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Mayhew

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(54) **REAL TIME CAMERA AND LENS CONTROL SYSTEM FOR IMAGE DEPTH OF FIELD MANIPULATION**

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **H04N 5/225**

(52) **U.S. Cl.** **348/207.11**; 348/239; 348/362; 348/363; 348/368

(58) **Field of Search** 348/239, 362, 348/368, 207.11, 207.1, 221.1, 229.1, 363

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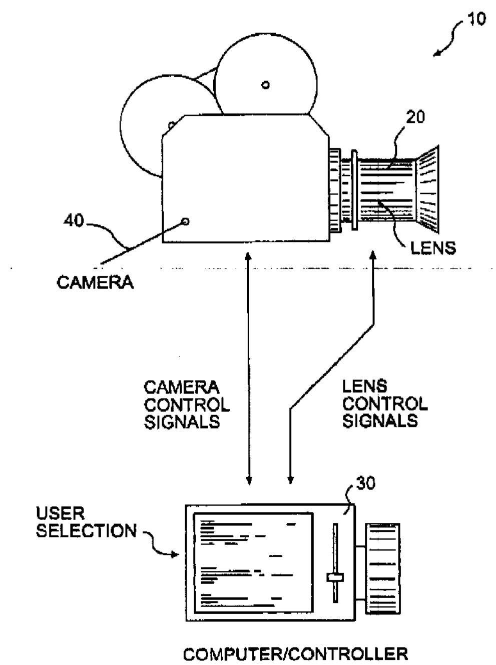
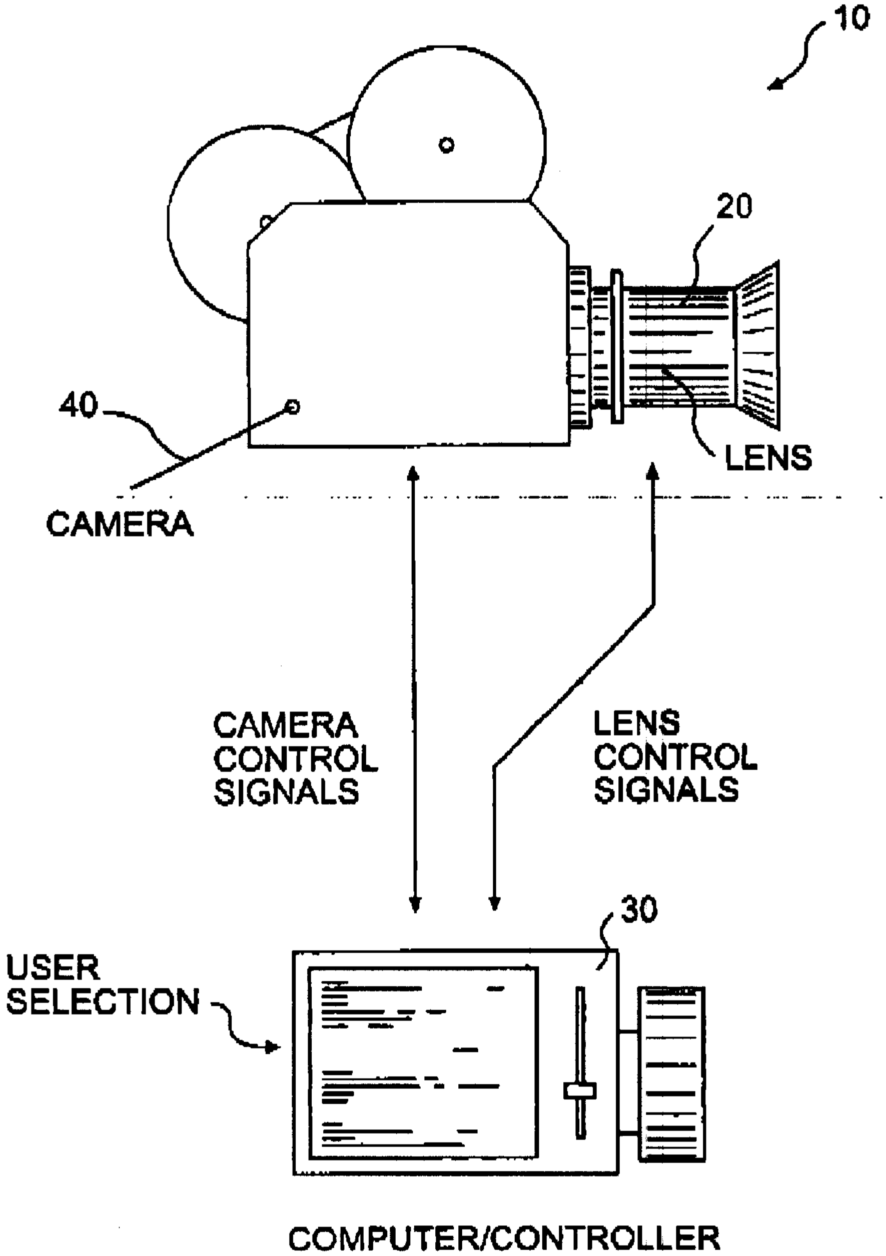
(57) **ABSTRACT**

A method is provided for real time control and manipulation of a moving imaging system lens's (prime, close-up, zoom, or anamorphic) depth of field. A computer control system is programed to perform a coordinated adjustment of a closed loop lens iris (aperture) and the shutter angle of a motion picture camera. The iris of the lens is reduced in size while simultaneously increasing the motion picture camera shutter angle an equal exposure (light transmission) amount, therefore, increasing the apparent image depth of field without a perceivable luminance shift. The image depth of field can be reduced by performing the above operation in reverse.

14 Claims, 3 Drawing Sheets



LENS AND CAMERA CONTROL



LENS AND CAMERA CONTROL

FIG. 1

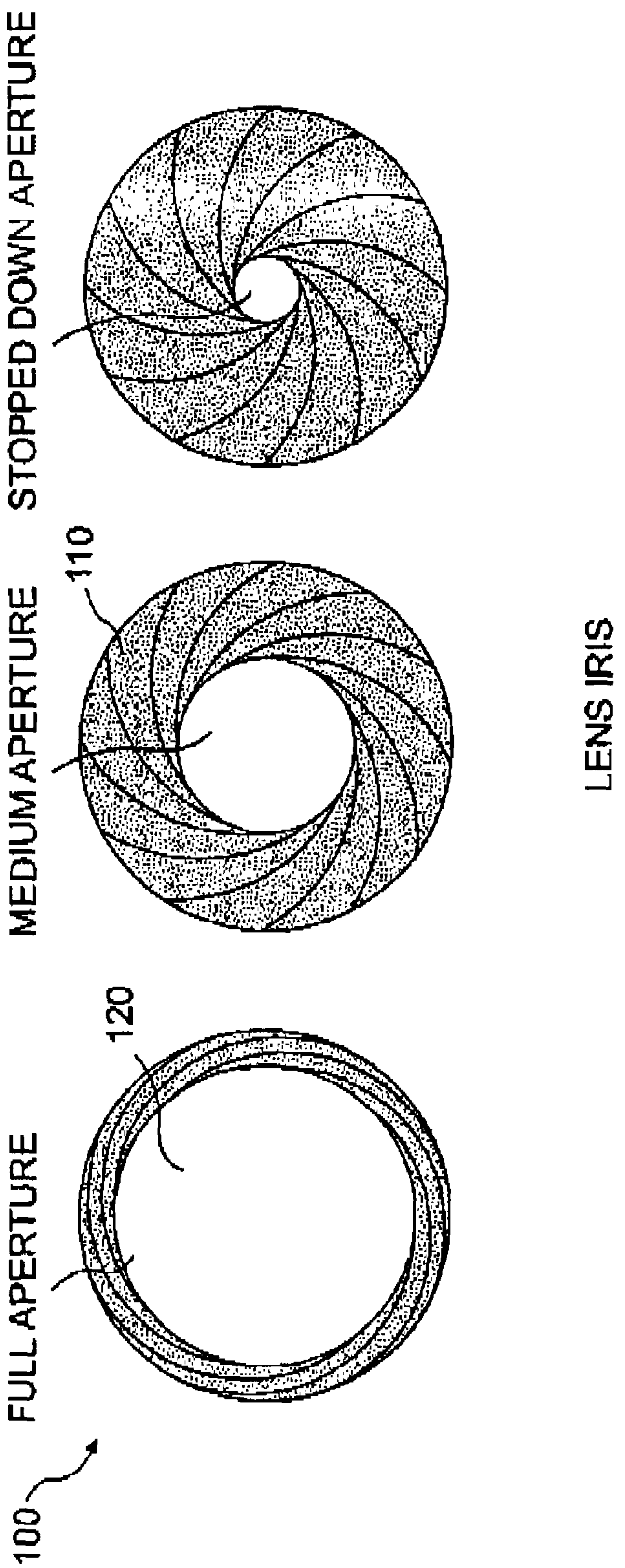
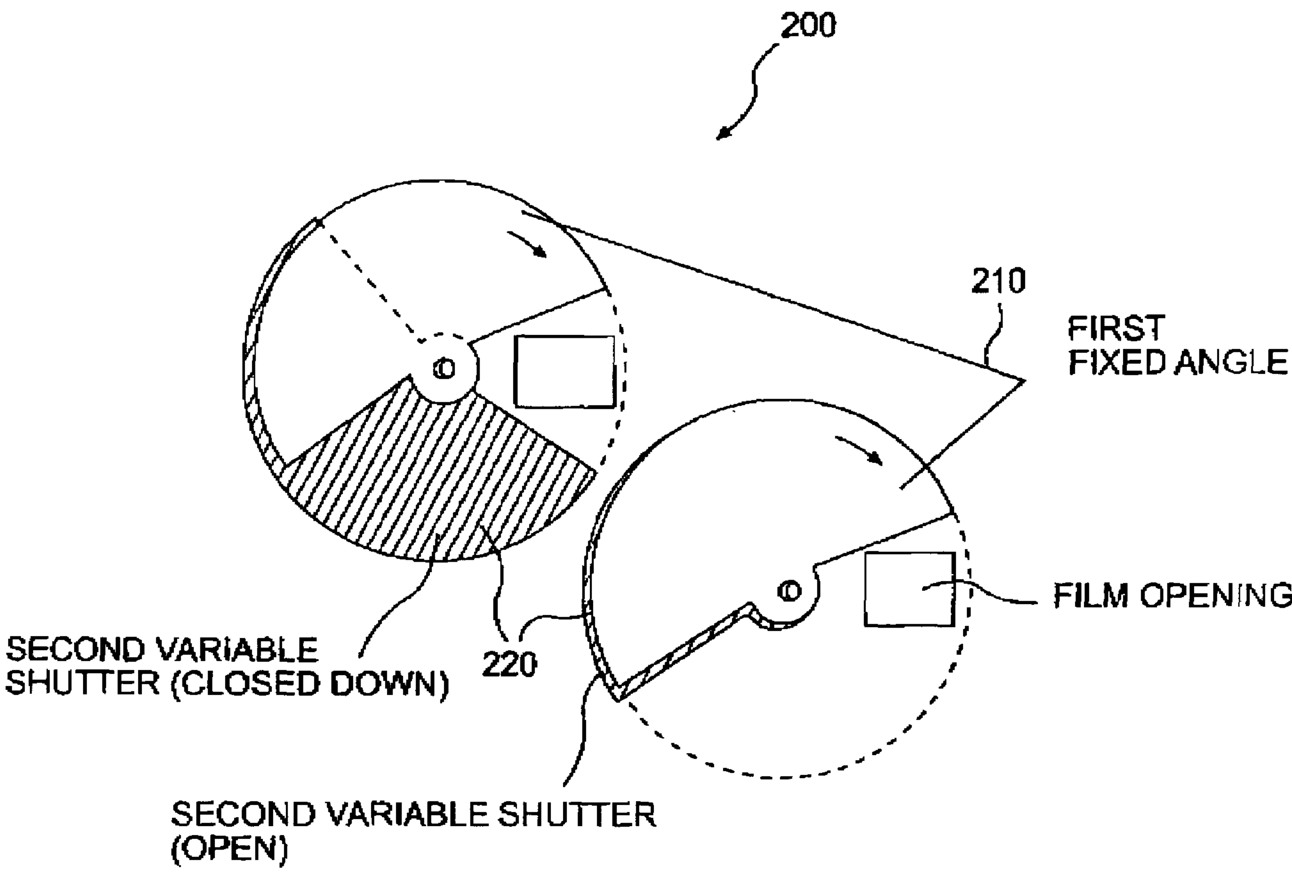

STOPPED DOWN APERTURE
MEDIUM APERTURE
110
120
FULL APERTURE
100
LENS IRIS

FIG. 2



MOTION PICTURE CAMERA
ADJUSTABLE SHUTTER

FIG. 3

REAL TIME CAMERA AND LENS CONTROL SYSTEM FOR IMAGE DEPTH OF FIELD MANIPULATION

This application claims the benefit of U.S. Provisional Application No. 60/065,220, filed Nov. 13, 1997.

FIELD OF THE INVENTION

This invention relates to optical systems for creating moving images using motion pictures or video recording means. It is more closely related to computer control systems that provide real time adjustment of the lens and camera function settings.

BACKGROUND OF THE INVENTION

The first camera was the camera obscura. It consisted of a light-tight box with a pin hole in one side. The later part of the Nineteenth Century saw the invention of flexible photographic film by George Eastman and a workable motion picture camera/projection system by Thomas Edison's New Jersey laboratories. On Dec. 28, 1895, the Lumieres brothers held the first public screening of Cinematographic films at the Grand Cafe, Boulevard des Capucines, Paris, and the "movies" were born.

Motion picture lenses provide a cinematographer with four basic optical variables with which to compose a given scene. These are focus, iris (aperture), filtration and change in focal length. Mostly, the lens is used simply as a conduit to pass light to film. Over the years lens mechanics and optics have improved, but for all intents and purposes, a lens today and its role in motion photography is the same as it was 100 years ago.

While modern motion pictures cameras operate on the same basic principles as those used by the Lumieres brothers, they differ in the recent use of computer control to allow for software driven adjustment of camera functions such as camera shooting speed and the camera shutter angle.

Contemporary motion picture cameras provide for shutter angle adjustment to control the image exposure. The amount of shutter opening adjustment varies among camera manufactures and may range as high as 220° of angular change. This degree of shutter angle adjustment could theoretically provide as much as 5 f/stops of exposure change. In practical applications, however, a very small shutter angle creates a strobing effect in moving subjects and, therefore, limits the exposure compensation to perhaps 3 f/stops.

Shutter angle adjustment is typically used when a cinematographer desires to slow the camera shooting speed down without varying the lens iris (f/or T stop) to compensate for the exposure change by modifying the image exposure time of the motion picture camera. Unlike a still camera, most modern motion picture cameras employ a spinning mirrored shutter system to provide for film exposure and reflex viewing. The reflective shutter is typically located at a 45° angle in front of the film plane. Since standard motion pictures are filmed at 24 frames per second (fps), the way to adjust the image exposure time and maintain a constant shooting speed is by changing the size of the opening in the shutter. The smaller the opening (angle) the shorter the exposure time for each image and vise versa.

Motion picture camera systems have been developed which provide for an automatic shutter angle adjustment to compensate for exposure changes due to a camera shooting speed change. For example, if a cinematographer is shooting a scene at 24 fps with 180° shutter angle, and he wishes to increase the speed of a subject's motion by 100% during the shot without a visible exposure change, the shooting speed would be ramp down to 12 fps, while simultaneously reducing the shutter angle to 90°. This 90° shutter angle reduction is equivalent to one full f/stop or 50% of the original exposure.

As the camera shooting speed is slowed down, the exposure time is increased because the shutter is not turning as fast, and therefore, its angle must be reduced to compensate for the increase in light. Images shot at 12 fps and displayed at the standard 24 fps projection speed will exhibit a 100% increase in subject movement speed. The exposure time of 12 fps is twice as long as 24 fps and therefore requires a shutter angle reduction of 50% to compensate for the increased exposure.

One method of providing for the compensation in shutter angle size in accordance with a change in exposure time is to control the camera via a remote computer. Exemplary cameras that operate in response to commands from such a computer include the Arriflex 35 mm 435 and 535A and 16 mm series motion picture 16SR3 cameras. This type of camera provides for the remote control of camera functions through the use of camera control software protocol via a computer interface. The camera and computer are also able to exchange data via the computer interface.

The computer control sends messages to the camera and the camera responds to those messages. The computer control can send two types of messages: a command to perform a certain task and a request for information on tasks or other functions. The camera in turn will either perform the commanded task, provide the requested information or issue a warning message that the commanded task cannot be performed. The communications protocol consists of messages to perform tasks and returned acknowledge or not acknowledge messages. The message format can be a string of characters with a defined format and meaning.

The advent of the moving optical element lens for image parallax scanning as described in U.S. Pat. No. 5,448,322 to Bacs, which is hereby expressly incorporated herein by reference, has now made possible the interlocking of coordinated settings changes of the lens iris and camera shutter angle. The moving optical element lens iris is controlled by a series of closed-loop actuators. The iris center can be positioned anywhere inside the lens's full effective aperture, frame-by frame. In addition, the iris can be scanned while a given frame is being exposed (as in 11 go motion" in animation).

More commonly, a scan path of a particular size is set and the iris follows this path continuously while the camera runs. The scan path is usually a circle around the center (the nominal Z axis) of the lens. The diameter of this path can be increased or decreased on the fly while a given scene is being recorded. The shape of the path can also be modified on the fly, for example, from a perfect circle to an ellipse. In addition to the scan path, the scan frequency, focus position and f-stop can also be adjusted on the fly via remote control. The f-stop is inversely related to the diameter of the entrance pupil (N=F/D, wherein N is the f-stop, F is the focal length of the lens, and D is the diameter of the aperture).

Another variable in optical photography is depth of field, which is explained by Rudolf Kingslake in his 1992 book *Optics in Photography.* As explained by Kingslake, if a camera is focused on an object at some definite distance from the camera's imaging plane, there will be a finite range of distances in front of and beyond the focused object in which everything will appear acceptably in focus. Outside

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