S. M. FAIRCHILD.

PHOTOGRAPHIC SHUTTER.

APPLICATION FILED DEC. 6, 1918.

1,325,317.

Patented Dec. 16, 1919.

6 SHEETS—SHEET 1.

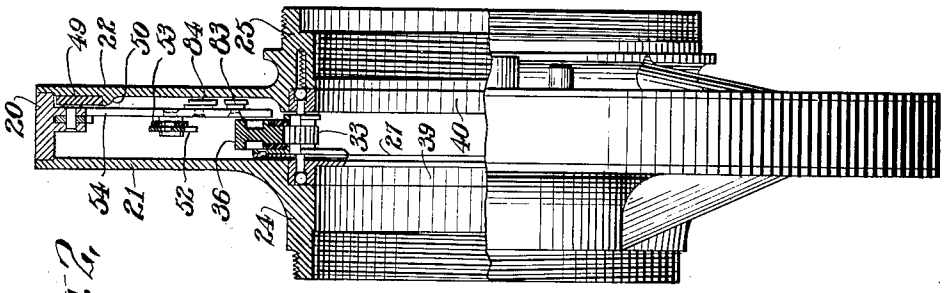

Fig. 2.

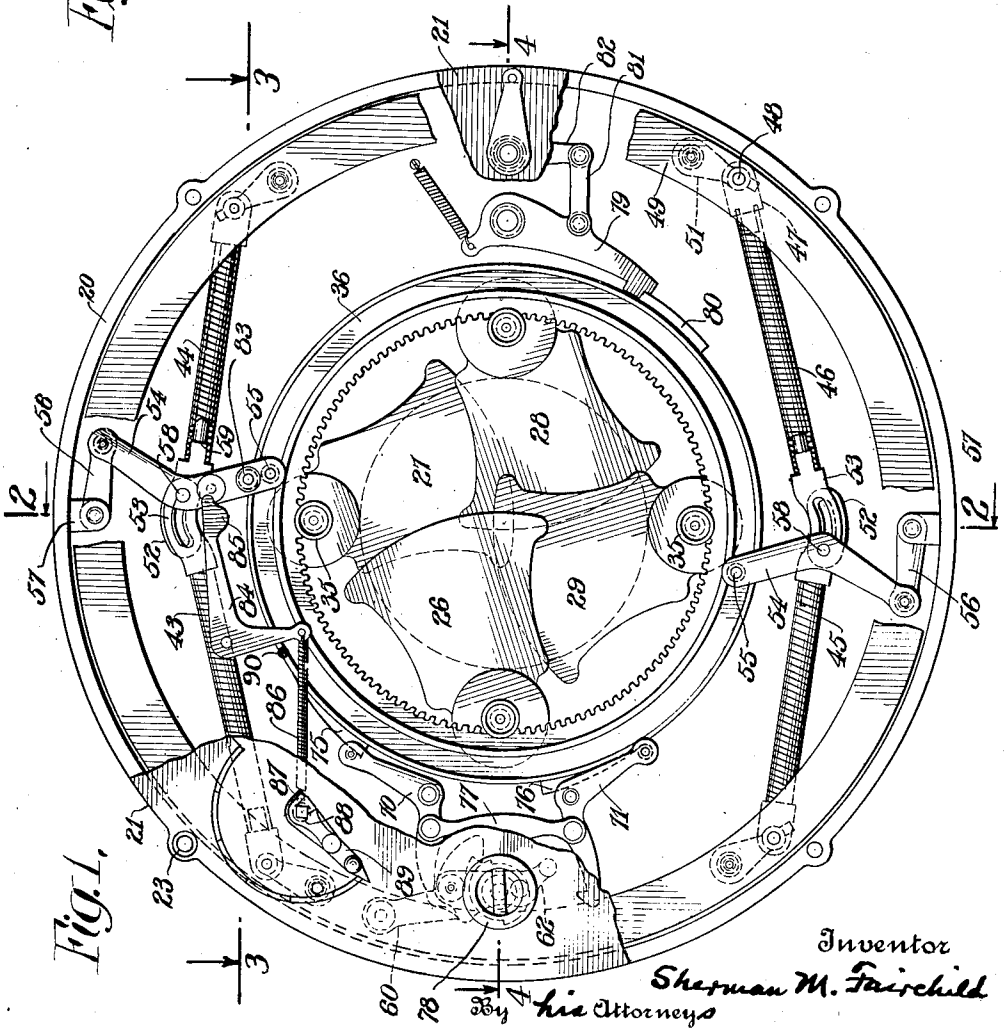

Fig. 1.

Inventor

Sherman M. Fairchild

By his Attorneys

Kerr, Page, Cooper & Hayward

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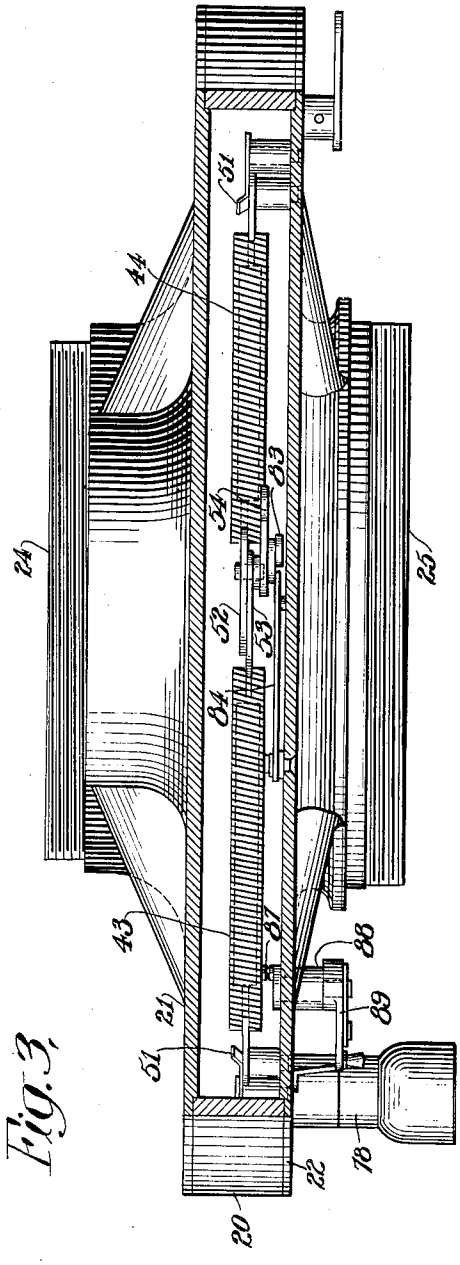

Fig. 3.

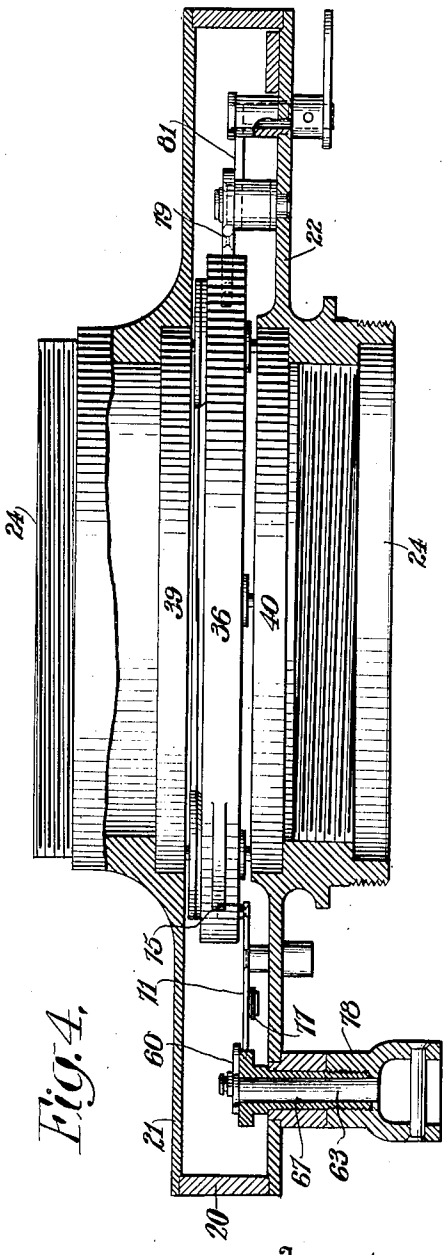

Fig. 4.

Inventor
Sherman M. Fairchild
By his Attorneys
Kerr, Page, Cooper & Hayward

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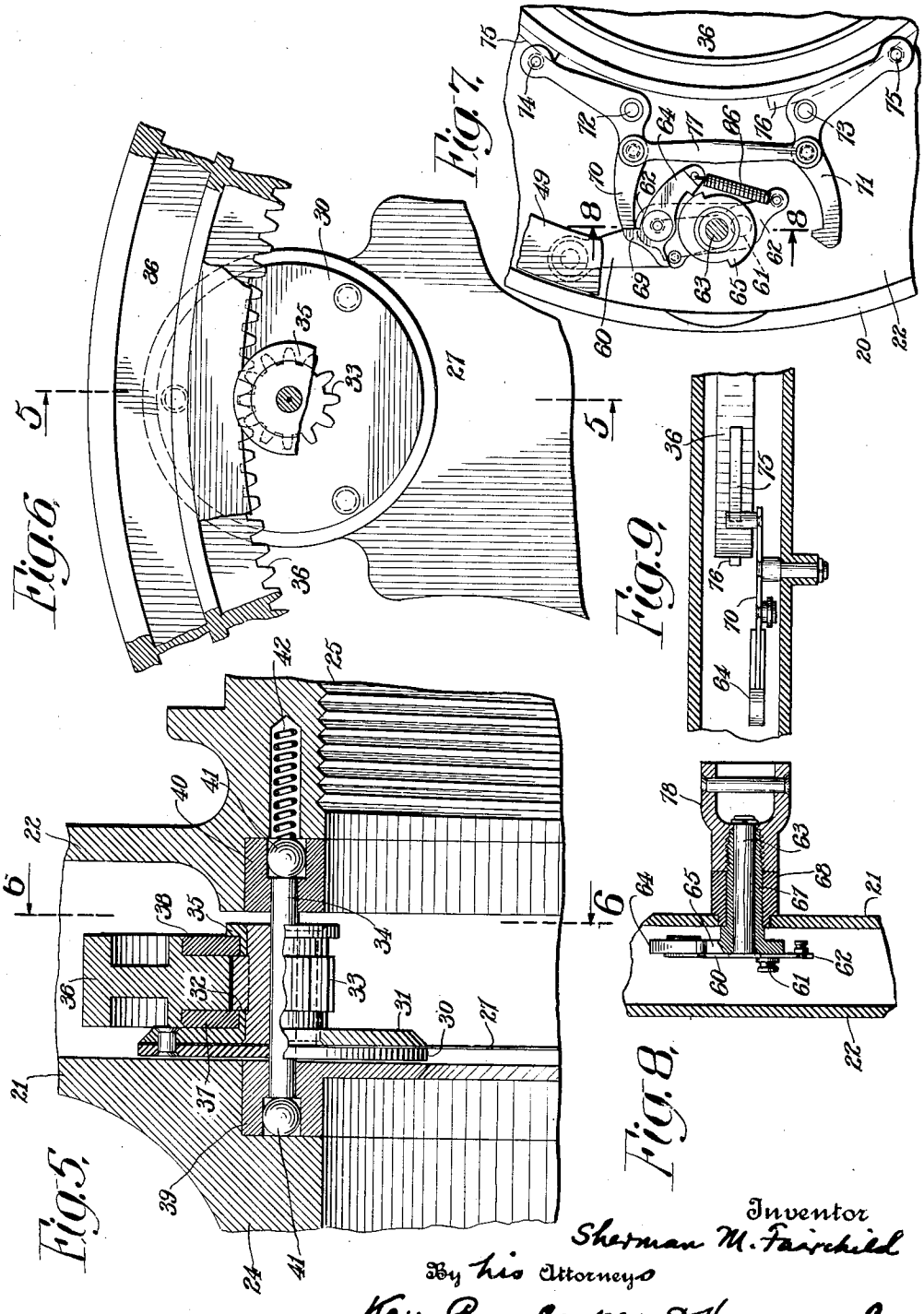

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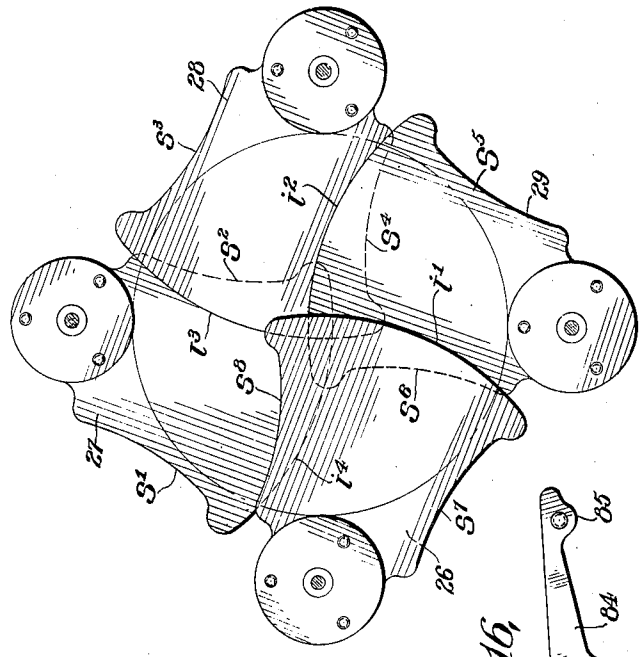

Fig. 15

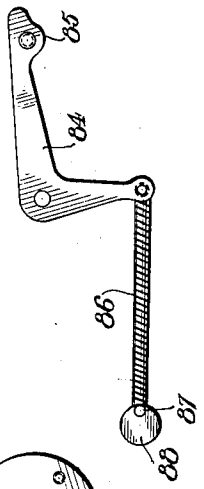

Fig. 16.

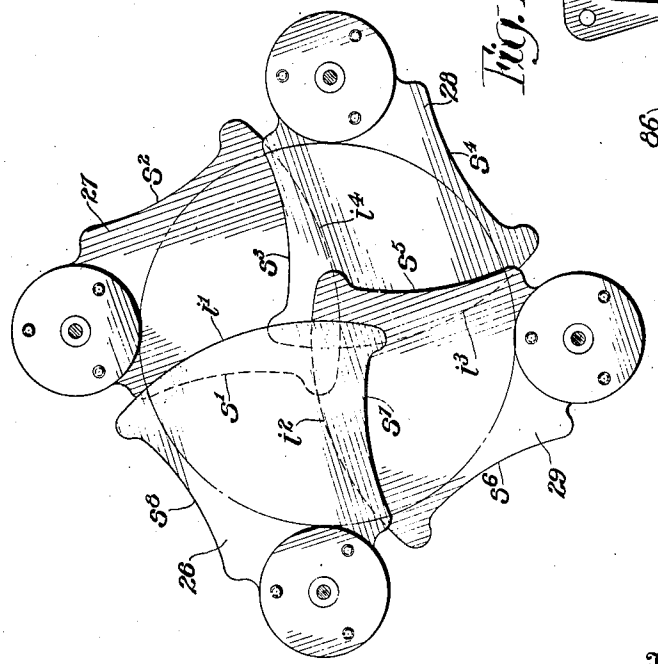

Fig. 10.

Inventor
Sherman M. Fairchild
By his Attorneys
Kerr, Page, Cooper & Hayward

S. M. FAIRCHILD.

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6 SHEETS—SHEET 5.

Fig. 12.

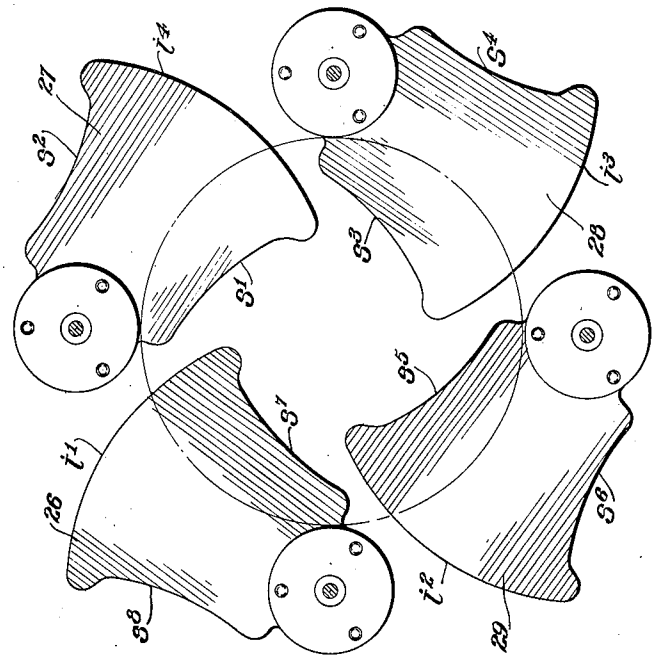
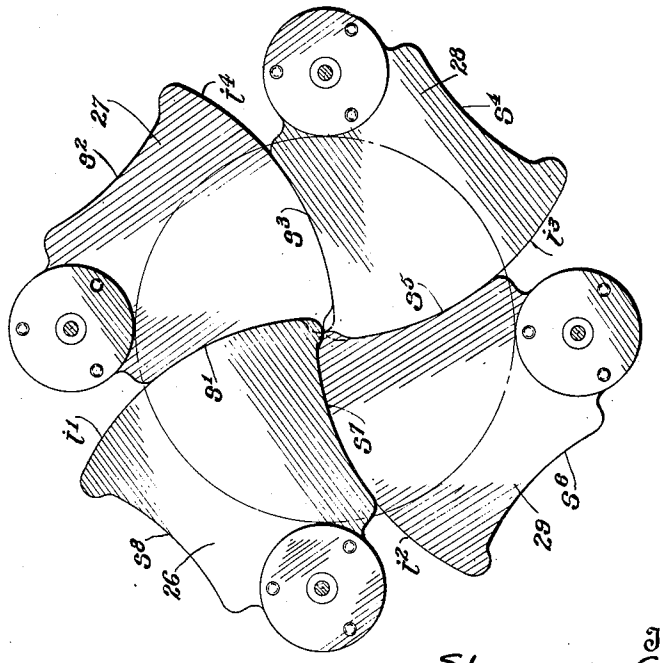


Fig. 11.



Inventor

Sherman M. Fairchild

By his Attorneys

Kerr, Page, Cooper & Hayward

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6 SHEETS—SHEET 6.

Fig. 14.

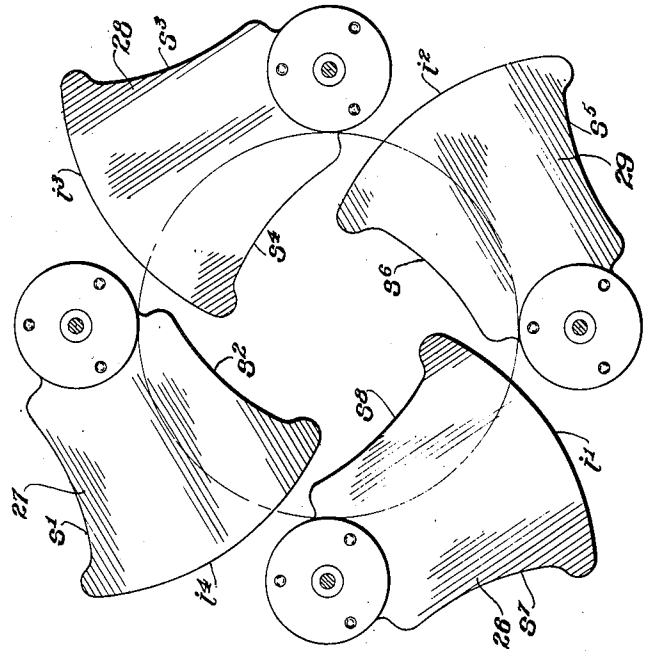
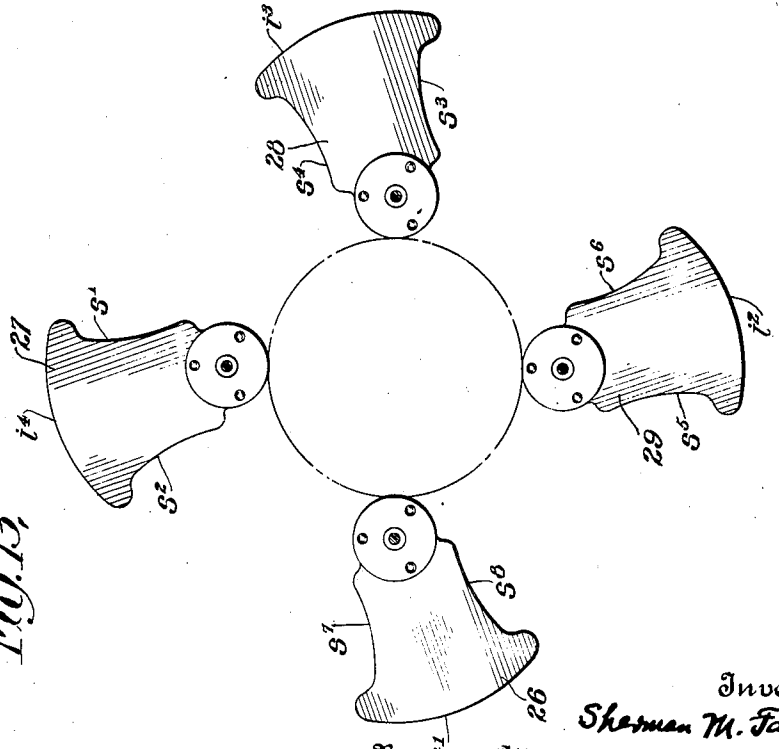


Fig. 13.



Inventor
Sherman M. Fairchild

By i¹ Attorneys
Kerr, Page, Cooper & Hayward

UNITED STATES PATENT OFFICE.

SHERMAN M. FAIRCHILD, OF ONEONTA, NEW YORK.

PHOTOGRAPHIC SHUTTER.

1,325,317. Specification of Letters Patent. Patented Dec. 16, 1919.

Application filed December 6, 1918. Serial No. 265,493.

To all whom it may concern:

Be it known that I, SHERMAN M. FAIRCHILD, a citizen of the United States, residing at Oneonta, county of Otsego, and State of New York, have invented certain new and useful Improvements in Photographic Shutters, of which the following is a full, clear, and exact description.

This invention relates to photographic shutters, and its chief object is to provide a shutter of high efficiency, that is, a shutter in which the light aperture will be fully open during the greater portion of the exposure period. Another object is to provide a shutter which will have a high efficiency at all speeds, high as well as low, and which will be reliable and accurate in operation. A further object is to provide a shutter of simple and durable construction, which can readily be taken apart and reassembled whenever necessary for cleaning, repairs, adjustment, or the like. To these and other ends the invention consists in the novel features of construction and combinations of elements hereinafter described.

Of the various constructions in which the invention can be embodied I have selected for illustration and specific description herein the one which at the present time is believed to exhibit the invention in its most convenient and effective form. This embodiment is shown in the accompanying drawing, in which

Figure 1 is a front view of a shutter of the so-called "inter-lens" type, that is, a shutter having opaque leaves or blades which operate between the front and rear components of the lens. In this figure the front plate of the shutter casing or housing is largely broken away to show the inner mechanism.

Figs. 2, 3 and 4 are sections on lines 2—2, 3—3, and 4—4, respectively, of Fig. 1.

Fig. 5 is a detail section, about on line 5—5 of Fig. 6, showing the mounting of one of the shutter leaves or blades, and the internal gear which drives the blades.

Fig. 6 is a detail section on line 6—6 of Fig. 5.

Fig. 7 is a detail front view of the setting mechanism.

Fig. 8 is a detail section on line 8—8 of Fig. 7.

Fig. 9 is a detail plan view of the parts shown in Fig. 7.

Figs. 10 to 15, inclusive, illustrate different positions of the blades in making an exposure.

The operative parts of the shutter illustrated are conveniently inclosed in a dust-proof casing or housing consisting of a shallow cylindrical ring 20, Figs. 1 and 2, and front and rear cover-plates 21, 22, secured to the ring by means of screws 23. Upon removal of these screws either cover-plate can be removed, whereupon the entire mechanism is exposed and can be taken apart and reassembled without the use of screwdriver or wrench. The cover-plates are centrally apertured and are provided, as usual, with interiorly threaded lens tubes 24, 25 to receive the lens cells, the rear tube being also exteriorly threaded for securement to the usual "flange," not shown, on the front-board of the camera.

In the present embodiment of the invention the shutter blades or leaves 26, 27, 28, 29 are more or less sector-shaped and are four in number, but it is to be understood the invention is not limited in these respects. The blades are pivoted on their axes, which are spaced equidistantly from each other and from the center of the light aperture, and are fixed between front and rear disks 30, 31, Figs. 5 and 6. Each inner disk has an axial flange 32 extending inwardly over the adjacent hub of the blade-actuating pinion 33 which is fixed on the blade-pivot 34 in any convenient manner. The opposite hub of the pinion is inclosed by a flanged ring 35. The pinions are rotated, and with them the shutter blades, by an internal gear 36 which is carried by two parallel rings 37, 38, (not shown in Fig. 1) fitting between the teeth of the pinions and the disk 31 and flange 35. The gear is thus supported on roller bearings so that it revolves with minimum friction, the parts 32 and 35 being in effect rollers concentric or co-axial with the blades. Moreover, these roller bearings maintain the gear concentric with the light aperture and keep the gear in mesh with all the pinions to the same depth. The pivots 34 are mounted in rings 39, 40, which are themselves removably fitted in rabbets encircling the light aperture, at the inner ends of the lens tubes 24, 25. The ends of the pivots rest on polished steel balls 41, serving as thrust bearings, and the pivots and blade-assemblies are held in proper position by light springs 42 seated in holes drilled in the rear lens tube and bearing on

the rear balls. The carrier rings 39, 40 being removably fitted in their rabbets, it will be seen that upon taking off either cover-plate the underlying carrier ring 39 or 40, as the case may be, is at once exposed and can be lifted off the pivots. The blades are made of thin opaque material of any suitable kind, for example hard rubber or sheet metal.

The shutter blades revolve first in one direction, and then in the other. That is, if in the first exposure the blades revolve clockwise from the initial closed position to the final closed position, in the next exposure the rotation will be counterclockwise, in the third clockwise again, and so on. The shutter therefore does not open during setting and hence the lens does not need to be capped. For this mode of actuation the internal gear is itself driven clockwise and counterclockwise in alternation by any convenient and suitable means, preferably by helical springs of the contractile type mounted in pairs. In the present instance two pairs are used, on diametrically opposite sides of the gear. If more than two pairs are used they should be spaced equidistantly. One pair may be used, but it is better to have two or more as a more even torque is produced on the gear and side-thrust is minimized. In the drawings, Fig. 1, the springs are designated by 43, 44, 45, 46. At their outer ends they are provided with flat terminals 47 which are apertured to fit over posts 48 on a flat annulus 49, rotatably mounted on a flange 50, Fig. 2, at the periphery of the rear cover plate 22. The spring terminals mentioned are held in place on their posts by means of spring clips 51. The springs are therefore securely anchored to the annulus (which, as is explained hereinafter, is shifted rotatably to put the springs under tension) yet can be readily disconnected therefrom by raising the clips 51.

At their inner ends the actuating springs 43, 44, 45, 46 are provided with flat terminals 52, 53, having longitudinal arc-shaped slots which overlap as shown when either spring of the pair is tensioned. The overlap, however, is incomplete, that is, the end of one slot is slightly in front of the adjacent end of the other, for the purpose explained below. The internal gear 36 is connected to the springs by means of levers 54, pivoted to the gear at the points 55 and fulcrumed on the swinging arms 56 which are pivoted between ears 57 on the casing wall 20. These levers are provided between their ends with studs 58 engaging the spring-terminals 52, 53 in the aforesaid arc-shaped slots.

In Fig. 1 the springs 43 and 46 are shown under tension. Hence, when the shutter is "released" the levers 54 are instantly swung clockwise on their fulcrums, thereby giving the internal gear 36 a partial rotation in the counterclockwise direction, sufficient in extent to revolve the blades (also in the counterclockwise direction) from the initial position shown in Fig. 10 to the final position shown in Fig. 15. In this operation the studs 68 are drawn (by the terminals 53) through the slots in terminals 52 and are brought up against the ends of the slots in said terminals 52 just as the blades overlap to close the light aperture. The levers thus encounter a yielding resistance at the end of their stroke. Each spring also has in it a rod 59, which is somewhat shorter than the distance between the inner ends of the spring terminals when the spring is fully contracted. The result is that after the levers have been slowed down, and just as the blades reach their final position, the slotted terminals of the active springs (that is, the springs which are actuating the blades) strike the stop rods in their respective springs and are brought to rest. At this time the studs 58 are held between the inner ends of the arc-shaped slots, as will readily be understood, and none of the springs is tensioned. That is, the shutter is not set.

To set the shutter for the next exposure the setting annulus 49, Fig. 1, must be given a partial rotation in the clockwise direction. Assuming the driving gear 36 to be held by the release mechanism, the levers 54 cannot swing. Hence this movement of the setting ring carries the spring terminals 53 in the clockwise direction. Terminals 52, however, are held by the studs 58, and hence the springs 44 and 45 are stretched. The shutter is now set, with the slotted terminals overlapping in the manner already described, and when the shutter is released the blades revolve in the clockwise direction from the position shown in Fig. 15 to that shown in Fig. 10.

The actuation of the setting ring or annulus 49 to tension the appropriate springs is effected by the following mechanism. The ring is connected by means of a link 60, Fig. 7, to a crankpin 61 on a lever 62 which is mounted on the inner end of the shaft 63. See also Fig. 8. Assuming the parts to be in the positions shown in Figs. 1 and 7 it will be clear that if the lever 62 is swung clockwise half a turn on the shaft 63 the link 60 will be raised and the ring 49 thereby shifted in the clockwise direction. This will bring the crankpin 61 above the shaft. Then if the lever be given another half-turn in the same direction the ring will be shifted in the opposite direction. These movements of the lever, by which the ring is shifted in one direction to tension springs 44—45 and then in the other direction to tension springs 43—46, are produced by means of a pawl 64 fulcrumed on the end of the lever and a two-toothed ratchet 65. The hooked end of the pawl is urged toward the ratchet by means

of a light spring 66 connected to one end of the lever 62, and the hub or sleeve 67 (of the ratchet) in which the shaft 63 is mounted is adapted to rotate in a bearing 68 removably fitted in the front cover plate 21. The pawl also has a finger 69, adapted to coöperate with either of two dogs 70, 71, pivoted at 72, 73 on the rear cover plate 22. The tails of these dogs are provided with studs 73, 74, riding on cam-ribs 75, 76 on the periphery of the driving gear 36. When the parts are in the position shown in Fig. 7 the hooked end of the pawl is held out of the path of the ratchet-teeth by the dog 70 engaging the finger 69. If now the shutter is released and the gear 36 is thereby caused to rotate in the counterclockwise direction, the downwardly moving rib 76 will rock dog 71 and, through the medium of the link 77, will rock dog 70 clockwise as the rib 75 descends. This movement of dog 70 releases the pawl 64 and allows the spring 66 to draw the hooked end down upon the ratchet. If the ratchet is now rotated in the direction of the arrow (clockwise in Fig. 7) the approaching tooth will engage the pawl and carry the same with it, thereby swinging the lever 62 on the shaft 63. This carries the stud 61 leftwardly and upwardly, and hence shifts the setting ring 49 in the clockwise direction as already described. The movement imparted to dog 71 by the cam-rib 76 was clockwise. Hence when the pawl has been carried a half-revolution around the axis of shaft 63 and ratchet 65 the finger 69 finds the hooked end of the lower dog in its path. The pawl is thus not only arrested (and with it the lever 62) but it is also swung out of engagement with the ratchet, leaving the latter free to continue its movement. At the next release of the shutter, the dogs are swung back to the positions shown in Fig. 7, and when the ratchet is again rotated the pawl 64, lever 62, link 60, etc., are also restored to the position shown in the figure.

From the foregoing explanation of the setting mechanism it will be seen that the pawl 64 is in the path of teeth on the ratchet 65 only during the actual settting operation, and that the pawl is swung into the engaging position automatically at the end of each exposure. Hence the ratchet can be continuously driven, with the result that after each exposure the shutter will be immediately reset. This is a highly advantageous feature, especially in airplane cameras, for the operator is not required to set his shutter but knows that it is always set and hence can give his whole attention to making the exposure. For this purpose the outer end of the sleeve 67 can be equipped with a coupling member 78 for connection with suitable driving mechanism, for example a flexible shaft driven by a small propeller (not shown) which is rotated by the air as the airplane travels. The member 78 may, of course, be rotated manually or may receive a suitable key for the same purpose.

The release mechanism is illustrated in Fig. 1, and includes a pawl 79 adapted to engage one end or the other of a lug 80 on the rim of the driving gear 36. The pawl is connected by a link 81 to a bell-crank lever 82 fulcrumed in the front cover plate 21 and having one arm on the outside of the same. Assuming the parts to be in the positions shown in Fig. 1, with springs 43 and 46 under tension, raising the outer arm of the release lever will disengage the pawl from the lug and allow the gear to turn counterclockwise, carrying the lug 80 above the pawl-tooth so at the next setting of the shutter the lug will be held by its lower end. If the setting mechanism is continuously driven, the release mechanism illustrated should, generally, be replaced by one of the trip type, so that continued pressure on the release lever or button will not cause repeated (and unintentional) exposures. Such mechanisms are well understood and hence need not be illustrated herein.

The "speed" of the shutter, that is, the period of exposure, is varied by means of a spring retarding mechanism shown in Figs. 1, 2 and 3. For this purpose the upper lever 54 is provided with a roller stud 83, and fulcrumed on the front cover-plate is a bell-crank lever 84 having at the end of its horizontal arm a lug 85. The other arm is connected by a spring 86 to a crank pin 87 (see Fig. 16) on a stud 88 which is mounted in the front cover plate and is capable of being rotated by a pointer 89 on the outside, thus bringing the depending arm of the bell-crank against the stop 90 (carried by the front cover plate) and tensioning the spring 86. As the driving gear 36 turns (counterclockwise in Fig. 1) the stud 83 meets the lug 85 and in order to pass must cam it upwardly. With the pointer in the position shown, with the lug 85 out of the path of the stud 83, the gear suffers no retardation. This gives the highest speed of which the shutter is capable. On the other hand, as the index-arm is turned clockwise the spring is tensioned. As a result the lever 54 suffers retardation when it meets the bell-crank, and the duration of the exposure time is therefore increased. After the exposure is completed the stud 83 lies to the left of the lug 85, so that the next engagement of the stud and lug will occur on the left edge of the latter. It will be seen that the lug 85 and stud 83 are normally separated, so that the gear must turn some distance before the retardation begins,—in fact it must turn far enough to open the shutter fully before it begins to slow up. Moreover, the stud passes the lug, and the retarding force

therefore ceases to be exerted, before the shutter begins to close. These are highly advantageous features, as they insure maximum speed of opening and closing and maximum duration of the period of full opening, thus giving a very high efficiency.

The shape and proportions of the blades or leaves shown are also advantageous features. The inner edges i^1, i^2, i^3, i^4, Figs. 10 to 15, are circular arcs having their centers of curvature at the respective axes on which the blades revolve. The side edges s^1, s^2, . . . s^8 are also circular arcs, of the same radius of curvature as the inner edges just mentioned, and they have an angular position relative to the said inner edges such that just before the leaves "break" to begin the exposure each inner edge i and the adjacent lateral edge s are parallel. Further movement of the blades then causes them to separate at the circumference and at the center of the light aperture simultaneously. Fig. 10 shows the blades fully closed. Fig. 11 shows them just before the break begins. Fig. 12 shows the blades at a later stage, at which instant about 40 per cent. of the light aperture area is open. Fig. 13 shows the blades with their movement somewhat more than half completed, that is, rotated about 180° from the position shown in Fig. 10. In Fig. 15 the blades have come to rest. Upon comparing Figs. 10 and 15 it will be observed that in the former the inner edges i^1, i^2, i^3, i^4 are overlapped by the side edges s^1, s^3, s^5, s^7, respectively; and that in Fig. 15 the inner edges are overlapped by the other side edges, s^2, s^4, s^6, s^8. The period of exposure, however, is from the last instant at which the blades are still fully closed (Fig. 11) to the instant at which they are next fully closed. During considerably more than half this period the light aperture is fully open, and during correspondingly less than half this period the blades are opening and closing. With four blades of the proportions indicated relative to the light aperture, and assuming that the velocity of the blades is substantially constant, the efficiency of the shutter exceeds 75 per cent. at the highest speed. As a matter of fact it is much greater, approximating 85 per cent. at the highest speed. Moreover, the efficiency is never less, since at slower speeds the retardation occurs during the period of full opening. At the ends of each side edge, next to the inner edge, each blade is provided with lateral lips m, which serve to keep the light aperture closed at the center until the blades are ready to break at the edges of the aperture. It will also be noted that although each blade at the end of the exposure is at a different position from the position it occupied at the beginning of the exposure, nevertheless the same part of the blade (in the present instance the central portion, comprising substantially the entire area of the blade) is interposed in the path of the light rays. Thus in Fig. 10 the blade 26 covers the upper left-hand quadrant of the aperture, and in Fig. 16, which shows the position at the end of the given exposure, the blade mentioned covers the lower left-hand quadrant, but in each position substantially the entire blade is in the path of the rays.

The embodiment illustrated herein is designed particularly for airplane cameras, in which the lens is always used at full aperture, and hence a diaphragm is not needed, but one of the well known iris or other type can be provided if desired.

It is to be understood that the invention is not limited to the specific construction herein illustrated and described but can be embodied in other forms without departure from its spirit as defined by the appended claims.

What I claim is:

1. In a photographic shutter, in combination, opaque means movable in opposite directions across the path of the light rays for making exposures; a member rotatively movable in opposite directions connected with said means to actuate the same; and a plurality of spring driving mechanisms connected with the actuating member at different points, whereby the driving torque in either direction on said member is exerted thereon at a plurality of points.

2. In a photographic shutter, in combination, a plurality of pivoted blades movable in opposite directions across the path of the light rays for making exposures, an annular member rotatable in opposite directions encircling the blades and connected therewith to actuate the same; and a plurality of spring driving mechanisms around the annular member and connected thereto at different points, whereby a driving torque in either direction is exerted on the annular member at a plurality of points.

3. In a photographic shutter, in combination, a plurality of pivoted blades movable in opposite directions across the path of the light rays for making exposures, a plurality of pinions connected with the blades to actuate the same; a driving gear meshing with the pinions, and a plurality of spring driving mechanisms connected with the gear at different points, whereby a driving torque in either direction is exerted on the gear at a plurality of points.

4. In a photographic shutter, in combination, opaque means movable across the path of the light rays; rotatably movable means for actuating said opaque means; driving springs connected with the actuating means for tensioning the springs in alternation whereby when one spring is acting to drive the actuating means the other is inactive.

5. In a photographic shutter, in combination, opaque means movable across the path of the light rays; a rotatably movable actuating member therefor, adapted to move said opaque means in one direction at one exposure and in the opposite direction at the succeeding exposure; a spring connected to said member to shift the same in one direction; a spring connected with said member to shift the same in the opposite direction; and means for tensioning the springs alternately.

6. In a photographic shutter, in combination, a rotary blade-actuating member encircling the light aperture; a plurality of pairs of oppositely disposed springs connected at their inner ends to said actuating member to drive the same in either direction; and means for tensioning one spring of each pair for one exposure and the other spring of each pair for the next exposure, whereby the said actuating member is moved clockwise at one exposure and counterclockwise at the next.

7. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member connected with the opaque means and movable in opposite directions; a pair of oppositely disposed springs; mechanism connected with the outer ends of the springs for tensioning the springs alternately; and means connecting the inner ends of the springs with the actuating member and enabling the untensioned spring to act as a yielding resistance to the actuating member as the latter approaches the end of its movement.

8. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member connected therewith and movable in opposite directions; a pair of oppositely disposed springs provided at their inner ends with overlapping terminals having longitudinal slots which overlap each other incompletely when either spring is tensioned; a stud extending through both slots and connected with the actuating member to drive the same; and means for tensioning the springs alternately.

9. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member movable in opposite directions and connected with said means; a pair of oppositely disposed springs having at their inner ends terminals provided with longitudinal slots which overlap each other when either spring is tensioned; a stud extending through both slots and connected with the actuating member to drive the same; and means for tensioning the springs alternately.

10. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member connected therewith and movable in opposite directions; a lever connected to the said actuating member to shift the same in opposite directions; a pair of oppositely disposed springs having terminals on their inner ends provided with longitudinal slots adapted to overlap incompletely when either spring is tensioned; a stud carried by the lever and extending through both slots in the said terminals; and means for tensioning the springs alternately.

11. In a photographic shutter, in combination, opaque means movable across the path of the light rays; a rotary actuating member connected therewith and movable in opposite directions; a lever connected with the actuating member to move the same; a pair of oppositely disposed springs connected at their inner ends to the lever; and means for tensioning the springs alternately.

12. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an annular actuating member connected therewith and movable rotatively; a lever connected with the actuating member to drive the same; a movable fulcrum for the lever; and spring actuating means connected with the lever to rock the same on its movable fulcrum.

13. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an annular actuating member connected therewith and rotatively movable in opposite directions; an annular tensioning member concentric with the actuating member and also rotatively movable in opposite directions; a plurality of pairs of oppositely disposed springs, each spring being connected by its outer end with the annular tensioning member; a plurality of levers, each connected to the actuating member to move the same and each connected to a pair of springs at the inner ends thereof; and means for shifting the tensioning member.

14. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member connected therewith; a plurality of driving springs connected by one end to the actuating member and at different points; a rotatively shiftable tensioning member to which each spring is connected by its other end; and means for shifting the tensioning member rotatively to tension said springs.

15. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member therefor, movable in opposite directions to move said opaque means in one direction at one exposure and in the opposite direction at the next exposure; a pair of oppositely disposed springs connected at their inner ends to said actuating member; and a tensioning member connected to the outer

ends of the springs and movable in opposite directions to tension the springs alternately.

16. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member connected with said means and movable in opposite directions alternately to move the opaque means correspondingly; oppositely disposed springs each connected at one end with the actuating member; a tensioning member connected to the other end of each spring; and means for shifting the tensioning member in one direction for one exposure and in the opposite direction for the next exposure.

17. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an annular actuating member connected with the opaque means and rotatively movable in opposite directions; an annular tensioning member concentric with the actuating member and also shiftable in opposite directions; oppositely acting springs connected to both members and carried thereby to move the actuating member first in one direction and then in the other; and means for shifting the tensioning member to tension the appropriate springs.

18. In a photographic shutter, in combination, opaque means movable across the path of the light rays; spring driving mechanism connected with the opaque means; a tensioning member movable in opposite directions to energize the driving mechanism; and means rotatable in one direction only and connected with the tensioning member to shift the same in one direction and the other alternately.

19. In a photographic shutter, in combination, opaque means movable across the path of the light rays; an actuating member therefor; spring driving mechanism connected with the actuating member; a tensioning member connected with the driving mechanism to energize the same; a crank connected with the tensioning member to actuate the same; a rotary driving element; and means controlled by the aforesaid actuating member to connect the driving element with the crank when the spring driving mechanism is deënergized and disconnect the same when the said mechanism is again energized.

20. In a photographic shutter, in combination, opaque means movable across the path of the light rays; spring driving mechanism connected with the opaque means; a tensioning member connected with the driving mechanism to energize the same; a crank connected to the tensioning member to actuate the same; a ratchet; a pawl carried by the crank and adapted to engage the ratchet to turn the former; and means controlled by the driving mechanism to disengage the pawl when the driving mechanism is energized.

21. In a photographic shutter, in combination, opaque means movable across the path of the light rays; spring driving mechanism therefor; a tensioning member connected with the driving mechanism to energize the same; a crank connected with the tensioning member to actuate the same; a ratchet; a pawl carried by the crank and adapted to engage the ratchet to turn the former; a dog normally coöperating with the pawl to hold the same out of engagement with the ratchet; and means moved by the driving mechanism to actuate and thereby release the dog when the driving mechanism operates.

22. In a photographic shutter, in combination, opaque means movable across the path of the light rays; a movable actuating member therefor; spring driving mechanism for the actuating member; a shiftable tensioning member to energize the spring driving mechanism; a crank connected with the tensioning member to shift the same; a ratchet; a pawl carried by the crank and adapted to engage the ratchet to turn the former; a pair of dogs connected together to operate in alternation and each adapted to hold the pawl out of engagement with the ratchet; and cam-means carried by the actuating member to shift one pawl into and the other out of the path of the pawl.

23. In a photographic shutter, in combination, a plurality of blades pivoted equidistantly around the light aperture, pinions concentric with and connected to the blades to actuate the same, a gear meshing with the pinions to drive the same, and roller bearings for the gear, concentric with said pinions and maintaining the gear and pinions in mesh to a constant depth.

24. In a photographic shutter, in combination, a plurality of pivoted blades; pinions concentric with the blades to actuate the same; rollers concentric with the pinions at opposite ends of the same; a gear meshing with the pinions to actuate the same; and supporting rings for the gear, bearing on said rollers and serving to maintain the gear in mesh with the pinions to a constant depth.

25. In a photographic shutter, in combination, a plurality of pivoted blades, actuating pinions concentric with the blades, rollers concentric with the pinions at opposite ends of the same, an internal actuating gear in mesh with the pinions, and a pair of axially spaced rings supporting the gear and bearing internally on said rollers.

26. In a photographic shutter, in combination, a casing having a cover plate provided with a lens tube and having an internal circular recess at the inner end of the lens tube, a supporting ring removably

mounted in said recess, and a plurality of swinging blades journaled in said ring.

27. In a photographic shutter, in combination, a casing comprising front and rear plates having front and rear lens tubes and having internal circular recesses co-axial with the lens tubes; a pair of axially spaced rings removably mounted in said recesses; a plurality of pivots extending from ring to ring and axially movable thereon; a plurality of ball thrust-bearings carried by the rings for the ends of said pivots; and a plurality of coil springs carried by one of said cover plates and arranged to gear axially on the adjacent thrust-bearings.

28. In a photographic shutter, in combination, a pair of axially spaced co-axial rings; a plurality of swinging blades arranged between the rings and journaled therein; ball thrust-bearings at the ends of the blade journals; and spring means arranged to maintain the thrust-bearings and the ends of the journal in predetermined positions relative to each other.

29. In a photographic shutter, in combination, a pair of axially spaced co-axial rings; a plurality of pivots extending between the rings and supported thereby; a plurality of blades mounted on said pivots; and a pair of spaced plates having co-axial apertures and having recesses around said apertures to removably support said rings.

30. In a photographic shutter, in combination, a pair of axially spaced co-axial rings; a plurality of pivots extending between the rings and supported thereby; ball thrust-bearings mounted in the rings at the ends of the pivots; and a plurality of blades mounted on the pivots to swing about the axes thereof.

31. In a photographic shutter, in combination, a pair of axially spaced co-axial rings; a plurality of pivots extending from ring to ring and supported thereby; blades mounted on the pivots to swing about the axes thereof; and front and rear cover-plates in which said rings are removably mounted.

32. In a photographic shutter, in combination, a pair of front and rear supporting-devices encircling the light aperture; a plurality of pivots around the light aperture; a plurality of blades mounted on the pivots; and spring means adapted to coöperate axially with the pivots to maintain the same in position.

33. In a photographic shutter, in combination, opaque means movable across the path of the light rays, actuating mechanism therefor, and a spring-actuated retarding member in the path of movement of said mechanism and adapted to coöperate with the same to retard the movement, thus affording a means to vary the speed of movement of said opaque means.

34. In a photographic shutter, in combination, opaque means movable across the path of the light rays, actuating mechanism therefor, a pivoted retarding member adapted to be engaged by a part of said driving mechanism to retard the latter after the movement of the said opaque means has begun, and a spring associated with said pivoted member to enable the latter to yieldingly oppose said part.

35. In a photographic shutter, in combination, opaque means movable across the path of the light rays, actuating mechanism therefor, a retarding member adapted to be engaged by a part of said driving mechanism after the movement of the said opaque means has been begun, a spring connected with said retarding member to enable the latter to yieldingly oppose said part, and means varying the tension of said spring.

36. In a photographic shutter, in combination, opaque means movable across the path of the light rays, a lever connected with said means to actuate the same and having a stud, a lever having a cam-lug for coöperation with said stud to retard the actuating lever and said opaque means, a spring connected with the retarding lever, and means for variably tensioning the spring.

37. In a photographic shutter, in combination, opaque means movable across the path of the light rays, means for driving said opaque means, a lever connected with said driving means to actuate the same and having a stud, a bell crank lever having on one arm a cam-lug to be engaged by said stud to rock the bell crank lever, a spring connected with the other arm of the bell crank lever to resist rocking thereof by the stud, and means for variably tensioning the spring.

38. In a photographic shutter, in combination, opaque means movable out of and into the path of the light rays, spring-actuated retarding means to vary the speed of movement of the opaque means and operative only while the said opaque means is out of the path of the light rays, and manually adjustable means to vary the retarding effect of the retarding means.

39. In a photographic shutter in combination, an opaque member pivotally supported with the capability of rotating in opposite directions to make exposures having an initial position in the path of the light rays, and means for shifting the said member in one direction out of its said initial position and into a final position in which substantially the same portion of the member is interposed in the path of the rays.

40. In a photographic shutter, in combination, an opaque member pivotally supported with the capability of rotating in

opposite directions to make exposures having an initial position in which substantially its entire area is in the path of the light rays, and means for shifting said member in one direction to a final position in which substantially the entire area of the member is again interposed in said path.

41. In a photographic shutter, in combination, a pivoted blade capable of rotating in opposite directions to make exposures having an initial position in the path of the light rays, and means for swinging said blade in one direction from said initial position to a different final position in which substantially the same portion of the blade is interposed in the path of the rays.

42. In a photographic shutter, in combination, a plurality of blades mounted on pivots outside of the light aperture and capable of rotating in opposite directions to make exposures, said blades having initial positions in which the major portion of each blade is interposed in the path of the light rays, and means for swinging all the blades in one direction to final positions in which the major portion of each blade is again interposed in said path.

43. In a photographic shutter, in combination, a plurality of blades pivoted outside of the light aperture and capable of rotating in opposite directions to make exposures, each of said blades having an initial position in which substantially its entire area is over a more or less sector shaped part of the aperture, and means for swinging the blades from their initial positions to final positions in which substantially the entire area of each blade is over another but similarly shaped portion of the aperture.

44. A pivoted shutter-blade having an end-edge in the form of a circular arc with its center at the axis of the blade and having side-edges in the form of circular arcs of the same radius of curvature as the said end-edge but directed toward the central radial line of the blade.

45. A pivoted shutter-blade having an end-edge in the form of a circular arc with its center at the axis of the blade and having side-edges in the form of circular arcs of the same radius of curvature as the said end-edge, the blade having also a lateral lip at the juncture of each side-edge with the end-gage.

46. In a photographic shutter, in combination, a plurality of pivoted blades extending into the light aperture and each having a side-edge overlapping the inner end-edge of an adjacent blade, each inner end-edge being a circular arc having its center of curvature at the axis of its blade and each side-edge being a circular arc of the same radius of curvature; and means for swinging the blades on their axes to open and close the light aperture; the axes of the blades and their said side-edges being so arranged relatively to each other that as the blades swing out to open the aperture each inner end-edge and the adjacent side-edge overlapping the same are substantially concentric at the instant of break.

47. In a photographic shutter, in combination, a plurality of pivoted blades extending into the light aperture and each having its inner end-edge in the form of a circular arc with its center at the axis of the blade and having a side-edge of the same form and same radius of curvature overlapping the end-edge of an adjacent blade, and each having a lateral lip at the juncture of its inner end-edge and its said side-edge; and means for swinging all the blades on their axes into and out of the light aperture to open and close the same; the axes of the blades and their said side-edges being so arranged relatively to each other that as the blades swing out to open the light aperture each inner end-edge and the overlapping side-edge are substantially concentric at the instant of break.

In testimony whereof I hereunto affix my signature.

SHERMAN M. FAIRCHILD.