 that could be used as the camera device 100 in an example embodiment. The apparatus 200 comprises:
a flash unit 210 (e.g. e.g. a gas discharge flash unit comprising a xenon, krypton or argon flash tube and a thyristor for initiating simmering in the flash tube);
20 an input 220 configured to obtain flash pulse control information (the input being e.g. a dedicated data port or a logical input provided by a general data port such an internal data bus of a device or at simplest e.g. a pair of electric connections);
a controller 230 configured to receive the flash pulse control information and to
25 accordingly control the flash unit 210 to produce a plurality of pulses interspersed at desired times during exposure of a digital image (the controller being formed using one or more dedicated or general processors such as central processing units and digital signal processors on in some embodiments of one or more components such as insulated gate bipolar transistors);
30 an image sensor 240 (e.g. a CMOS sensor) comprising a plurality of read-out lines 242 that each comprise a number of image sensor pixels that can be reset and read-out;
a battery 250 for providing operating voltage; and
a capacitor 260 for enabling high instantaneous power draw by the unit 210; and
an image sensor control circuitry 270 for controlling operations of the image sensor 240.
35 For example, the image sensor control circuitry can be configured to reset and subsequently read the read-out lines 242. The resetting can be performed sequentially by lines of pixels, line by line as well as the read-out of the read-out lines 242. In an example embodiment, the image sensor control circuitry is configured to provide each

read-out line 242 an equal exposure time by scanning the lines of pixels with same rate on resetting and reading the lines of pixels.

5 In an example embodiment, the apparatus 200 further comprises a memory 280. The memory 280 comprises, for example, any of: work memory 282 such as random access memory or flash random access memory; and persistent memory 284 such as flash random access memory, magnetic memory such as hard disc storage, optical memory such as cd-rom, and / or memory stick such as a universal serial bus memory stick. The memory 280 in Fig. 2 also comprises software 286. In case the controller 230 is a
10 processor, the software 286 is executed by the processor so that the processor can control operations of the apparatus 200 accordingly. It should be understood, though, that some operations can still be hardwired e.g. for simplicity and / speed. For example, a flash light discharging can be triggered by a semiconductor such as a thyristor or transistor in response to receiving a suitable trigger signal. Hence, the controller 230
15 can also understandably be formed as a combination of software based operations (using a processor and software) and hardwired circuitry.

In an example embodiment, the flash unit is configured to produce the plurality of pulses by simmer voltage triggering.
20

It should be understood that in some other examples and especially in some of the appended claims, the apparatus may relate to a decision making unit that controls other parts without comprising the image sensor 240 or other parts of cameras (optics, the flash unit etc.) or to a larger entirety comprising one or more further details described
25 herein or known from digital imaging technology in general.

In an example embodiment, the flash unit 210 is configured to emit light at least 500 or 1000 times brighter at the peak of the pulses than at the lowest light emission between the pulses. This is in contrast with e.g. the known DSLR flash guns that may produce a
30 train of pulses within some 50 % fluctuation of intensity when measured over 5 % of the pulse duration i.e. among 20 samples.

In an example embodiment, the controller 230 is configured to identify from the flash pulse control information pulse beginning moments and to cause the flash unit 210 to
35 begin each pulse on a pulse beginning moment. These moments can be expressed e.g. as microseconds from the pulse beginning or some other time reference or by reference to some predetermined scheme such as a table in which a number of predetermined pulse beginning moments are defined. In another example embodiment, the flash pulse control information is received in two or more parts. For example, each pulse beginning

moment can be separately indicated. Such separate indications can be interpreted by the controller 230 as an indication of a new pulse beginning moment.

5 In an example embodiment, the controller 230 is configured to begin the first of the plurality of pulses as of the beginning of the exposure time. In practice, there can be a short delay after the beginning of the exposure time, e.g. some hundreds of microseconds, provided that the first pulse has sufficient time to expose image pixels in the first read-out line before that line will be read. With this regard, the sufficient time depends on the desired homogeneity of the exposure, the algorithms used for leveling
10 brightness over the exposed image frame and on the shape of the pulse when considered in a time – intensity graph i.e. on the intensity distribution.

In an example embodiment, the controller 230 is configured to end the last of the plurality of pulses before the end of the exposure time. For example, the controller 230
15 can be configured to cause timing the pulses such that they end on beginning of the read-out of first read-out lines of a band of read-out lines.

The exposure time can be varied based on the implementation. For example, the exposure time can be greater or equal to any of 5 ms, 10 ms, 20 ms or 25 ms. On the
20 other hand, the exposure time can be less or equal to 100 ms or 50 ms.

In an example embodiment, the plurality of pulses comprises two pulses that last for identical durations.

25 In an example embodiment, the image sensor is configured to expose each of the bands by the corresponding pulse before read-out of the lines in the band in question. To this end, the image sensor can be used in phases so that each band is reset, exposed using flash light and read one by one. In an example embodiment, additional illumination need is evaluated separately for each band and the energy of each pulse is correspondingly adjusted. For example, some of the bands may be correspond to
30 objects too far to benefit from flash light illumination. The controller 230 can be configured not to produce any pulse at all for such a band to save power. Conversely, some bands may correspond to light and proximate objects that would easily be over-exposed for which case the controller can be configured to reduce the energy of the
35 corresponding pulse or omit altogether the corresponding pulse.

In an example embodiment, the apparatus is a battery operated apparatus e.g. using a battery as a power supply. The capacitor 260 can be let to recharge after each pulse. However, it can be expected that with the battery power, the capacitor may lose

charging from one pulse to the next so that each pulse begins with lower intensity than the one before. To this end, each of the pulses can be configured to produce identical or corresponding energy. The different pulses can last for different times and correspondingly. Lower flash intensity and power (e.g. on following pulses when the capacitor is depleting) can be compensated by greater pulse duration so that the light energy from one pulse to next pulse or the end of the exposure time remains constant or substantially constant. The pulses can be configured to cause identical or corresponding exposure for each read-out line of the image sensor.

- 10 In an example embodiment, the flash unit 210 is further configured for external triggering for producing a single flash pulse that is stronger than those that can be produced by the simmering.

15 In an example embodiment, the apparatus is configured to enable reading out only a selected portion of the read-out lines of the image sensor so that the read-out time of the selected portion of the read-out lines is not greater than the pulse time of the externally triggered single flash pulse. For instance, apparatus can be configured to use the externally triggered single flash pulse when such a pulse is better suited for the photographing than one or more pulses produced by simmering.

20 In an example embodiment, the controller is further configured to determine operation characteristics of the flash unit 210. The controller 230 or another part such as a processor in the apparatus 200 can be configured to determine the pulse beginning moments taking into account of the determined operation characteristics. Moreover, information received from the image sensor can be used as such to detect evenness of brightness in entire image frames and that evenness information can be used in addition or instead of the operation characteristics to adapt the operation of the apparatus.

30 Fig. 3 shows an exemplary timing chart illustrating various events and intensities of pulses formed according to an example embodiment. The timing chart is greatly simplified so that there are only some tens of read-out lines to be reset and read in three different bands, each with about 20 read-out lines for illustrational reasons. In Fig. 3, a digital image is taken in three bands using three respective pulses in order to illustrate some example embodiments better than two bands or with more bands. It should be borne in mind that the number of pulses and bands can be adopted according to circumstances including, for example, the hardware configuration of the camera or image sensor and its read-out circuitry, the ambient light, and desired exposure. It should also be understood that the flash pulses drawn and explained with reference to

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Fig. 3 relate to taking a digital image and there may be other flash pulses before Fig. 3 process e.g. for any of focusing; red-eye reduction; and / or automatic exposure adjustment.

- 5 The flash pulse control information is obtained in step 310. Then, the pulse periods are determined 320. In order to start exposing the image sensor in a first band, resetting 330 of the read-out lines of the first band is carried out. This first band of read-out lines comprises e.g. one third of the read-out lines 242. A pulse is caused 340 using the flash unit 210 for exposing the first band or the portion of it that has been reset but not yet
10 read-out. In Fig. 3, the pulse is produced after the resetting 330 of the read-out lines of the first band is completed. The read-out of the first band is then started and carried out, 350. If Fig. 3, each pulse is produced to end just before read-out 350. If the common exposure time of all read-out lines 242 of one band of read-out lines 242 is not long enough for a pulse duration (e.g. capacitor depleted that far that a longer pulse would
15 be needed), the pulse can be let end after the read-out of first read-out lines and / or to start before the resetting of the last read-out lines of the band.

Fig. 3 makes clear an interesting aspect of some example embodiments. The exposure time of each read-out line equals to the time as of resetting to read-out. For example,
20 after resetting the first read-out line, some 19 other read-out lines are reset and then all the read-out lines have common exposure period that lasts for about 4 scan periods (time taken to read-out or reset one read-out line). Hence, the total exposure period is about 23 scan periods or line scan units as in the legend of the time axis of Fig. 3 out of which the common exposure period lasts about 17 %. If all the read-out lines of Fig. 3
25 were to be exposed by one pulse, then the exposure time would have to be at least 60 scan periods plus the pulse duration. Assume that the total read-out duration would be e.g. 20 ms, as the case could be with a high resolution image sensor of e.g. 40 Mpixels to 100 Mpixels. The exposure period should then be no shorter than 1/50 s, which would be too long for typical outdoors photographing with even little sunshine and usual
30 optics.

During (see Fig. 4) or after (as in Fig. 3) the read-out of the first band, resetting of a second band of read-out lines (adjacent to the first band) is started and carried out, 330', a second pulse (340') is formed (starting moment) after resetting all the read-out
35 lines of the second band and the read-out of the second band is carried out, 350'. There are different other embodiments with this respect. For example, Fig. 4 illustrates an example embodiment in which resetting of the next band's read-out lines is started immediately after each pulse used to expose the preceding band's read-out lines. In that example embodiment, all the desired read-out lines 242 can be read with little

additional delay. Further, Fig. 5 illustrates another example embodiment in which the pulses are produced a little before completion of resetting of a band of read-out lines.

Next, resetting 330", exposing 340 " and read-out 350" of a third band of read-out lines (adjacent to the second band) is performed correspondingly with the second band.

The process exemplified by Fig. 3 can be carried such that all the read-out lines (from which image information is needed) are read in succession line by line without pause and possibly with constant speed so that two or more pulses are formed with a timing that enables all the read-out lines to be exposed by at least one of the pulses.

In Figs. 3 and 4, the resetting of the read-out lines 242 of the image sensor 240 pauses for the pulse and read operations time or at least for the time of each pulse. However, in an example embodiment, the resetting of the read-out lines 242 proceeds continuously without pausing from the first to last read-out line that is desired to be read. Fig. 5 shows a modification of Figs. 3 and 4 according to such an example embodiment. In sake of clarity of the drawing, some of the texts are now omitted. In this example embodiment, some read-out lines 242 are illuminated partly by two different pulses. This effect can be at least partly compensated by software. In one example embodiment, the sensitivity (ISO value) of these pixels on these read-out lines is reduced e.g. by reducing their biasing so as to reduce risk of over-exposure.

Fig. 6 shows a process according to an example embodiment. The process comprises: obtaining 610 flash pulse control information; and controlling 620 according to the pulse control information a flash unit to produce a plurality of pulses interspersed at desired times during exposure of a digital image.

Without in any way limiting the scope, interpretation, or application of the claims appearing below, a technical effect of one or more of the example embodiments disclosed herein is that an entire digital image can be sufficiently flash-light illuminated even if the read-out time of the image sensor takes most of the exposure period. Another technical effect of one or more of the example embodiments disclosed herein is that flash light can be used with exposure periods shorter than the read-out time of all read-out lines. Another technical effect of one or more of the example embodiments disclosed herein is that motion can be better stopped in pictures taken with flash on an image sensor with relatively long read-out time. Yet another technical effect of one or more of the example embodiments disclosed herein is that it may be possible to avoid containing an automatic neutral density filter that might be needed to enable long

enough exposure when shooting against strong backlight that could otherwise be needed in advanced camera phones, for example.

5 Embodiments of the present invention may be implemented in software, hardware, application logic or a combination of software, hardware and application logic. The software, application logic and/or hardware may reside on the work memory or persistent memory of the apparatus 200. In an example embodiment, the application logic, software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a “computer-readable
10 medium” may be any non-transitory media or means that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer, with one example of a computer described and depicted in Fig. 2 (in the embodiment that the controller comprises a computer program code execution capable element). A
15 computer-readable medium may comprise a computer-readable storage medium that may be any media or means that can contain or store the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer.

20 If desired, the different functions discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the before-described functions may be optional or may be combined.

25 Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

30 It is also noted herein that while the foregoing describes example embodiments of the invention, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

WHAT IS CLAIMED IS

1. An apparatus comprising:
an input configured to obtain image flash pulse control information; and
5 a controller configured to receive the flash pulse control information and to accordingly control a flash unit to produce a plurality of pulses interspersed during exposure of a digital image.
2. The apparatus of claim 1, wherein the flash pulse control information comprises
10 an indication of a time at which each of the pulses should be produced.
3. The apparatus of claim 1 or 2, wherein the flash pulse control information comprises an indication of an amount of illumination energy with which each of the
15 pulses should be produced.
4. The apparatus of any of preceding claims, wherein the flash unit is controlled to emit light at least 500 times brighter at the peak of the pulses than at the lowest light emission between the pulses.
- 20 5. The apparatus of any of preceding claims, wherein each of the pulses is configured to produce identical or corresponding energy.
6. The apparatus of any of preceding claims, wherein the apparatus is a battery operated apparatus that comprises a battery as a power supply.
25
7. The apparatus of any of preceding claims, wherein the apparatus comprises an image sensor configured to take a digital image during the exposure time using flashlight produced by the flash unit.
- 30 8. The apparatus of claim 7, wherein the image sensor comprises numerous read-out lines.
9. The apparatus of claim 8, further configured to reset the read-out lines in two or more bands so that in each of the two or more bands, the image sensor is exposed
35 using one of the pulses.

10. The apparatus of claim 9, wherein the controller is configured to control the flash unit to produce each of the pulses during different time periods each of which different time periods overlaps with exposure periods of all read-out lines of one band.
- 5 11. The apparatus of claim 9 or 10, wherein the controller is configured to control the flash unit to produce each of the pulses after the first pulse to begin before and extend over the time on which the reading of the read-out lines of one of the bands begins.
- 10 12. The apparatus of any of claims 9 to 11, wherein the controller is configured to control the flash unit to produce each of the pulses before the last pulse to overlap over time on which the resetting of the read-out lines of one of the bands ends.
13. The apparatus of any of preceding claims, further comprising the flash unit.
- 15 14. The apparatus of claim 13, wherein the flash unit is a gas discharge flash unit capable of producing the plurality of pulses by simmer voltage triggering.
- 20 15. The apparatus of claim 13 or 14, wherein the flash unit is further capable of producing a single pulse by external triggering for producing a single flash pulse that is stronger than those that can be produced by the simmering.
- 25 16. The apparatus of claim 15 further configured to use the externally triggered single flash pulse when such a pulse is better suited for the photographing than one or more pulses produced by simmering.
- 30 17. The apparatus of any of preceding claims, wherein the apparatus is configured to enable reading only a selected portion of the read-out lines of the image sensor so that the read-out time of the selected portion of the read-out lines is not greater than the pulse time of the externally triggered single flash pulse.
18. A method comprising:
obtaining flash pulse control information; and
controlling according to the pulse control information a flash unit to produce a
35 plurality of pulses interspersed at desired times during exposure of a digital image.
19. The method of claim 18, wherein the flash pulse control information comprises an indication of a time at which each of the pulses should be produced.

20. The method of claim 18 or 19, wherein the flash pulse control information comprises an indication of an amount of illumination energy with which each of the pulses should be produced.

5

21. The method of any of claims 18 to 20, wherein each of the pulses is configured to produce identical or corresponding energy.

10

22. The method of any of claims 18 to 21, further comprising controlling an image sensor configured to take a digital image during the exposure time using flashlight produced by the flash unit.

15

23. The method of claim 22, wherein the image sensor comprises numerous read-out lines.

24. The method of claim 23, further comprising resetting the read-out lines in two or more bands so that in each of the two or more bands, the image sensor is exposed using one of the pulses.

20

25. The method of claim 24, further comprising controlling the flash unit to produce each of the pulses during different time periods each of which different time periods overlaps with exposure periods of all read-out lines of one band.

25

26. The method of claim 24 or 25, further comprising controlling the flash unit to produce each of the pulses after the first pulse to begin before and extend over the time on which the reading of the read-out lines of one of the bands begins.

30

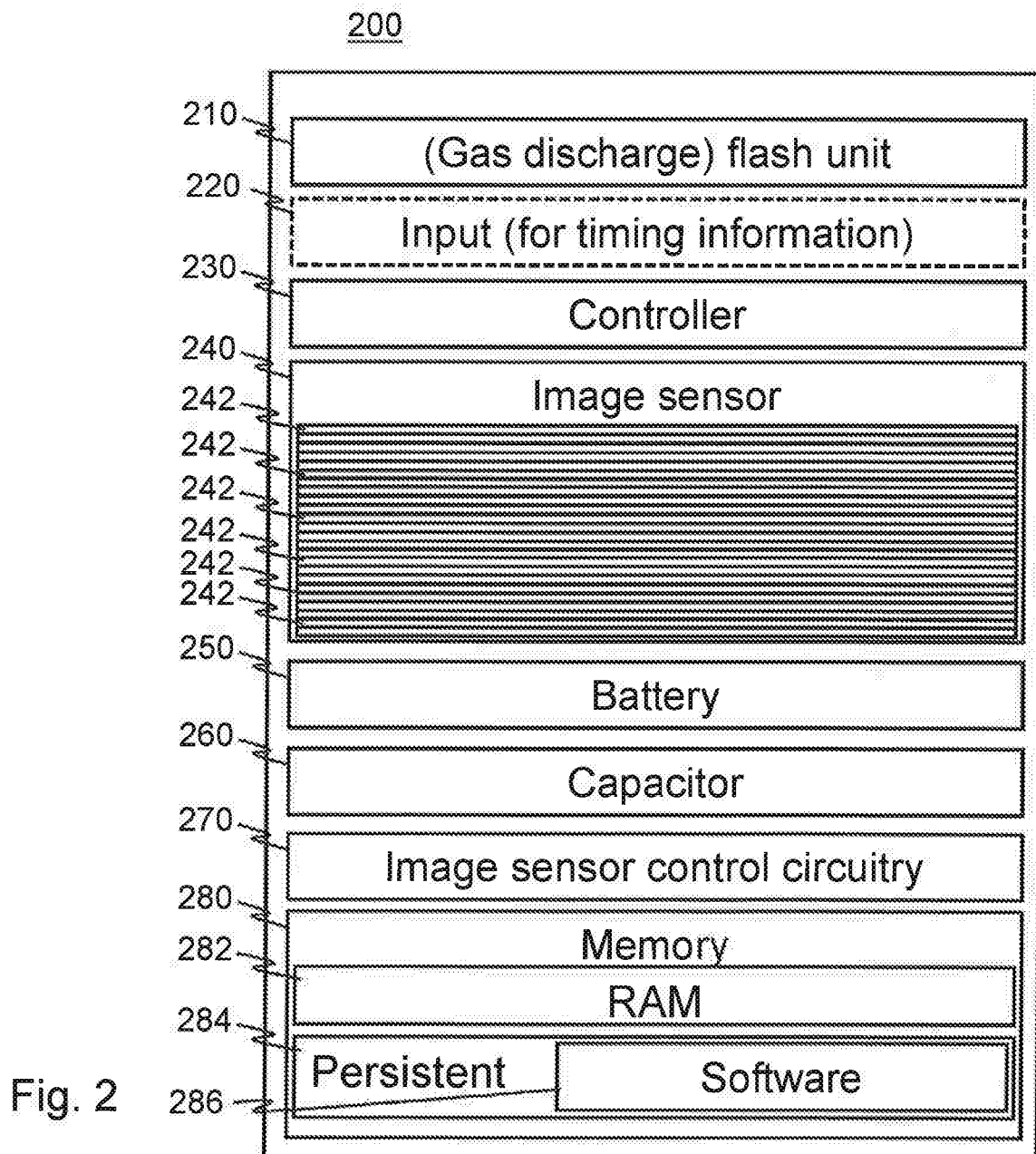
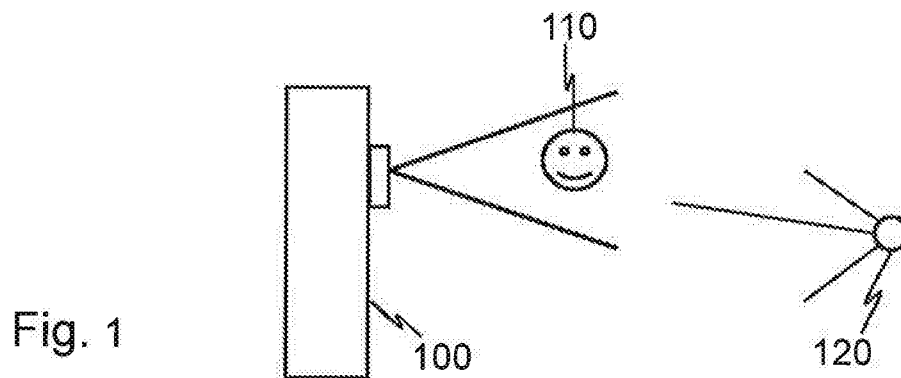
27. The method of any of claims 24 to 25, further comprising controlling the flash unit to produce each of the pulses before the last pulse to overlap over time on which the resetting of the read-out lines of one of the bands ends.

35

28. The method of any of claims 18 to 27, further comprising causing producing of a single externally triggered flash pulse and reading only a selected portion of the read-out lines of an image sensor so that the read-out time of the selected portion of the read-out lines is not greater than the pulse time of the externally triggered single flash pulse.

29. A computer program comprising computer executable program code configured to cause an apparatus perform, when executing the program code, the method of any of claims 18 to 28.

- 5 30. The computer program of claim 29, wherein the computer program is a computer program product comprising a computer-readable medium bearing computer program code embodied therein for use with a computer.



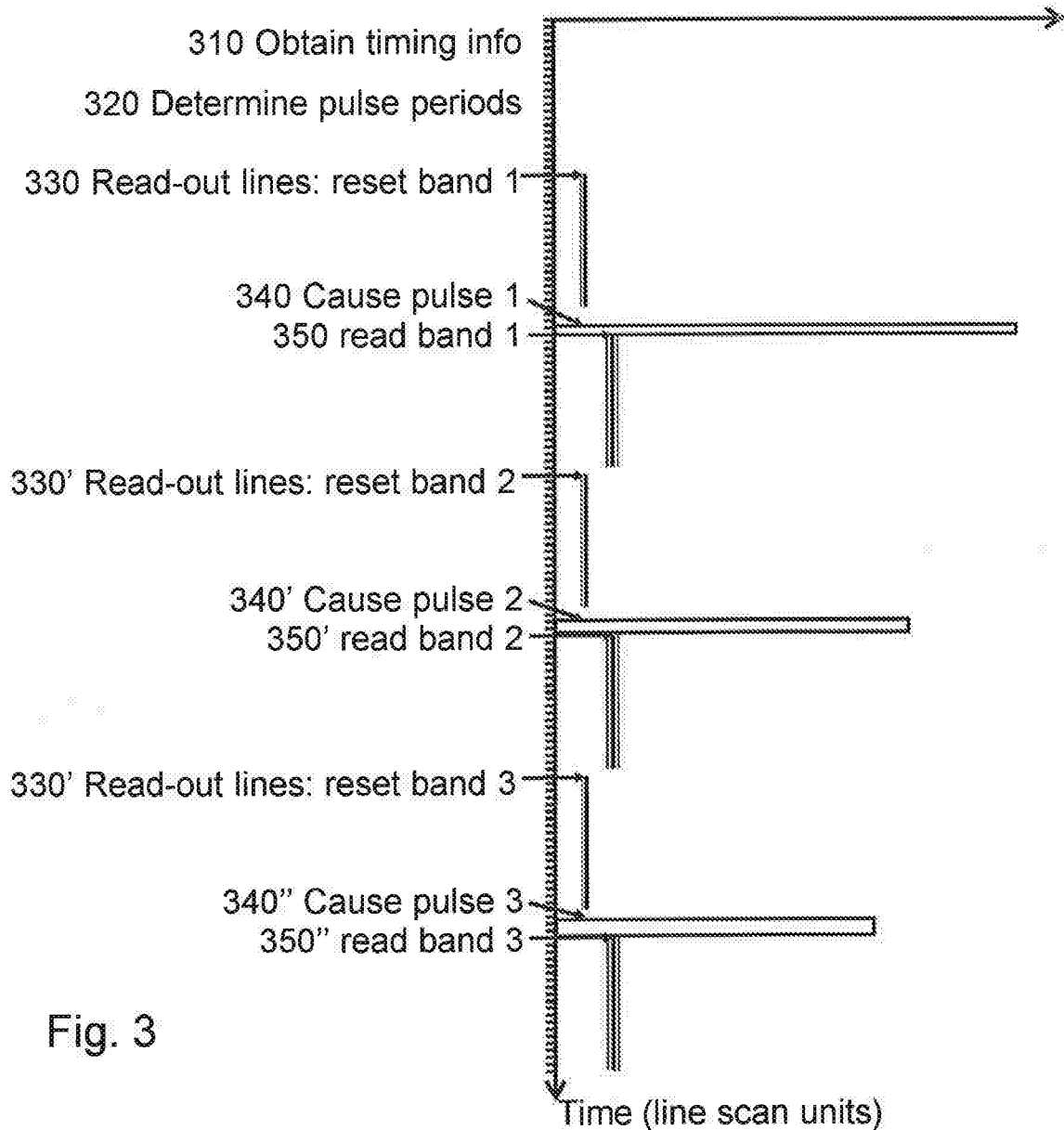


Fig. 3

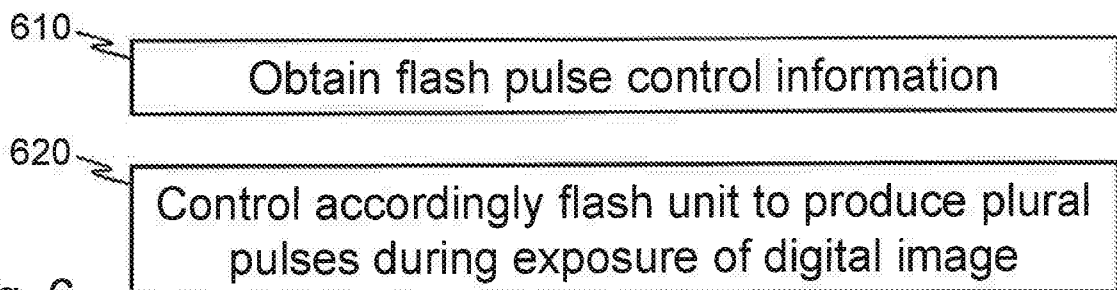


Fig. 6

3/3

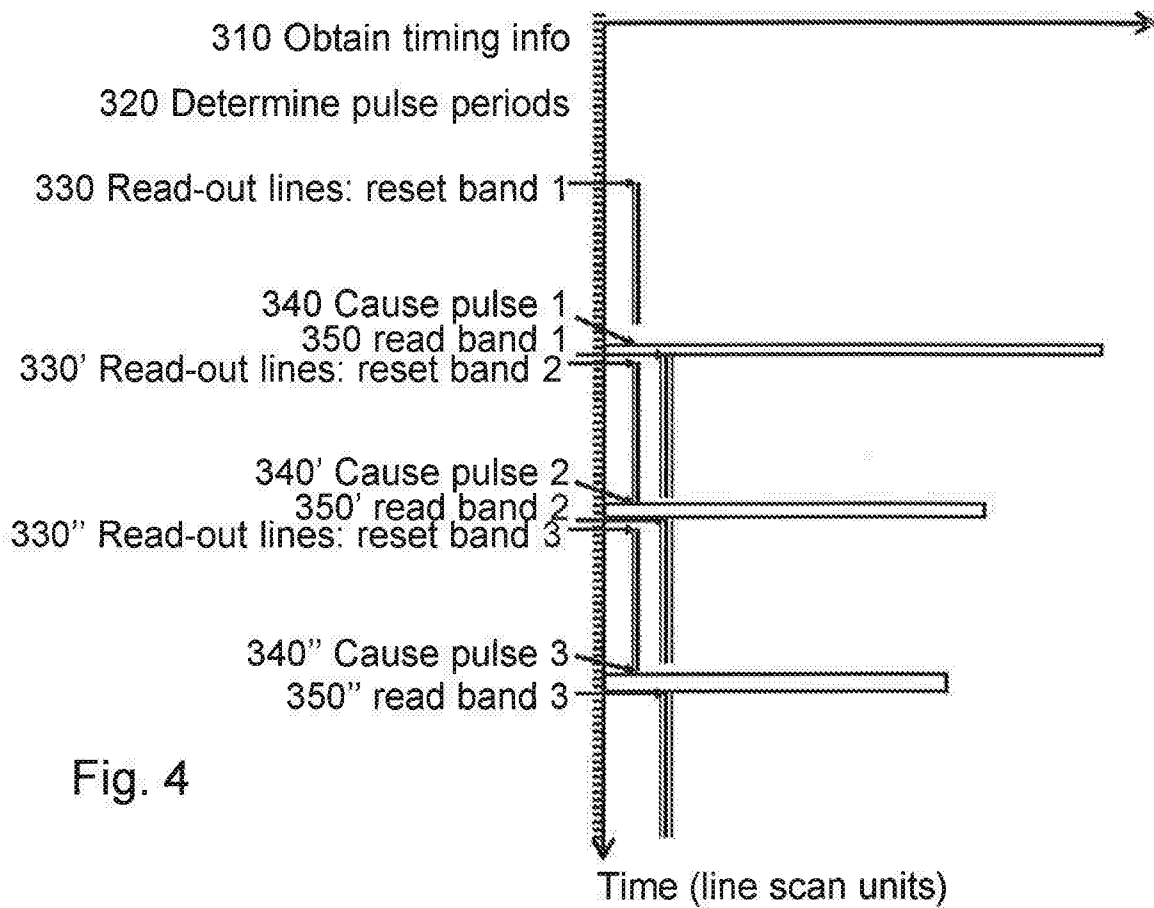


Fig. 4

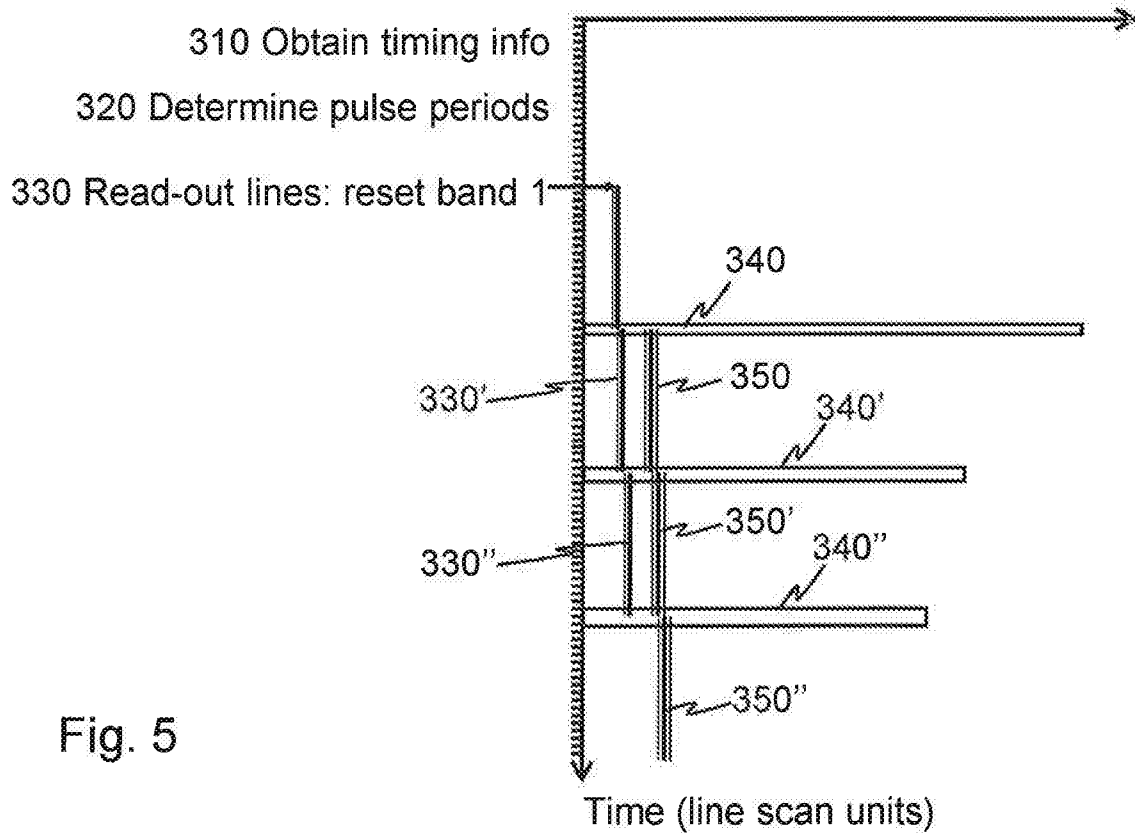


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2014/050027

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: G03B, G06T, H04N, H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base, and, where practicable, search terms used)

EPO-Internal, WPI, XPAIP, XPESP, XPESP2, XPETSI, XPI3E, XPIEE, XPIOP, XPOAC, XPRD, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011081142 A1 (TSAI RICHARD [US]) 07 April 2011 (07.04.2011) abstract; pars. [0005], [0014]-[0046]; claims; figs. 1, 2, 4, 5.	1-3, 18-20, 29-30
X	US 2002140845 A1 (YOSHIDA YUTAKA [JP] et al.) 03 October 2002 (03.10.2002) abstract; pars. [0012]-[0023], [0034]-[0090]; claims; figs. 1-9.	1, 5, 13, 18, 21, 29
X	US 2003007088 A1 (RANTANEN HENRY [FI] et al.) 09 January 2003 (09.01.2003) abstract; pars. [0001]-[0004], [0009], [0018]-[0029], [0031], [0038]-[0059]; claims; figs. 2, 3.	1, 4, 6-18, 22-29
A	US 2005218823 A1 (DOWE DAVID R [US]) 06 October 2005 (06.10.2005) entire document.	1-30

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

12 September 2014 (12.09.2014)

Date of mailing of the international search report

19 September 2014 (19.09.2014)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2014/050027

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ALMABOUADA, F. et al. 'Power supply for Xenon flash-lamp'. In Proceedings of International Seminar on Plasma Physics (SIPP 2011), UKM Ouargla, February 2011, pp. 250-254, paper pC2, entire document.	1-30
A	WO 8607515 A1 (EASTMAN KODAK CO [US]) 18 December 1986 (18.12.1986) entire document.	1-30

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2014/050027

CLASSIFICATION OF SUBJECT MATTER

IPC
G03B 15/03 (2006.01)
H04N 5/235 (2006.01)
H04N 5/335 (2011.01)
H05B 41/34 (2006.01)

INTERNATIONAL SEARCH REPORT
Information on Patent Family Members

International application No.
PCT/FI2014/050027

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