

PATENT SPECIFICATION

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(54) ZOOM LENS

(71) We, KARL VOCKENHUBER, of 118 Pötzleinsdorferstrasse, Vienna 18, and RAIMUND HAUSER, of 2 Goldeggasse, Vienna 4, both of Austria, and of 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 zoom lens suitable for use in a film projector and comprising positive front and rear components fixed relative to one another and a relatively axially displaceable negative intermediate component.

According to the present invention, there is provided a zoom lens suitable for use in a projector consisting of positive front and rear components fixed relative to one another and a relatively axially displaceable negative intermediate component; said front component consisting of a negative first lens, a positive second lens and a positive third lens, the spacing between said first and second lenses being substantially half the axial length of said positive front component, said intermediate component being a single negative lens; and said rear component consisting of a plurality of positive lens elements and an interposed negative lens element.

It has been found that several advantages stem from having the distance between the first and second lenses of the front component greater than the diagonal of the cine format. The distance between these two lenses provides a particularly advantageous correction combined with a short structural length.

There is also the advantage that the brightness at the outer image edge amounts to more than 40% of the brightness in the image centre as expressed by a relative aperture of 1:1.2 while maintaining a correction which is characterised by high contrast over the entire image field and the entire range of focal lengths of the zoom lens. Another advantage is that the zoom lens requires relatively few lenses and these can also be produced from relatively inexpensive kinds of glass.

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

FIGURE 1 shows diagrammatically an axial section through a zoom lens for a film projector (not shown);

FIGURE 2 illustrates lens elements of the zoom lens in their setting for minimum focal length; and,

FIGURE 3 shows the elements in their settings for maximum focal length setting of the zoom lens.

FIRST EXAMPLE.

The zoom lens in Figure 1 comprises ten lens elements. The front element is rigidly associated with a base lens assembly whose negative component is two cemented elements.

As is apparent from Figure 2 the lens elements form three distinct parts. The first part I provides a positive front lens assembly; the second part II comprises a negative lens element slidable along the zoom lens axis; and the third part III comprises a positive base lens assembly which is rigidly coupled to the positive front lens I. The first part I faces the long conjugated back focus point and the third part III faces the short conjugated back focus point.

In the tables hereinbelow, in all of the three embodiments the symbol r refers to the radii of curvature of the surfaces of the lens elements (the units are arbitrary since only the relative magnitudes are of importance), the symbol d to the lens

element thicknesses (measured in the same units of length), and the symbol n_d to the refractive indices and V_d to the Abbe numbers, this being based to a setting to a minimum overall focal length $f_{\min} = 1$.

DIMENSIONS

		n_d		V_d
$r_1 - 7,825$	d_1 0,156	/ 1,668	/	41,9
$r_2 + 3,940$	d_2 0,656			
$r_3 + 4,673$	d_3 0,257	/ 1,620	/	60,3
$r_4 - 10,336$	d_4 0,008			
$r_5 + 5,451$	d_5 0,211	/ 1,620	/	60,3
$r_6 - 37,513$	d_6 0,125.... $f_{\min}$			
	d_6 2,519.... $f_{\max}$			
$r_7 - 5,802$	d_7 0,109	/ 1,678	/	55,2
$r_8 + 4,397$	d_8 2,676.... $f_{\min}$			
	d_8 0,282.... $f_{\max}$			
$r_9 + 6,239$	d_9 0,187	/ 1,589	/	61,3
$r_{10} - 18,918$	d_{10} 0,008			
$r_{11} + 2,024$	d_{11} 0,273	/ 1,641	/	60,1
$r_{12} - 25,749$	d_{12} 0,008			
$r_{13} + 1,000$	d_{13} 0,398	/ 1,641	/	60,1
$r_{14} + 10,406$	d_{14} 0,113			
$r_{15} - 4,847$	d_{15} 0,339	/ 1,720	/	50,4
$r_{16} - 0,660$	d_{16} 0,078	/ 1,699	/	30,1
$r_{17} + 0,523$	d_{17} 0,183			
$r_{18} + 1,292$	d_{18} 0,296	/ 1,717	/	48,0
$r_{19} - 1,753$				
	$f_{\min} = 1,000$			
	$f_{\max} = 1,900$			
	Relative Aperture 1:1,2			
	$2y' = 0,523$			

SECOND EXAMPLE.

The basic zoom lens has the same arrangement of elements as shown in Figures 1 to 3 but the dimensions of the elements are different from those of the first example.

DIMENSIONS

			n_d		v_d
$r_1 -$	6,240				
$r_2 +$	3,990	d_1	0,156	/	1,618
		d_2	0,656		49,8
$r_3 +$	4,680	d_3	0,234	/	1,620
$r_4 -$	10,238	d_4	0,008		60,3
$r_5 +$	4,963	d_5	0,234	/	1,620
$r_6 -$	121,306				60,3
		d_6	0,102 f_{min}		
$r_7 -$	5,821		2,364 f_{max}		
$r_8 +$	3,784	d_7	0,109	/	1,623
		d_8	2,700 f_{min}		56,9
$r_9 +$	7,825		0,438 f_{max}		
$r_{10} -$	11,700	d_9	0,187	/	1,589
$r_{11} +$	2,152	d_{10}	0,008		61,3
$r_{12} -$	12,932	a_{11}	0,273	/	1,641
$r_{13} +$	0,952	d_{12}	0,008		60,1
$r_{14} +$	13,916	d_{13}	0,393	/	1,589
$r_{15} -$	6,006	d_{14}	0,117		61,3
$r_{16} +$	0,429	d_{15}	0,078	/	1,699
$r_{17} +$	0,503	d_{16}	0,351	/	1,720
$r_{18} +$	1,104	d_{17}	0,246		50,4
$r_{19} -$	1,931	d_{18}	0,312	/	1,720
					50,4

$f_{min} = 1,000$
 $f_{max} = 1,825$
 Relative Aperture 1:1,2
 $2y' = 0,523$

THIRD EXAMPLE

This example is cheaper to make than the first two examples because only eighteen different lens surface curvatures have to be provided instead of the nineteen provided in the first two examples.

DIMENSIONS

			n_d	v_d
$r_1 -$	6,400	d_1	0,160 / 1,618	49,8
$r_2 +$	4,092	d_2	0,673	
$r_3 +$	5,600	d_3	0,240 / 1,620	60,3
$r_4 -$	10,000	d_4	0,008	
$r_5 +$	4,516	d_5	0,240 / 1,620	60,3
$r_6 -$	124,416	d_6	0,104 f_{min} 2,424 f_{max}	
$r_7 -$	6,770	d_7	0,112 / 1,623	56,9
$r_8 +$	3,604	d_8	2,769 f_{min} 0,449 f_{max}	
$r_9 +$	8,026	d_9	0,192 / 1,589	61,3
$r_{10} -$	54,640	d_{10}	0,016	
$r_{11} +$	2,224	d_{11}	0,232 / 1,589	61,3
$r_{12} -$	8,997	d_{12}	0,052	
$r_{13} +$	0,912	d_{13}	0,384 / 1,589	61,3
$r_{14} +$	10,194	d_{14}	0,144	
$r_{15} -$	6,215	d_{15}	0,420 / 1,805	25,4
$r_{16} +$	0,536	d_{16}	0,240	
$r_{17} +$	0,825	d_{17}	0,304 / 1,691	54,7
$r_{18} -$	2,001			

$f_{min} = 1,021$
 $f_{max} = 1,865$
 Relative Aperture 1:1,2
 $2y' = 0,523$

In all of the dimensions given in the above three examples the following tolerances are to be assumed to apply: a deviation of the curvature of individual surfaces by up to $\pm 10\%$ of the refractive power of the corresponding lens element; a deviation of the thicknesses of up to $\pm 10\%$ of the focal length of the corresponding lens element, a deviation of the refractive indexes of up to $\pm 0,03$ and of the Abbe numbers of up to ± 5 .

WHAT WE CLAIM IS:—

1. A zoom lens suitable for use in a projector consisting of positive front and rear components fixed relative to one another and a relatively axially displaceable negative intermediate component; said front component consisting of a negative first lens, a positive second lens and a positive third lens, the spacing between said first and second lenses being substantially half the axial length of said positive front component, said intermediate component being a single negative lens; and said rear component consisting of a plurality of positive lens elements and an interposed negative lens element.

2. A zoom lens as claimed in claim 1 and substantially as set forth in any one of the three examples hereinbefore described.

3. A projector having a zoom lens as claimed in claim 1 or claim 2 and in which the spacing between the said first and second lenses in the front component is greater than the diagonal of the cine format.

DIMENSIONS

			n_d	v_d
$r_1 -$	6,400			
$r_2 +$	4,092	d_1 0,160 /	1,618 /	49,8
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$r_5 +$	4,516	d_4 0,008		
$r_6 -$	124,416	d_5 0,240 /	1,620 /	60,3
		0,104 f_{min}		
$r_7 -$	6,770	d_6 2,424 f_{max}		
$r_8 +$	3,604	d_7 0,112 /	1,623 /	56,9
		2,769 f_{min}		
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$r_{11} +$	2,224	d_{10} 0,016		
$r_{12} -$	8,997	d_{11} 0,232 /	1,589 /	61,3
$r_{13} +$	0,912	d_{12} 0,052		
$r_{14} +$	10,194	d_{13} 0,384 /	1,589 /	61,3
$r_{15} -$	6,215	d_{14} 0,144		
$r_{16} +$	0,536	d_{15} 0,420 /	1,805 /	25,4
$r_{17} +$	0,825	d_{16} 0,240		
$r_{18} -$	2,001	d_{17} 0,304 /	1,691 /	54,7
		$f_{min} = 1,021$		
		$f_{max} = 1,865$		
		Relative Aperture 1:1,2		
		$2y' = 0,523$		

In all of the dimensions given in the above three examples the following tolerances are to be assumed to apply: a deviation of the curvature of individual surfaces by up to $\pm 10\%$ of the refractive power of the corresponding lens element; a deviation of the thicknesses of up to $\pm 10\%$ of the focal length of the corresponding lens element, a deviation of the refractive indexes of up to $\pm 0,03$ and of the Abbe numbers of up to ± 5 .

WHAT WE CLAIM IS:—

1. A zoom lens suitable for use in a projector consisting of positive front and rear components fixed relative to one another and a relatively axially displaceable negative intermediate component; said front component consisting of a negative first lens, a positive second lens and a positive third lens, the spacing between said first and second lenses being substantially half the axial length of said positive front component, said intermediate component being a single negative lens; and said rear component consisting of a plurality of positive lens elements and an interposed negative lens element.

2. A zoom lens as claimed in claim 1 and substantially as set forth in any one of the three examples hereinbefore described.

3. A projector having a zoom lens as claimed in claim 1 or claim 2 and in which the spacing between the said first and second lenses in the front component is greater than the diagonal of the cine format.



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