

PATENT SPECIFICATION (11)

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(54) IMPROVEMENTS IN ZOOM LENS

(71) We, OPTIGON RESEARCH AND DEVELOPMENT CORPORATION, of P.O. Box 1740, Santa Monica, California, United States of America, a corporation organized and existing under the laws of the State of California, 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:—

This invention relates to lenses of variable focal length.

In zoom lenses a plurality of lens groups are generally utilized, some axially movable for zooming or change of focal length and image compensation, and some for focusing. A common arrangement is a four lens group in which the first group generally has limited axial motion for focusing; the second and third groups are axially moved to effect zooming or variation of the equivalent focal length (EFL), and the fourth lens group is stationary with respect to the film plane. Various mechanism for producing movement of the lens groups for zooming with predetermined motion are well known. Such mechanisms include a so-called one touch control ring or sleeve for zooming and focusing, while some utilize separate rotatable control rings for zooming and focusing. The one-touch control is considered by many to be preferable in that it is not necessary to shift the hand between a zooming ring and a focusing ring.

In zoom lenses, the compactness of the lens is limited by the extent of the motions required by axial movement of the second and third groups and the spacing provided therefor to effect zooming over the desired range.

Recently lenses have been optically designed as exemplified in U.S. Patent No. 3,975,089 to provide more compactness in zoom lenses, particularly those of shorter focal lengths by axially moving the front group during zooming to change the position of an imaged object and decrease the travel required by the zooming or magnifying lens group. This decreases the front

vertex distance (FVD) of the overall lens. Such movement of the front or first group may also contribute to optical correction of various aberrations which are otherwise present in zoom lenses.

The present invention consists in a lens of variable focal length comprising a housing, two lens groups in said housing in respective mounts therefor, a guide member in said housing supporting said mounts and having two guide means for predetermining relatively unequal axial movement of respective mounts therein to vary the focal length of said lens, wherein said guide member is axially displaceable in said housing to focus said lens, an operating member is movable axially and rotatively with respect to said housing, a connection is provided between said operating member and said lens mounts, whereby axial motion of said operating member causes said mounts to move axially in respective guide means relative to said guide member and each other, and a connection is provided between said operating member and said guide member, whereby rotation of said operating member produces axial displacement of said guide member with said two groups in relative fixed relation therein.

Included within the scope of the invention are zoom lenses of various optical designs and number of lens groups.

One embodiment of the present invention includes a new and improved mechanism for providing unequal axial motion of two or more lens groups, including the front lens group in a zoom lens to vary the EFL of the lens and further includes a means for focusing the lens by axially moving all groups in fixed relation using the same control means as is utilized during zooming.

Briefly stated, the present embodiment comprises a lens group guiding member having a plurality of guide means thereon which predetermine the movement of lens groups which are moved axially in unequal relation to zoom or vary the focal length of the lens. The lens guiding member further mounts a lens group in fixed relation therein. Means are provided for moving all

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of the movable groups in accordance with the defined guide means in non-equal relative relationship and the same operating means are utilized to axially shift the guiding member including all lens groups in fixed relative relation to effect focusing.

The embodiment includes a new and improved zoom lens mechanism. The mechanism can be used to impart relative unequal motion to two or three lens groups to vary equivalent focal length of the lens, while permitting all lens groups to be shifted in fixed relation to each other for focusing. In the mechanism the same control member is utilized to effect zooming and also to effect axial shifting of all lens groups in fixed relation to effect focusing of the lens. The mechanism permits simultaneous non-equal axial motion of three different lens groups.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a view of a lens mechanism embodying the invention in longitudinal half section;

Fig. 2 is a graphical representation of the movements of the lens groups of the lens in Fig. 1;

Fig. 3 is a view seen in the plane of lines 3—3 of Fig. 1;

Fig. 4 is a view in perspective of lens mounts of the lens of Fig. 1;

Fig. 5 is a developed planar view of elements of the lens of Fig. 1;

Fig. 6 is a developed planar view of the operating member of the lens of Fig. 1, seen from the inside thereof; and

Fig. 7 is a view seen in the plane of lines 7—7 of Fig. 1.

The invention is applicable to lens of various focal length ranges and optical designs, but is disclosed in a zoom lens 10 for a 24×36mm image frame camera having a focal range of 36—83mm.

The lens 10 includes from the objective side a first lens group I of positive power, a second lens group II of negative power, a third lens group III of negative power, and a fourth lens group IV of positive power.

As hereinafter described groups I, II and III are simultaneously axially movable unequal distances with respect to group IV to vary the focal length of the lens, and all groups are axially movable in fixed relation to focus the lens. The relative movements of groups I, II and III, with respect to the axial object side vertex of group IV is shown in Fig. 2. The optical properties of a lens as disclosed for a 36—83mm focal length range are disclosed and claimed in U.S. Patent No. 3,975,089.

Lens 10 comprises a housing member 11, having a camera mounting portion 12, shown

as a thread mount. However, a bayonet mount may also be provided. Carried with housing member 11 is a focusing member 13, threadably mounted to housing 11 at 14, and having internal threads 15. Member 13 has limited rotation on threads 14 as hereinafter described. Member 13 has longitudinally extending, angularly spaced arm 16 which extend to a ring 17. Ring 17 is fastened as by screws 18 to an outer sleeve member 19. Sleeve member 19 is an extension of focusing member 13. A member 20 has external threads 21 mating with threads 15. A longitudinal slot 22 is defined in threads 21, and a pin 23 carried by housing 11 extends into slot 22. This arrangement provides a means for shifting member 20 axially without rotation. The threads 15 and 21 have a much greater pitch than threads 14. Member 20 has a forwardly extending cylindrical or tubular portion 24 having a plurality of lens guide means defined therein, as hereinafter explained. Tubular portion 24 functions as a lens support member and lens zooming guide member.

An operating member 25 for both focusing and zooming comprises an outer sleeve 26, and an inner sleeve 27. Outer sleeve 26 has longitudinal slots 28 and 29 therein, each receiving a pin 30 extending from sleeve member 19. Such pin and slot arrangement permits axial or longitudinal movement of operating member 25 with respect to sleeve member 19, but connects the two for rotational motion.

Sleeve member 19 has a forwardly extending portion 32 in sliding contact with a mount 34 for lens group I (space shown therebetween for clarity). Mount 34 has a rearwardly extending cylindrical portion 35 coaxially overlying tube 24 (portion 35 is in practice in sliding contact with tube 24, but clearance is shown for clarity). Portion 35 has longitudinal slots 37a and 37b defined therein for reasons hereinafter described.

Lens group II is carried in a mounting member 38 within tube 24. Member 38 as more clearly shown in Figs. 3 and 4, comprises an annular lens mounting portion 39 having a plurality of guide shoes or finger 40—43 extending rearwardly therefrom. The shoes or fingers are raised from the peripheral surface 45 of portion 39. The external surfaces of shoes 40 are formed on a common radius and slidably engage the internal periphery of tube 24. The length of the shoes 40—43 serve to essentially eliminate tilt of lens group II. Longitudinally directed slots 46 and 47 are defined in shoes 40 and 42, respectively.

Lens group III is carried in a mounting member 50 having an annular mounting portion 51 with guide shoes 52—55 extend-

ing forwardly therefrom. Shoes 52—55 have peripheral surfaces raised with respect to the surface of portion 51. The external surfaces of shoes 52—55 are defined on a common radius and slidably engage the inner periphery of tube 24. The length of shoes 52—55 essentially eliminates tilt of lens group III.

Reference is now made to Fig. 5 which shows a planar developed view of tube 24, cylindrical portion 35 of mount 24 and mounts 38 and 50, in conjunction with Figs. 1, 3 and 4.

A follower pin 56 extending from mounting member 50 through slot 46 in shoe 40 of member 38 into a guide means in the form of a cam slot 57 in tube 24. Pins 58 and 59 extend from member 38 through similar guide means in the form of cam slots 60 and 61 in tube 24, and into slots 37a and 37b, respectively, in member 35. A follower pin 63 carried in member 35 extends through a guide means in the form of a cam slot 64 in member 24 into slot 47 in mount 38.

Pin 58 and pin 59 extend into a ring 66 (Fig. 1) about member 35 and tube 24. Ring 66 has a pair of outer rearwardly extending lugs 67 which threadably receives pins 68 extending into slots 69 in portion 27 of operating member 25. Slots 69 are contoured in accordance with the pitch of threads 15 and 21 as shown in Fig. 6 for reasons hereinafter made apparent.

The operating member 25 is arranged to effect zooming of the lens upon axial sliding movement along sleeve 19 with respect to tube 24, and focusing of the lens upon rotation thereof.

For focusing, member 25 is rotated. The connection of pins 30 in slots 29 produces rotation of member 13 through arms 16. The rotational motion of member 13 on fine pitch threads 14 is limited by a detent 70 extending from an angularly positionable member 71 positioned in a recess 72 on housing member 11. Detent 70 extends into a notch 73 in focusing member 22 to limit rotation thereof and retain it in housing 13. Member 20 is restrained from rotation by pin 23 and moves axially of housing 11. As member 16 moves axially lens groups II, III and IV therein move in fixed relative relation. Cylindrical portion 35 of lens mount 34 rides on tube 24 and all lens groups therefore move axially in fixed relation. Such motion is similar to movement of a lens of predetermined focal length in focusing.

For zooming, groups I, II and III move relative to group IV as shown in Fig. 2, with variation in focal length. In this arrangement, group I is moved to decrease the extent of motion required by group II and group III, and provide a more compact

lens. The movements shown in Fig. 2 are for a lens of 36—83mm equivalent focal length for an image frame of 24×36mm. However, the movements and mechanism therefor described may be utilized in lens of various sizes and focal length ranges.

As operating member 25 is moved axially with respect to tube 24, pins 58 and 59 connected to ring 66 and mount 38 move axially and rotatively in guide slots 60 and 61. See Fig. 5. This imparts a predetermined axial and rotative movement of mount 38 and lens group II. As mount 38 rotates the edges of slot 46 engage pin 56 and impart rotational movement thereto. This causes pin 56 and mount 50 with lens group III to follow the contour of guide means or cam slot 57 in tube 24. Mount 50 and lens group III thus has the motion shown in Fig. 2. Pin 63 carried in portion 35 and extending through guide means or cam slot 64 in tube 24 is received in slot 47. The edges of slot 47 angularly move pin 63 in slot 64 to predetermine the relative axial movement of member 35 and hence mount 34 and lens group I. Group I moves simultaneously with group II and group III with respect to Group IV as shown in Fig. 2.

With the arrangement described, motion imparted to one lens group (group III) in accordance with its guide means produces predetermined relative axial motion of two other lens groups in accordance with their respective guide means. If desired or necessary in accordance with an optical design, one or more guide slots may be contoured to provide a dwell of one or more lens groups during a portion of the zooming range. The follower pins and cam slots are sized to minimize any lost motion.

The portion 27 of operating member 25 is provided with circumferentially extending slots 69 receiving pins 68 attached to the rearwardly extending lugs 67. The slots 69 are defined on the same pitch as threads 15. As member 13 and tube 24 advance or retract during focusing movement as operating member 25 is rotated, pins 68 will advance and retract. The contour of slots 69 permits free movement of pins 68 with rotation of member 25 and prevents any binding or undesired longitudinal motion of member 20. This arrangement does permit simultaneous axial and rotational movement of operating member 25 for continuous focusing while zooming. The interdigitating shoes 40—43 and 52—55 of lens mounts 38 and 50 have sufficient angular clearance therebetween for the relative axial motion required.

It will be understood that various relative motions may be imparted to the movable lens groups dependent on the shape of the guide or cam slots. While not readily apparent from the drawings, the slots 57, 130

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60, 61 and 74 all have the same minimum dimension for pin travel to prevent any binding. The slots may be termed cams or guides and the respective pins as follows inasmuch as the pins follow the guide or cam slots.

The relative lens powers may vary for different optical designs and focal length ranges and the particular lens power arrangement shown herein is only exemplary. The invention further includes a zoom lens having only three lens group all of which move relatively for zooming, and in fixed relation for focusing. Also included are lens having only two groups for zooming which move axially with respect to one or more non-zooming groups, and all move in fixed relation for focusing.

The invention is applicable to any zoom lens design where lens groups are relatively moved in guide means in or on a guide member for change of focal length and the guide member is shifted axially for focusing.

WHAT WE CLAIM IS:—

1. A lens of variable focal length comprising a housing, two lens groups in said housing in respective mounts therefor, a guide members in said housing supporting said mounts and having two guide means for predetermining relatively unequal axial movement of respective mounts therein to vary the focal length of said lens, wherein said guide member is axially displaceable in said housing to focus said lens, an operating member is movable axially and rotatively with respect to said housing, a connection is provided between said operating member and said lens mounts, whereby axial motion of said operating member causes said mounts to move axially in respective guide means relative to said guide member and each other, and a connection is provided between said operating member and said guide member, whereby rotation of said operating member produces axial displacement of said guide member with said two groups in relative fixed relation therein.

2. A lens as claimed in claim 1, wherein each of said guide means comprises a guide slot in said guide member and each of said mounts carries a follower extending into a respective one of said slots.

3. A lens as claimed in claim 1, wherein said guide member is tubular in form, and a further lens group is provided in a

further mount therefor, said further mount having a rearwardly extending portion overlying said guide member and slidable thereon.

4. A lens as claimed in claim 1, further comprising a further lens group and a further mount therefor, said further mount having a portion slidable on the surface of said guide member, a further guide means on said guide member, and a connection from said further mount to said further guide means in said guide member.

5. A lens as claimed in claim 4, wherein one of said two mounts is movable axially and rotatively in said guide member, a longitudinal slot is defined in said one mount, and a follower extends from said further mount through said further guide means in said guide member into said longitudinal slot in said one mount, whereby rotative movement of said one mount causes said further mount to move in accordance with further guide means.

6. A lens as claimed in claim 5, wherein the other of said two mounts is disposed within said guide member and movable axially and rotatively therein, and a follower extends from said other of said two mounts through another longitudinal slot in said one of the two mounts into said two guide means in said guide member.

7. A lens as claimed in claim 1, wherein said operating member is a sleeve coaxial with said guide member, a focusing member is rotatable with respect to said housing, said coupling means comprise a longitudinal slot in said sleeve member receiving a pin therein carried by a connecting sleeve member, said connecting sleeve member connects said focusing member to said operating member, and said guide member is threadably coupled to said focusing member and restrained from rotation.

8. A lens as claimed in claim 1, wherein a fourth lens group is mounted in said guide member in fixed relation thereto.

9. A lens of variable focal length constructed, arranged and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

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The relative lens powers may vary for different optical designs and focal length ranges and the particular lens power arrangement shown herein is only exemplary. The invention further includes a zoom lens having only three lens group all of which move relatively for zooming, and in fixed relation for focusing. Also included are lens having only two groups for zooming which move axially with respect to one or more non-zooming groups, and all move in fixed relation for focusing.

The invention is applicable to any zoom lens design where lens groups are relatively moved in guide means in or on a guide member for change of focal length and the guide member is shifted axially for focusing.

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2. A lens as claimed in claim 1, wherein each of said guide means comprises a guide slot in said guide member and each of said mounts carries a follower extending into a respective one of said slots.

3. A lens as claimed in claim 1, wherein said guide member is tubular in form, and a further lens group is provided in a

further mount therefor, said further mount having a rearwardly extending portion overlying said guide member and slidable thereon.

4. A lens as claimed in claim 1, further comprising a further lens group and a further mount therefor, said further mount having a portion slidable on the surface of said guide member, a further guide means on said guide member, and a connection from said further mount to said further guide means in said guide member.

5. A lens as claimed in claim 4, wherein one of said two mounts is movable axially and rotatively in said guide member, a longitudinal slot is defined in said one mount, and a follower extends from said further mount through said further guide means in said guide member into said longitudinal slot in said one mount, whereby rotative movement of said one mount causes said further mount to move in accordance with further guide means.

6. A lens as claimed in claim 5, wherein the other of said two mounts is disposed within said guide member and movable axially and rotatively therein, and a follower extends from said other of said two mounts through another longitudinal slot in said one of the two mounts into said two guide means in said guide member.

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