

PATENT SPECIFICATION

(11) 1 383 784

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- (21) Application No. 17932/74 (22) Filed 31 Oct. 1972
 (62) Divided out of No. 1 383 782
 (31) Convention Application No. 258 816 (32) Filed 1 June 1972 in
 (33) United States of America (US)
 (44) Complete Specification published 12 Feb. 1975
 (51) INT CL² G02B 7/10 // 15/14
 (52) Index at acceptance G2J 23C B7C7 B7C8



(54) IMPROVEMENTS IN OR RELATING TO ZOOM LENS

(71) We, PONDER & BEST, INC., of 11201 W. Pico Blvd., Los Angeles, California, United States of America, a corporation organised 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 and more particularly relates to variable focal length or zoom lenses.

Zooming lenses of the type using a front focusing group followed by a zooming group and image plane position compensation group, otherwise known as a compensating group, are quite widely known. Lenses of this type generally utilize two operating members, one for focusing and the other for clearing the equivalent focal length of the lens. Some lenses have been provided utilizing a single operating member which is moved axially on the lens barrel for zooming and which is rotated on the lens barrel for focusing. Such a lens is shown in U.S. Patent 3,169,461. The construction as shown in that patent is relatively uncomplicated where only a single movable zooming group is utilized.

However, where there must be two or more axially movable lens groups in a zoom lens, means must be provided to present predetermined relative movement between the lens groups as each are moved axially.

The present invention consists in a lens assembly comprising an elongated cylindrical member, a sleeve-like operating member disposed about said cylindrical member adapted to move axially with respect to said cylindrical member for varying the focal length of said lens, first and second guide means defined on said cylindrical member, each having axial and tangential directional components, a first mounting member for a first lens group in said cylindrical member and having a first connection to said first guide means, a second mounting member for a second lens group

within said first mounting member, and having a second connection to said second guide means, means connecting a said operating member to said first mounting member whereby axial movement of said operating member moves said first mounting member axially and rotatively within said cylindrical member in accordance with said first guide means, and means connecting said first and second mounting members whereby rotative movement of said first mounting member produces movement of said second mounting member in said second guide means.

One embodiment of the present invention is a new and improved construction for a zoom lens utilizing a single operating member for both focusing and zooming which facilitates non-linear relative axial motion of two lens groups within a lens housing. More specifically, the operating member is arranged so that as it moves axially on the lens housing and moves one axially movable lens group, the motion imparted to the said one axially movable lens group imparts predetermined axial motion to the second movable lens group.

Briefly stated, the present embodiment comprises a lens having a cylindrical member with first and second guide slots defined therein. A first lens group has a mounting member with a pin extending therefrom into a first of the guide slots and therethrough to be received in an annular channel in the operating member. The first mounting member also has an axial slot defined therein. A second lens group is in a second mounting within the first mounting member and has a pin extending therefrom through the axial slot into the second guide slot. When the operating member is moved axially it moves the first pin in the first slot in both an axially and tangential direction, and as the first guide means rotates the sides of the axial slot engage the second pin and move it in the second guide slot so that predetermined non-linear relative motion is imparted to both of the movable lens groups.

[Price 33p]

The embodiment is a new and improved zoom lens for a still camera. It includes a new and improved mechanism for imparting non-linear relative motion to two movable lens groups.

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

FIG. 1 is a side longitudinal half section, partly cut away of a lens assembly embodying the invention;

FIGS. 2a and 2b are exploded, isometric views of the movable lens elements of the lens of Fig. 1;

FIG. 3 is a top plan view of the lens of Fig. 1 with the focusing barrel cut away to expose the zoom tube;

FIG. 4 is a view of the lens of Fig. 1 with a portion thereof cut away to reveal a mechanism for selecting between the modes of operation;

FIG. 5 is a sectional view of the lens as shown in Fig. 4 but rotated about ninety degrees;

FIG. 6 is a sectional view of a portion of the lens showing a detail of construction thereof;

FIG. 7 is a schematic diagram of the lens elements;

FIG. 8 are curves showing the relative movement of the zooming elements in the zooming mode of operation and

FIG. 9 is a curve showing magnification versus focusing distance for close-up focusing.

As shown in Fig. 1, an overall lens 10 embodying the invention comprises a zoom tube 11, a focusing member 12, a focus and zoom ring 13 adapted to rotate member 12 and also slide longitudinally with respect thereto, housing member 14, 15 and 16 adapted to mount the fixed objective, hereinafter identified as Group IV, and a camera mount 17 secured to member 16. Tube 11 is fixed to member 14. The mount 17 as shown has a thread-type attachment. However, it may have a bayonet-type attachment dependent upon the camera body to which the lens 10 will be mounted.

The lens 10 further includes a mode selector ring or barrel 18 disposed about tube 11 and member 14, a focus and zoom ring support 19 which is rotatable and slidable with respect to barrel 18, a lens mount 20 for the focusing lens group I, a lens mount 21 for zoom lens group II and a lens mount 22 for the compensating lens group III. Lens mount 21 and lens group II are carried at one end of a zoom tube or ring 23, while lens mount 22 and lens group III are carried in a zoom tube or ring 24 within ring 23. Ring 23 has extensions 25 thereon as will be more clear from exploded views of Fig. 2a and 2b.

Fig. 2b illustrates essentially the same elements as Fig. 2a but with the parts

rotated one hundred eighty degrees. Fig. 2a shows the mode ring 18 while Fig. 2b shows the focus and zoom ring 13 with the forward portion thereof cut away. The purpose of extensions 25 is to release a detent switch to permit the lens to be used in a zooming mode of operation or a macro mode.

During the zoom mode of operation, lens group II is moved along the length of tube 11 to vary the equivalent focal length (EFL) of the lens while compensating group III moves at a predetermined rate with respect to the zooming lens primarily to compensate for the image plane shift which occurs during zooming. While lens group III primarily acts as a compensator, it also cooperates with group II to vary the focal length. As will hereinafter be explained during the macro mode of operation, lens groups II and III move in fixed relation to focus an object at a very close distance to the lens.

A guide pin 26 is threadably received in tube 23 and extends therefrom through either a guide slot Z or a cam slot M in tube 11. The end of pin 26 is received within a channel 28 defined in the end of focus and zoom ring support 19.

With this arrangement, it will be seen that as focus and zoom ring 13 is moved linearly along tube 11, the pin in channel 28 will move in one of slots Z or M to impart a predetermined forward and reverse movement determined by the contour of cam slots Z or M, with respect to the linear movement of ring 13. A guide pin 30 extends from ring 24 through a longitudinal slot 31 in ring 23, through either of cam slots Z1 or M1 in tube 11 and into a cutout or recess 32 in mode ring 18. It will be noted that cam slots M and M1 in opposite sides of tube 11 have the same contour, while cam slots Z and Z1 have substantially different contours. As will hereinafter be more fully explained during a zooming mode of operation, the guide pins 26 and 30 move in cam slots Z and Z1, respectively, while the same pins move in cam slots M and M1, respectively, during the macro mode of operation. Otherwise stated, there is a first pair of guides Z and Z1 for lens groups II and III during zooming and a second pair of guides M and M1 for close-up focusing.

In Fig. 1, the lens is shown with the lens groupings in position for a maximum focal length. Focusing is effected by rotating ring 13. Ring 13 receives in a slot 33 therein pins or screwheads 34 extending from focusing member 12. Thus member 12 will rotate with ring 13 on focusing threads 35 on tube 11 to cause lens mount 20 attached to member 36 to advance or retract with respect to tube 11.

If it is desired to change the focal length from the maximum towards the minimum, ring 13 is moved longitudinally with respect

to tube 11 and carries therewith pin 26 in channel 28. Pin 26 moves in cam slot Z in tube 11 and carries therewith tube 23 and lens group II mounted therein. Tube 23 may move longitudinally with respect to tube 24 by virtue of the slot 31 therein through which guide pin 30 extends. The rotary movement of tube 23 produces relative movement of guide pin 30 due to the walls defining slot Z1. Therefore, pin 30 will move in slot Z1 at a predetermined rate. Lens group III moves at a predetermined longitudinal rate with respect to lens group II.

With this related movement, ring 13 may be operated along tube 11 to vary the EFL of the lens system between the maximum and minimum design EFL's. Curves showing the relative movement of lens groups II and III with respect to lens group IV during the zooming mode of operation are set forth in Fig. 8.

When it is desired to change to the macro mode of operation, ring 13 is moved to the maximum EFL position as shown in Fig. 1. This enables the guide pins 26 and 30 to enter connecting slots S and S1 between the cam slots Z, M and Z1 and M1, respectively, in tube 11. At this time, pin 30 is extending through slot 31 in zoom tube 23, slot S1 and into recess 32 in mode ring 18.

Disposed within mode ring 18 at the end of tube 11 is a selector latch ring 38 seen more clearly in Fig. 2a, which has two detent recesses 39 and 40 defined therein and adapted to receive a detent latch member 41. As shown in Fig. 1, 4 and 5, latch member 41 is acted upon by a spring 42 received in a slot 43 defined by the outer periphery of member 16 and mode ring 18. Member 41 has a slot 44 therein which receives there-through a threaded guide pin 45 carried in member 14.

Latch member 41 is thus movable under or against the influence of spring 42 a predetermined distance defined by the length of slot 43. As shown in Figs. 1 and 4, latch 41 is in an unlatched position without detent 40 by virtue of the fact that extension 25 of zoom tube 23 has engaged the leading edge 46 and moved member 41 back against the bias of spring 42. Mode ring 18 may now be rotated to allow latch 41 to enter detent 39 and switch to the macro mode of operation.

As more clearly shown in Fig. 3, when the lens is to be switched to the macro mode of operation, the zoom ring will be fully retracted, pin 30 will be received in recess 32 of mode ring 18. Then mode ring 18 is rotated in the direction of the arrow in Figure 3 to move pin 30 to the other end of slot S1 so that pin 30 may now move in slot M1. At the same time pin 26 will rotate in slot S to a position where it may enter cam slot M.

Slots M and M1 are arranged to provide equal movement of tubes 23 and 24. Ring 13 together with support member 19 and its channel 28 are moved longitudinally along tube 11. The movement of ring 13 causes pins 26 and 30 to follow cam slots M and M1, respectively, and lens groups II and III move for close focusing with a fixed distance therebetween.

In the particular lens system hereinafter described, an object may be photographed in the macro mode at a distance of between about 1.18 meters and 8 centimeters from the front lens.

As more clearly shown in Fig. 4, when the extension 25 strikes detent latch member 41, then mode ring 18 may be rotated and for this purpose, finger grasps 47 may be provided thereon. As more clearly shown in Figs. 4 and 6, member 15 is recessed as exemplified at 48 to permit the extensions 25 to engage the latch member 41.

To prevent unintended switching of the lens from zoom to macro, or vice versa, when it is at the maximum focal length position, frictional means, not shown, may be provided between the end of mode ring 18 and limit ring member 49 which extends about mounting member 17. Such frictional means may take many forms and would be adapted to allow rotation of mode ring 18 upon a predetermined torque assuming that latch member 41 is withdrawn from the slots 39 or 40.

The ring 50 is the usual aperture setting adjustment which would be disposed behind lens L13. Such construction and the connection to the adjustment therefor are well known in the art and are not set forth here to simplify the disclosure.

By way of illustration, the optics of a lens having effective focal lengths of 70—205 mm with a relative aperture of 1:3.65 which may be utilized is shown in Fig. 7. The first or focusing group is effective to focus an object from infinity to 1.8 meters and is a three-element construction L1, L2 and L3 with a positive convex-concave and double convex cemented doublet and a single convex-concave positive lens. Therefore, the first group is positive.

Group II is the zooming lens and is a three-element construction L4, L5 and L6, a double convex, double concave cemented doublet and a double concave negative lens. The second group or zoom lens therefore is of negative power.

Group III comprising lenses L7 and L8 is a two-element cemented construction with a double concave, convex-concave construction, and is of negative power.

Group IV is a telephoto type lens utilizing a seven-element construction L9, L10, L11, L12, L13, L14, and L15 and is a positive lens group.

The overall lens data, with reference to Fig. 7, is set forth in the following table where radii (R) and distances between lens surfaces on the axis of the lens are in millimeters, N_d is the index of refraction and V_d is the Abbe number.

TABLE I

Lens		Radius in mm	Lens Thickness or Air Space Distance	N_d	V_d
L1	r1	268.54			
	r2	80.13	1.9	1.71736	29.5
L2	r3	-410.77	6.9	1.58913	61.2
	r4	90.60	0.3		
L3	r5	3376.49	5.3	1.51009	63.4
	r6	222.96	2.041 - 47.555		
L4	r7	-81.30	4.7	1.78472	25.7
	r8	154.03	1.3	1.66672	48.4
L6	r9	-184.02	2.7		
	r10	51.53	1.0	1.66672	48.4
L7	r11	-47.69	28.624 - 6.000		
	r12	33.79	1.0	1.52249	59.6
L8	r13	153.92	4.8	1.62588	35.6
	r14	88.43	24.389 - 1.500		
L9	r15	-36.55	6.5	1.48749	70.0
	r16	-56.17	1.46	1.80518	25.5
L11	r17	61.15	0.3		
	r18	284.27	3.87	1.48749	70.0
L12	r19	38.35	0.3		
	r20	-104.13	6.0	1.48749	70.0
L13	r21	94.78	1.023	1.64328	47.8
	r22	-20.19	49.846		
L14	r23	-53.33	1.48	1.69700	48.5
	r24	135.84	0.267		
L15	r25	-53.64	4.0	1.58921	41.0
			160.000mm		

It will be noted that the overall dimension of the lens between surfaces r1 and r25 is substantially less than the maximum effective focal length, 205 mm. Therefore a very compact telephoto lens is provided.

The lens assembly shown in Figures 1 to 9 is also disclosed in our copending applications Nos. 50174/72 (1,383,783) and 50173/72 (Serial No. 1,383,782).

The focal lengths of the various lens groups are as follows:

Group I	+ 126.000 mm
Group II	- 63.900 mm
Group III	- 82.888 mm
Group IV	+ 44.040 mm
Groups II and III with 6.0 mm spacing	- 34.620 mm

The movements of lens groups II and III during the zooming are set forth in Fig. 8. During the macro mode of operation the air space between the adjacent lens surfaces of Groups II and III is held constant at 6.0 mm.

This lens when not in the macro mode will focus down to 1.8 meters. To focus below this distance, and to increase magnification, group I is left at a focus distance of 1.8 meters, while groups II and III are simultaneously moved forward with a constant air space therebetween.

WHAT WE CLAIM IS:—

1. A lens assembly comprising an elongated cylindrical member, a sleeve-like operating member disposed about said cylindrical member adapted to move axially with respect to said cylindrical member for varying the focal length of said lens, first and second guide means defined on said cylindrical member, each having axial and tangential directional components, a first mounting member for a first lens group in said cylindrical member and having a first connection to said first guide means, a second mounting member for a second lens group within said first mounting member, and having a second connection to said second guide means, means connecting said operating member to said first mounting member whereby axial movement of said operating member moves said first mounting member axially and rotatively within said cylindrical member in accordance with said first guide means, and means connecting said first and second mounting members

whereby rotative movement of said first mounting member produces movement of said second mounting member in said second guide means.

2. A lens assembly according to claim 1 further including a third mounting member for a third lens group rotatively connected to said cylindrical member for focusing said lens, means connecting said third mounting member to said sleeve-like member whereby rotation of said sleeve-like member serves to focus said lens, and axial movement of said sleeve-like member moves said first and second lens groups in said first and second guide means.

3. A lens assembly according to claims 1 or 2 wherein a pin is connected to said first mounting member and extends into an annular groove in said operating member, whereby said operating member may be rotated without producing axial movement of said first and second mounting members.

4. A lens assembly according to claim 1 wherein said first and second guide means are first and second slots in said cylindrical member, a pin member extending from each of said mounting members, the pin of said first mounting member extending through said first slot and engaged by said operating member, said connecting means being defined by the pin in said second mounting member extending through a longitudinal slot in said first mounting member to said second slot in said cylindrical member.

5. A lens assembly according to claim 4 further including a third lens group rotatable with respect to said cylindrical member for focusing of said lens, said operating member having an annular groove therein receiving the pin of said first mounting member whereby rotation of said operating member on said cylindrical member does not axially move said first lens group.

6. A lens assembly according to claim 5 wherein said operating member has a longitudinal groove therein receiving a pin extending from said third lens group whereby axial movement of said operating member on said cylindrical member does not rotate said third lens group.

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whereby rotative movement of said first mounting member produces movement of said second mounting member in said second guide means.

2. A lens assembly according to claim 1 further including a third mounting member for a third lens group rotatively connected to said cylindrical member for focusing said lens, means connecting said third mounting member to said sleeve-like member whereby rotation of said sleeve-like member serves to focus said lens, and axial movement of said sleeve-like member moves said first and second lens groups in said first and second guide means.

3. A lens assembly according to claims 1 or 2 wherein a pin is connected to said first mounting member and extends into an annular groove in said operating member, whereby said operating member may be rotated without producing axial movement of said first and second mounting members.

4. A lens assembly according to claim 1 wherein said first and second guide means are first and second slots in said cylindrical member, a pin member extending from each of said mounting members, the pin of said first mounting member extending through said first slot and engaged by said operating member, said connecting means being defined by the pin in said second mounting member extending through a longitudinal slot in said first mounting member to said second slot in said cylindrical member.

5. A lens assembly according to claim 4 further including a third lens group rotatable with respect to said cylindrical member for focusing of said lens, said operating member having an annular groove therein receiving the pin of said first mounting member whereby rotation of said operating member on said cylindrical member does not axially move said first lens group.

6. A lens assembly according to claim 5 wherein said operating member has a longitudinal groove therein receiving a pin extending from said third lens group whereby axial movement of said operating member on said cylindrical member does not rotate said third lens group.

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