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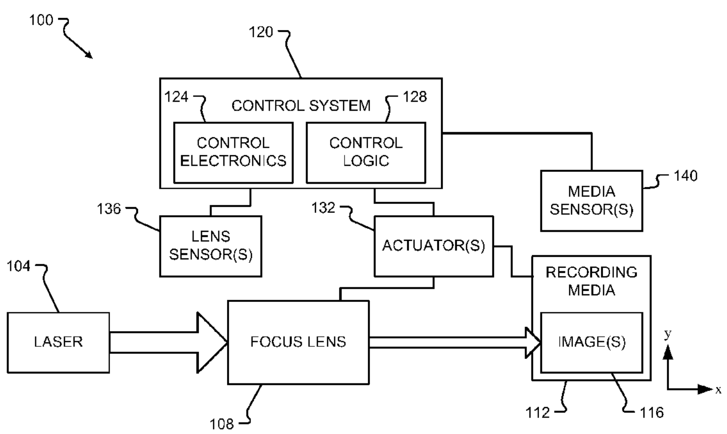

Fig. 1

(57) **Abstract**: An encoder and a method of operating an encoder is provided. The disclosed encoder includes a focus lens having one or more position sensors that enable the focus lens to maintain a focusing position, even when the focus lens is not focused on a writing media. The one or more position sensors enable the encoder to continue its encoding process without having to process a full focus acquisition each time the focus lens returns to the writing media.

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LASER ENCODER FOR SMALL METALLIC PATCHES AND METHOD OF OPERATING THE SAME

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefits of and priority, under 35 U.S.C. § 119(e), to U.S. Provisional Application Serial No. 61/944,662 filed February 26, 2014, which is incorporated herein by reference in its entirety for all that it teaches and for all purposes. The present application also claims the benefits of and priority, under 35 U.S.C. § 119(d), to Swiss Patent Application No. 01005/14 filed July 2, 2014, which is incorporated herein by reference in its entirety for all that it teaches and for all purposes.

FIELD OF THE INVENTION

[0002] The present invention is generally directed toward laser encoders and methods of producing encoded media with the same.

BACKGROUND

[0003] The use of identification documents and other credentials is pervasive. Credentials are used on a daily basis for a number of different purposes. Credentials are most commonly used to prove identity, to verify age, to access an asset (e.g., secure area, financial account, computing resource, etc.), to evidence driving privileges, to cash a check, and so on. Airplane passengers are required to show a credential during check in, and sometimes at security screening and prior to boarding their flight. We also live in an ever-evolving cashless society where credentials are used to make payments, access an automated teller machine (ATM), debit an account, or make a payment, etc. Many industries require that their employees carry photo identification credentials on the job and to access various locations on a job site.

[0004] The production of credentials, which may also be referred to herein as security documents, is required to continually evolve to thwart counterfeiting and the like. Many security documents are produced with embedded holograms, personalized laser perforations, and personalized holographic images. Examples of such technologies are described, for example, in U.S. Patent Nos. 7,140,540; 5,421,619; 4,814, 594, and 4,680,459, each of which are hereby incorporated herein by reference in their entirety. As the complexity of security features on these security documents increase, so too does the complexity and costs associated with producing the security features. The unfortunate side-effect is that security documents become more and more costly to the end consumer.

[0005] What is needed is a system and method of manufacturing security documents and, in particular, security features on security documents such that counterfeiting is effectively combated, without necessarily increasing the costs associated with producing the security features.

SUMMARY

[0006] It is, therefore, one aspect of the present invention to provide a system and method for producing security documents and the like. In some embodiments, an encoder is provided that is capable of producing security documents. In some embodiments, the encoder includes:

a laser configured to generate a laser beam of sufficient intensity to encode an image on a recording media that is established as a patch on a substrate;

a focus lens positioned between the laser and the substrate;

at least one actuator configured to move the focus lens toward and away from the substrate;

at least one sensor configured to determine a position of the focus lens within its range of motion as controlled by the at least one actuator; and

control electronics configured to receive a sensor input from the at least one sensor and, based at least in part on the sensor input, control the at least one actuator such that the focus lens maintains a substantially constant distance from the substrate as the focus lens moves beyond an edge of the recording media and before the focus lens moves back over the recording media during a sweep reversal.

[0007] It is another aspect of the present disclosure to provide a method for producing security documents and the like. In some embodiments, the method includes:

moving a focus lens of an encoder relative to a recording media in a first direction and while moving the focus lens of the encoder relative to the recording media in the first direction, causing the encoder to record one or more images on the recording media with a focused laser;

determining that the focus lens has moved beyond an edge of the recording media while moving in the first direction;

stepping the focus lens a predetermined distance in a direction substantially orthogonal to the first direction;

reversing a motion of the focus lens relative to the recording media such that the focus lens is moving back toward the recording media, but in a second direction that is opposite the first direction, wherein during at least one of the stepping and reversing

motion a position of the focus lens is measured with at least one sensor to ensure that the focus lens is maintained at a substantially constant displacement relative to the recording media surface;

determining that the focus lens has moved back over the recording media while moving in the second direction; and

while the focus lens is moving over the recording media in the second direction, causing the encoder to continue recording the one or more images on the recording media with the focused laser.

[0008] The present disclosure will be further understood from the drawings and the following detailed description. Although this description sets forth specific details, it is understood that certain embodiments of the invention may be practiced without these specific details. It is also understood that in some instances, well-known circuits, components and techniques have not been shown in detail in order to avoid obscuring the understanding of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present disclosure is described in conjunction with the appended figures, which are not necessarily drawn to scale:

[0010] Fig. 1 is a block diagram depicting an encoder in accordance with at least some embodiments of the present disclosure;

[0011] Fig. 2A is a first isometric view of a movable lens and a y-position sensor for the same in accordance with at least some embodiments of the present disclosure;

[0012] Fig. 2B is a second isometric view of the movable lens and y-position sensor depicted in Fig. 2A;

[0013] Fig. 2C is a third isometric view of the movable lens and y-position sensor depicted in Fig. 2A;

[0014] Fig. 2D is a front view of the movable lens and y-position sensor depicted in Fig. 2A;

[0015] Fig. 3A is a front view of the movable lens and a z-position sensor for the same in accordance with at least some embodiments of the present disclosure;

[0016] Fig. 3B is a first isometric view of the movable lens and z-position sensor depicted in Fig. 3A;

[0017] Fig. 3C is a second isometric view of the movable lens and z-position sensor depicted in Fig. 3A;

[0018] Fig. 3D is a third isometric view of the movable lens and z-position sensor depicted in Fig. 3A;

[0019] Fig. 4 is a block diagram depicting control circuitry for an encoder in accordance with embodiments of the present disclosure;

[0020] Fig. 5 is a state diagram depicting states implemented by a state machine of an encoder in accordance with embodiments of the present disclosure;

[0021] Fig. 6 is a flow diagram depicting an encoding method in accordance with embodiments of the present disclosure; and

[0022] Fig. 7 is a flow diagram depicting a method of controlling lens movement based on a Focus Error Signal (FES) in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0023] The ensuing description provides embodiments only, and is not intended to limit the scope, applicability, or configuration of the claims. Rather, the ensuing description will provide those skilled in the art with an enabling description for implementing the described embodiments. It being understood that various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the appended claims.

The Encoder

[0024] While embodiments of an encoder 100 will be described in connection with encoding images or the like on a recording media such as a security document, it should be appreciated that the encoder 100 can be utilized to encode any number of objects with a laser or some other focused radiation. In other words, embodiments of the present disclosure should not be construed as being limited to encoders for security documents.

[0025] The illustrative encoder 100 of Fig. 1 is shown to include a laser 104, a focus lens 108, recording media 112, and a control system 120 to control relative movements between the focus lens 108 and recording media 112. The control system 120 may be configured to move the focus lens 108 relative to the recording media 112 via one or more actuators 132 and based on control feedback information received from lens sensor(s) 136 and/or media sensor(s) 140. In other words, the control system 120 may be adapted to move the focus lens 108 relative to the recording media 112 in the x, y, and/or z direction, where the z-direction is orthogonal to the x-y plane depicted in Fig. 1 (e.g., into or out of the paper). As the focus lens 108 moves relative to the recording media 112, one or more images 116 are recorded on the recording media, potentially in the form of a security feature. It should be appreciated that the control system 120 may also control operations of the laser 104 (e.g., ON, OFF, intensity, etc.) so as to control the amount of energy focused by the focus lens 108 and eventually delivered to the recording media 112, thereby adjusting the depth with which the image(s) 116 are recorded and/or the locations of the image(s) 116 on the recording media 112.

[0026] The laser 104 may correspond to any type of light-emitting source capable of producing collimated light. The laser beam produced by the laser 104 may be directed toward the recording media 112, but with a focus lens 108 positioned between the laser 104 and the recording media 112. It should be appreciated that one or more optical elements (e.g., mirrors, prisms, other lenses, etc.) may also be positioned between the laser 104 and focus lens 108 and/or between the focus lens 108 and recording media 112. The focus lens 108 is used to adjust a location of radiation delivered to the recording media 112 in the x-y plane. Thus, the focus lens 108 can be movable in the x and/or y-direction and/or the recording media 112 can be movable in the x and/or y-direction (e.g., by being placed on a movable surface or table).

[0027] The focus lens 108 may also be movable relative to the recording media 112 in the z-direction so as to enable a focus of the laser energy delivered to the recording media 112. In other words, if the focus lens 108 is moved in the z-direction the focal point of the laser energy will adjust in the z-direction. The focus lens 108 may be positioned in the z-direction so as to place the focal point of the laser energy received from the laser 104 on the recording surface (e.g., a top surface) of the recording media 112. By focusing the laser energy on the recording surface of the recording media 112, the one or more images 116 may be produced.

[0028] In some embodiments, the position of the focus lens 108 relative to the recording media 112 can be determined by the control system using control feedback signals received from one or both of lens sensors 136 and/or media sensors 140. The control feedback signals may be received and processed by control logic 128 of the control system 120. Depending upon the material of the recording media 112, the strength of the laser 104, the energy included in the laser beam produced by the laser 104, the desired line width of the image(s) 116, the image design 116, and other factors, the control logic 128 uses the control feedback signals to determine how to move the focus lens 108 relative to the recording media 112.

[0029] The determination/output of the control logic 128 may be provided to control electronics 124 of the control system 120. The control electronics 124 may provide one or more control signals to the actuator(s) 132, thereby causing the focus lens 108 to move relative to the recording media 112 in the x, y, and/or z-direction. As will be discussed in further detail herein, the manner in which the focus lens 108 is moved relative to the recording media 112 may be specifically controlled to achieve quicker production times, more accurate images 116, and the like in an effort to reduce production costs and/or waste costs associated with poorly produced images 116.

The Scanning System

[0030] The disclosed encoder 100 records images on a small metallic patch (or any other recording media 112, which may be metallic or non-metallic), which is positioned on, attached to, or embedded in a card, for instance. The encoder 100 records the images on the patch by employing a focused high power laser beam to ablate pits in the metallic film of the patch. The image 116, in some embodiments, is recorded by scanning the beam in a raster across the film surface in a sweep forward (X) .. step (Y) .. sweep reverse .. step .. motion. The pits are recorded during the sweeps (e.g., writing tracks).

[0031] The focused laser beam is delivered to the patch surface by an optical head. The focusing lens 108 (objective) of the head may take on any form factor. One illustrative embodiment of a focusing lens 212 and head 200 (showing one example of lens 108) is shown in Figs. 2A-3D. The depicted embodiment of the focusing lens 212 is attached to the body/bobbin 224 of the optical head by a fine suspension 216, which allows the lens 212 to move in the focus direction (Z axis) as well as in the step direction (Y axis). The head 200 has one or more linear motor actuators 132 that apply forces on the lens 212 in the y and z-direction. The head provides the control logic 128 with a Focus Error Signal (FES), which is valid when the beam intercepts the reflective patch. The FES may be produced by a combination of a y-position sensor feedback and a z-position sensor feedback signal. The y-position sensor shown in Figs. 2A-2D may include a y-position light emitter 204, a y-position mask 208, and a y-position light detector 220. The z-position sensor shown in Figs. 3A-3D may include a z-position light emitter 304, a z-position mask 308, and a z-position light detector 320. A slot or aperture in the z-position mask 308 may be orthogonally-oriented relative to a slot or aperture in the y-position mask 208 (due to the orthogonal nature of the measured y and z-positions.

[0032] The sweeps are accomplished by moving the card, which is loaded and clamped onto a shuttle, rapidly back and forth. The steps are accomplished by moving the optical head body 224 in discreet steps (e.g., 96 microns per discreet step) with the suspension 216 and by moving the focusing lens 212 in fine steps (e.g., 25 nanometer resolution) with the suspension 216. A relatively uniform velocity is desirable when recording images to the small metallic patch so the beam is swept off the patch (in X only) during a normal recording.

[0033] In some embodiments, the laser beam is focused precisely on the patch surface for the laser 104 to deliver a sufficient energy density to the film to ablate a pit in the film. The control electronics 124 drive the Z-axis focus lens motor to maintain focus during the entire image write process. The encoder electronics (e.g., control electronics 124 and control logic 128) employs the FES generated by the optical head to do this. When the beam is off the patch, the FES signal is not available to the electronics. The absence of the FES signal complicates the focusing system as explained in detail herein below.

[0034] Accurate image recording requires precise displacement of the focusing lens in the y-direction. To accomplish this precise displacement, the lens y-position sensor is employed in the optical head 200. The y-position sensor utilizes, in one embodiment, an analog lens position signal that is generated by a bicell photodetector 220, or the like, which comprises two independent photo elements (e.g., two light detectors or photo diodes). The sensor signal is the difference in the current generated by each of the elements. The photo current is directly proportional to the intensity of the light generated by the light source 204, which passes through the rectangular slit of the mask 208 and falls on the elements of the detector 220. When the lens 212 is centered in its range of travel, the illumination falling on the elements is equal and the sensor signal is effectively zero. Y motion of the bobbin/lens/mask 200 results in an imbalance in the illumination and hence a non-zero signal. With a precise choice of mechanical dimensions, the sensor will generate a linear signal over the ± 48 microns employed by the scanning system.

<u>The Focus System</u>

[0035] The focus system is configured to constantly maintain the best focus position of the laser beam within a few microns of patch film surface while the encoder is writing an image 116. This is a common requirement for disk oriented optical memory devices such CD, DVD and Blu-Ray players. Unlike these devices, however, the encoder 100 maintains focus even though the beam is departing from the media surface at the end of each sweep. There is no time for focus to be reacquired when the beam returns to the media surface (e.g., back to the small metallic patch) so the lens 212 is configured to be held at its z-position when the beam departed the patch until it returns to the patch where a valid FES is once again available.

[0036] In order to hold the lens focus position, it is desirable to have a measure of the lens position in the z-direction. For this reason, the z-sensor signal is incorporated in the optical head 200. This z-position sensor is similar y-position sensor and operates under the same principle (e.g., with the use of a bi-cell photodetector 320, mask 308, and light source 304), except that the rectangular slot or aperture of the z-position mask 308 is configured orthogonal to the rectangular slot or aperture of the y-position mask 208 (e.g., the long dimension of one slot is orthogonal to the long dimension of the other slot). The z-position sensor can have a ±0.5 mm range but some non-linearity can also be tolerated.

[0037] A block diagram of the focus system control electronics 124 is shown in Fig. 4. The focus system operates with two servo systems that drive the focus lens z-linear motor actuator. They are referred to in the following text as the focus loop and the hold loop. A switch determines which of the loops is closed (e.g., active). During an image write operation, when the beam is over the patch and the FES signal is valid, the focus loop is closed (e.g., active); otherwise, the hold loop is closed (e.g., active). When focus loop is closed/active the servo attempts to keep the FES signal at a zero level. The optics of the optical head that generate this signal ensure that a zero level does indeed correspond to a best focus condition on the patch.

[0038] When the focus hold loop is closed/active, the lens position 212 is determined directly by the DAC value at the summing junction. The focus hold loop algorithm implemented in the control system 120 of the encoder 100 operates under the following assumptions:

- Only two DAC values are managed during an image write, the DAC value holding the lens when the beam is to the left of the patch and the DAC value holding the lens when the beam is to the right of the patch.
- The two DAC values are determined during an initial focus acquisition, which may be performed during manufacture of the encoder itself or during installation of the encoder.
- The DAC values are adjusted during each Y step.
- The two DAC values can differ significantly from each other.
- During an image write operation the beam is always moved in very small steps in Y between tracks.
- An image is only written on new cards where the card and patch are expected to be very flat when mounted on the encoder shuttled that sweeps the card. As such the DAC values need to change only 1 or 2 bits between tracks.

- The electronics measures the card shuttle position thus the beam position on the card is known to a high precision at all times.
- The electronics knows when the beam is over the patch and a valid FES signal is available.

[0039] Given that the focus hold DAC changes are small during an image write a rate limited control strategy is adopted. This means that only the direction of DAC change need be determined, not the magnitude. The system is more robust and can tolerate large disruptions of the FES signal. Also, the linearity requirements on the Z sensor optics are alleviated.

[0040] The focus system is controlled by a state machine, a non-limiting example of which is shown in Fig. 5. The nomenclature for the illustrative state machine is as follows:

- Z(R,F): measurement of the z sensor signal at the right edge of patch with the focus loop closed
- Z(R,H): measurement of the z sensor signal at the reversal with the focus loop open
- Z(L,F): measurement of the z sensor signal at the left edge of patch with the focus loop closed
- Z(L,H): measurement of the z sensor signal at the reversal with the focus loop open
- DAC(R): the DAC value used for the focus hold loop at the right side of the patch
- DAC(L): the DAC value used for the focus hold loop at the left side of the patch

Focus Hold

[0041] One method of encoding one or more images on a recording media 112 is shown in Fig. 6. The encoder 100, in some embodiments, sweeps the focused laser beam rapidly across the recording media (e.g., small metallic patch) (step 604), and off the media when reversing direction (step 608, 612, and 616). The beam spot is very small and is moved in the Z axis (e.g., normal to the media plane) to follow the contours of the patch surface. The encoder does this by employing an analog servo that utilizes a FES derived from the optical head. As mentioned above, the problem is that the error signal goes to 0 when the beam moves off the media as it does during normal sweeps of an image write. If focus is lost at sweep turn around, there is no time to reacquire focus when the beam returns to the patch.

[0042] One solution to this problem is to hold the focusing lens position constant at its on-patch where it moves off the patch (step 620). Focus will then be maintained when the beam returns to the patch at the same position it left from. This can mean holding the lens 212 in place along the z-axis. This is preferably done by employing a sensor 136 that can accurately measure the lens 212 position in a servo loop. The z-position of the lens 212 is maintained until it is determined that the lens 212 has moved back over the recording media (step 624). In some embodiments, this determination is made in response to detecting a valid FES signal. With the lens 212 positioned back over the recording media, the image(s) 116 can continue to be recorded on the media (step 628).

<u>Laser Beam Y Positioning</u>

[0043] The encoder of the present disclosure receives no position information from the card and, thus, is forced to position the laser beam open loop. In the y-direction (e.g., cross track), beam motion is accomplished by moving the optical head and moving the focusing lens side-to-side (see above). In some embodiments, head motion employs a glass scale to measure displacement. The scale measurement is accurately referenced to the card shuttle. The scale provides an accurate reference point every 96 microns. Beam motion between the reference points is provided by the focusing lens. The lens 212 position is controlled by a servo using the lens y-position sensor 136 for feedback. Over the 96 microns, the sensor signal is very linear and repeatable. A DAC under processor control can be employed to inject a lens offset command into the loop. The loop is calibrated by inspection of a written calibration image.

<u>Patch Detection – Basic Media</u>

[0044] The encoder 100 disclosed herein can accurately position the beam relative to the shuttle reference stops. If a card or other type of recording media 112 is loaded such that the card edges are accurately referenced against the stops then the beam can be accurately positioned relative to the card edges. Experience with certain types of encoders suggest that accurate registration occasionally fails to occur.

[0045] The nominal position of the patch on the card is known to the encoder 100 via the image file loaded by the host into encoder memory. The variation of patch position relative to the reference card edges has yet to be specified.

[0046] A typical image is written in the center of the patch. Any misalignment between image and patch is easily detected and is most likely displeasing to the card holder. As such, it is useful that the encoder 100 can measure the actual position of the patch. Assuming the patch to be accurate in size, it is possible to measure the patch position by measuring it at two points. For basic media, if one edge of the patch runs parallel to the sweep direction and another edge is perpendicular, then the encoder can measure the patch position by detecting these edges. The basic media exhibits a marked discontinuity in reflectance at the edges, which the encoder can easily detect.

[0047] Detection of the edge running perpendicular to the sweep direction is easy. Moving off the patch in the track-to-track direction is more problematic as focus is lost for an extended period of time. Fortunately, the focus hold method disclosed easily accommodates long periods of lost focus.

<u>Patch Detection – Premium Media</u>

[0048] Premium media can have an undefined holographic border, which basically means that the patch edges are undefined, and therefore cannot in general be reliably detected. Fortunately, the encoder can detect fine (e.g., hardly visible) holographic features in the recording area. By knowing the expected location of a holographic feature, the encoder can detect the media edge and compare the beam location at detection against the expected location. Thus, a patch position error can be detected and the target position of the image adjusted to center the image on the patch.

[0049] With reference to Fig. 7, additional details of how the FES signal can be used to determine whether the lens 212 is positioned above a recording media or not will be described in accordance with embodiments of the present disclosure. The method begins by obtaining a FES signal as the lens 212 moves during a sweep (step 704). The movement of the lens 212 relative to the recording media 112 eventually moves the lens 212 away from the edge of the recording media 112, thereby resulting in the FES becoming invalid. Upon determining that the FES is invalid (step 708), the method proceeds by correlating the invalid FES to a determination that the lens 212 has moved beyond the edge of the recording media 112 (step 712). While the FES is invalid, the z-position sensor is used to control movement (or restrict movement) of the lens 212 in the focus direction (step 716).

[0050] In the foregoing description, for the purposes of illustration, methods were described in a particular order. It should be appreciated that in alternate embodiments, the methods and steps thereof may be performed in a different order than that described. It should also be appreciated that the methods described above may be performed by hardware components or may be embodied in sequences of machine-executable instructions, which may be used to cause a machine, such as a general-purpose or special-purpose processor or logic circuits programmed with the instructions to perform the methods. These machine-executable instructions may be stored on one or more machine readable mediums, such as CD-ROMs or other type of optical disks, floppy diskettes, ROMs, RAMs, EPROMs, EEPROMs, SIMs, SAMs, magnetic or optical cards, flash memory, or other types of machine-readable mediums suitable for storing electronic instructions. Alternatively, the methods may be performed by a combination of hardware and software.

[0051] Specific details were given in the description to provide a thorough understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that the embodiments may be practiced without these specific details. For example, circuits may be shown in block diagrams in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures, and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

[0052] Also, it is noted that the embodiments were described as a process which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process is terminated when its operations are completed, but could have additional steps not included in the figure. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination corresponds to a return of the function to the calling function or the main function.

[0053] Furthermore, embodiments may be implemented by hardware, software, firmware, middleware, microcode, hardware description languages, or any combination thereof. When implemented in software, firmware, middleware or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine readable medium such as storage medium. A processor(s) may perform the necessary tasks. A code segment may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

[0054] While illustrative embodiments of the disclosure have been described in detail herein, it is to be understood that the inventive concepts may be otherwise variously embodied and employed, and that the appended claims are intended to be construed to include such variations, except as limited by the prior art.

What Is Claimed Is:

1. An encoder, comprising:

a laser configured to generate a laser beam of sufficient intensity to encode an image on a recording media that is established as a patch on a substrate;

a focus lens positioned between the laser and the substrate;

at least one actuator configured to move the focus lens toward and away from the substrate;

at least one sensor configured to determine a position of the focus lens within its range of motion as controlled by the at least one actuator; and

control electronics configured to receive a sensor input from the at least one sensor and, based at least in part on the sensor input, control the at least one actuator such that the focus lens maintains a substantially constant distance from the substrate as the focus lens moves beyond an edge of the recording media and before the focus lens moves back over the recording media during a sweep reversal.

2. The encoder of claim 1, further comprising:

a state machine comprising a first state and a second state, the first state corresponding to a state where a focus loop is active due to the focus lens being positioned over the recording media, the second state corresponding to a state where a hold loop is active due to the focus lens not being positioned over the recording media.

3. The encoder of claim 2, wherein state machine is switched between the first and second states based on a Focus Error Signal (FES).

4. The encoder of claim 3, wherein the first state corresponds to a state where the FES is valid and wherein the second state corresponds to a state where the FES is invalid.

5. The encoder of claim 1, wherein the at least one sensor comprises a light source and a bicell detector that includes at least two light-detecting elements, wherein each of the at least two light-detecting elements receive light from the light source and a comparison of the signals from each of the at least two light-detecting elements is used to generate the sensor input provided to the control electronics.

6. A method, comprising:

moving a focus lens of an encoder relative to a recording media in a first direction and while moving the focus lens of the encoder relative to the recording media in the first direction, causing the encoder to record one or more images on the recording media with a focused laser;

determining that the focus lens has moved beyond an edge of the recording media while moving in the first direction;

stepping the focus lens a predetermined distance in a direction substantially orthogonal to the first direction;

reversing a motion of the focus lens relative to the recording media such that the focus lens is moving back toward the recording media, but in a second direction that is opposite the first direction, wherein during at least one of the stepping and reversing motion a position of the focus lens is measured with at least one sensor to ensure that the focus lens is maintained at a substantially constant displacement relative to the recording media surface;

determining that the focus lens has moved back over the recording media while moving in the second direction; and

while the focus lens is moving over the recording media in the second direction, causing the encoder to continue recording the one or more images on the recording media with the focused laser.

7. The method of claim 6, wherein the recording media comprises a metallic patch.

8. The method of claim 7, wherein the metallic patch comprises a holographic feature.

9. The method of claim 6, wherein the at least one sensor comprises a light source and at least two light detectors, each of which generate a photo current that are compared to one another to determine a location of the focus lens along its range of travel.

10. The method of claim 6, further comprising:

obtaining a Focus Error Signal (FES) as the focus lens moves in the first direction and the second direction;

determining that the FES is invalid;

correlating the invalid FES to the determination that the focus lens has moved beyond the edge of the recording media; and

while the FES is determined to be invalid, using the at least one sensor to control movement of the focus lens in a focus direction.

11. The method of claim 10, further comprising:

implementing a state machine that operates control electronics of the encoder, wherein the state machine switches between at least one state where a focus loop is active and at least one state where a hold loop is active, wherein the focus loop is active when the FES is valid, and wherein the hold loop is active when the FES is invalid.

12. The method of claim 11, wherein the control electronics of the encoder control one or more servo motors that move the focus lens and wherein the control electronics control the one or more servo motors in an attempt to keep the FES signal at a 0 level when the focus loop is active.

13. The method of claim 12, wherein the control electronics implement a focus hold loop algorithm when the focus loop is active.

14. The method of claim 13, wherein the focus hold loop algorithm only determines a direction of a Digital-to-Analog Converter (DAC) signal output and not a magnitude of the DAC signal output.

15. The method of claim 6, wherein the recording media comprises a metallic patch attached to a plastic card.

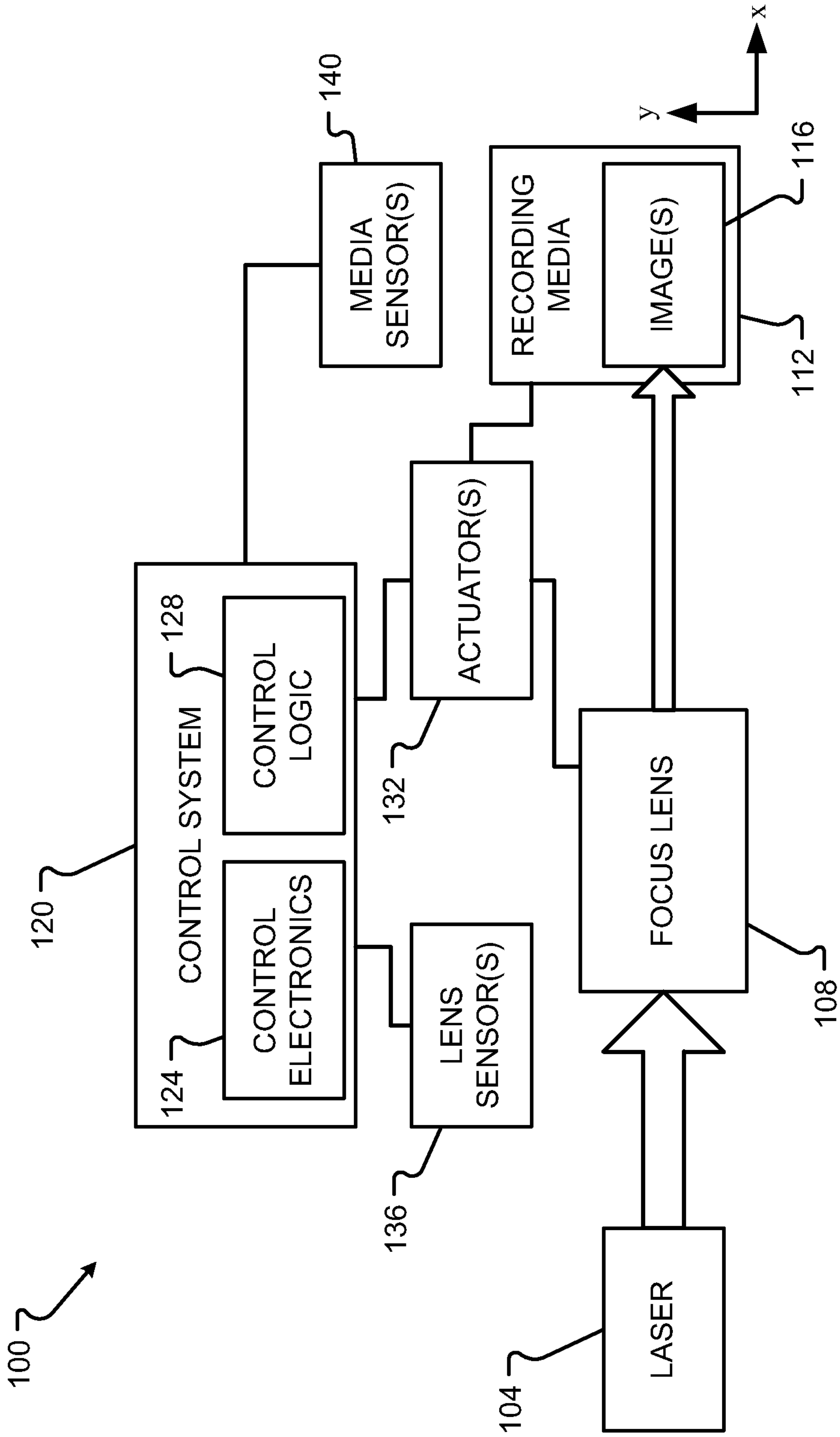
100
LASER
104
FOCUS LENS
108
RECORDING MEDIA
112
IMAGE(S)
116
CONTROL SYSTEM
120
CONTROL ELECTRONICS
124
CONTROL LOGIC
128
ACTUATOR(S)
132
LENS SENSOR(S)
136
MEDIA SENSOR(S)
140
x
y

Fig. 1

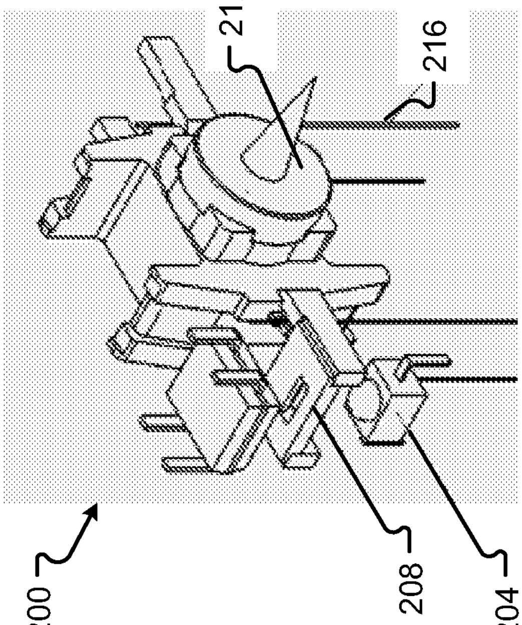

Fig. 2A

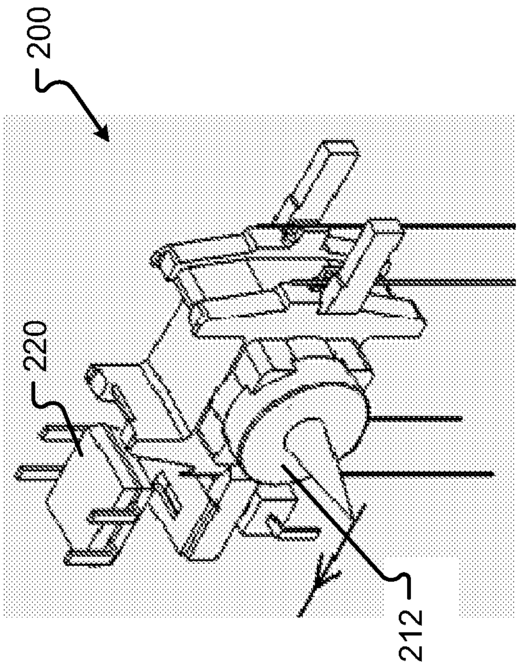

Fig. 2B

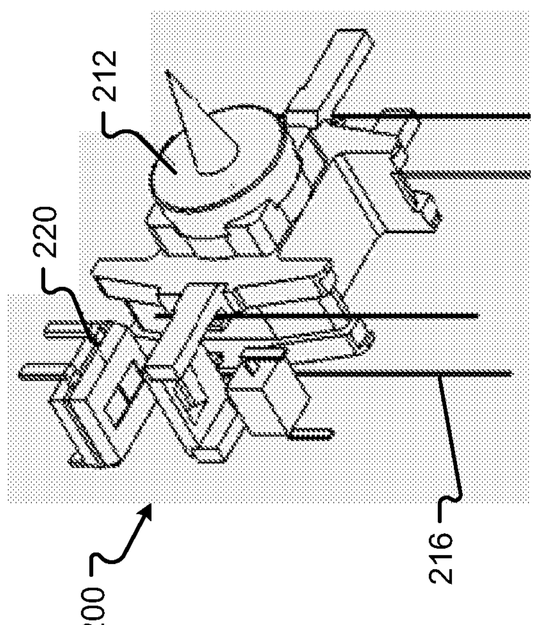

Fig. 2C

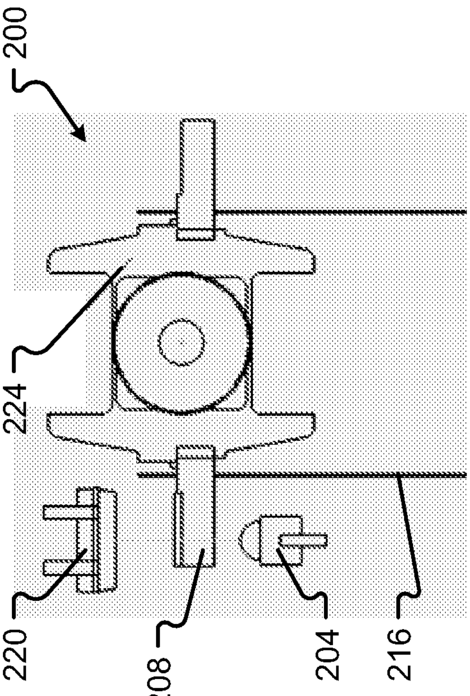

Fig. 2D

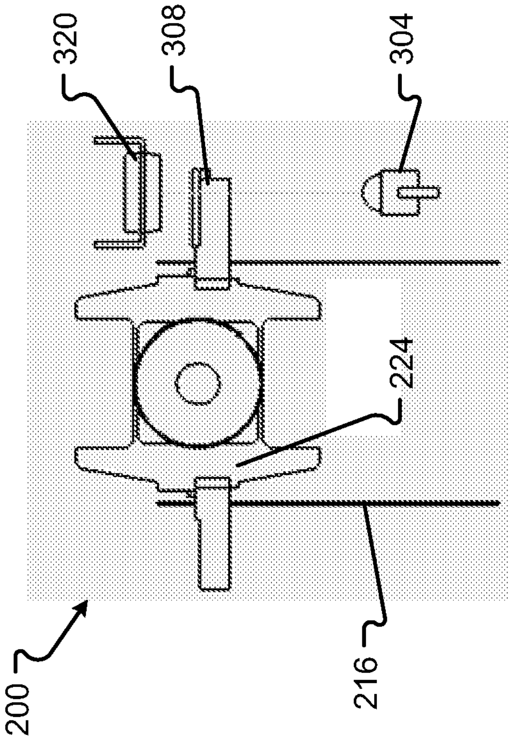

Fig. 3A

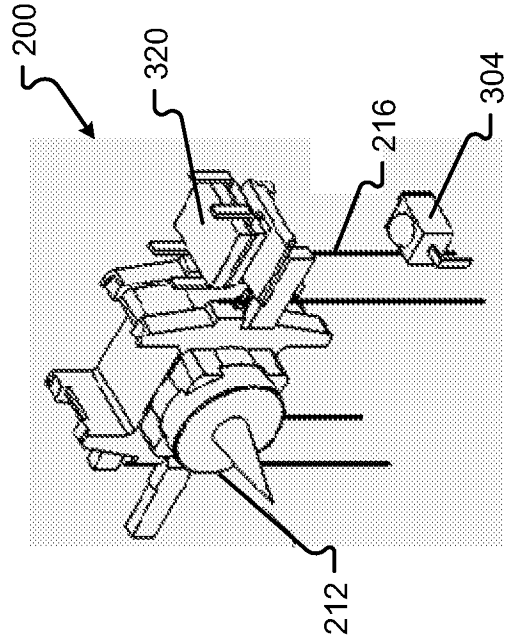

Fig. 3B

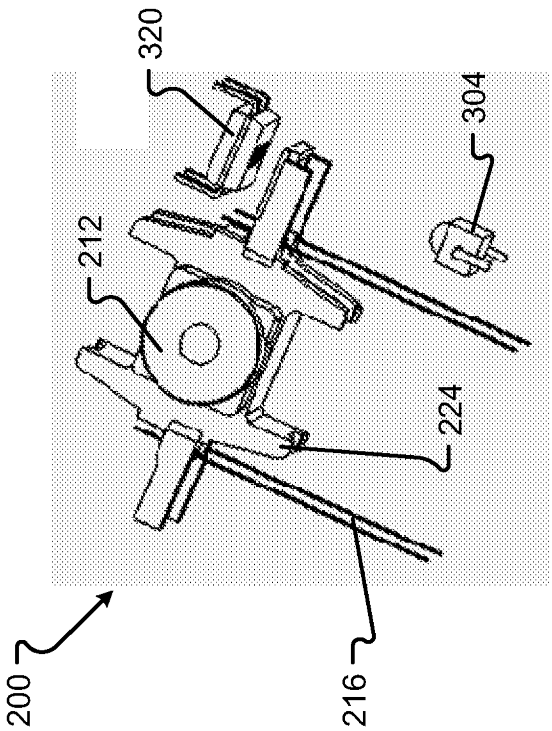

Fig. 3C

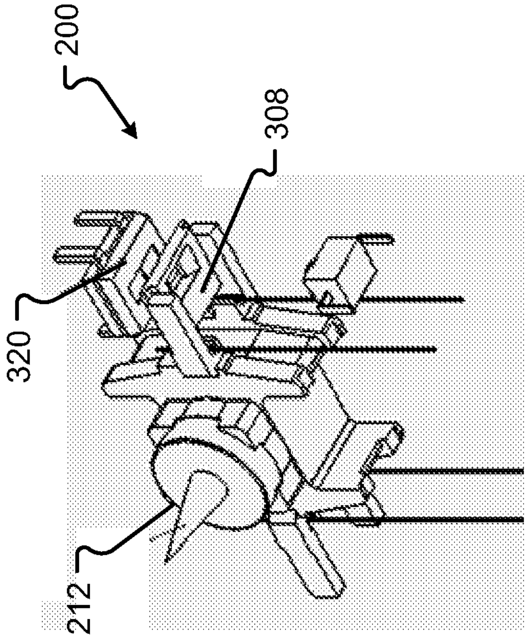

Fig. 3D

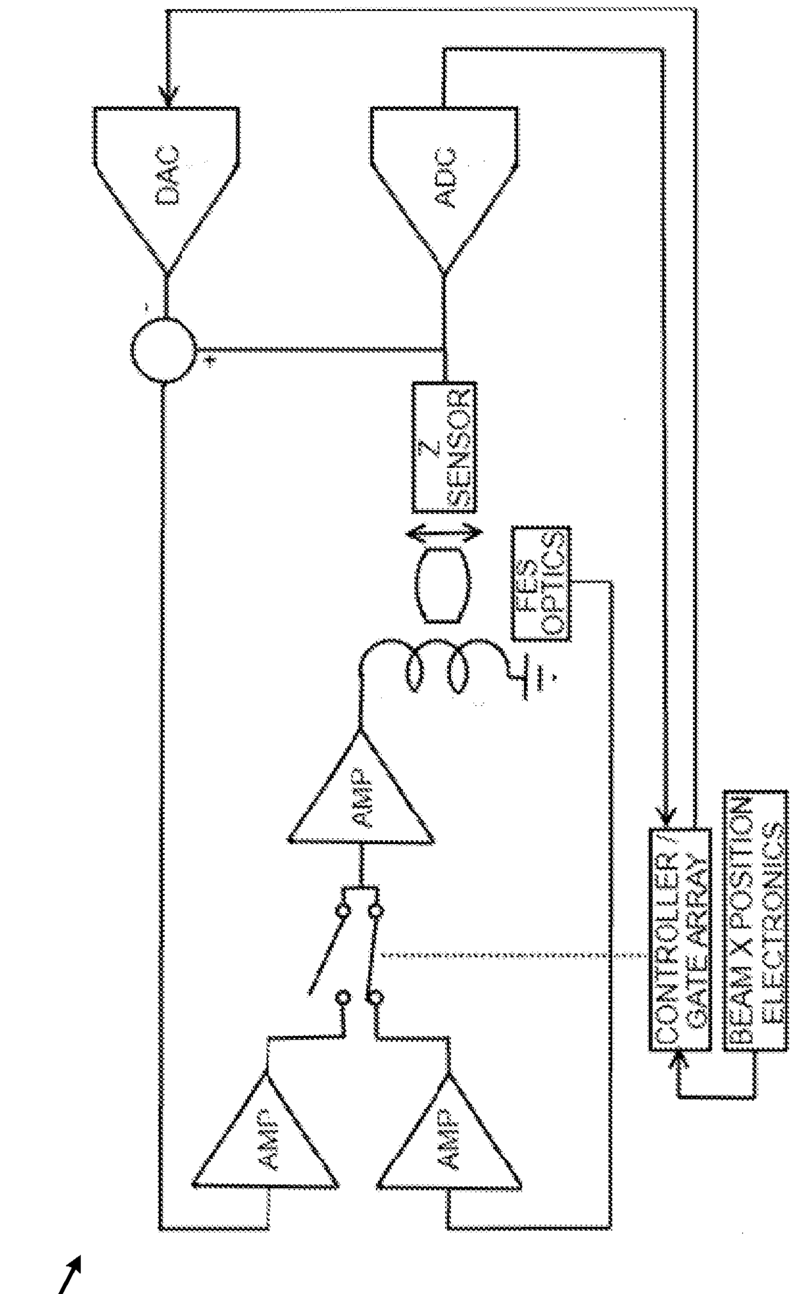
DAC
ADC
Z SENSOR
FES OPTICS
AMP
AMP
AMP
CONTROLLER / GATE ARRAY
BEAM X POSITION ELECTRONICS
400

Fig. 4

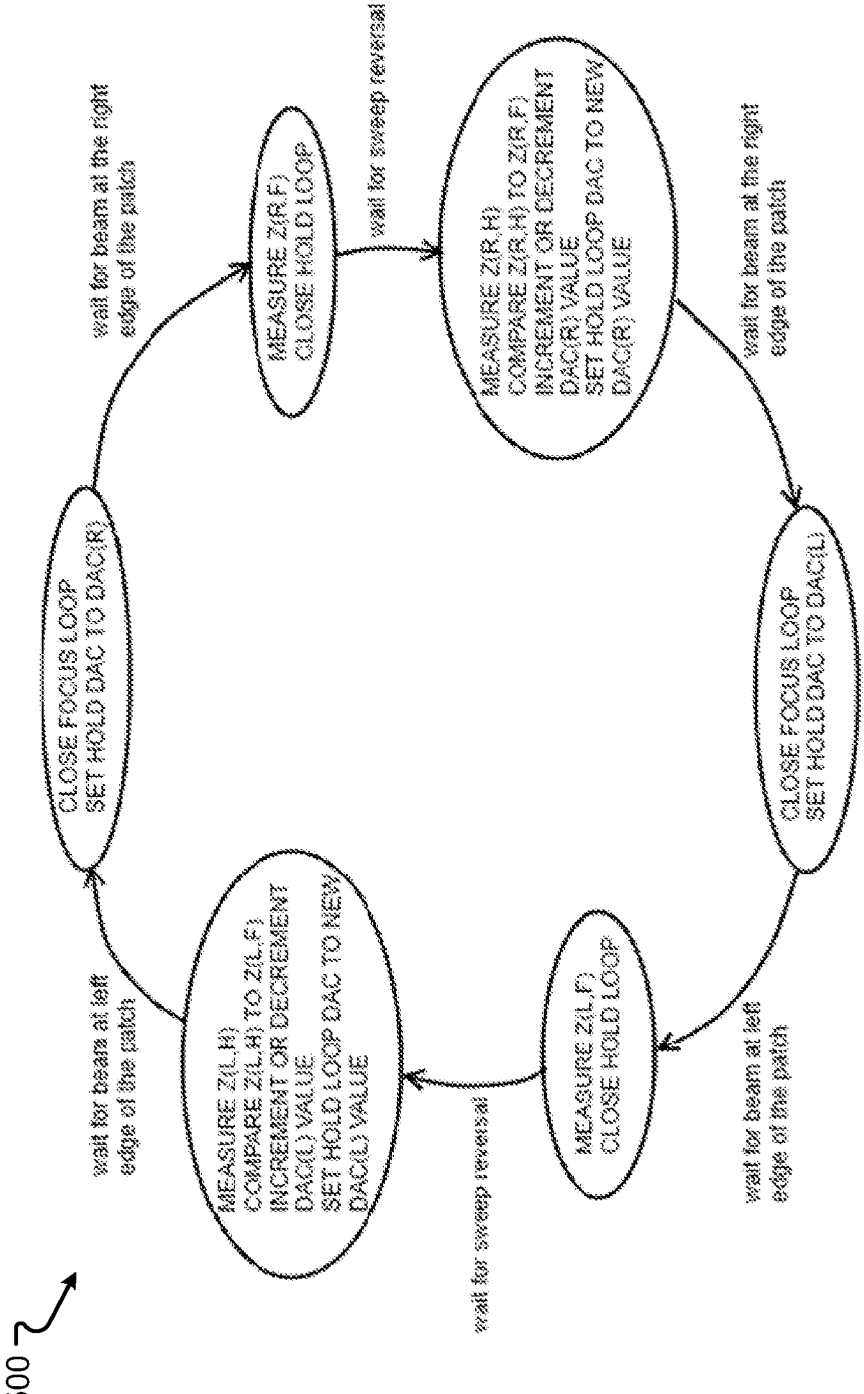
500
wait for beam at the right edge of the patch
MEASURE Z(R,F)
CLOSE HOLD LOOP
wait for sweep reversal
MEASURE Z(R,H)
COMPARE Z(R,H) TO Z(R,F)
INCREMENT OR DECREMENT DAC(R) VALUE
SET HOLD LOOP DAC TO NEW DAC(R) VALUE
wait for beam at the right edge of the patch
CLOSE FOCUS LOOP
SET HOLD DAC TO DAC(L)
wait for beam at left edge of the patch
MEASURE Z(L,F)
CLOSE HOLD LOOP
wait for sweep reversal
MEASURE Z(L,H)
COMPARE Z(L,H) TO Z(L,F)
INCREMENT OR DECREMENT DAC(L) VALUE
SET HOLD LOOP DAC TO NEW DAC(L) VALUE
wait for beam at left edge of the patch
CLOSE FOCUS LOOP
SET HOLD DAC TO DAC(R)

Fig. 5

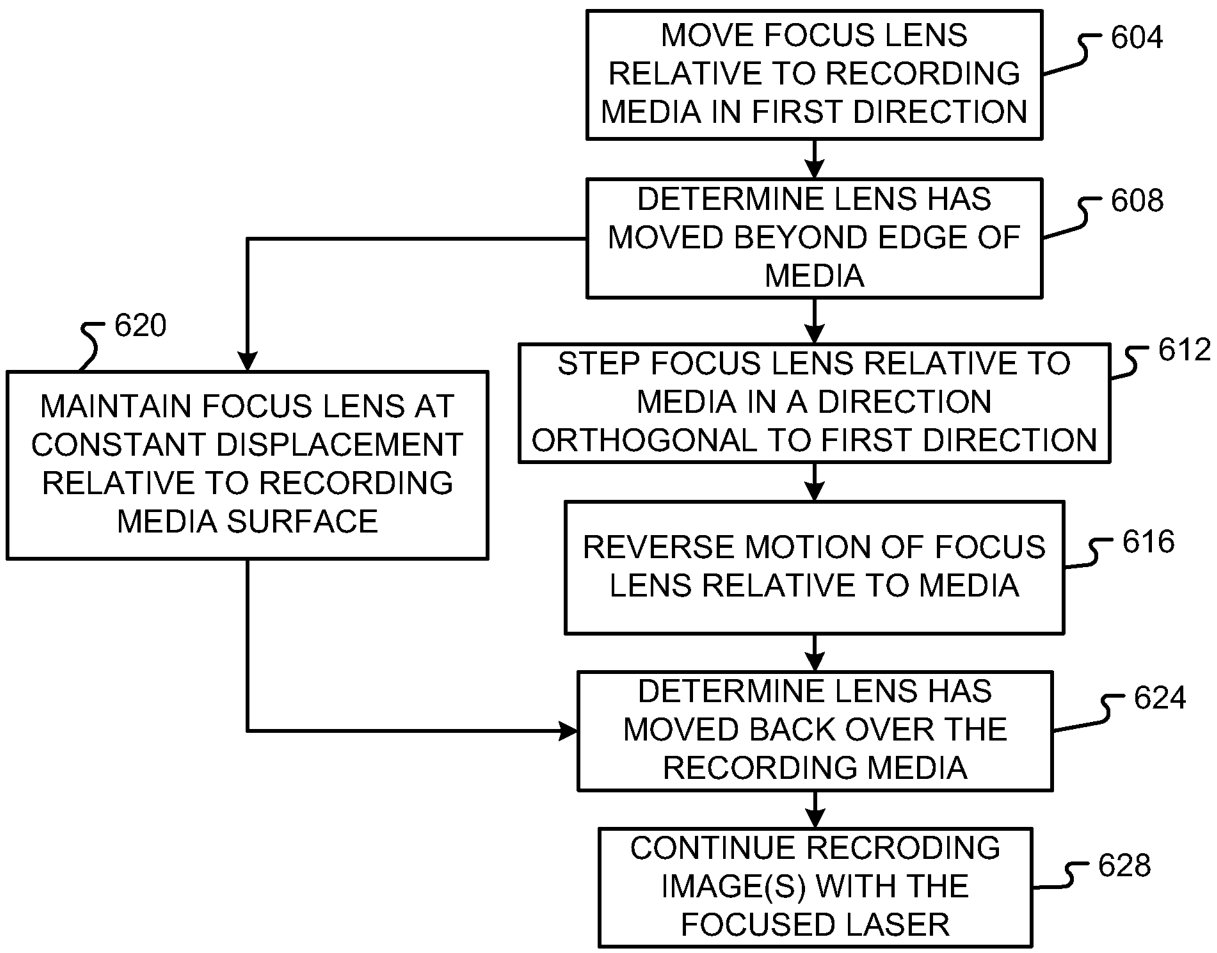
MOVE FOCUS LENS RELATIVE TO RECORDING MEDIA IN FIRST DIRECTION
604
DETERMINE LENS HAS MOVED BEYOND EDGE OF MEDIA
608
STEP FOCUS LENS RELATIVE TO MEDIA IN A DIRECTION ORTHOGONAL TO FIRST DIRECTION
612
620
MAINTAIN FOCUS LENS AT CONSTANT DISPLACEMENT RELATIVE TO RECORDING MEDIA SURFACE
REVERSE MOTION OF FOCUS LENS RELATIVE TO MEDIA
616
DETERMINE LENS HAS MOVED BACK OVER THE RECORDING MEDIA
624
CONTINUE RECRODING IMAGE(S) WITH THE FOCUSED LASER
628

Fig. 6

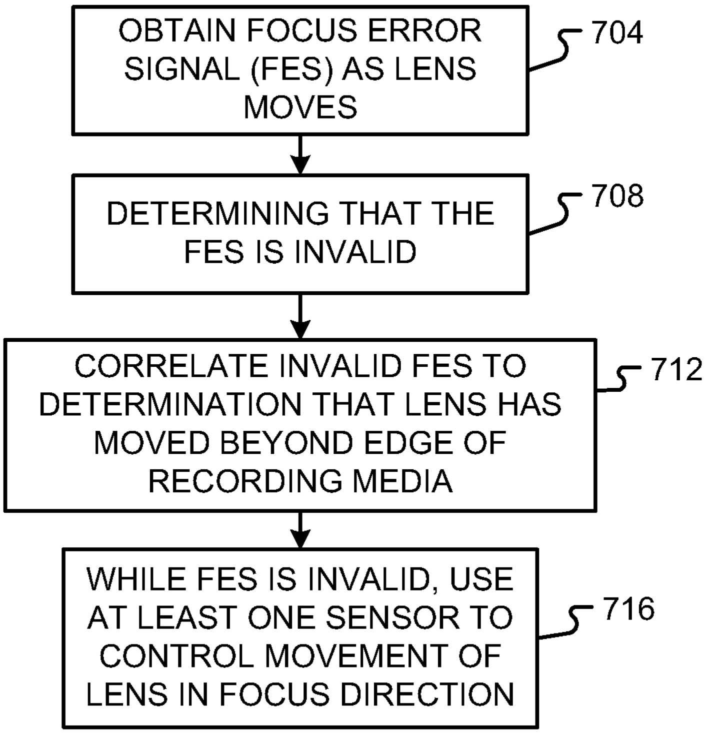
OBTAIN FOCUS ERROR SIGNAL (FES) AS LENS MOVES
704
DETERMINING THAT THE FES IS INVALID
708
CORRELATE INVALID FES TO DETERMINATION THAT LENS HAS MOVED BEYOND EDGE OF RECORDING MEDIA
712
WHILE FES IS INVALID, USE AT LEAST ONE SENSOR TO CONTROL MOVEMENT OF LENS IN FOCUS DIRECTION
716

Fig. 7