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PATENT SPECIFICATION

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(54) CAMERA

(71) We, KARL VOCKENHUBER, of 118 Pötzleinsdorferstrasse, Vienna 18, and RAIMUND HAUSER, of 2 Goldeggasse, Vienna 4, both of Austria and Austrian nationality, 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 a camera for still or cinematographic photography having a lens of variable focal length and an aperture diaphragm.

An optical system of variable focal length is known that makes it possible to use the maximum depth of field range required in each case, depending upon the focal length. Such a lens is provided with a servo device that re-adjusts the focusing of the optical system to the 'near-infinity' point, by which is meant the distance at which the rear depth-of-field range lies within infinity, in any focal setting from close-up to infinity. The readjustment is based on a given aperture stop or the original aperture setting of the lens in which the diameter of the circle of confusion still shows an admissible value, i.e. when the eye still perceives sharp objects that lie in front or to the rear of the object plane proper.

In such a system, when the lens is stopped down from the original diaphragm setting, the rear depth-of-field limit will go beyond infinity, that is to say the lens would be capable of focusing converging rays. Therefore, a considerable part of the depth-of-field range available for picture taking will be lost.

In accordance with the present invention there is provided a camera comprising a zoom lens which includes a varifocal front lens and a fixed focus rear lens, means defining a film plane, and an aperture setting means, wherein the position of the focal plane (as herein defined) of the zoom lens varies in dependence upon the aperture setting and the focal length, such that for any focal length and any aperture setting the rear limit of the depth-of-field does not lie beyond a defined distance.

The term "the focal plane" as used herein is intended to mean the plane of best focus. In the case of a perfectly compensated

lens there is only one focal plane that is to say parallel light incident upon the lens at any point on its surface will be focussed at a predetermined distance from the lens. On the other hand, in respect of a lens which is not fully compensated light incident at different diameters is brought to a point at a different focal distance. The focal plane in such a case is the plane of best focus that is to say the plane of focus at which the image of maximum intensity is formed. Effectively therefore, at small apertures the focal plane is determined by the effective focal length at the centre of the lens and at wider apertures the focal plane is determined by the effective focal length near the edges of the lens.

The invention will now be described with reference to embodiments shown by way of example in the accompanying drawings, wherein:

Figure 1 show, schematically, a device in accordance with the invention mounted in a movie camera;

Figures 2—5 show different embodiments of control for the drive of the base objective;

Figures 6 and 7 show indicator devices controlled by cam curves;

Figures 8 and 9 show the image in the viewfinder, as seen by the photographer;

Figure 10 is a diagram illustrating the advantages of the invention graphically;

Figure 11 shows a diagrammatic sketch of another embodiment in accordance with the invention; and

Figure 12 shows an embodiment of Figure 11.

In Figure 1 a zoom lens has a varifocal front lens 1, a rear lens 2 of fixed focal length which is adjustable by means of a gear 3 to be described later.

The front lens 1 has a front lens element that can be adjusted by a knurled knob 19 for focusing and serves to set the rear limit of the depth of field; the rear limit being incapable of going beyond infinity. An image aperture 7 is periodically masked by means of a rotating shutter 4, from the light entering from the front 1 and from the rear lens 2, while a film stored in a cassette 5 is moved by a ratchet pawl (not shown) in a known

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manner. It should be noted that as used in this specification, the term "lens" is meant to include optical devices having one or several lens elements.

5 For the control of the correct exposure of the film there is a photo-electric cell 6, to which is directed the light for picture-taking that has been deflected by the shutter. The photo-electric cell 6 is coupled to a diaphragm control motor 9 via a switching device 8, shown schematically, its power being supplied by a battery 10. Two cams 12 are mounted on a motor shaft 11. Each cam controls one diaphragm lamella 13, 14, for stopping-down the light for picture-taking. A deflecting prism 15 is arranged between the front lens 1 and the rear lens 2 of the zoom lens, and the prism diverts a small percentage of the light for picture-taking into a path of rays defined by an optical viewfinder system 16.

20 In the switching device 8, an operating mode switch 17 is provided for two positions: Position I for servo-focus operation as per the invention, and position II for normal operation without any servo-focus control. In both positions I and II, the diaphragm control motor 9 is governed by the photoelectric cell 6. By throwing operating switch 17 into position II all that results is a change of rotation of the diaphragm control motor 9 (position I, rotation counter-clockwise, position II clockwise). It is necessary, however, when switching from position I to position II, or vice versa, to return the lamellae of the diaphragm to a zero position, in which the diaphragm aperture has a maximum opening, and to determine, based on this position, the diaphragm setting, in dependence on the pre-selected direction of the drive.

40 To that end, a contact 17a of the operating mode switch 17 briefly short-circuits the photo-electric cell, during the change of rotation of the diaphragm control motor 9, thereby simulating a completely dimmed incidence of light. But since the polarity of the control motor 9 has already been reversed (contact pair 17b), the lamellae 13, 14 of the diaphragm are returned to the zero position. Contact 17a is closed for a short time only, e.g. by means of fulcrum spring acting in the operational mode switch 17, so that the direction of displacement of the control motor 9 at the end of the switch-over is programmed by the position of contact 17b, when contact 17a is opened.

55 The cams 12 controlling lamellae 13 and 14 of the diaphragm have been designed—(starting with the zero-position at maximum diaphragm aperture, as shown in Figure 1) in such a way that a predetermined, reduced opening of the diaphragm will result from a rotation of shaft 11, in one direction as well as in the opposite one, around the same angle of rotation.

On shaft 11, within the range of the control gear 3 of the rear lens 2, a toothed segment 18 has been mounted, which (starting with the position shown in Figure 1) meshes with a gear of the control gear unit 3, during counter-clockwise rotation of shaft 11 (position I for servo-focus). This means that when the user of the camera has switched the operational mode switch 17 to position I, while the diaphragm lamellae 13, 14 are adjusted to the correct aperture, the rear lens 2 is adjusted by the diaphragm motor 9 by an amount determined by the transmission in gear 3, and which is dependent upon the aperture stop. Since the adjustment of the rear lens 2 takes place within very narrow limits, the shifting of the optical system may take place by way of a screw-threaded socket, e.g. with a fine thread.

In position II of the operating switch 17, the polarity of the diaphragm motor 9 is reversed. The lamellae 13, 14 are displaced then by the same amount as in the case of an adjustment in operational mode position I. For a clockwise rotation of the shaft I, the toothed segment 18 does not mesh with the gear 3 so that no adjustment of the rear lens 2 takes place.

In order to permit the operator a controllable focusing of the zoom lens, in position II of operational mode switch 17, a range indicator connected with operational switch 17 (e.g. a pair of sectional wedges) may be movable into the path of rays of the view finder.

100 Figures 2 and 3 show an alternative for controlling the adjustment of the rear lens in synchronism with the control of the diaphragm. Diaphragm motor 9 controls, by way of motor shaft 11, the adjustment of the diaphragm lamellae 13, 14, in a known manner. The power input of the motor is dependent upon the out of balance condition of a Wheatstone bridge 20, having a photo-electric cell 6 connected in one of its branches. Shaft 11 also carries a contact disc 21 that is interrupted by two axially counter-positioned circuit breakers 22. The contact disc 21 is in a power circuit for a motor 23 adjusting the rear lens 2 and a battery 24 acting as energy source. Shaft 25 of the control motor 23 carries a disc 26 positioned axially opposite the disc 21. The disc 26 supports two current collectors 27 that lie against the circuit breakers 22 of disc 21 in the zero position, i.e. when the diaphragm aperture is largest (Figure 3).

125 Shaft 25 also supports a gear wheel 28 that meshes with the control gear 3 of the rear lens 2. Within the electric circuit of the control motor 23 of the rear lens 2, there is a set of switches 29 with three switch positions I, II, and III that serve as an operational mode switch. Position I corresponds to the

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invention. In position I (similar to the device in accordance with Figure 1) the control motor 23 of the base objective is regulated in dependence on diaphragm motor 9. When the contact disc 21 is rotated by shaft 11, the current collectors 27 are switched on to current-carrying planes and the motor 23 is connected to the battery voltage 24 via the closed set of switches 29a. The switch pair 29b, on the other hand, is open. When the correct diaphragm aperture has been set, the contact disc 21 stops, and the disc 26 with collectors 27 keeps turning until the collectors are opposite the circuit breakers 22. The adjustment of the base objective that is dependent upon the aperture setting is achieved by gear 3.

In position II, the contact pair 29a is open, while pair 29b is closed and the motor 23 is connected directly to battery 24, but its polarity has been reversed.

Consequently the rear lens 2 is returned to zero position, i.e. in the position in which the objective is adapted for a normal range setting. At the end of the adjustment, a peg 30 mounted on the base objective, actuates a circuit breaker 31 in the drive circuit of the control motor 23. Upon renewed servo-focus adjustment, the motor 23 will be controlled by contact disc 21 and switch 31 will be again closed.

Finally, when a switch 29 is in position III, both switch pairs 29a, b, are open and no motor drive of the control gear unit 3 of the base objective is possible.

In Figure 4 parts having the same functions have been given the same reference numbers as in Figures 2 and 3. Position I again corresponds to the invention. The only difference is that the operating mode switch 29' in position II connects the control motor 23 of the base objective to additional current collectors 32, which are mounted on a disc 33 that is connected with control gear 3 of the rear lens 2, and therefor is in function similar to the disc 26.

A contact disc 34 fixedly mounted on a shaft 35, is placed axially opposite the disc 33, but without any connecting gear. Disc 34 is connected similarly to disc 21, directly to battery 24 and also has two circuit breakers. Shaft 35 is driven by a pinion 36 and a toothed segment 37 that engages pinion 36, and can be swivelled around an axis 39 which may be displaced about a control curve 38. The swivelling of the toothed segment 37 is effected by a cam follower 40 hinged thereto and which follows a control cam 41 mounted on the front lens 1.

Starting with the well-known equation

$$u \times v = f^2,$$

where u is the object distance, v is the image distance, and f is the focal length, of the zoom lens, it is possible to shift the base objective

2 in proportion to the adjustment of the focal length of the zoom lens, when control cam 41 has a gradient that is proportional to f^2 . With the aid of a setting device 42, it is possible to pre-program the distance u desired or needed for taking the picture by a change of the position of axis 39 mounted on the setting device for toothed segment 37 within curve 38. The scale assigned to the setting device 42 is proportional to u .

When the switch 29 is turned to position II and the focal length is adjusted, the toothed segment 37 that produces quotient f^2/u rotates pinion 36 and contact disc 34 by means of cam 41 and follower 40. At the same time, the current collectors 32 connect the motor 23 driving the base objective with the battery 24. The conversion of the path of adjustment of the base objective in proportion to v can be realised (in analogy to parts 41, 40 37) by way of an additional cam (not shown) for the rear lens 2. Motor 23 is driven until the adjustment of the focal length is completed and the current collectors 32 of disc 33 lie opposite the current-breakers of contact disc 34.

Due to the high power of refraction of the rear lens 2, it is possible to focus on an object located in a macro range by means of small paths of displacement. In this case, the image plane of the zoom lens remains constant even in the case of modifications of the focal length when u (focusing device 42) has been pre-programmed.

A particular advantageous embodiment of the invention is shown in Figure 5. The adjustment of the base objective as a function of the diaphragm setting is done by the motor, in accordance with Figure 1. For the sake of simplicity, the control of the lamellae of the diaphragm by motor 9 is not shown again.

In addition, a motor 43 for the adjustment of focal length has been provided, driving a spur gear 45 on the front lens 1 by way of a driving pinion 44. Derived from the rotation of the spur gear 45 by pinion 47, a wiper 48 is rotated relative to a stationary contact disc 49. In dependence on the relative angular position of the wiper 48 and disc 49, an output signal that is proportional to the focal length f or f^2 , or to $\log f$ or $\log f^2$, is conveyed to a control circuit 50. Similarly, this is done by the diaphragm setting motor 9 by means of a stationary contact disc 51 and a wiper 52. An output signal proportional to the aperture stop k or to the logarithm of the aperture stop k is conveyed to control circuit 50.

The control circuit 50, in turn, emits an output signal that contains the shortest permissible range for taking a picture (front depth of field limit u_1) or the still allowable size of the object for a format-filling picture (optical reduction V at the front depth of

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field limit. This output signal may be calculated on the basis of the formula

$$u_1 = \frac{f^2}{2Uk}$$

or on the basis of the equation

$$V = c \frac{k}{f},$$

in which

$$\frac{1}{2U}$$

and/or c , represent constant factors. In the case of logarithmic division proportional to f^2 and/or to aperture stop k of discs 49, 31, the calculation of the distance u_1 may be done by simple subtraction. When discs 49, 51 are not divided logarithmically, the quotient

$$\frac{f^2}{k} \text{ or } \frac{k}{1}$$

may also be found by means of a bridge circuit.

After the drive for the rear lens is switched off, the desired information is indicated to the operator of the camera in the view-finder by means of luminous diodes 56 with which threshold-value switches 55 set at different values have been connected in circuit.

Within the transfer circuit between diodes 56 and control circuit 50, a switch 52' has been placed that can be actuated by a peg 53 on the focusing control ring 54 of the front lens 1. The connection between the control circuit 50 and indicating device 56 is broken by switch 52' in the case of a range setting of the front lens outside the position of infinity, i.e. when the rear depth-of-field limit is limited.

A mechanical arrangement for indicating the front depth-of-field limit u_1 to the operator of the camera is shown in Figure 6. Instead of a contact disc 51 of Figure 5, a cam 56 is coupled with the diaphragm control motor 9 by way of the shaft 11. The front lens 1 which is controlled by a motor 43 that controls the focal length, carries a cam 57. Both cams 56 and 57 are provided with a logarithmic gradient proportional to the focal length f or f^2 (cam 57) and to aperture stop k (cam 56).

A cross-shaped lever 58 has two points 59, 60 engaging cam 56 and cam 57 respectively. The lever 58 is mounted in such a way that it may be rotated about and shifted via a slit 61 along a stationary peg 62. An extension 63 of the lever 58 acts as an indi-

cator which, e.g. is visible in the view-finder of the camera. An adjustable scale 64 is adjacent the indicator 63. The adjustment of the scale takes place against a spring 67 by means of front adjustment ring 54 via a gear unit 65 and a drum 66. A cable line 67' is wound on the drum 66 and is connected to the scale 64.

When focal length f of the zoom lens is adjusted by means of the motor 43 and when the diagram 13, 14 and the position of the rear lens 2 are adjusted by means of motor 9, points 59, 60 will be shifted according to the logarithm of the aperture stop k or logarithm f^2 respectively whereby, the difference of the paths of adjustment is taken up by the lever 58. Then, indicator 63 immediately indicates the allowable front depth-of-field limit u_1 depending on the range setting through the front lens.

A similar device is shown in Figure 7, but this does not show the front depth-of-field limit, but rather the allowable size of the object for a format-filling picture.

On the front lens 1 two similarly shaped cams 68 have been provided, which like the cam 57, have a logarithmic gradient, but which is proportional to logarithm f . In principle, it would be possible to provide a single cam 68 only. Inasmuch as the path of follower 59 which engages cam 56, is proportional to the logarithm of the aperture setting (according to Figure 6) during the adjustment of the diaphragm and of the rear lens 2, the difference between logarithm of the aperture stop k and logarithm f (cam 68) is indicated by compound lever 58.

The deviation of the indicator 63 immediately indicates a measurement of the optical reduction.

In addition, a spring loaded follower 69, which rotates around a stationary axis, engages one of the cams 68. A pinion 71 may be rotated by toothed segment 70 of the follower 69 during movement of the cam 68.

An additional cam 72, which is connected with the frontal member 54 for the purpose of range-finding, is followed by a spring-loaded follower 73 which (like the follower 69) can be rotated so as to drive a pinion 74. The two pinions 71 and 74 are connected by way of a differential 75. A gear wheel 76 at the end of a differential 75 drives a movable rack 77, which is connected directly with a scale 78 which is visible, for example, in the view-finder of the camera and which changes, when driven by gear wheel 76, its position relative to the indicator 63, against the tension of spring 67. Scale 78 and indicator 63 indicate symbolically the size of an object in dependence on the focal length and on the diaphragm that is still allowable in order to achieve a sharply defined and format filling-picture.

The shape of cam 72 is proportional to the logarithm of the focusing distance u of the object from the focus on the object side.

Accordingly, scale 78 assumes (following the focussing of front lens 54) a position relative to indicator 63 at zero, that indicates from which size of the object on the picture can be taken so as to fill the format.

The scale graduations that are visible to the operator of the camera are shown in Figures 8 and 9.

Figure 8 shows the picture of the scale when the front lens is focused at infinity. Thus, all symbols 79a to 79e of scale 78 are visible. By servo-focusing, for instance according to Figure 7, indicator 63 is placed opposite symbol 79c. Now, the photographer knows that, according to the camera setting and/or to the exposure of the film, objects up to the size of a half-length photo can be taken and nevertheless achieve a sharply defined, format-filling picture.

If the picture is to be taken within a space, the photographer will first calculate the largest possible picture range (diagonal of the space) and adjust the front lens accordingly. Scale 78 is thereby shifted to the left, as may be seen for instance in Figure 9. Thus there is a most simple indication which image area is available for the picture under changed conditions. It is evident that in lieu of scale 78 with the symbols 79a to e scale 64 with the indications for the shortest allowable front depth-of-field limit can be made visible in the view-finder.

For a clearer indication, the field to the right of indicator 63 may be covered by a flag 80.

By way of conclusion, we shall illustrate by the diagram in Figure 10, the advantages obtainable over known systems, by means of the invention. On the abscissa, the distance u_1 from the focus on the object side to the front depth-of-field limit has been plotted; the focal length f has been plotted on the ordinate.

The conditions as shown by the solid curves 81, 83 can be achieved by the above described embodiment while the dotted curves 82, 84 are of a known camera (with an original aperture of $k=1.2$). For example, with a diaphragm aperture stop of $k=22$ (curves 81, 82), the allowable range is $u_1=2m$ for a focal length of 42.5 mm while in the case of the known device, there will be a loss of a 100% in the allowable distance from the object (4 m).

Also an advantage is shown, particularly clearly, in the case of a smaller diaphragm aperture, f.i. $f/8$ (curves 83, 84), where it is possible to shoot with the camera in accordance with the invention already when the distance from the object is to $u_1=3.5 m$ and at a focal length of $f=32.5 mm$, while a sharply defined picture can be achieved by

the known camera only at a distance from the object of 6 m.

However, on the basis of a simple recalculation, this means also that at the same optical reduction, it is possible with the above described embodiments to work with a considerably larger diaphragm aperture, so that picture-taking will be possible also under unfavourable lighting conditions.

The invention is not restricted to the use of an electromotor, for the adjustment of the base objective and/or of the lamellae of the diaphragm. There is a conceivable use of galvanometers, of moving iron and rotary magnet systems, or generally of devices that convert an electric value into a mechanical one.

Instead of the follower control devices shown in Figures 2 to 4, potentiometers, optoelectric, inductive, capacitive transformers, etc. could be used, likewise f.i. the luminous diodes schematically shown in Figure 5 as indicating devices could be replaced by small lamps, if necessary of different colours.

An embodiment of the invention based exclusively on optical means is shown in Figures 11 and 12. In Figure 11 the image of infinitely remote objects is shown schematically for various diaphragm openings. The pencil of rays 101 corresponds to the maximum opening of an objective 100, that is to a diaphragm aperture number of $k=2$. The pencil of rays 102 correspond to a diaphragm aperture of $k=4$ the pencil of rays 103 to $k=8$. The pencils of rays 101, 102, and 103 intersects in a plane 104, after intersecting, each in its focus, the optical axis of objective 100. The plane 104 corresponds to the plane of the film of a camera. The image of the infinitely remote object with a diameter of U (diameter of the circle of confusion) is certainly not sharply defined, but this out-of-focus image of the object does not have any noticeable consequences for a photographic picture.

As may be seen from Figure 11 the foci F_2 and F_3 do not coincide with the focus F_1 . This phenomenon is due to a certain aperture defect of objective 100, which can be defined by the following derivation. According to the beam theorem, the ratio of diameter d of objective 100 to diameter U of the circle of confusion is equal to the ratio of the focal length f to the distance of the focus v to the plane 104.

$$d/U = f/v$$

$$v = \frac{f}{d} \times U \quad \text{when} \quad \frac{f}{d} = k$$

$$v = k \times U$$

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This condition means that when postulating a constant diameter U of the circle of confusion, the distance of the focus from the plane of the image 104 is directly proportional to the relative aperture k . This is also clearly evident from Figure 11.

Now, if lens 100 has an aperture defect characterized by the above equation, the circle of confusion will remain constant for any diaphragm aperture. In this way, the advantage is achieved over known objectives that even with smaller aperture stops and a constantly large circle of confusion, the rear depth-of-field limit remains at infinity without losing any of its sharp definition at maximum diaphragm aperture.

The aperture defect of the objective is characterized by curve 105, the development of the aperture defect encounters problems of

production technology at smaller aperture stop figures.

In Figure 12, a design of an objective is shown that has an aperture defect according to Figure 11. The lens contours drawn in solid lines show a fully corrected rear lens for a movie camera. If the lens is intended to have a certain aperture defect, radii r_{10} and r_{11} , and/or the distance s_8 from the last lens apex to the plane of the image 104 will be modified. It is evident that the change of radii to be changed for attaining the desired aperture defect will depend on the design of the lens. In the following the data of the rear lens as shown in Figure 12 will be indicated. The lens thicknesses have been designated by d in the table. The distances of the apices, the indices of refraction, and the Abbe numbers have been designated by s , n_d , and v_d , respectively.

40	L_1	r_1	+ 3.166	d_1	=0.177	1.689	49.5
		r_2	-31.162	s_1	=0.62	+0.27	
	L_2	r_3	+ 0.974	d_2	=0.32	1.713	53.8
		r_4	- 9.037	s_2	=0.193		
45	L_3	r_5	- 1.5	d_3	=0.355	1.785	26.1
		r_6	+ 0.849	s_3	=0.355		
50	L_4	r_7	- 4.586	d_4	=0.22	1.641	60.1
		r_8	- 1.33	s_4	=0.11		
	L_5	r_9	+ 1.165	d_5	=0.33	1.641	60.1
		r_{10}	- 7.204	s_5	=1.135		

WHAT WE CLAIM IS:—

1. A camera comprising a zoom lens which includes a varifocal front lens and a fixed focus rear lens, means defining a film plane, and an aperture setting means, wherein the position of the focal plane (as herein defined) of the zoom lens varies in dependence upon the aperture setting and the focal length, such that for any focal length and any aperture setting the rear limit of the depth-of-field does not lie beyond a defined distance.

2. A camera as claimed in Claim 1, wherein the position of the focal plane of the zoom lens is varied by means for displacing the rear lens in dependence upon the aperture setting.

3. A camera as claimed in Claim 2, in which the means for displacing the rear lens in dependence upon the aperture setting comprises a servo mechanism.

4. A camera as claimed in Claim 3, in which the means for displacing the rear lens includes an additional control device for displacing the rear lens independently of the aperture setting.

5. A camera as claimed in Claim 4, wherein the additional control device includes a servo mechanism operative to displace the rear lens in dependence upon the focal length setting of the front lens.

6. A camera as claimed in Claim 2, wherein the means for displacing the rear lens is coupled by way of a gear train to a drive so as to vary the aperture setting.

7. A camera as claimed in Claim 6, in which the aperture is varied by mutual displacement of lamellae movable by means of the said drive and means are provided for disengaging the drive from the gear train of the rear lens.

8. A camera as claimed in Claim 7, wherein the aperture setting means comprises a pair of lamellae arranged to be opened and closed by symmetrical cam means driven by a motor, the cam means being such that rotation thereof in either sense when the aperture setting is maximum results in a decrease of the aperture and wherein the motor is connected to a mode setting switch for selecting

This condition means that when postulating a constant diameter U of the circle of confusion, the distance of the focus from the plane of the image 104 is directly proportional to the relative aperture k . This is also clearly evident from Figure 11.

Now, if lens 100 has an aperture defect characterized by the above equation, the circle of confusion will remain constant for any diaphragm aperture. In this way, the advantage is achieved over known objectives that even with smaller aperture stops and a constantly large circle of confusion, the rear depth-of-field limit remains at infinity without losing any of its sharp definition at maximum diaphragm aperture.

The aperture defect of the objective is characterized by curve 105, the development of the aperture defect encounters problems of

production technology at smaller aperture stop figures.

In Figure 12, a design of an objective is shown that has an aperture defect according to Figure 11. The lens contours drawn in solid lines show a fully corrected rear lens for a movie camera. If the lens is intended to have a certain aperture defect, radii r_3 and r_4 , and/or the distance s_3 from the last lens apex to the plane of the image 104 will be modified. It is evident that the change of radii to be changed for attaining the desired aperture defect will depend on the design of the lens. In the following the data of the rear lens as shown in Figure 12 will be indicated. The lens thicknesses have been designated by d in the table. The distances of the apices, the indices of refraction, and the Abbe numbers have been designated by s , n_d , and v_d , respectively.

40	L_1	r_1	+ 3.166	d_1	=0.177	1.689	49.5
		r_2	-31.162	s_1	=0.62	+0.27	
	L_2	r_3	+ 0.974	d_2	=0.32	1.713	53.8
		r_4	- 9.037	s_2	=0.193		
45	L_3	r_5	- 1.5	d_3	=0.355	1.785	26.1
		r_6	+ 0.849	s_3	=0.355		
50	L_4	r_7	- 4.586	d_4	=0.22	1.641	60.1
		r_8	- 1.33	s_4	=0.11		
	L_5	r_9	+ 1.165	d_5	=0.33	1.641	60.1
		r_{10}	- 7.204	s_5	=1.135		

WHAT WE CLAIM IS:—

1. A camera comprising a zoom lens which includes a varifocal front lens and a fixed focus rear lens, means defining a film plane, and an aperture setting means, wherein the position of the focal plane (as herein defined) of the zoom lens varies in dependence upon the aperture setting and the focal length, such that for any focal length and any aperture setting the rear limit of the depth-of-field does not lie beyond a defined distance.

2. A camera as claimed in Claim 1, wherein the position of the focal plane of the zoom lens is varied by means for displacing the rear lens in dependence upon the aperture setting.

3. A camera as claimed in Claim 2, in which the means for displacing the rear lens in dependence upon the aperture setting comprises a servo mechanism.

4. A camera as claimed in Claim 3, in which the means for displacing the rear lens includes an additional control device for displacing the rear lens independently of the aperture setting.

5. A camera as claimed in Claim 4, wherein the additional control device includes a servo mechanism operative to displace the rear lens in dependence upon the focal length setting of the front lens.

6. A camera as claimed in Claim 2, wherein the means for displacing the rear lens is coupled by way of a gear train to a drive so as to vary the aperture setting.

7. A camera as claimed in Claim 6, in which the aperture is varied by mutual displacement of lamellae movable by means of the said drive and means are provided for disengaging the drive from the gear train of the rear lens.

8. A camera as claimed in Claim 7, wherein the aperture setting means comprises a pair of lamellae arranged to be opened and closed by symmetrical cam means driven by a motor, the cam means being such that rotation thereof in either sense when the aperture setting is maximum results in a decrease of the aperture and wherein the motor is connected to a mode setting switch for selecting



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the sense of rotation of the cam means, the gear train connected to the rear lens being such that a rotation of the cam means in a first sense results in a simultaneous axial displacement of the rear lens whereas rotation of the cam means in the opposite sense may be effected without simultaneous displacement of the rear lens.

9. A camera as claimed in Claim 8, wherein the gear train comprises a cog having a segment with missing teeth which meshes with an adjacent cog when rotated in said first sense but not when rotated in the opposite sense.

10. A camera as claimed in any one of claims 1 to 9, wherein the vari-focal front lens comprises a focussing element.

11. A camera as claimed in any one of claims 2 to 9, wherein a device is provided for determining the quotient of the square of the focal length of the zoom lens and the aperture stop k , the said quotient being representative of the hyperfocal distance, that is to say the distance to the nearest object in focus.

12. A camera as claimed in Claim 11, wherein the said quotient is determined by a device connected to receive an indication of the logarithm of the square of the focal length of the zoom lens and the logarithm of the aperture stop.

13. A camera as claimed in Claim 11 or 12, in which the device for determining the hyperfocal distance operates electrically and comprises a visual indicator.

14. A camera as claimed in Claim 13, wherein the indicator is mounted within the camera viewfinder.

15. A camera as claimed in Claim 14, wherein the indicator is a threshold value switch connected to lights or luminous diodes.

16. A camera as claimed in Claim 15, wherein a device is provided to render ineffective the hyperfocal distance indicator

device when the distance setting of the front lens is at less than infinity.

17. A camera as claimed in Claim 16, wherein when the drive for the rear lens is switched off, a range indicator unit is introduced into the path of rays of the viewfinder.

18. A camera as claimed in Claim 11 or 12, wherein the adjustment of the focal length of the vari-focal front lens and the adjustment for the aperture setting are coupled to curved members serving as cams shaped in such a manner as to impart to associated followers a displacement proportional to the logarithm of the square of the focal lens and the logarithm of the aperture stop, respectively, the followers being mechanically connected to a pointer for indicating the hyperfocal distance.

19. A camera as claimed in Claim 18, in which the front lens incorporates a focussing element and in which the pointer moves in front of the scale which is movable in accordance with the focussing range of the front lens.

20. A camera as claimed in Claim 1, wherein the rear lens presents, at least over a certain area, an aperture defect that shifts the optimum focal plane as defined by the image by means of the marginal rays in each case, substantially according to the condition

$$v = U \times k,$$

where v is the distance of the circle of confusion with a diameter U from the focal point, in each case, and where k is the aperture stop.

21. A camera as claimed in Claim 20, wherein the rear lens is dimensional as listed below, where the values r are the radii of the lenses, d the lens thicknesses, s the distances of their apices, n_d the refractive indices, and v_d the Abbe numbers:

L ₁	r ₁	+ 3.166	d ₁	=0.177	1.689	49.5
	r ₂	-31.162	s ₁	=0.62	+0.27	
L ₂	r ₃	+ 0.974	d ₂	=0.32	1.713	53.8
	r ₄	- 9.037	s ₂	=0.193		
L ₃	r ₅	- 1.5	d ₃	=0.355	1.785	26.1
	r ₆	+ 0.849	s ₃	=0.355		
L ₄	r ₇	- 4.586	d ₄	=0.22	1.641	60.1
	r ₈	- 1.33	s ₄	=0.11		
L ₅	r ₉	+ 1.165	d ₅	=0.33	1.641	60.1
	r ₁₀	- 7.204	s ₅	=1.135		



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22. A camera having a zoom lens substantially as herein described with reference to and as illustrated in Figure 1, Figure 2, Figure 4, Figure 5, Figure 6, Figure 7 or Figures 11 and 12 of the accompanying drawings.

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