

Oct. 10, 1933.

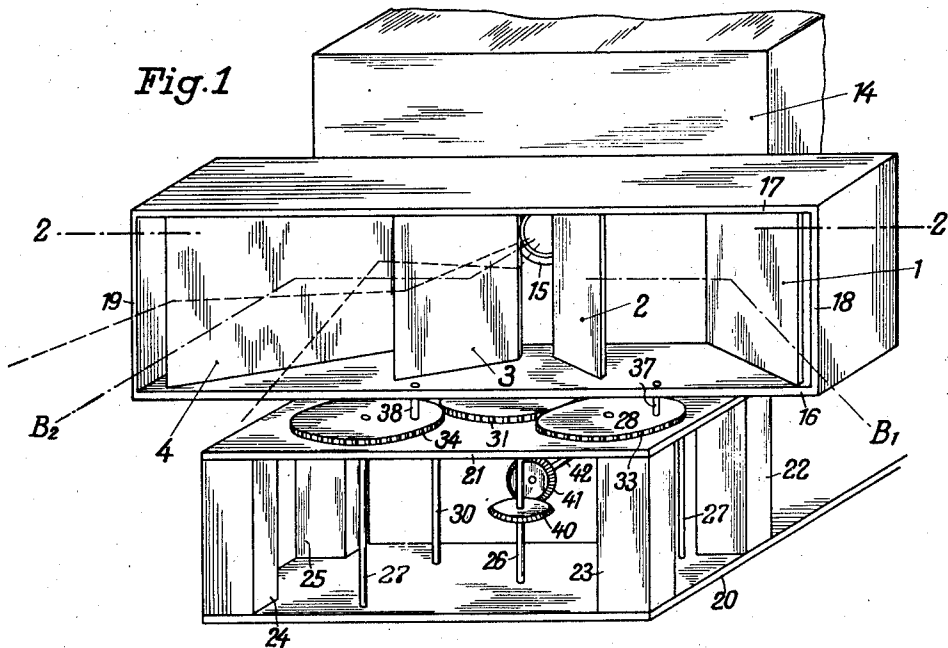
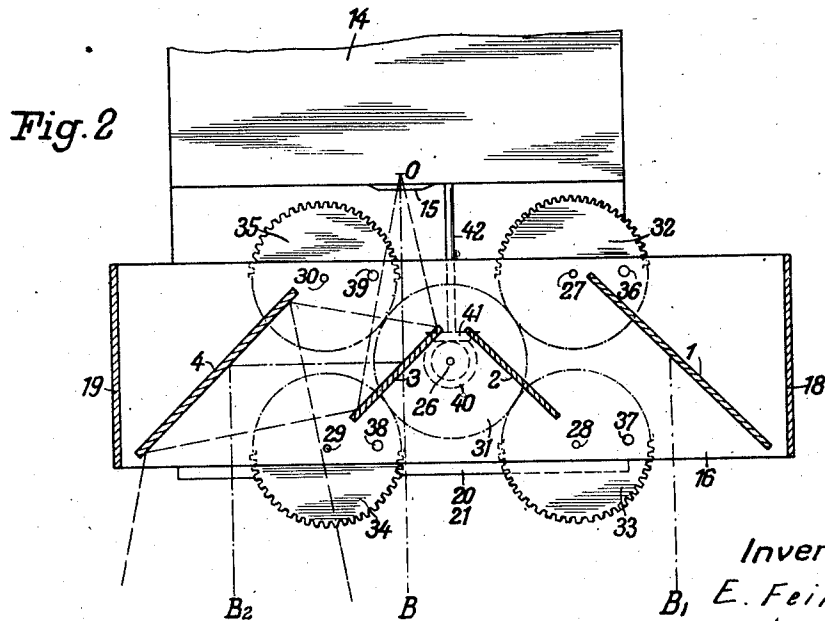
E. FEIL

1,929,685

REFLECTOR SYSTEM FOR STEREOCINEMATOGRAPH CAMERAS

Filed Feb. 17, 1931

3 Sheets-Sheet 1



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by E. F. Hendrick
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Oct. 10, 1933.

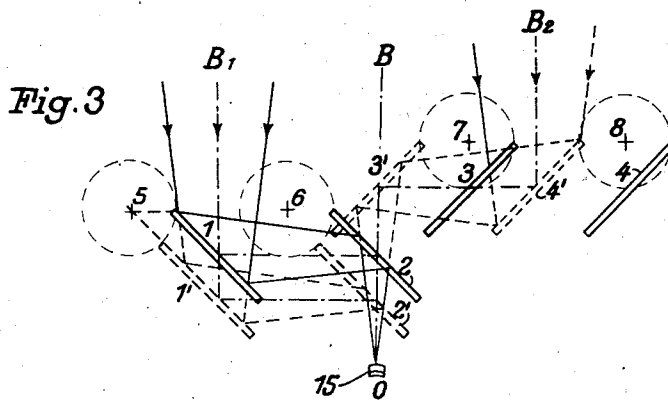
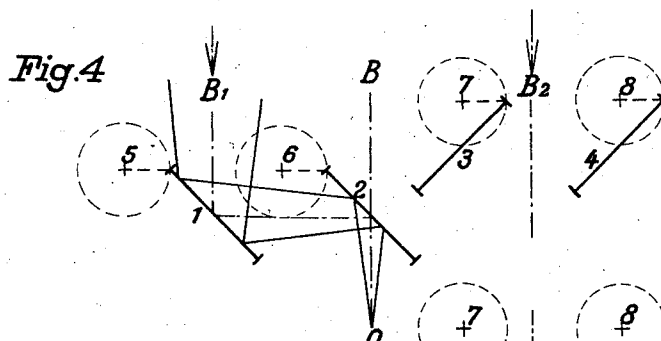
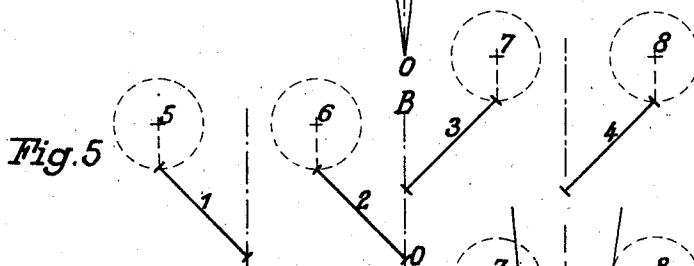
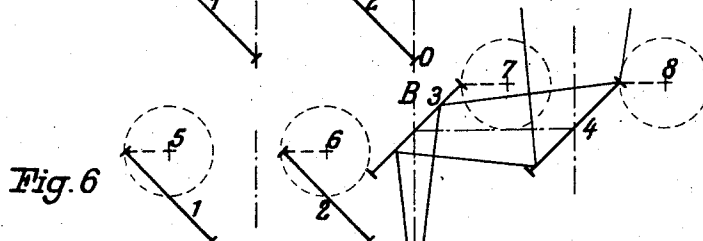
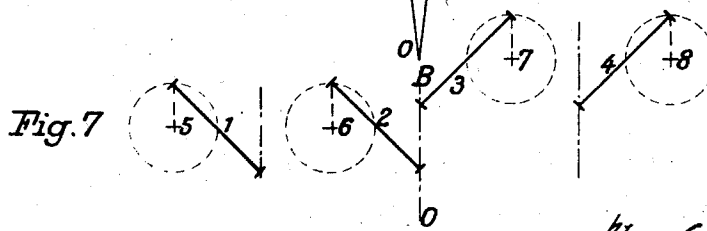
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REFLECTOR SYSTEM FOR STEREOCINEMATOGRAPH CAMERAS

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3 Sheets-Sheet 2



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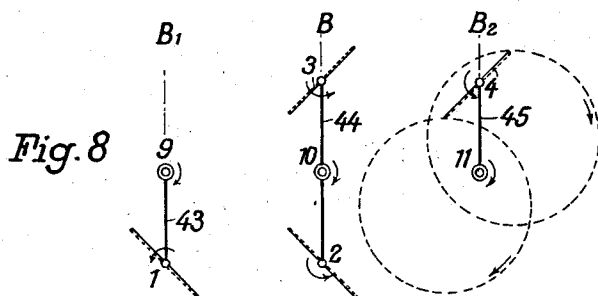
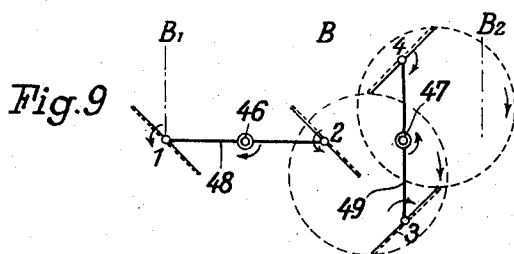
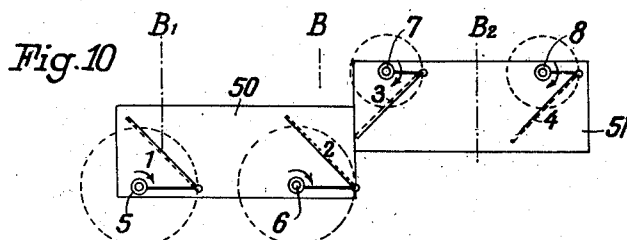
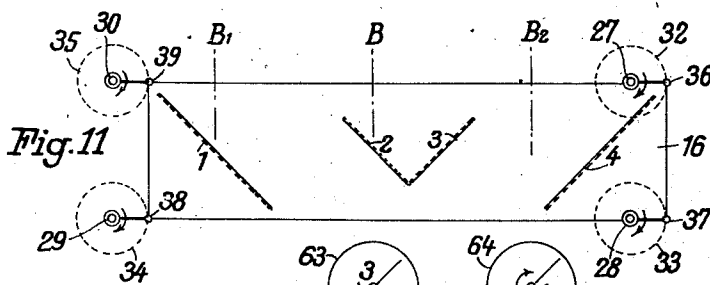
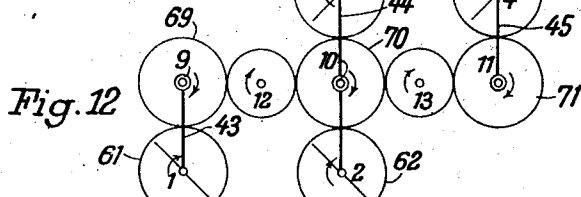
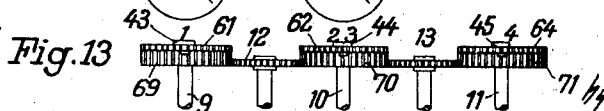
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REFLECTOR SYSTEM FOR STEREOCINEMATOGRAPH CAMERAS

Filed Feb. 17, 1931

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

1,929,685

REFLECTOR SYSTEM FOR STEREO-CINEMATOGRAPH CAMERAS

Edmund Feil, Berlin, Germany

Application February 17, 1931, Serial No. 516,486,
and in Germany February 17, 1930

7 Claims. (Cl. 88—16.6)

My invention relates to stereo-cinematograph cameras, i. e., cameras for making cinematograph pictures which when reproduced have a stereoscopic effect, as described in my copending application for patent of the United States, Ser. No. 475,029, filed August 13, 1930, and particularly to a reflector system for such cameras.

It is an object of my invention to so design the reflector system that certain sources of error in the old systems are eliminated.

My system is of the type in which at opposite sides of the optical axis of an objective a pair of reflectors is arranged. Such pairs are known as "Knight" pairs and each pair includes two parallel mirrors. The two Knight pairs are combined into what is known as the "Wheatstone" four-mirror system.

There are two types of Wheatstone systems: In the first either all four, or only the two inner reflectors, are moved to one or the other side before each exposure so that only one set of rays reaches the objective. In the other type, the two outer reflectors are fixed and the two inner ones are combined into a single reflector which before each exposure is placed parallel to that one of the outer reflectors which is coordinated to the set of rays admitted to the objective by rotation through 90 degrees.

Reflector systems of this type have the advantage of possessing inner orientation, i. e., if their reflectors are properly positioned, the paths of two rays coming from the same point at a greater distance from the camera but belonging to opposite sets of rays coincide after final deflection, so that identical distant points are reproduced exactly at the same point of the film and of the screen on which the film is projected. Identical nearer points are pitched apart only for the parallactic distance. If this condition is fulfilled the right and left pictures are so orientated with respect to each other that if moving pictures are projected with a suitable stroboscopic device, they are viewed stereoscopically.

As is known in the art, the condition of inner orientation is fulfilled if: the two reflectors in each Knight pair are parallel; all four reflectors of the Wheatstone are at right angles to a single plane; and all four reflectors when in active position are symmetrical to a plane at right angles to the first-mentioned plane, which last-mentioned plane extends through the optical axis of the objective.

The parallelism of the reflectors causes each ray, after the final deflection, to be parallel to its initial direction, and so, obviously, the com-

plete set of rays is projected; the position at right angles to the first-mentioned plane causes both sets of rays to be parallel to each other, provided they were parallel before deflection; and the symmetry causes identical rays to be equally deflected toward the symmetry plane.

Obviously inner orientation will prevail only if, while moving from one active position into the other, the reflectors in the Knight pairs must not be displaced or turned with respect to each other, nor one pair be displaced or turned with respect to the other pair, as otherwise there would be errors of level, lateral position and angle of two successive pictures of the same row and of the pictures in the two rows at opposite sides.

Sources of such errors are present in the old systems because their reflectors are movable with respect to each other and it is necessary to position exactly a moving face with respect to a fixed one. This requires a degree of precision which is soon lost owing to wear. Moreover, in the existing systems the movement is jerky, which brings about vibration and other errors. Therefore, in the old systems accidental errors as well as inherent errors must be expected.

The sources of error are eliminated according to my invention by providing, in combination with a single objective, a frame adapted to be displaced in a single plane and in a continuous curve with respect to the objective, and on the frame I secure reflective units, i. e. the Knight pairs previously described. There reflective units may be of any type, such as mirrors, prisms or the like. By these means the reflectors are moved continuously and all points of all reflectors describe continuous curves which are equal for each set of rays. Each reflector while being displaced, is held exactly parallel to its initial position. Notwithstanding the movement, each ray remains parallel to its initial direction after it has been deflected, and, as the reflectors of each Knight pair keep in their relative position, the path of the ray is invaried after the final deflection, notwithstanding the movement of the reflectors.

Outer orientation relates to the position of the reflectors to the film and to the position of the symmetry plane in space. Outer orientation has never been considered in the old systems. It is obtained, for instance, by means of a water level for placing the symmetry plane vertically in space.

In the accompanying drawings several embodiments of my invention are illustrated more or less diagrammatically by way of example.

In the drawings

Fig. 1 is a perspective illustration, and

Fig. 2 is a section on the line 2—2 in Fig. 1, of a reflector system in which the axes about which the reflectors rotate bodily, are arranged on a rectangle,

Figs. 3 to 7 are diagrams showing a system and various positions of its parts in which the axes are arranged on a parallelogram,

Figs. 8 and 9 are diagrams of systems in which the reflectors are mounted to rotate at the ends of cranks,

Fig. 10 shows a pair of rotary frames, each with a pair of reflectors,

Fig. 11 is a diagram of the system illustrated in Figs. 1 and 2,

Fig. 12 is a plan view, and

Fig. 13 is an elevation of a driving mechanism for the system illustrated in Fig. 8.

In all figures 1 and 2 are the reflectors of the first, and 3 and 4 are the reflectors of the second Knight pair or group of reflectors. B' is a ray reflected by the first, and B^2 is a ray reflected by the second group. OB is the symmetry plane of the system which includes the optical axis of the objective 15.

Referring first to Figs. 1, 2, and 11, four vertical shafts 27, 28, 29, and 30 are mounted to rotate in a frame having an upper and a lower plate 21 and 20, respectively, and four stays 22 to 25. 32 to 35 are gear wheels on the respective shafts, and 31 is a central gear wheel meshing with the four other wheels. 26 is the shaft of the central gear wheel, 40 is a bevel gear on the shaft 26, and 41 is a bevel gear on a driving shaft 42 by which rotation is imparted to shaft 26.

36 to 39 are crank pins on the respective gear wheels 32 to 35, and 16 to 19 is a frame which is secured on the crank pins so that the two Knight pairs or groups 1, 2 and 3, 4 in the frame are rotated bodily and in parallel to themselves.

14 is the front end of the camera with the objective 15.

The rotation of the driving shaft 42 is so timed with respect to the means, not shown, for moving a film past the objective 15 that the driving shaft, and consequently the shafts of the system, rotates through 180 degrees in the interval between two picture changes. The crank pins 36 to 39 are so positioned that at half time between two changes the pins are either at the right end or at the left end of their stroke. Fig. 2 shows them at the right end. When the change occurs the crank pins are at 90 degs. to the aforesaid final positions.

In a camera the shutter, not shown, of which is opaque for .25, and transparent or open for .75 of its area the picture change occurs while the reflector system rotates through $1/8$ rev., and the exposure while it rotates through $3/8$ rev. The reflectors consequently must move out of the range of one group of rays, and into the range of the other group, during $1/8$ rev.

The diameter of the circles described by the reflectors represents the total displacement from half time the exposure of a picture at the left to half time the exposure at the right, and is preferably somewhat larger than the projection of the central reflectors 2 and 3 on a plane at right angles to the symmetry plane OB. The optical basis of the system is equal to the pitch of those two rays (parallel to the symmetry plane OB before deflection) which after deflection both are in the optical axis and consequently in the symmetry plane OB. Strict inner orientation as defined

above obtains if the reflectors 1, 2 and 3, 4 operate so that any two rays B' and B^2 which are equidistant from the symmetry plane OB, are again equidistant after reflection and parallel to their original direction.

Parallelism of the rays obtains if, as shown, the two reflectors of each pair or group are parallel to each other, and the condition of equidistance obtains if the angles included by the reflectors of the two pairs with the symmetry plane OB are equal but oppositely directed at opposite sides of the plane. The planes of all reflectors should be at right angles to a plane which in turn is at right angles to the symmetry plane OB.

It is repeated that the condition of symmetry does not relate to the reflectors but to the condition of the rays before the first and after the last deflection. The direction of the rays intermediate the final deflections only underlies the condition that the total length of symmetrical rays should be equal at both sides of the symmetry plane OB. Therefore, as will be illustrated in Figs. 3 to 7, the groups or Knight pairs may be arranged with the crank pins on a parallelogram, so that one pair is pitched nearer the objective 15 than the other. The symmetry plane may be parallel to the feeding direction of the film.

The apparatus illustrated in Figs. 1, 2, and 11 has the advantage that the reflectors are readily adjusted for parallelism, equal angles and vertical position, and that their parallelism is independent of the movement. Movement in a plane is also readily effected. Errors as to lateral or vertical position, and distortion errors, are eliminated for all pictures.

Referring now to Figs. 3 to 7, the pairs or groups are arranged as described with reference to Figs. 1 and 2 but the axes 5, 6 of the first pair or group 1, 2 are pitched nearer to the objective 15 than the axes 7, 8 of the second pair or group 3, 4. The dotted-line positions in Fig. 3 correspond to $1/8$, ($1' 2'$) and to $1/2$ rev. ($3' 4'$). Parallelism and equidistance are not interfered with during the movement of the reflectors, as will appear from Figs. 4 to 7 which show four positions, each at an angle of 90 degrees to the preceding one. The upper limit of the displacement is determined by the consideration that each group of rays must strike the reflectors to a sufficient extent while its lower limit is determined by the condition that no rays from any group may get to the objective 15 while rays of the other group are admitted to the objective.

In the old systems referred to the fact that symmetry of the rays is required, led to difficulties of assembling and adjusting. Nor was any attention paid to the outer orientation as defined above, that is, the position of the system and its symmetry plane to the film, and the position of such plane in space. According to my invention the symmetry plane is arranged in parallel relation to a straight line which is fixed for the films of all cameras, and located by a line connecting the perforations of the film when at the focus. Horizontal lines of the scene will then be parallel to the feeding direction of the film, or at right angles thereto. If the camera is adjusted so that the symmetry plane OB is vertical in space all vertical lines of the scene will be vertical, and all horizontal lines horizontal, in the pictures.

All reflectors move continuously and not intermittently, like the old systems referred to, and their movement is not interrupted during exposure. Each group alternately moves into the reach of its coordinated group of rays while the

other group is in inactive position. Each point of each reflector describes a plane curve and the planes of all curves are parallel and at right angles to the symmetry plane OB. All curves are endless and congruent in each group of reflectors, but they may be congruent throughout. Preferably the curves are circles, as shown, but I am not limited to any particular type of curve.

In Figs. 8 to 11 the rear faces of the reflectors are indicated by dotted lines.

Referring first to Figs. 8, 12, and 13, the system has three shafts 9, 10, and 11 to which rotation is imparted by suitable means, not shown, 43 and 45 are single cranks on the respective shafts 9 and 11, and 44 is a double crank on shaft 10. The reflector 1 of the first, and the reflector 4 of the second group are mounted to rotate on the cranks 43 and 45, respectively, while the reflector 2 of the first, and the reflector 3 of the second group are mounted at opposite ends of the double crank 44. Means, not shown, are provided for rotating the reflectors on their cranks while the shafts rotate, as indicated by the arrows. The reflectors rotate on their cranks at the same angular velocity as the crank shafts but in the opposite direction, and the reflectors in each group rotate at the same angular velocity and in the same direction.

Means for operating the system Fig. 8 are shown in Figs. 12 and 13. The shafts 9, 10, and 11 support gear wheels 69, 70, and 71, respectively, which mesh with gear wheels 61, 62, 63, and 64 at the ends of the respective cranks. 12 and 13 are pinions in mesh with the gear wheels 69, 70 and 71, respectively. As will appear from Fig. 13 the gear wheels 61 to 64 are at a higher level on their cranks than the pinions 12, 13, and in order to permit meshing of the wheels 61 . . . and the pinions 12, 13 with the wheels 69 . . . these wheels are broader than normal. The diameters of the wheels and pinions are equal.

Referring to Fig. 9, 46 and 47 are two shafts, each with a double crank 48 and 49, respectively. The reflectors 1 and 2 of the first group are mounted to rotate at the ends of crank 48, and the reflectors 3 and 4 of the second group are mounted to rotate at the ends of the crank 49. The directions of rotation of the shafts and cranks are indicated by the arrows.

While in Fig. 8 the cranks are at 180 degrees to each other they are at 90 degrees in Fig. 9. The pitch of the shafts 9, 10, 11 in Fig. 8 is about equal to half the stereoscopic base, and the pitch of the shafts 46 and 47 in Fig. 9 is about equal to $\frac{1}{4}$ the stereoscopic base.

Referring to Fig. 10, the two reflectors 1, 2 and 3, 4 of each group are actuated by shafts 5, 6 and 7, 8, respectively, as in Fig. 3, and are secured on frames 50 and 51, respectively.

I claim:

1. A reflector system for stereo-cinematograph cameras, comprising a single objective, reflective units with reflectors arranged in groups at both sides of the optical axis of said objective, each group being capable of displacing rays parallelly onto said objective and means for moving said units in continuous curves while maintaining the reflectors parallel to their initial position, to alternately bring each group to the exclusion of the other into position, so that the reflected light is incident on the objective.

2. A reflector system for stereo-cinematograph cameras comprising a single objective, a frame, means for moving said frame in a single plane and in a continuous curve, and reflective units

with reflectors arranged in groups at both sides of the optical axis of said objective and secured to said frame, each group being capable of displacing rays parallelly onto said objective, and the movement of said frame alternately bringing each group to the exclusion of the other, into position so that its reflected light is incident on the objective.

3. A reflector system for stereo-cinematograph cameras comprising a single objective, a frame, means for moving said frame in a single plane and in a continuous circular curve, and reflective units with reflectors arranged in groups at both sides of the optical axis of said objective and secured to said frame, each group being capable of displacing rays parallelly onto said objective, and the movement of said frame alternately bringing each group to the exclusion of the other, into position so that its reflected light is incident on the objective.

4. A reflector system for stereo-cinematograph cameras comprising a single objective, shafts disposed substantially perpendicularly to the longitudinal axis of the objective and defining the corners of a parallelogram, a plurality of said shafts lying on each side of the objective and comprising groups, cranks on said shafts, a reflector mounted to rotate on each crank, the reflectors of each group being parallel to each other, and means for rotating the shafts of each group at equal but opposite angular velocities, and for rotating all reflectors of a group at equal angular velocity and in the same direction, the reflectors of each group being capable of displacing rays parallelly onto said objective, and the movement of said shafts alternately bringing each group to the exclusion of the other, into position so that its reflected light is incident on the objective.

5. A reflector system for stereo-cinematograph cameras comprising a single objective, four reflectors making up a Wheatstone system, three shafts, two shafts having a single arm thereon, a double-armed crank on the central shaft, with its arms at 180° to each other, said shafts being substantially parallel, a reflector mounted to rotate on each arm, the arms of the outer shafts being pitched at 180° to each other, and means for rotating said shafts in the same direction, the reflectors of each of the outer arms being parallel with and cooperating with the adjacent reflector of the central shaft, the groups of reflectors being pitched at such angles to each other that upon rotation of the shafts, each group of reflectors alternately, to the exclusion of the other, transmits its reflected light, displaced parallelly and inwardly, onto the objective.

6. A reflector system for stereo-cinematograph cameras, comprising a single objective, four reflectors making up a Wheatstone system of two groups, the reflectors of each group being substantially parallel to each other and adapted to displace parallelly onto the objective, two shafts, means for rotating said shafts in opposite directions, a double crank on each shaft, with its arms at 180° to each other, a reflector mounted to rotate on each arm, the reflectors on each double crank comprising a group, said cranks being pitched at 90° to each other, and means for rotating the reflectors on each crank in the same direction.

7. A reflector system for stereo-cinematograph cameras, comprising a single objective, reflective units with reflectors arranged in groups at both sides of the optical axis of said objective, the

flectors of each group being substantially parallel to each other and being adapted to displace rays parallelly onto said objective, said axis extending in parallel to the means for feeding a film through the system, and means for moving said units in continuous curves while maintaining the reflec-

tors parallel to their initial position, whereby each group of reflectors will alternately, to the exclusion of the other group, transmit its reflected rays onto the objective.

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