

PATENT SPECIFICATION

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(54) ZOOM LENS

(71) We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America of 343 State Street, Rochester, New York 14650, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a zoom optical system.

Most prior art zoom lenses, particularly those in cinematographic cameras, occupy an objectionably large amount of space to provide adequate room for relative movement of the lens components. This difficulty is compounded by the fact that the largest dimension of such lenses usually must be added to one of the long camera dimensions, which tends to make the camera unwieldy. Motion picture cameras generally are arranged in this manner to align the optical axis of the lens perpendicular to the camera's exposure aperture or film gate which generally is parallel with the camera's shortest dimension.

In our application Serial No. 1,316,926 there is described and claimed a camera having a rectangular parallelepiped shape with its shortest dimension being its depth dimension which extends forwardly from the photographer. In order to accomplish such a reorientation of camera dimensions, the film gate is arranged in a plane perpendicular to the object plane of the camera's lens system, which requires a folded optical system. The folding of the optical system has the further advantage of reducing the largest dimension of the lens to render it commensurate with the reduced depth dimension of the camera.

In addition, the focusing of prior zoom lenses for different subject distances has generally been accomplished by moving the

front objective. Since this requires that the front component of the system be movable, the lens mounts must be large and cumbersome and cannot be fully sealed against dust and moisture which are objectionable in any optical system, and are particularly harmful in a zoom lens since zoom lenses contain many moving parts. There has also been proposed a zoom lens comprising a fixed front component and movable rear zoom components, wherein focusing for different subject distances is accomplished by moving the zoom components, but this is done at the expense of changing the zoom range when the lens is focused.

In accordance with the present invention there is provided a zoom optical system comprising, from front to rear, a reversed-telephoto objective, a movable zooming component for varying the focal length of the system, an adjustable compensating component and a rear positive component, the reversed-telephoto objective comprising a mirror, located between a front negative component and a positive component, for changing the direction of the optical axis of the system.

According to the present invention there is also provided a cinematographic camera having such a zoom optical system.

In the accompanying drawings:—

Fig. 1 is a section through a zoom lens system according to the invention; and

Fig. 2 is a partial perspective view of portions of a camera incorporating the lens system shown in Fig. 1.

As shown in Fig. 1, a lens system according to a preferred embodiment of the invention includes a zoom portion and a fixed portion. The zoom portion includes a reversed-telephoto objective I, a movable zooming component II for varying the focal length of the lens system, and an adjustable compensating component III that maintains the

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image in focus at the focal plane as the movable zooming component is adjusted. Behind the zoom portion is a beamsplitter B for directing a portion of the light from the zoom portion to a reflex viewfinder, shown in Fig. 2, and a fixed portion IV of the system for forming an image on the film plane of the camera in which the lens is incorporated. The reversed-telephoto objective I includes a front negative meniscus component 1 spaced relatively widely from a rear positive component 2. This reversed telephoto arrangement provides space for a mirror M to fold the optical axis of the lens through 90°. Since reversed-telephoto lenses are characterized by a relatively short focal length, which is equal to or shorter than the back focus, the reversed-telephoto objective I also provides a relatively wide field angle without significantly increasing the lens diameter. Front negative meniscus component 1 is fixed in relation to the fixed portion IV, so that the entire lens can be sealed against dust, moisture and other harmful materials. In addition, the fixed front component makes it possible to design a camera having an uncluttered front portion. Rear positive component 2 is adapted for axial movement to focus the lens for various subject distances, which enables front component 1 to be fixedly mounted. Movement of rear component 2 to focus the lens does not alter the zoom range of the lens.

The focal length of the system and hence the magnification of the image formed by the reversed-telephoto objective I is varied by axial movement of the movable zooming

component II which consists of an air spaced doublet including a negative meniscus element 3 concave to the rear and a weak negative meniscus element 4 concave to the front and in edge contact with the element 3.

The adjustable compensation component III is a cemented doublet including a front negative meniscus element 5 and a rear biconvex element 6. The components II and III are mechanically coupled for opposed linear motion so that when movable zooming component II moves to change magnification, adjustable compensating component III moves to maintain focus. Located between lens components II and III is a diaphragm D, and means (not shown) can be provided for adjusting the diaphragm aperture in response to displacement of the zoom components. Since the lens components II and III are located between the mirror M and the beamsplitter B, they can be moved to vary magnification without interference by reflectors. Thus, the system is provided with two folds in the optical path without significantly lengthening the axial length of the system, and these folds enable the largest physical dimension of the system to be reduced.

Many types of lenses could be employed with the zoom portion described above. In the disclosed embodiment the fixed portion IV is a simple airspaced triplet including front and rear positive elements 7 and 9, and a middle negative element 8.

A preferred example of a zoom system according to the invention may be constructed according to the following data:

Element	N	V	Radii (mm)	Thicknesses or Separations (mm)
1	1.50	67.0	$R_1 = 35.6$	$t_1 = 3.48$
			$R_2 = 24.1$	$S_1 = 36.02$
2	1.64	60.1	$R_3 = 32.6$	$t_2 = 2.73$
			$R_4 = -103.6$	$S_2 = 3.06 \text{ to } 13.28$
3	1.50	67.0	$R_5 = 51.8$	$t_3 = 0.90$
			$R_6 = 9.27$	$S_3 = 2.17$
4	1.50	67.0	$R_7 = -19.4$	$t_4 = 2.92$
			$R_8 = -54.8$	$S_4 = 17.74 \text{ to } 7.52$
Diaphragm				$S_5 = 7.2 \text{ to } 1.53$
5	1.72	29.3	$R_9 = 16.4$	$t_5 = 0.97$
			$R_{10} = 7.92$	$t_6 = 4.37$
6	1.66	50.8	$R_{11} = -62.9$	$S_6 = 2.02 \text{ to } 7.67$
			$R_{B1} = \infty$	$t_B = 11.13$
B	1.49	57.4	$R_{B2} = \infty$	$S_7 = 0.85$
			$R_{12} = 13.2$	$t_7 = 2.58$
7	1.69	56.2	$R_{13} = -267.8$	$S_8 = 0.93$
			$R_{14} = -19.3$	$t_8 = 2.73$
8	1.62	36.6	$R_{15} = 9.56$	$S_9 = 0.83$
			$R_{16} = 12.9$	$t_9 = 2.96$
9	1.61	58.8	$R_{17} = -33.4$	

In the above Example the lens elements are numbered from front to rear from 1 to 9 as shown in Fig. 1, N is the refractive index for each of the lens element materials for the D line of the spectrum, V is the index of dispersion for each of the elements, and R, t and S are the radii of curvature, thicknesses, and spacings of the lens elements, numbered by subscript from front to rear.

The zoom lens described in the above Example has a constant back focal length of 7.0 mm. and an overall length of 105.6 mm. and it is well corrected for apertures up to at least f/2.7. The equivalent focal length varies from 9.95 mm. to 22.42 mm.

In Fig. 2, an optical system according to the invention is shown mounted in a cinematographic camera. Light from an object scene is transmitted by front negative meniscus component 1 of the reversed-telephoto objec-

tive to the mirror M which is positioned at an angle of 45° with respect to the plane of component 1. The mirror reflects the light towards rear positive component 2 which is mounted with its plane at 90° with respect to the plane of component 1, so that the optical axes of components 1 and 2 are normal with respect to each other i.e. the mirror puts a first fold in the system.

Component 2 is mounted by a ring 20 on a support plate 22 in the camera. Ring 20 is provided with a screw thread 23, and is axially movable in response to its rotation to focus the lens for different subject distances. The movable zooming component II and the adjustable compensating component III are mounted in barrel mounts 24 and 26, respectively, which are slidably mounted on slide rods 28 for movement along the optical axis L of the system.

To control the relative motion of the components II and III, the camera includes a zoom mechanism, which may take any known form. The zoom mechanism shown in Fig. 2 includes a linking lever 30 pivotally mounted on a fixed pivot pin 32 and having one end 34 pivotally connected to a sleeve 36 attached to barrel mount 24, and the other end 38 pivotally connected to a sleeve 37 attached to barrel mount 26 for effecting opposed linear motion of the components II and III. Thus, the relative movement of these components is determined by the location of fixed pivot pin 32 with respect to the ends of linking lever 30. Movement is transmitted to the components by a bell crank 40 which is pivotally mounted on an axle 42. The bell crank 40 has a slot 44 at one end for receiving a pin 46, and a control knob 48 at the other end accessible from the exterior of the camera for actuation by an operator. The camera body is provided with a recess 50 so that knob 48 need not extend beyond the surface thereof.

In response to vertical movement of knob 48, bell crank 40 pivots and urges sleeve 37 along slide rod 28 through the connection of pin 46 in slot 44. Such horizontal displacement of sleeve 37 is transmitted by means of linking lever 30 to sleeve 36, which is urged in the opposite direction by the rotation of the linking lever 30 about its fixed pivot pin 32. The dimensions of linking lever 30 are such that focus is substantially maintained throughout the zoom range. As indicated above, an adjustable diaphragm D is located between the components II and III. It should be noted that all of the movable parts of the lens are located between the folds of the system, thus simplifying the structure of the means for moving the various lens members.

The beamsplitter B is located behind the adjustable compensating component III, for transmitting a portion of the light from the zoom portion along an axis L' to a reflex viewfinder and for reflecting the remaining portion of that light through the fixed portion IV to the film plane of the camera. The beamsplitter B comprises a pair of prisms 52 and 54 having a semi-reflective interface 56 which transmits a portion of incident light and reflects the remaining portion at an angle

of 90°, the beamsplitter B providing a second fold in the optical system. Light transmitted by the beamsplitter passes through a viewfinder relay 58 and is reflected by a prism 60 to an erecting prism 62 which in turn directs an upright image through a mask 64 and an eyepiece 66. The provision of a first fold at the front of the lens has made possible the incorporation of a compact prism arrangement for erecting the viewfinder image, since only three additional folds are required in the viewfinder system.

Thus, a compact zoom optical system has been provided which lends itself well to incorporation in a camera having a small depth, the system being of relatively simple construction and additionally making possible the use of a simple reflex viewfinder.

WHAT WE CLAIM IS:—

1. A zoom optical system comprising, from front to rear, a reversed-telephoto objective, a movable zooming component for varying the focal length of the system, an adjustable compensating component, and a rear positive component, the reversed-telephoto objective comprising a mirror, located between a front negative component and a positive component, for changing the direction of the optical axis of the system.
2. A zoom optical system according to Claim 1, wherein a second reflector is disposed between the adjustable compensating unit and the rear positive component, for again changing the direction of the optical axis.
3. A zoom optical system according to Claim 1 or 2, wherein the rear positive component comprises a positive air spaced triplet.
4. A zoom optical system as hereinbefore exemplified in the Example.
5. A cinematographic camera having a zoom optical system according to any one of the preceding claims.
6. A cinematographic camera according to Claim 5, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

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The beamsplitter B is located behind the adjustable compensating component III, for transmitting a portion of the light from the zoom portion along an axis L' to a reflex viewfinder and for reflecting the remaining portion of that light through the fixed portion IV to the film plane of the camera. The beamsplitter B comprises a pair of prisms 52 and 54 having a semi-reflective interface 56 which transmits a portion of incident light and reflects the remaining portion at an angle

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Thus, a compact zoom optical system has been provided which lends itself well to incorporation in a camera having a small depth, the system being of relatively simple construction and additionally making possible the use of a simple reflex viewfinder.

WHAT WE CLAIM IS:—

1. A zoom optical system comprising, from front to rear, a reversed-telephoto objective, a movable zooming component for varying the focal length of the system, an adjustable compensating component and a rear positive component, the reversed-telephoto objective comprising a mirror, located between a front negative component and a positive component, for changing the direction of the optical axis of the system.
2. A zoom optical system according to Claim 1, wherein a second reflector is disposed between the adjustable compensating unit and the rear positive component, for again changing the direction of the optical axis.
3. A zoom optical system according to Claim 1 or 2, wherein the rear positive component comprises a positive air spaced triplet.
4. A zoom optical system as hereinbefore exemplified in the Example.
5. A cinematographic camera having a zoom optical system according to any one of the preceding claims.
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