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United States
Kirchhoff

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[45] **Aug. 7, 1973**

[54] **VARIABLE FOCAL LENGTH ANAMORPHOTIC CINECAMERA SYSTEMS**

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[21] Appl. No.: **175,513**

[30] **Foreign Application Priority Data**

Sept. 1, 1970 Germany .... P 20 43 193.0

[52] **U.S. Cl.** .... **350/181,** 95/42, 95/44 C, 350/173, 350/182, 350/184

[51] **Int. Cl.** **G02b 13/12,** G02b 15/16

[58] **Field of Search** 350/181, 183, 184, 350/185, 186, 40–44

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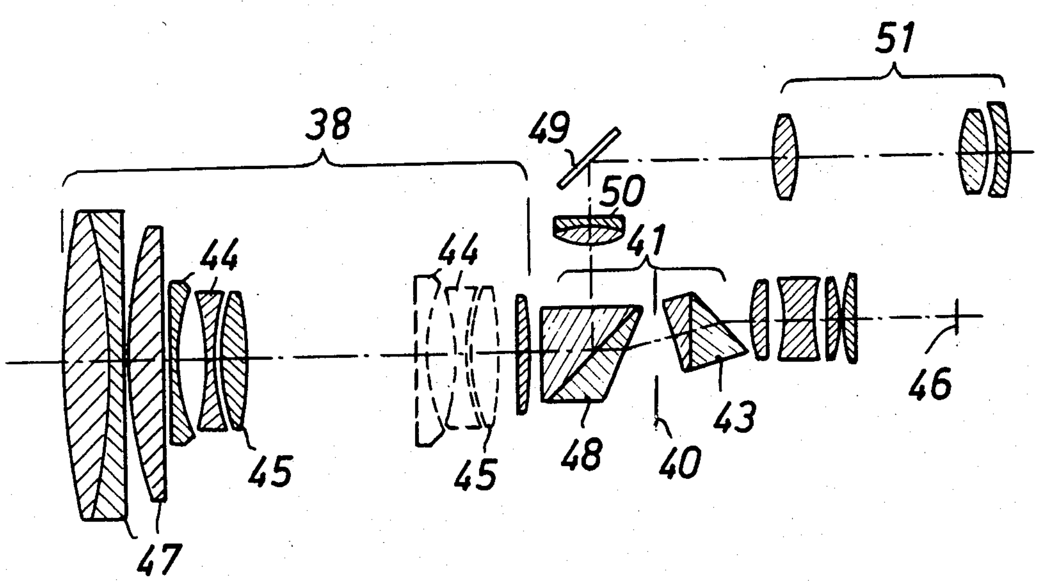
Primary Examiner—John K. Corbin
Attorney—Townsend F. Beaman et al.

[57] **ABSTRACT**

A variable focal length cinecamera system consisting of an afocal auxiliary lens system by means of which, through modification of the spacing between optical elements constituting the said lens system, the focal length of the system can be changed while the intercept length is maintained constant, and of a succeeding permanently installed basic lens focused at infinity. An afocal anamorphotic system is provided between the afocal auxiliary lens system and the basic lens.

4 Claims, 17 Drawing Figures



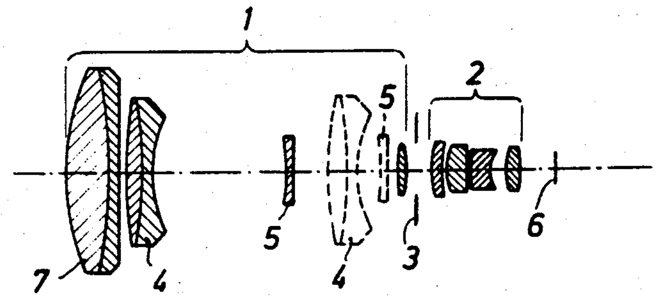


Fig.1
PRIOR ART

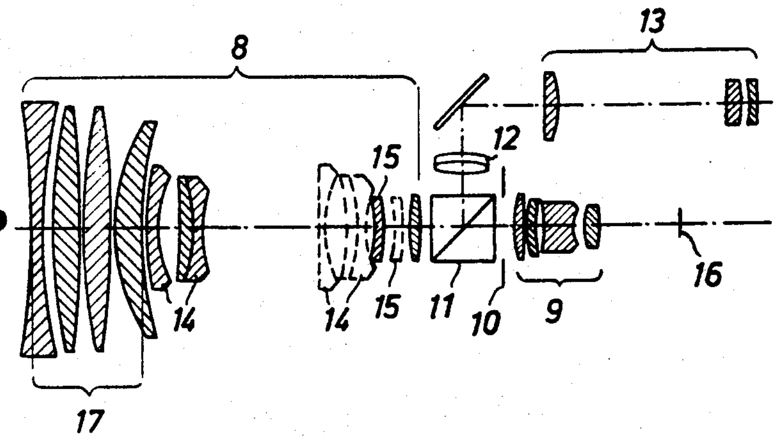


Fig.2
PRIOR ART

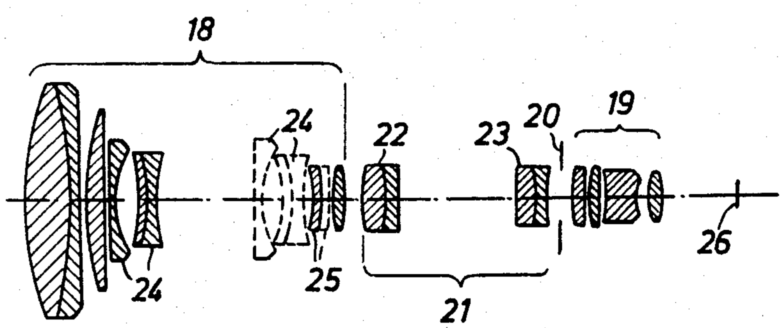


Fig.3

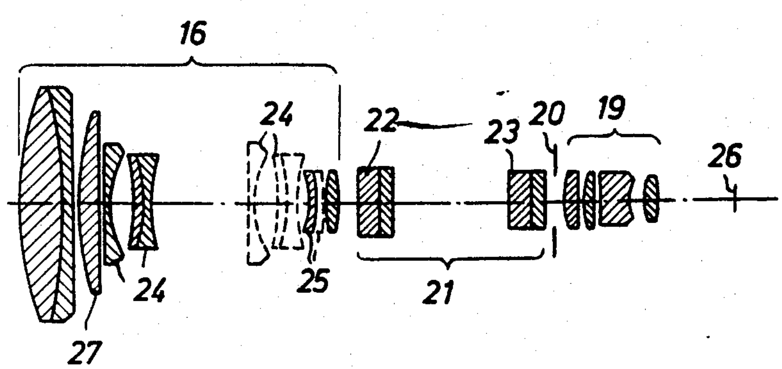


Fig.4

Fig. 5

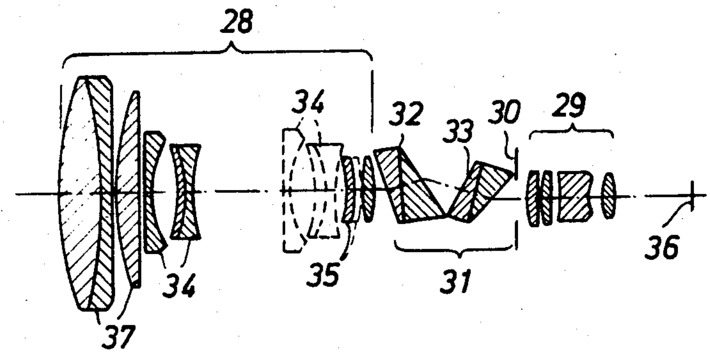


Fig. 6

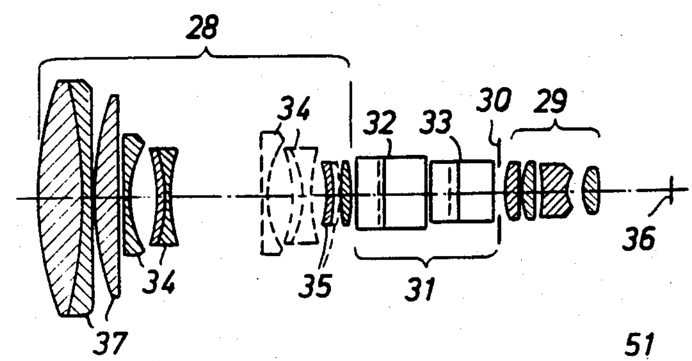


Fig. 7

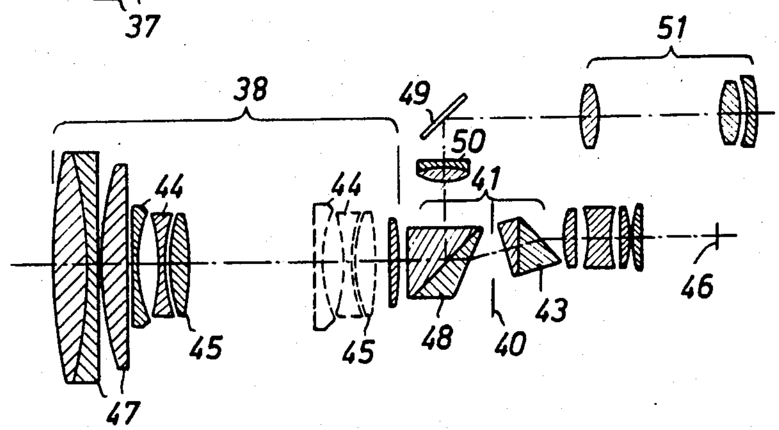
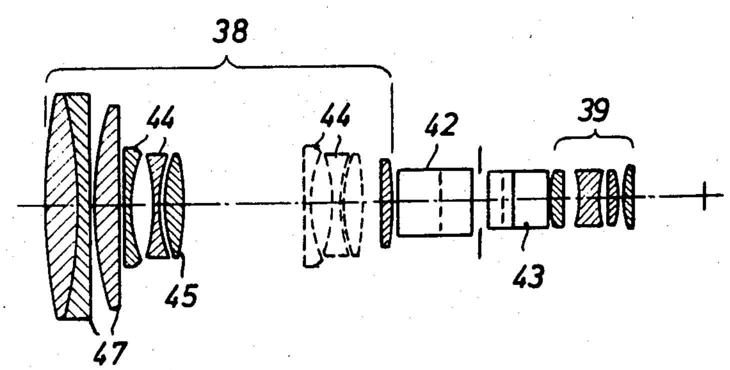


Fig. 8



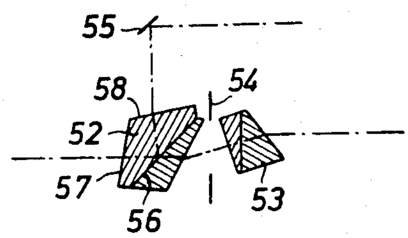


Fig. 9

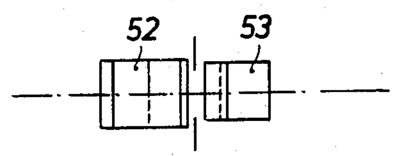


Fig. 10

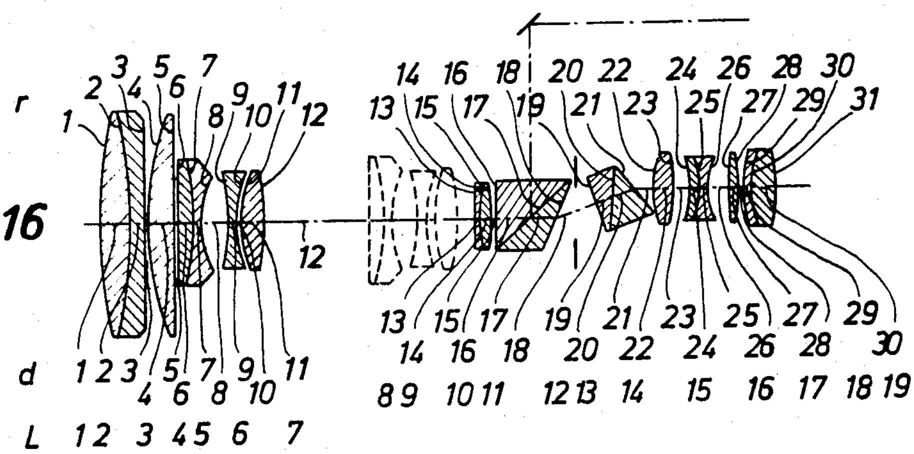


Fig. 16

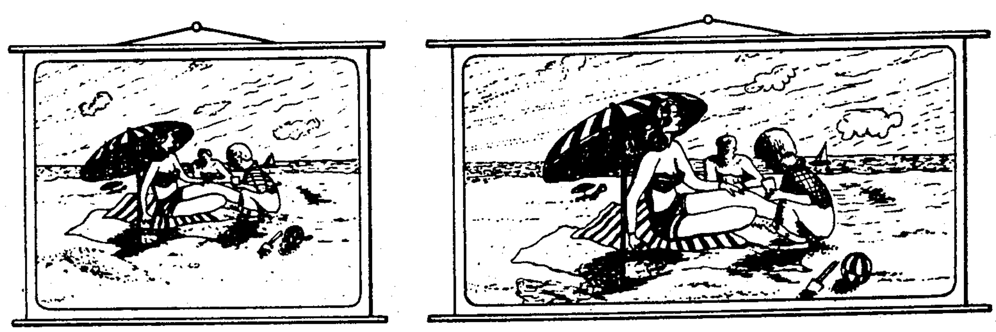


Fig. 17

Fig. 11

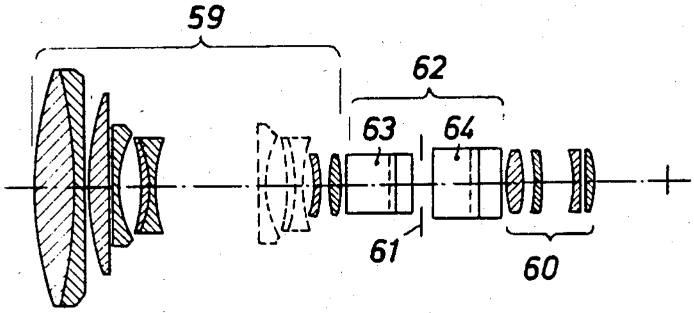


Fig. 12

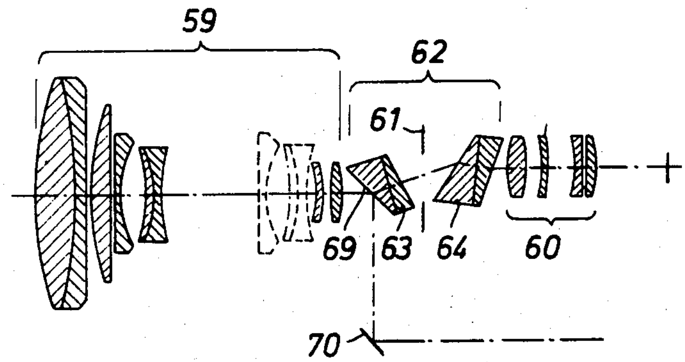


Fig. 13

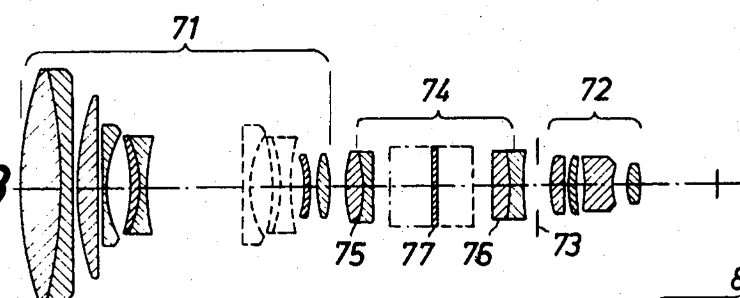
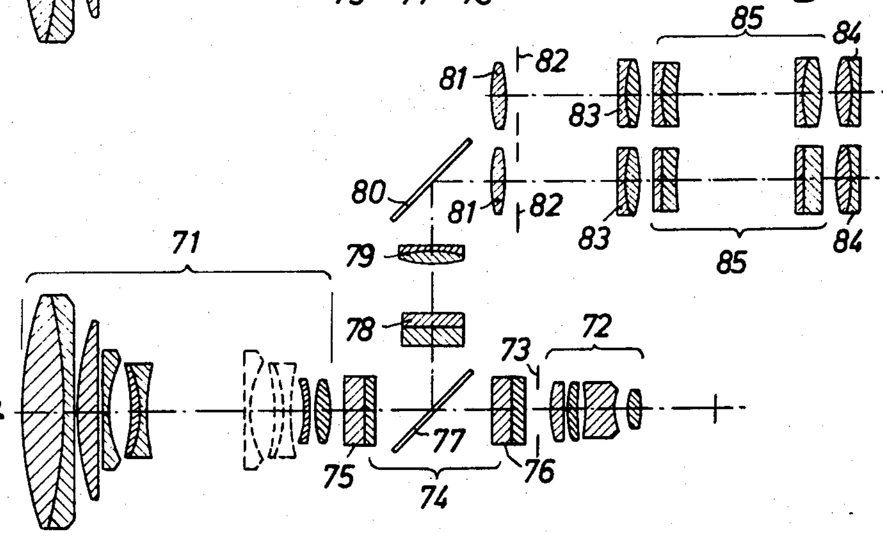


Fig. 15

Fig. 14



VARIABLE FOCAL LENGTH ANAMORPHOTIC CINECAMERA SYSTEMS

BACKGROUND OF THE INVENTION

The present invention relates to a variable focal length cinecamera system.

The invention embodies an optical arrangement for the exposure of anamorphotic film films of wide-screen format, using conventional variable focal length systems (zoom lenses). Application to 8 mm film used by amateurs, is in particular envisaged.

While normal film projection in cinemas has long departed from the old 1 : 1.33 (frame height : frame width) projection format, and has since adopted the formats 1 : 1.85, 1 : 2 and 1 : 2.25 because of the better picture obtained, no similar development has thus far taken place in the case of 8 mm film.

As much as 10 years ago, anamorphotic camera systems built for 8 mm film in accordance with German Federal Patent DBP 1 028 802, began to appear on the market.

The mushrooming development which followed the introduction of variable focal length camera lenses, with the result that nowadays hardly any 8 mm cameras are being designed with fixed focal length lenses, meant the end of 8 mm format wide-screen films of the anamorphotic type. Thus far, it has been found impossible to unite the advantages of the anamorphotic wide-screen picture with those which use variable focal length camera lenses.

The provision of an anamorphotic auxiliary system with a focussing device of the kind required for camera applications, has been applied, in accordance with German Patents 971 922 or 1 028 802, to variable focal length lenses but leads to dimensions on the part of the anamorphotic auxiliary system, which are out of the question as far as application to an 8 mm camera is concerned. Trials which were carried out in this direction using anamorphotic auxiliary lens systems, failed to produce any practical result because of the large diameters, installed lengths and weights of these auxiliary lens systems.

SUMMARY OF THE INVENTION

The primary object of the invention is to overcome this drawback and to achieve a practical result which requires hardly any enlargement of the optical parts of the camera system as compared with non-anamorphotic (orthomorphotic) camera lenses of the variable focal length kind.

The invention commences from known variable focal length camera lenses of this kind, which consist of a zoom section and a fixed basic lens and in which a front element is used for focussing (range-finding). Often, at any rate in the Gaussian area of reproduction, these lenses possess a telecentric ray path between the zoom section and the basic lens.

In most cases, lenses of this kind are provided with a prism which, through an inclined partially mirrored surface, reflect out part of the passing radiation in a direction generally perpendicular to the optical axis.

This reflected light fraction is picked up by a viewfinder optical system and can also be employed for light-metering purposes.

In front of the basic lens in most cases the camera diaphragm is arranged and this regulates (either manually or under the control of a photoelectric cell) the quantity of light arriving on the film.

The present invention consists in the use of zoom systems with a basic lens, which are so corrected that between the zoom and basic sections not only is there a telecentric ray path in the Gaussian area but also that in this space the widely divergent reproduction rays for all the image points are telecentric and as far as possible exhibit no zoning, an anamorphotic system being arranged in this space.

The fact that in accordance with the invention the said space is in a thus-corrected zoom system, is used to accommodate the anamorphotic system, has the major advantage that in this space of the zoom lens, despite changes in focal length and modification of the camera focus, the ray path is always constant so that the anamorphotic system can be more effectively corrected; in contrast to this, in the conventional anamorphotic auxiliary lenses, the adjustment of the ensuing zoom system results in a change in the angular fields and apertural angles of the rays, with focal length.

A further advantage resides in the fact that the anamorphotic system is located in said space in the immediate vicinity of the diaphragm (at the location of the narrowest point in the ray system) and thus occupies the least possible amount of space in terms of diameter and length.

Furthermore, in this arrangement no additional spherical lens system for focussing the anamorphotic system, is required, unlike the case with the two cited German Patents 971 922 and 1 028 802.

The focussing facility provided in the zoom system by the adjustment of the front element, is operative simultaneously for the zoom system, the anamorphotic section and the basic lens.

It is particularly advantageous, where the intended purpose of anamorphotic shooting using zoom systems, is concerned, to use here not the conventional anamorphotic systems comprising cylindrical lenses, but known kinds of anamorphotic prism systems.

These prism systems can, if installed in fixed, non-pivoting fashion, be strictly achromatic and consist of only two prisms each.

In contrast to the cylindrical system, these prisms, provided that their ray path has been adequately telecentrically corrected, produce no inherent reproduction abberations of the kind caused by surface curvatures. In effect, they only have to be corrected for the transverse colour error and for symmetry of distortion.

Also, they can be made much shorter than cylindrical Galilean lens systems whose individual elements must have much smaller reflective powers than the reflective power of the basic lens in order to achieve reproduction which is adequately free of zoning.

Also, the difficulties of maintaining the optical axis between the cylindrical individual elements, a particular difficulty in the case of small cylindrical systems of relatively high reflective power, is obviated.

The invention secures especial advantages in the context of the use of prismatic anamorphic systems when they are applied to zoom systems of certain kinds to be more fully described hereinafter, for anamorphotic reproduction which systems already incorporate a prism for reflecting out a certain proportion of the light for viewing purposes.

In accordance with the invention, then, the available prism for splitting off this light fraction can be replaced by one of the two acromatic prisms and this so designed that it also performs the requisite splitting function for the view-finder.

To achieve anamorphotic reproduction with this kind of zoom system, virtually the only extra outlay is that involved by a single achromatic prism.

It will immediately be apparent that this arrangement involved the least additional outlay in terms of space and optical facilities and also represents the best economic solution to the problem of shooting anamorphotic film with zoom lenses.

The anamorphotic prism provided here, which at the same time splits off the light fraction for the view-finder image, has an entry face which is perpendicular to the optical axis, while the partially mirrored surface is at 45° to the optical axis.

In accordance with the invention, the entry face and the surface of the prism used to split off the viewfinder light fraction, can equally well subtend other angles with the optical axis.

The anamorphotic plane can, in accordance with the invention, be located vertically and/or horizontally.

Whatever the case, the light fraction which is split off for the view-finder is taken in the direction of the anamorphotic plane.

In the event that the anamorphotic plane is horizontal, in accordance with the invention, the entry face of the first prism is used to reflect out the light fraction for the view-finder.

Equally, a suitable face on the second prism (the one adjacent to the basic lens), can be used for this purpose.

All that is then necessary is to ensure that in the ray path to the view-finder, which must of course be orthomorphotic as far as possible, by the introduction of a compensating prism into a telecentric ray path the anamorphotic distortion of the view-finder image is cancelled.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 illustrates a conventional zoom system;

FIG. 2 illustrates a conventional zoom system in which part of the light is supplied to a view-finder and focussing telescope;

FIG. 3 is a vertical section through a first arrangement in accordance with the present invention:

FIG. 4 is a horizontal section through the arrangement of FIG. 3;

FIG. 5 is a vertical section through a second embodiment of the invention;

FIG. 6 is a plan view of the embodiment of FIG. 5;

FIG. 7 is a vertical section through a third embodiment of the invention;

FIG. 8 is a plan view of the embodiment of FIG. 7;

FIG. 9 is a vertical section through an anamorphotic prism system, suitable for the implementation of the invention, which incorporates facilities for the splitting off of a certain light fraction, this prism system, with the associated zoom section and basic lens, constituting a fourth embodiment of the invention;

FIG. 10 is a plan view of the embodiment of a prism system shown in FIG. 9;

FIG. 11 is a vertical section through a fifth embodiment of the invention;

FIG. 12 is a plan view of the embodiment of FIG. 11;

FIG. 13 is a vertical section through a sixth embodiment of the invention;

FIG. 14 is a horizontal section through the embodiment of FIG. 13;

FIG. 15 is a view, rotated through 90°, of the additional anamorphotic, afocal cylindrical lens system (in section), used in the embodiment of FIGS. 13 and 14;

FIG. 16 is a section similar to that of FIG. 7, through a seventh embodiment of the invention, although this figure is devoted primarily to listing the references for a worked numerical example (the references of FIG. 16 have been selected independently of those in the other figures); and

FIG. 17 is a scale comparison of the normal format and the anamorphotic wide-screen picture producted in accordance with the invention, the latter having been shot and projected at the same focal length and at the same distance.

DESCRIPTION OF PREFERRED EMBODIMENTS

The conventional zoom system shown in FIG. 1 consists of a zoom section 1 and a basic lens 2. Between these a diaphragm 3 for the system is arranged. Divergent lenses 4 and 5 are differentially displaced for purposes of alteration of the focal length in order, simultaneously with this alteration, to obtain a constant intercept length at a point 6 on the image.

In the wide-angle position, the lenses 4 and 5 are shown in solid lines while in the telephoto position they are shown in broken line. To focus, a collective element 7 is displaced axially.

The zoom system shown in FIG. 2, of conventional design, is equipped with a splitter device which physically splits off part of the light and directs it to a view-finder and range-finder telescope.

It consists of a zoom section 8, a basic lens 9, a diaphragm 10, a splitter prism 11, a telescope lens 12 and a field lens with a lens reversal system 13. The eyepiece of the view-finder telescope has not been shown. A divergent element 14 and a divergent lens 15 are displaced by different amounts in order to alter the focal length so that simultaneously with the change in focal length a constant intercept length at an image point 16 is achieved. In the wide-angle position, the lenses 14 and 15 are shown in full line while in the telephoto position they are shown in broken line.

For focussing, a collective element 17 is displaced axially.

In the first embodiment of the invention, shown in FIGS. 3 and 4, between a zoom section 18 and a basic lens 19, and in front of a diaphragm 20, an anamorphotic, afocal, cylindrical lens system 21 is arranged. The afocal cylindrical lens system 21 is effective in the vertical plane in FIG. 3 but not in the horizontal plane of FIG 4. It consists of a positive element 23 and thus in the vertical plane of FIG. 3, has a focal length extending action.

The resultant anamorphotic factor is between 1.5 *x* and 2 *x*, as with anamorphotic auxiliary lens systems.

A divergent element 24 and a divergent lens 25 are displaced by different amounts in order to alter the focal length, so that simultaneously with this alteration the intercept length at an image point 26, is maintained constant.

In the wide-angle position, the lenses 24 and 25 have been drawn in full line and in the telephoto position, in broken line. A corrective element **27** is axially displaced for focussing.

It is possible equally well, of course, to arrange the effective plane of the anamorphotic system **21** in the horizontal.

In this case, the cylindrical lens **22** will be a divergent one and the cylindrical lens **23** a convergent one, so that a focal length shortening effect is obtained in the horizontal plane.

In the embodiment of the invention as shown in FIGS. **5** and **6**, an anamorphotic prism system **31** is arranged in front of a diaphragm **30**, between a zoom section **28** and a basic lens **29**.

The anamorphotic prism system **31** is operative in the vertical plane of FIG. **5** but not in the horizontal plane of FIG. **6**. It consists of an achromatic prism **32** and an achromatic prism **33** so disposed in relation to one another that in the vertical section a focal length extending action is produced.

The resultant anamorphotic factor, as with conventional anamorphotic auxiliary lens systems, lies between 1.5 *x* and 2 *x*. A divergent element **34** and a divergent lens **35** are displaced by different amounts to adjust the focal length, so that simultaneously with this adjustment the intercept length at an image point **36** is maintained constant.

In the wide-angle position, the lenses **34** and **35** are shown in full line and in the telephoto position, in broken line. For focussing purposes, a collective element **37** is displaced axially.

It is equally possible, of course, to move the effective plane of the anamorphotic prism system **31** into the horizontal.

In this case, the achromatic prisms **32** and **33** are so arranged that in the horizontal a focal length contracting effect is obtained, as illustrated for example in FIGS. **11** and **12**.

FIGS. **7** and **8** show a zoom system for the third embodiment of the invention, in which between a zoom section **38** and a basic lens **39** there is an anamorphotic prims system **41**.

The anamorphotic prism system **41** is effective in the vertical plane (FIG. **7**) but not in the horizontal plane (FIG. **8**).

It consists of an achromatic prism **42** and an achromatic prism **43** which are so disposed in relation to one another that in the vertical section a focal length extending effect occurs. Between these two prisms **42** and **43** a diaphragm **40** of the system is arranged.

The achromatic prism **42** here has an entry surface disposed perpendicularly to the optical axis and a cemented surface **48** disposed at 45° to the optical axis, which is partially mirrored and splits off a fraction of the light in the vertical direction, supplying it to a view-finder and range-finder telescope of which latter the telescope lens **50**, the mirror **49** and the field lens with a lens reversal system **51**, are shown.

The eyepiece of the view-finder telescope is not shown here. The anamorphotic factor obtained by the prism system **41**, lies between 1.5 *x* and 2 *x* as with conventional anamorphotic auxiliary lens systems.

A divergent element **44** and a convergent element **45** are displaced by differential amounts in order to change the focal length, so that simultaneously with the change in focal length the intercept length is maintained constant.

In the wide-angle position, the lenses **44** and **45** are shown full drawn and in the telephoto position in broken line. For focussing a collective element **47** is displaced axially. It is equally possible, of course, to arrange the effective plane of the anamorphotic system **41** in the horizontal. In this case the achromatic prisms **42** and **43** are so disposed that a focal length contracting effect is produced in the horizontal plane, as indicated for example in FIGS. **11** and **12**. The light fraction split off for the view-finder and range-finder telescope, is then taken in a horizontal direction.

A comparison between the illustration of FIG. **2** and that of FIG. **7**, clearly shows that in accordance with the invention, simply by the provision of an additional cemented prism, an anamorphotic zoom system can be created from the conventional zoom system.

The fourth embodiment of the invention, shown in FIGS. **9** and **10**,provides an anamorphotic prism system with a simultaneous facility for splitting off a light fraction, which system consists of respective achromatic prisms **52** and **53** with an intermediate diaphragm **54**, and a mirror **55** which supplies the light fraction reflected from a partially mirrored surface **56** to the prism **52** which is disposed at 45° to the optical axis, to the view-finder and range-finder telescope the components of which have not been illustrated here.

The entry face **57** of the prism **52** is in this case not perpendicular to the optical axis of the preceding zoom section (not shown).

The exit face **58** of the prism **52**, for the view-finder light fraction, is appropriately inclined so that that section of the achromatic prism **52** which is delimited by the faces **56**, **57** and **58** and is used for the view-finder light fraction, does not introduce any reproduction error despite the inclination of the faces, because the prisms are located in a telecentric ray system which is as far as possible free from zoning.

The fifth embodiment of the invention, shown in FIGS. **11** and **12**, is a zoom system in which, between a zoom section **59** and a basic lens **60**, an anamorphotic prism system **62** is arranged.

The anamorphotic prism system **62** is effective in the horizontal plane (FIG. **12**) but not in the vertical plane (FIG. **11**).

It consists of an achromatic prism **63** and an achromatic prism **64** so disposed in relation to one another that in the horizontal section a focal length contracting effect is produced.

Between these prisms **63** and **64**, a diaphragm **61** of the system is arranged.

The achromatic prism **63** here has an entry face **69** disposed at 45° to the optical axis, this face being partially mirrored and splitting off a fraction of the entering light in a horizontal direction via a mirror **70** to a view-finder and range-finder telescope, (not shown). The anamorphotic factor determined by the prism system **62** is between 1.5 *x* and 2 *x* as in the case of conventional auxiliary lens systems.

The sixth embodiment is illustrated in FIGS. **13** to **15**. Here, in accordance with the invention, a zoom system is equipped, between a zoom section **71** and a basic lens **72**, and in front of a diaphragm **73**, with an anamorphotic afocal cylindrical lens system **74**. The anamorphotic cylindrical lens system **74** is effective in the vertical section of FIG. **13** but not in the horizontal section of FIG. **14**. It consists here of a cemented convergent cylindrical lens **75** and a cemented divergent cylindrical lens **76**, and here has a focal length extending effect.

Between the cemented cylindrical lenses **75** and **76** there is a plane-parallel glass plate **77** arranged at 45°, one surface of which is partially mirrored and which splits off a fraction of the light in the horizontal direction, to a view-finder and range-finder telescope.

This ray system, which in the vertical plane and because of the presence of the cemented convergent cylindrical lens **75**, has become convergent, becomes telecentric again in this plane because of the presence of a divergent cylindrical lens **78** which is optically identical with the divergent cylindrical lens **76**. A spherical lens **79**, via a mirror **80** and field lens **81**, reproduces the now anamorphotic image in the plane of a field of view diaphragm **82**.

This anamorphotic picture is reproduced again at infinity, via a spherical lens reversal system section **83**. Between the first section **83** of the lens reversal system **85** and a second section **84**, the ray path is telecentric again and the anamorphotic, afocal cylindrical lens system **85** produces the same measure of focal length contraction as the focal length extension produced by the cylindrical lens system **74**.

To clarify this situation, FIG. **15** illustrates a view of this cylindrical lens system **85**, in section and rotated through 90° about the axis. The half section **84** of the lens reversal system here again produces an undistorted view finder image which can be viewed through an eyepiece (not shown).

In the following, a numerical example of an anamorphotic camera lens of variable focal length, in accordance with the invention, will be considered.

FIG. **16** illustrates a vertical section in which the designations used for the numerical example are marked. The light fraction split off for the view-finder and range-finder telescope is here taken in a vertical direction at 90° to the axis. The anamorphotic prism system is likewise effective in the vertical plane and has a focal length extending factor of 1.5 *x*.

The numerical example is distinguished by very small zone areas at all angular fields.

r_1 to r_{15} and r_{22} to r_{31} designate the radii of curvature. The angles **16'** to **21'** are the angles of inclination of the faces of the prisms P_{10} to P_{13}, measured between the normal to the particular face and the optical axis in the vertical section.

d_1 to d_{30} indicate the glass thicknesses and airgaps measured at a ray coinciding with the optical axis on entry to the system.

L_1 to L_9 and L–to L_{19} indicate the individual lenses and the prisms are marked P_{10} to P_{13}.

The relative aperture for which the present example is corrected, is F : 1.8 in the horizontal section and F : 2.7 in the vertical section.

The attached table, lists the individual values of the numerical example.

FIG. **17** illustrates the picture effect which the invention makes possible, as compared with that of a normal format.

TABLE

No.	Radii/ angles	Thicknesses/ intervals	n_d	ν_d	Lenses/ prisms
1' +	13.1289				
2' –	7.7022	0.6611	1.56882	56.13	L_1
3' –	49.9274	0.2278	1.72825	28.41	L_2
4' +	6.2469	0.0233	1		
5' +	136.1229	0.5356	1.51680	64.17	L_3
6' +	109.4952	0.0489–3.8325+	1		
7' –	4.6981	0.3111	1.74077	17.60	L_4
8' +	1.8938	0.1111	1.62041	60.33	L_5
9' –	3.2178	0.5556	1		
10' +	2.8434	0.1209	1.64050	60.10	L_6
11' +	3.1146	0.0870–0.1609+	1		
12' –	6.6896	0.4533	1.65113	55.89	L_7
13' +	15.1548	4.1106–0.2530+	1		
14' +	2.1111	0.1111	1.61484	51.16	L_8
15' –	9.1723	0.2222	1.62041	60.33	L_9
16'	0.0000°	0.0556	1		
17' +	45.0000°	0.5222	1.64050	60.10	P_{10}
18' +	23.4700°	0.4389	1.62636	35.34	P_{11}
19' –	16.1350°	0.8667	1		
20' +	3.4837°	0.2500	1.69895	30.07	P_{12}
21' –	41.5330°	0.5000	1.64051	60.10	P_{13}
22' +	1.4778	0.3944	1		
23' –	6.0128	0.3989	1.60361	53.63	L_{14}
24' –	1.8416	0.2572	1		
25' –	0.9250	0.3043	1.72373	38.11	L_{15}
26' +	1.3000	0.0889	1.64831	38.84	L_{16}
27' +	3.9486	0.3730	1		
28' –	3.9706	0.2263	1.62041	60.33	L_{17}
29 +	2.9648	0.0111	1		
30' +	1.5556	0.1292	1.63980	34.61	L_{18}
31' –	2.9378	0.4592	1.64250	57.96	L_{19}
		+ variable			

Intercept length $s'_{-} = 1.475$

	Wide-angle position	Telephoto position
Focal lengths:	$f_{horiz.} = 1.046$	$f_{horiz.} = 3.899$
	$f_{vert.} = 1.562$	$f_{vert.} = 5.842$
Total length of the basic lens ($r_{23} - r_{31}$)		$f = 2.269$

The effective angular field of the basic lens is 10°.

I claim:

1. A variable focal length cinecamera system comprising an afocal auxiliary lens system having a plurality of optical elements capable of being moved relative to each other to change the focal length of said lens system, the intercept length being maintained constant, a succeeding permanently installed basic lens focused at infinity, a camera diaphragm arranged between said afocal auxiliary lens system and said basic lens, and an afocal anamorphotic system located between said afocal auxiliary lens system and said basic lens adjacent said diaphragm, said diaphragm being arranged at a point in the optical system where the cross section of the imaging ray bundle is at a minimum whereby the size of said anamorphotic system can be minimized.

2. A variable focal length cinecamera system comprising an afocal auxiliary lens system having a plurality of optical elements capable of being moved relative to each other to change the focal length of said lens system, the intercept length being maintained constant, a succeeding permanently installed basic lens focused at infinity, an afocal anamorphotic system consisting of at least two achromatic prisms located between said afocal auxiliary lens system and said basic lens, and a view-finder telescope, a face of one of said prisms being used to split off part of the light traveling through said system to enable the view-finder image to be observed through said view-finder telescope.

3. A variable focal length cinecamera system comprising an afocal auxiliary lens system having a plurality of optical elements capable of being moved relative to each other to change the focal length of said lens system, the intercept length being maintained constant, a succeeding permanently installed basic lens focused at infinity, an afocal anarmophotic system located between said afocal auxiliary lens system and said basic lens, a view-finder telescope, and a partially mirrored face within said afocal anamorphotic system, said partially mirrored face serving to split off part of the light traveling through said system to enable the view-finder image to be observed through said view-finder telescope.

4. A cinecamera system as claimed in claim **3** in which said anamorphotic system comprises at least two cylindrical lenses and a partially reflective mirror arranged between said lenses, said mirror serving to split off the light for the view-finder image which is observed through said view finder telescope.

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