A. FRUWIRTH.

PROCESS OR COPYING CAMERA.

APPLICATION FILED SEPT. 20, 1920.

1,401,902. Patented Dec. 27, 1921.

7 SHEETS—SHEET 1.

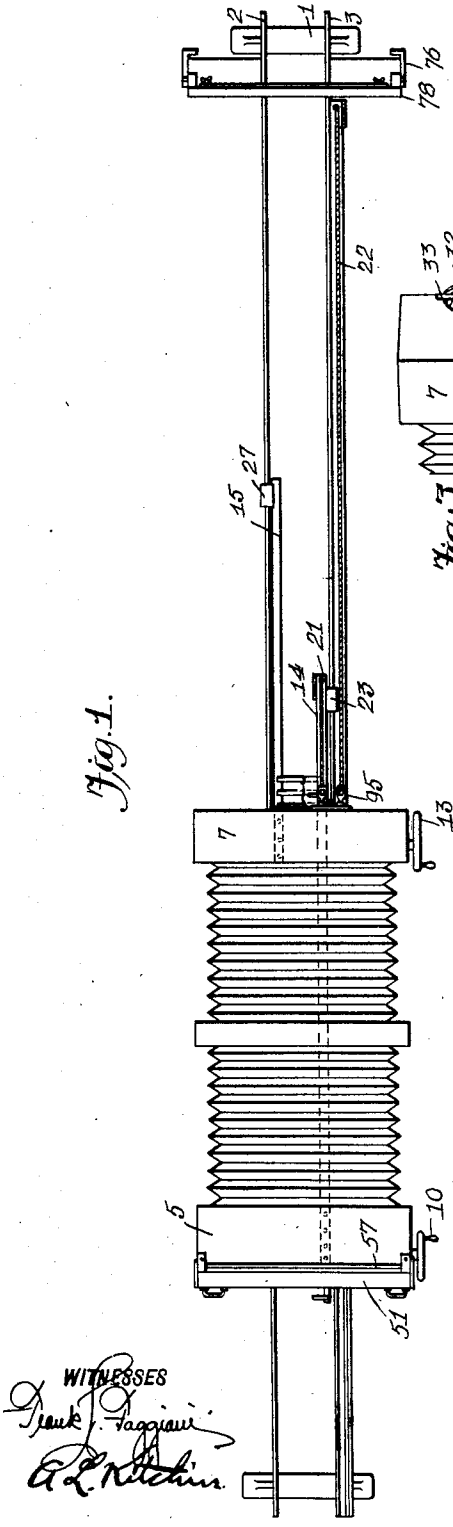

Fig. 1.

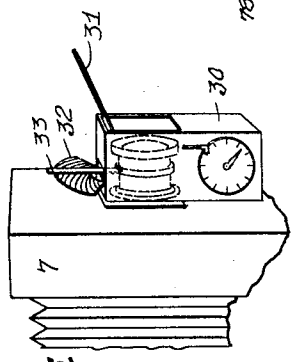

Fig. 3.

Fig. 2.

WITNESSES

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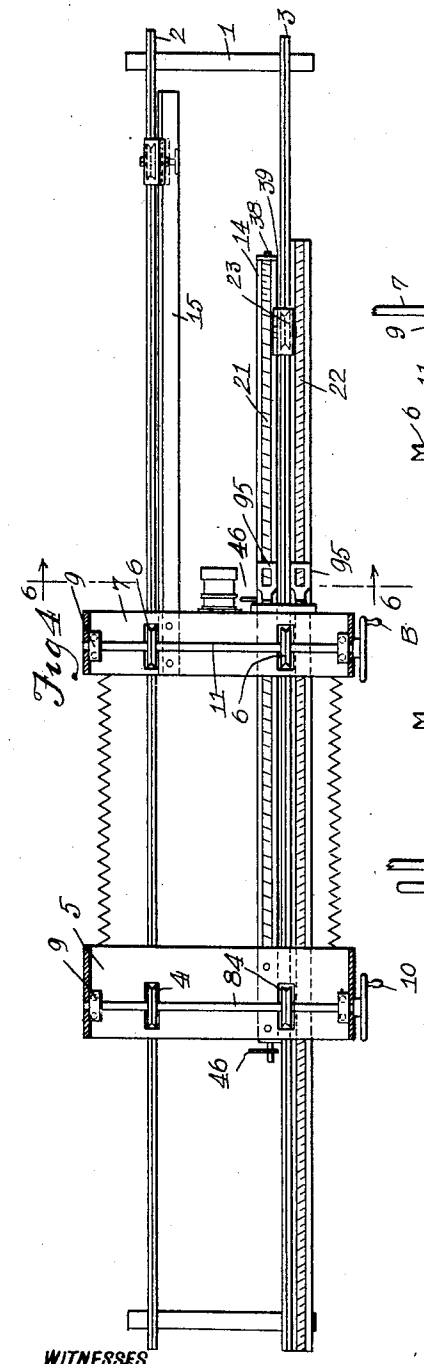

Fig 4

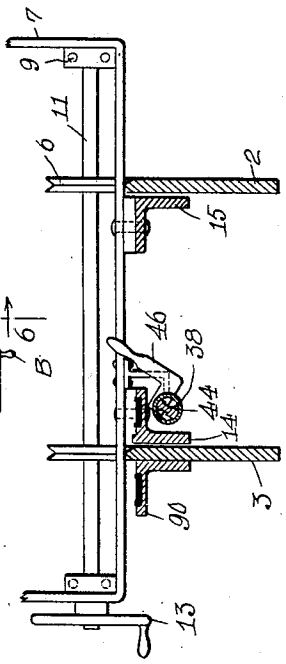

Fig 6

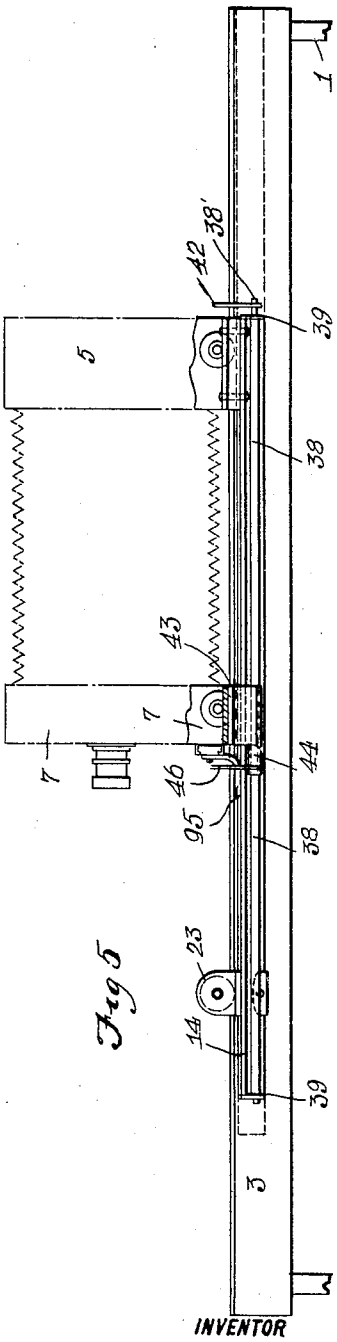

Fig 5

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7 SHEETS—SHEET 3.

Fig. 7.

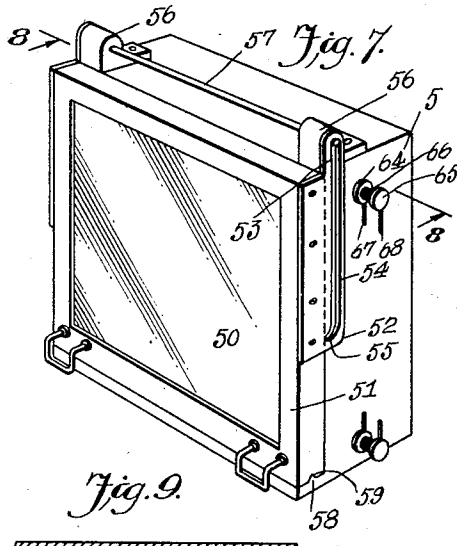


Fig. 8.

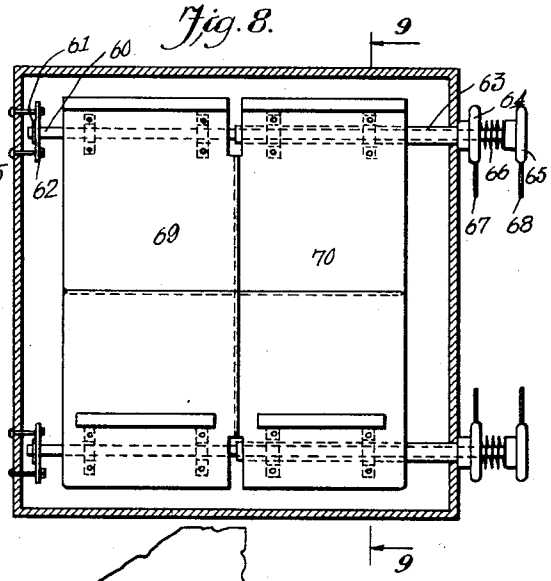


Fig. 9.

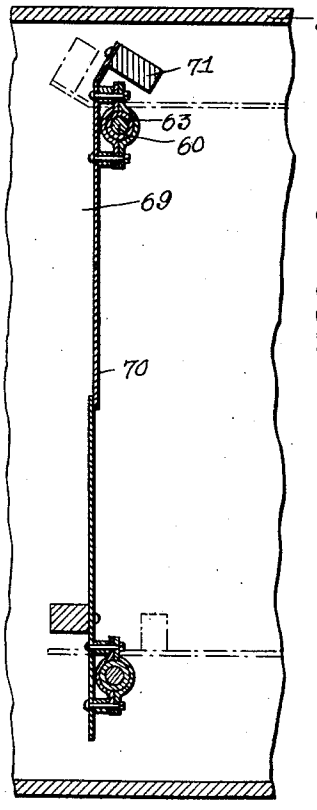
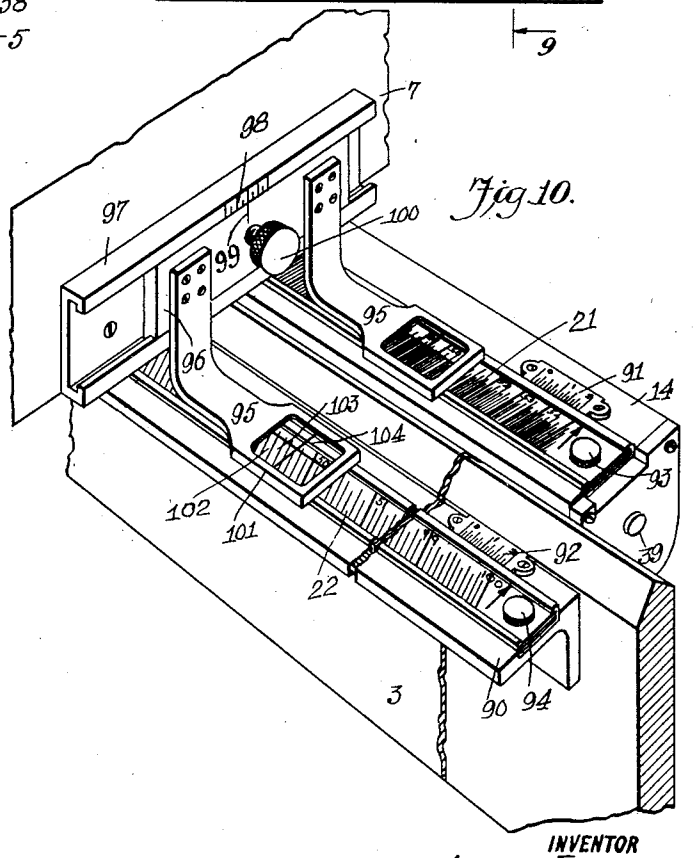


Fig. 10.



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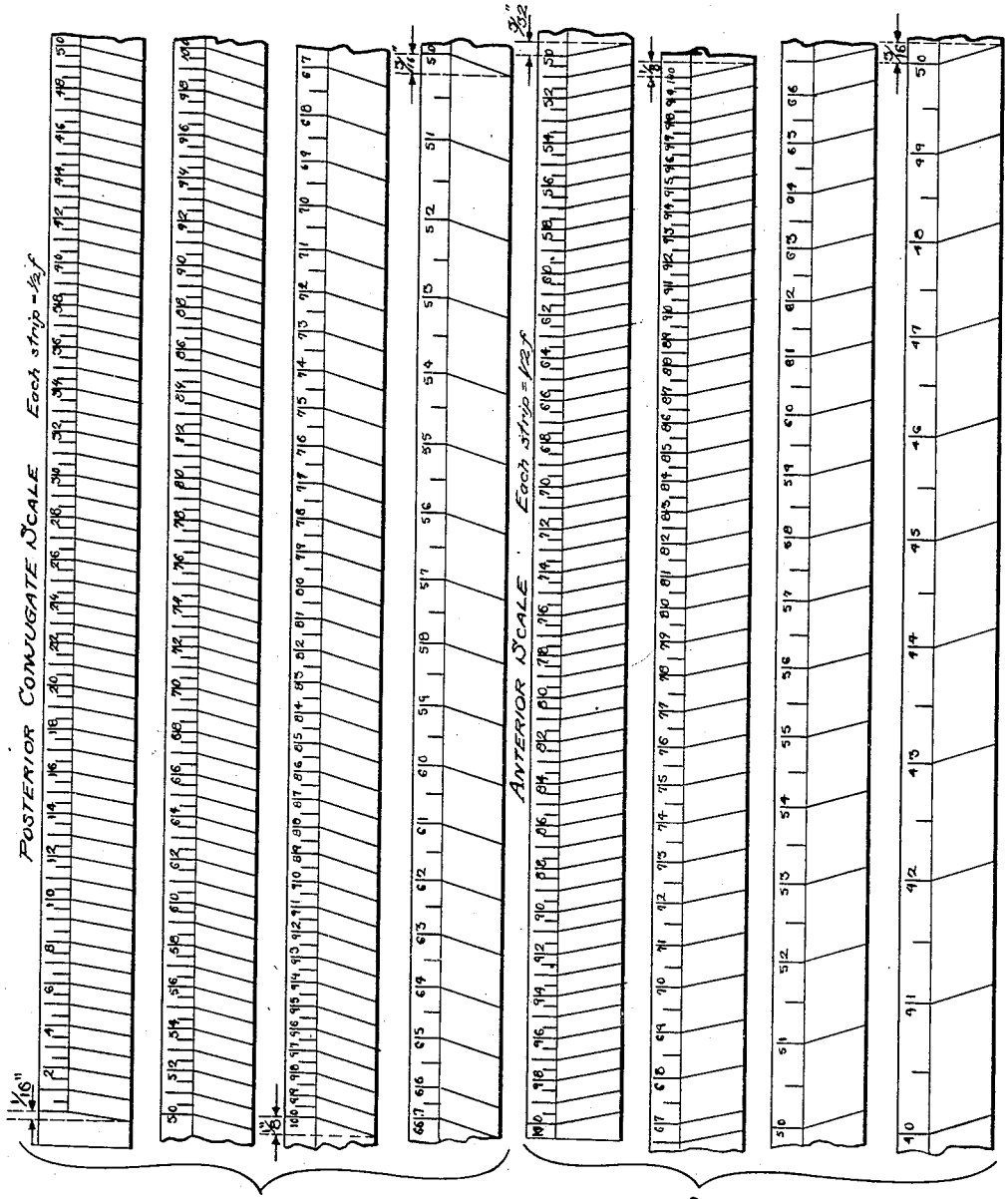

Fig 11

Fig 12

WITNESSES

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7 SHEETS—SHEET 5.

Fig. 16.

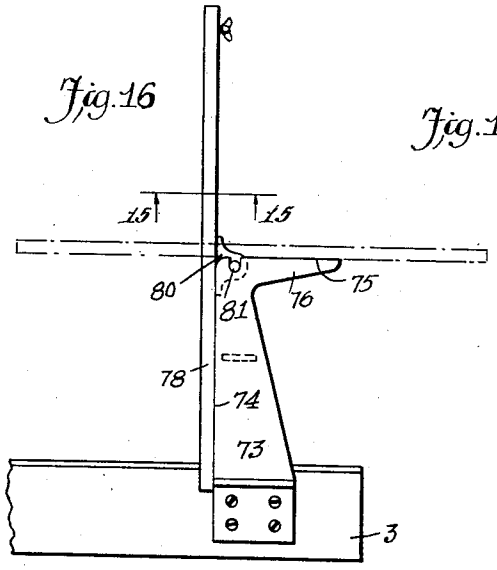


Fig. 13.

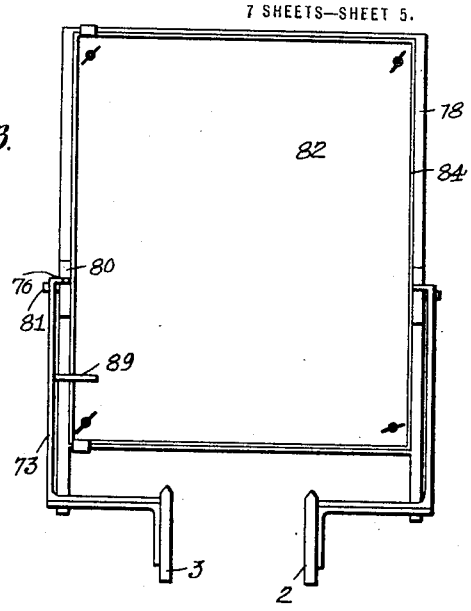


Fig. 14.

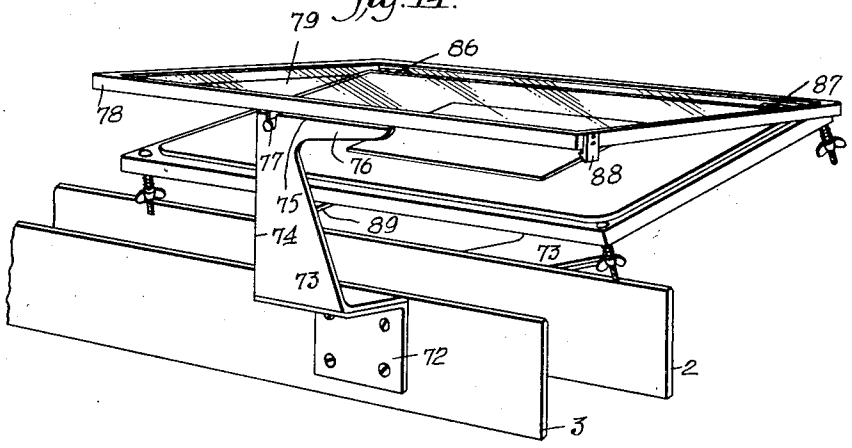
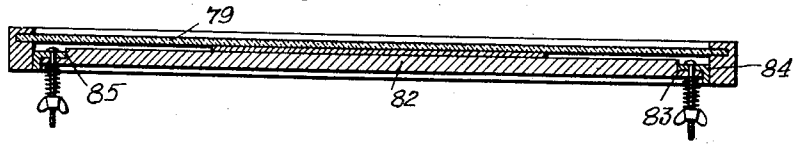


Fig. 15.



WITNESSES

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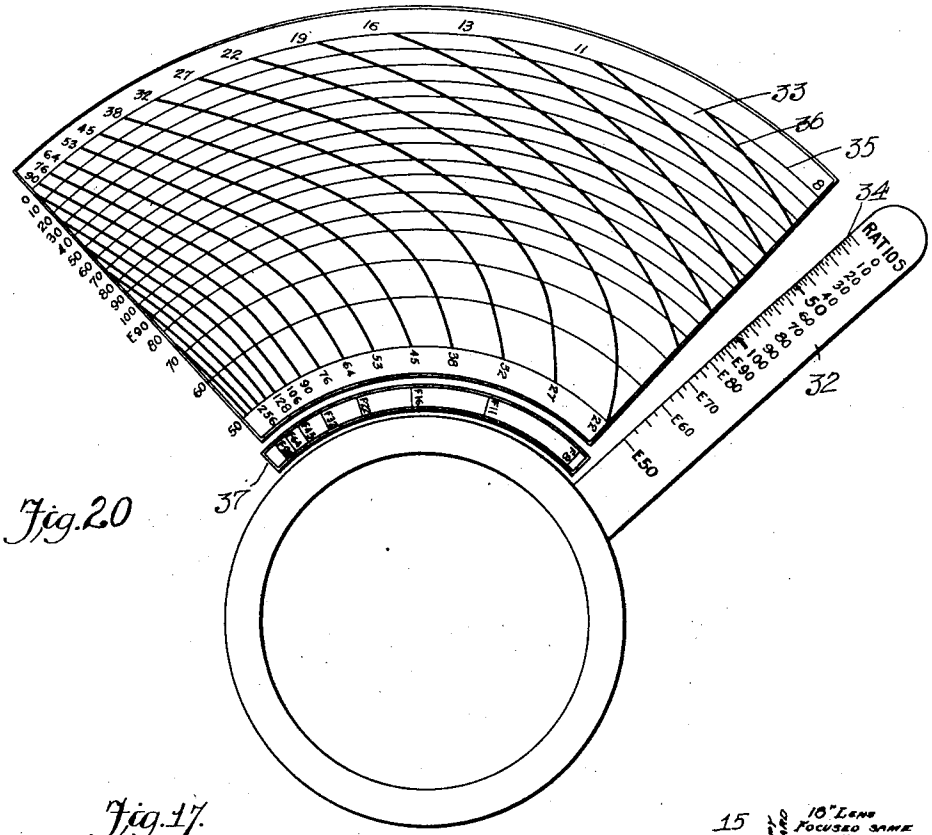


Fig. 20

Fig. 17.

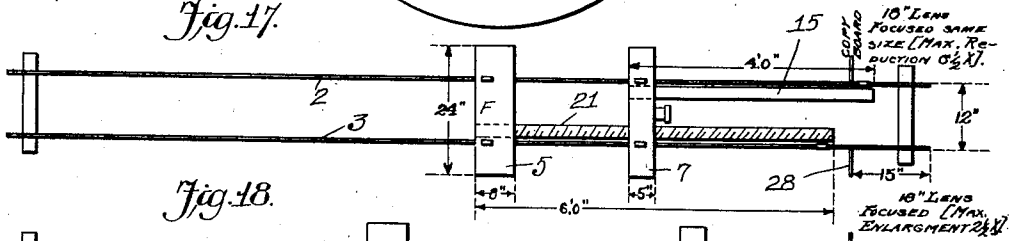


Fig. 18.

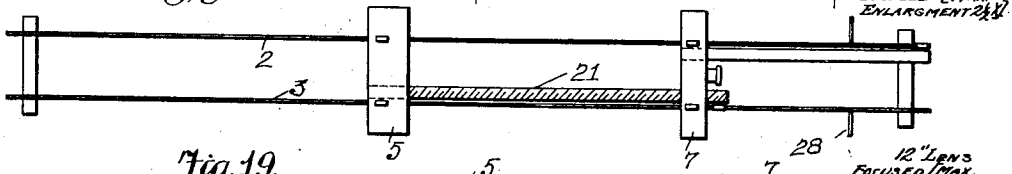
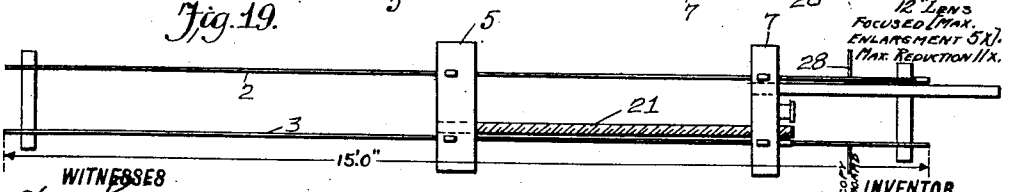


Fig. 19.



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1,401,902.

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7 SHEETS—SHEET 7.

Fig. 22.

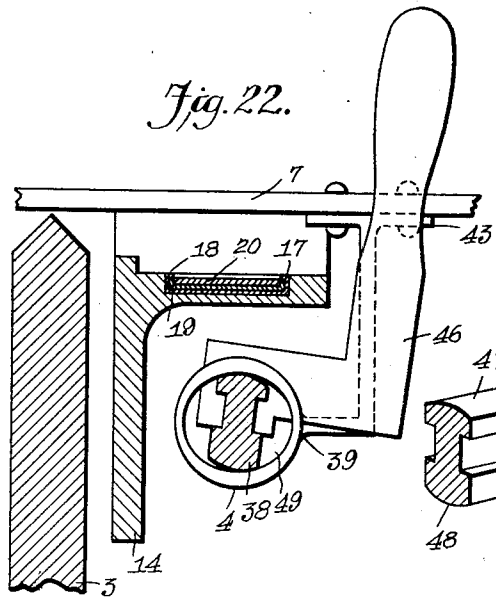


Fig. 21.

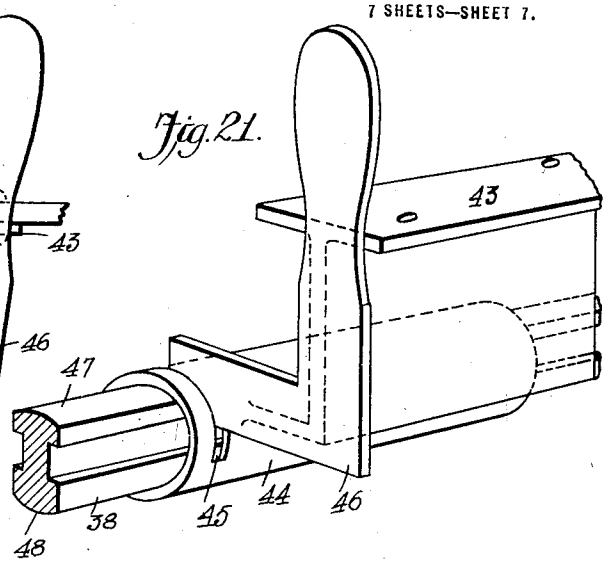


Fig. 23.

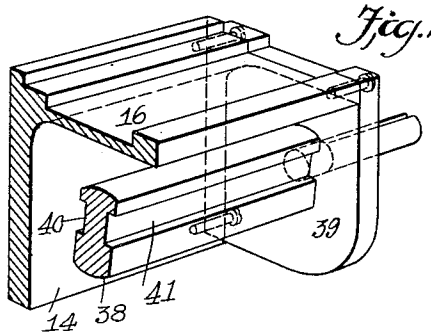
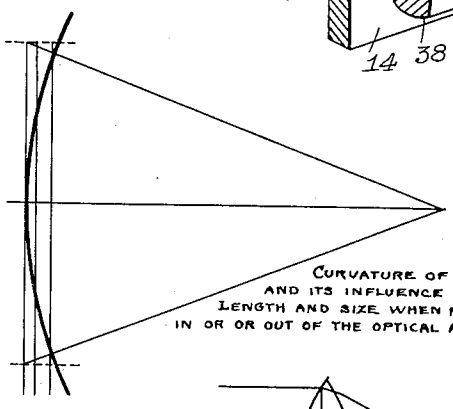
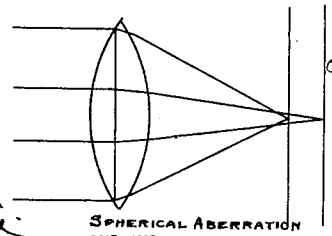


Fig. 25.



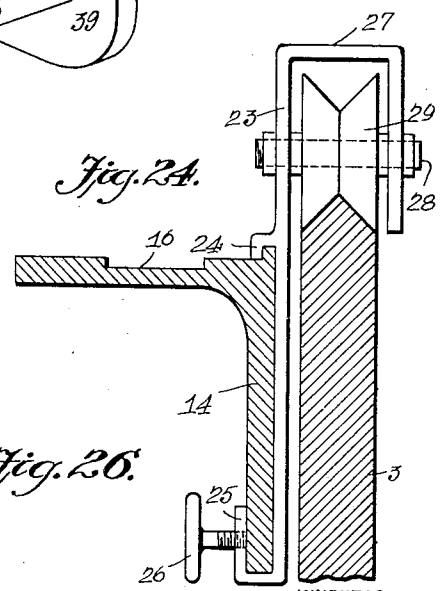
CURVATURE OF FIELD AND ITS INFLUENCE ON FOCAL LENGTH AND SIZE WHEN FOCUSED IN OR OR OUT OF THE OPTICAL AXIS

Fig. 26.



SPHERICAL ABERRATION AND ITS INFLUENCE ON FOCAL LENGTH

Fig. 24.



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UNITED STATES PATENT OFFICE.

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PROCESS OR COPYING CAMERA.

1,401,902. Specification of Letters Patent. Patented Dec. 27, 1921.

Application filed September 20, 1920. Serial No. 411,417.

To all whom it may concern:

Be it known that I, ARTHUR FRUWIRTH, a citizen of the United States, and a resident of the city of New York, borough of Brooklyn, in the county of Kings and State of New York, have invented a new and Improved Process or Copying Camera, of which the following is a full, clear, and exact description.

This invention relates to cameras and particularly what are known as process or copying cameras used for enlarging or reducing purposes.

One of the objects of the invention is to present a complete unit involving a number of attachments whereby a novice may secure excellent results when either reducing or enlarging an object.

Another object is to construct the practical or physical parts of the camera in such a manner that wabbling or loose motion will be eliminated.

Another object of the invention is to provide a camera using a number of scales for substantially automatically securing the proper enlargement and proper focus without the use of technical knowledge or experience.

An additional object is to provide a camera in which are presented front and rear frames formed so as to be easily manipulated and to assume an accurate position without requiring a delicate adjustment and without requiring the services of an experienced operator.

In the accompanying drawings—

Figure 1 is a top plan view of a camera disclosing an embodiment of the invention.

Fig. 2 is a side view of the structure shown in Fig. 1.

Fig. 3 is a detail fragmentary perspective view showing part of the lens frame and associated parts embodying certain features of the invention.

Fig. 4 is a fragmentary top plan view somewhat similar to Fig. 1, but showing the parts on an enlarged scale, and with certain parts broken away.

Fig. 5 is a longitudinal section through the mechanism shown in Fig. 1.

Fig. 6 is a transverse sectional view through Fig. 4 on the line 6—6.

Fig. 7 is a perspective view of the rear or image frame, the same disclosing certain features of the invention.

Fig. 8 is a sectional view through Fig. 7 on the line 8—8, the same being on an enlarged scale.

Fig. 9 is a sectional view through Fig. 8 on the line 9—9, the same being on an enlarged scale.

Fig. 10 is an enlarged fragmentary perspective view showing certain indicating members connected with the lens frame and their relation to the scales.

Fig. 11 is a plan view of part of a scale embodying certain features of the invention.

Fig. 12 is a plan view of a second scale embodying certain features of the invention.

Fig. 13 is a rear view of a copyboard and certain associated parts disclosing certain features of the invention.

Fig. 14 is a perspective view of the copyboard shown in Fig. 13, the same being shown arranged in a horizontal plane and open for receiving the copy.

Fig. 15 is a sectional view through Fig. 16 on the line 15—15, the same being on a slightly enlarged scale.

Fig. 16 is an edge view of the structure shown in Fig. 13.

Fig. 17 is a diagram showing in top plan the camera illustrated in Fig. 1 and how the same may operate.

Fig. 18 is a diagram similar to Fig. 17, but showing the parts in another position.

Fig. 19 is a diagram similar to Fig. 18, but showing the parts adjusted so that one arm will overhang the supporting frame.

Fig. 20 is a plan view of a dial and iris diaphragm operating arm, said dial and arm embodying certain features of the invention.

Fig. 21 is a fragmentary perspective view showing a tubular support, a bar actuating arm, and associated parts embodying certain features of the invention.

Fig. 22 is a sectional view showing the tube and key in Fig. 1 in elevation.

Fig. 23 is a fragmentary perspective view showing one end of an angle bar and adjusting bar embodying certain features of the invention.

Fig. 24 is a fragmentary sectional view showing one of the hangers and supporting

wheels connected to the image frame and lens frame of the camera.

Fig. 25 is a diagram showing the action of rays of light on a curved surface and the indication of the degree of sharpness produced at the different parts of said surface.

Fig. 26 is a diagram indicating how the length of the focus is changed by spherical aberration.

In the production of a process camera it is necessary to have the parts accurately positioned in order to secure good results even when an experienced operator is using the camera. Since automatic scales are in use the accuracy and steadiness of the various parts are doubly essential. Heretofore cameras and their supports were made principally of wood, and by reason of such construction would get out of true on account of temperature, moisture and other reasons which would necessitate a more or less constant readjustment of the scales to get even reasonably good results. To obviate these difficulties cameras have been recently made from metal, including their supports, and a large number of these difficulties have been overcome thereby. However, the metal process camera now in common use slides sidewise similar to the construction shown in my prior Patent No. 971,367. This sliding motion will sooner or later wear the sliding metal parts and introduce a wabble. Means have been provided for taking up this wabble or slack, but when this slack has been taken up the various parts of the camera are out of their original alinement, and consequently the scales when used are out of registry with the camera. Another disadvantage in cameras heretofore used is that the bases of image and lens frames are comparatively narrow, as for instance from four to seven inches for a height of frame from twenty-four to thirty inches. This width of base naturally multiplies or aggravates any slight wabble or inaccuracy of any of the parts, and such inaccuracy when depending upon the scales is again exaggerated so that the scales will not produce the results desired. Where this condition is present the scales must be readjusted or the focus must be secured in the old way, namely, by a physical examination and physical focusing. This is especially true as one of the scales must be stationary and the other movable. To secure this arrangement the scales are arranged adjacent the upper part of the base which is an appreciable distance from the optical axis of the lens of the camera. It will, of course, be understood that the focal distances are measured in the optical axis of the lens but indicated on the scales which are a considerable distance below the lens, and this fact will cause any slight inaccuracy produced by wabbling, warping or bending of the base or other parts to disturb the parallelism of image-, lens- or copyplane. When this parallelism of these three is destroyed the scales will become almost useless as they produce inaccurate results.

Heretofore not only have the objectionable conditions above pointed out with respect to the camera body itself produced trouble in securing accurate results, but the crude way in which the copyboard or copyplane has been constructed. Heretofore the copyboard or plane consisted usually of a plain wooden board positioned in close proximity to the hot arc lamps which has a tendency to produce twisting. The copy must be secured to this board by tacks or some other crude way, and where the copy is of appreciable thickness, as for instance a book, the image to be copied will be an appreciable distance toward the lens and consequently will throw the scale out of alinement or else the scale must be adjusted to compensate for this difference in thickness.

The fact that modern cameras are provided with a movable lens frame (for instance actuated by a coarse pitch screw) makes mounting of the posterior scale particularly awkward, as the position of the scale as a whole in regard to the lens must be altered. It becomes necessary, therefore, to connect the scale rigidly with the lens frame and move both as a unit which does not benefit the focus.

The various weaknesses and the various faulty constructions above mentioned necessitate the complete reconstruction of the camera if substantially accurate results are to be secured at all times by a person not expert in the line of process cameras, and also must be reconstructed on different lines if accurate results are to be secured quickly. In the accompanying drawings a complete construction is presented including a number of attachments which are essential to the complete camera and without these various features which coact together to produce accurate results the camera would be inefficient.

Referring to the accompanying drawings by numerals, 1 indicates various supporting members of any desired kind which form an under frame work on which the base or tracks 2 and 3 are mounted. These tracks are preferably V-shaped on the upper surface, as indicated in Fig. 6, and accommodate two wheels 4 on the rear or image frame 5 and two wheels 6 on the front or lens frame 7. Wheels 4 are rigidly secured to a shaft 8 and extend through suitable ball-bearings 9 carried by the frame 5, one end of the shaft 8 extending through the frame 5 so that the operating wheel 10 may be rigidly secured thereto and moved by the operator whenever desired. The wheels 6 are rigidly secured to shaft 11, which shaft

is supported in the front frame 7 by suitable ball bearings 12, one end of shaft 11 extending through the frame 7 so that the wheel 13 may be rigidly secured thereto. This arrangement provides a proper and strong support for what may be termed the camera body which includes frames 5 and 7, the connecting bellows and associated parts. Though the parts are thus strongly supported the mounting of the shafts 8 and 11 prevents any appreciable wear while either frame may be adjusted independently. This arrangement provides, however, only one set of supports for each frame and in order to prevent the forward and rearward tilting the rear or image frame 5 has an arm 14 rigidly secured thereto, while the front frame 7 has an arm 15 rigidly secured thereto, said arms being L-shaped in cross section, as shown in Fig. 6, and arranged so that the upper surfaces will be slightly below the upper surface of the tracks 2 and 3. The arm 14 is provided with a groove 16 (Figs. 22 and 23) in which a casing 17 fits having an overhanging flange 18 on each edge so as to hold in place the strip 19, which strip carries a plate 20 on which are arranged graduations 21. This plate 20 with the graduations form what is known as the posterior scale which coacts with the anterior scale 22 hereinafter fully described. It will thus be seen that the scale 21 moves with the rear or image frame 5. Arranged along or at any convenient point on the arm 14 is a hanger 23 (Fig. 24). This hanger is provided with hook sections 24 and 25, section 25 carrying a set screw 26 which is readily operated by fingers so to lock the hanger 23 at any point along the arm 14. At the upper part the hanger 23 is bent over forming a hood structure 27 which accommodates the shaft 28 on which the grooved roller 29 is mounted, said roller fitting accurately the V-shaped upper edge of track 3. Ordinarily the hanger 23 is clamped to the arm 14 near the front end of the arm which is quite a distance away from the shaft 8 mounted in frame 5. In the accompanying drawing the particular camera illustrated indicates that the arm 14 is six feet long (Fig. 17) though it will be evident that this arm could be longer or shorter without departing from the spirit of the invention. In any event the arm is comparatively long and forms the third support for the frame 5, the first two supports being wheels 4. It will also be noted from Fig. 17 that the tracks 2 and 3 are twelve inches apart, though this is not absolute, it is desirable. This wide bearing surface and the length of the arm 14 acts to hold the image frame 5 in perfect position in respect to the remaining parts of the camera. The arm 15 rigidly secured to the front or lens frame 7 is usually not as long as arm 14 though it could be longer or shorter as desired. Said arm in Fig. 17 is shown as four feet long and provided with a hanger identical with hanger 23 so that it may be adjusted back and forth over arm 15 whenever desired. This adjustment is desirable as indicated in Fig. 19, hereinafter fully described.

The lens frame 7 may be of any usual or preferred construction and provided with a lens of any suitable kind associated with the usual iris diaphragm now in common use. However, in order to secure a unitary result a special arrangement is provided in connection with the lens as indicated in Figs. 3 and 20. As indicated in Fig. 3 an interval timer 30 is mounted on the lens casing, said timer being an old and well known structure and provided with a shutter 31 which at the right time drops into a closed position and thereby covers the lens. This timer is provided with a clockwork which may be set to secure the dropping of the shutter 31 whenever desired. Though this timer is old and well known it is desirable on process cameras in order to allow the operator to permit the proper length of exposure and at the same time use this idle time in finishing negatives, or in some other work. Associated with the timer 30 is a chart 33 and an arm 32 shown more particularly in Fig. 20. The arm 32 is connected to the usual iris diaphragm provided in the camera and as the arm swings the diaphragm opens and closes for producing the desired light opening. As is well known this light opening must be varied to secure the best results under varying conditions of light, the condition of the matter to be photographed, and other circumstances. Heretofore the diaphragm has been set by the operator merely from his experience in the work so that a novice would probably secure very erratic results. In order to present means which will allow a novice or a comparative novice to secure as good results as an expert operator the chart 33 is provided and associated with the arm 32. The arm 32 is provided with a number of graduations 34, while the chart 33 is provided with spaced arc shaped lines 35 and curved lines 36 intersecting the lines 35. Suitable numbers indicating certain values are arranged at one end of the lines 35, while numbers are arranged adjacent each end of the curved line 36, also indicating certain values. Arranged below the chart 33 is the regular shop notation 37 as provided on every lens, fitted with an iris diaphragm.

As indicated the lever or arm 32 is attached to the turning ring of the iris diaphragm of the lens, said attachment being so arranged that the left edge of the arm is in line with the indicating mark or notch of the iris diaphragm. The arm also is

designed to carry a series of graduations 34 representing the main ratios of a focusing scale. The position of the dial or chart 33 with regard to the notation of the F values on the lens is such that, if for instance the lever or arm 34 indicates a diaphragm opening of F/16 then beginning of curve 16 (on the outer circle) is in line with the left indicating edge of the lever. The notations on the outer circle are simply a repetition of the regular diaphragm notations on the lens. When the arm 34 is turned to the right until its left edge meets the intersection of curve 16 and line 35 marked 10, then the actual F value of the diaphragm for a 10% reduction is reëstablished, that is, it is the $\frac{1}{16}$ part of the conjugate focal length. If the lever is then turned to the next intersection of line 36, numbered 16, and line 35, numbered 20, then the actual value of the diaphragm for a 20% reduction is again reëstablished, and so on all along the curved line 36 marked 16 on the chart 33. The exposure time in each case remains the same. If one minute was correct at ratio 10 it is equally correct at ratio 100.

The same holds true with the other curves or lines 36 as with the line 36, marked 16. In half-tone work a diaphragm opening of approximately $\frac{1}{64}$ part of a conjugate distance has been found satisfactory for the main exposure on the copy, this being supplemented by one or two short exposures through larger diaphragms. If these openings are adopted as standard for the bulk of the work and the respective exposures through the two or three diaphragms established by practical tests, then the making of half-tone negatives is reduced to a very simple scientific basis, to the exclusion of cross errors in timing and choosing the correct diaphragms (or diaphragm openings).

In Figs. 4, 5 and 6 and Figs. 21, 22 and 23 will be seen an arrangement which permits the operator to readily lock the frames 5 and 7 together or disengage the arms so that they may be adjusted independently. When the frames are locked together the rotation of either of the wheels 10 and 13 will propel the complete camera body along the tracks 2 and 3, whereas when these frames are unlocked or free the respective wheels 10 and 13 will merely shift the frame to which it is connected. This connecting or locking means consists of a bar 38 having a reduced portion at each end fitting into the respective end blocks 39 rigidly secured to the arm 14 whereby the bar is freely rotatable. Preferably this bar is provided with longitudinal grooves 40 and 41 which extend for the full length of the bars between the respective blocks 39. The extension 38′ of bar 38 at the rear of the rear frame 5 is provided with a key handle 42 whereby the bar may be rotated manually whenever desired. The front frame 7 has a bracket 44 rigidly secured thereto by rivets or other means, said bracket carrying a tubular member 44 which may be formed integral therewith or rigidly secured thereto in any desired manner. The tubular member 44 is provided with a slot 45 adjacent one end for receiving the end of key 46, which key is provided with end loosely fitting the bar 38 with lugs extending into the grooves 40 and 41 (Fig. 23) whereby the bar may freely slide through the tube 44 and through the key 46, though the key 46 may at any time turn the bar. The bar 38 is provided with arc shaped surfaces 47 and 48 which are preferably part of the same circle and adapted to engage to press against the tube 44 so as to lock the tube 44 and parts connected therewith rigidly to the bar 38 when the key has been raised or turned to the position shown in Fig. 21. This is carried out by reason of the fact that the bore 49 in tube 44 is elliptical and the surfaces 47 and 48 are positioned around the major axis of the elliptical opening or bore 49 when the key 46 is moved downwardly and is engaging the tube 44 adjacent the minor axis of the bore 49 when the key has been elevated or moved to a locked position. The bar 38 is freely rotatable in the end blocks 39, but the elliptical formation of the bore 49 prevents a free rotation and causes the sleeve 44 and the bar 38 to be locked rigidly together when moved to a certain position whereby the front and rear frames are locked together and moved as a unit. As the bar 38 is carried by arm 14 and the tubular member or sleeve 44 is carried by the front frame 7, the front and rear frames are movable independently when either the key 44 or the key 46 is in its lowermost position, but are locked together when either of the keys has been raised to an upper or locked position. The key 46 has been made substantially L-shaped so as to provide an overbalancing weight for holding the bar 38 in an unlocked position when the bottom part of the key is engaging one end of the slot 45. Friction against the respective parts will cause the sleeve and the bar to remain locked when moved to such a position.

In Figs. 7, 8 and 9 will be seen a new construction of shutters and a new arrangement of ground glass holder. The ground glass plate 50 is mounted in any suitable manner in a frame 51 which may be metal or other material, and which is provided with side plates 52 each of which has an upwardly extending section 53 projecting above the body of the frame 5 and a groove 54 extending longitudinally of the plate 52 into the extension 53 and provided with a curved end 55 opposite the extension 53. The frame 5 is provided with brackets 56 which carry a shaft or journal pin 57 projecting into the slots 54 in their respective plates 52 so that

when desired to dispense with the ground glass 54 the frame 51 is moved upwardly and then turned to a horizontal position and moved forwardly until the pin 57 is fitting in the end of the curved portion 55 of slot 54. This results in the frame 51 and the ground glass 50 being located on top of the frame 5 out of the way and the arrangement of the curved section 55 prevents accidental rear shifting of the frame. After the ground glass frame has been thus moved out of the way the plate frame may be substituted and the exposure made in the usual manner. Preferably a raised portion of the pin 58 is provided at the lower part of frame 5 and extends into a notch 59 in the frame 51 so as to center the frame when in use.

In Figs. 8 and 9 a form of shutter is provided which divides the negative into four sections and presents means whereby a picture may be taken on any one of the four sections or any number of the four sections. Arranged at the upper part of the frame 5 is a rod 60 which if desired may be hollow for the purpose of lightness, said rod carrying a pin 61 at the point where it projects through the supporting journal plate 62 so as to prevent any shifting movement of the rod 60 in one direction. Telescoped on top of this rod is a tube 63 extending approximately half way across the frame 5, said tube having a hand member 64 rigidly secured thereby while the rod has a handle 65 rigidly secured thereto. A spring 66 is interposed between the hand members 64 and 65 and consequently prevents normally any longitudinal movement of any of these members. Indicating pins 67 and 68 are connected to each of these hand members, said pins being parallel with the plates 69 and 70 rigidly clamped to the rod 60 and tube 63 respectively. When either of the hand members have been turned through an arc of about 90 degrees the respective shutters or plates 69 and 70 will be turned to the same extent and said turning movement will be indicated by the pointers 67 and 68. It will be observed that the plates or shutters overlap to a small extent so that in case it should be desired to swing plate 69, for instance, hand member 65 will be depressed slightly against the action of spring 66. This would move the plate 69 in a direction longitudinally of shaft 60 until the plate 69 has cleared the plate or shutter 70, whereupon the hand member 65 may be turned for moving the plate 69 to the dotted position shown in Fig. 9. A weight 71 is arranged on the shutter 69 and on one side thereof and in such a manner as to overbalance the shutter 69 either when in a vertical position or a horizontal position. If desired stops could be provided for allowing the hand members 64 and 65 to rotate only in one direction, though ordinarily this is not necessary. When it is desired to move the plate 70 alone the hand member 64 could be turned or could be first pulled in a direction to compress spring 66 and then turned according to whether the plate 70 overlaps the other plates or is positioned in front of the same. A set of plates and operating mechanism is arranged at the bottom of frame 5 similar to those just described at the top and will therefore need no additional description. This construction and arrangement permits any quarter of the negative to be exposed, any half, any three-quarters, or the entire negative.

In Figs. 1, 2, 15 and 16 will be seen a new form of copyboard or copyplane coacting with scales 21 and 22 for securing accurate results automatically, quickly, and easily. In the formation of copyboards it is desirable to provide a construction wherein a picture or article to be copied shall always be in the same plane regardless of the thickness of the article and in that way be at the proper distance from the camera body to secure a perfect focus when the camera body has been set properly with respect to the scales. In carrying out this idea the copyboard is formed with a pair of brackets 72 rigidly secured to the tracks 2 and 3 and in turn having auxiliary brackets 73 rigidly secured thereto, each of said auxiliary brackets having a vertical edge 74, a horizontal edge 75, part of which is on the extension 76, and a comparatively deep notch 77 offset a short distance from edge 74. A frame 78 preferably of metal is provided and carries plate-glass 79 which is held in place in any desired manner, as for instance, by groove construction as shown in Fig. 15. A pair of journal brackets 80 are secured to the frame 78, each bracket carrying a pin 81 adapted to fit in the respective notches 77, these journal brackets being offset sligthly from the center toward the bottom edge of frame 79 when the frame is in a vertical position as illustrated in Fig. 16. This position and the offsetting of the pin 81 from the edge 74 causes the frame 79 to remain in a vertical position. The part resting against edge 74 when manually moved to that position will remain in a substantially horizontal position against the edge 75 when manually moved to that position. The rear face of the plate glass 79 is always in the same position in regard to the scales and consequently, when a thin piece of paper is placed against the rear face or when a thick book is placed against the rear face the picture on the paper or book is always in correct position to be scale focused without readjusting the scales for any altered picture plane. In order to hold a thin article or a thick article against the rear face of the glass 79 a supporting board 82 is provided which may be of metal,

wood, or other material, preferably wood for the sake of lightness, said board 82 being provided with an annular notch 83 in which a wood frame 84 is fitted. Preferably the frame 84 is substantially L-shaped in cross section as indicated in Fig. 15. In forming the board 82 the center part is raised as shown in Fig. 15 so as to be flush with or project beyond the frame 84, and thereby act to hold the copy in proper position against the glass 79. Also the board 84 is preferably covered with a felt covering 85 which acts to prevent any sliding or shifting of the copy when the parts are moved to the position shown in Fig. 14. The frame 84 is hinged at 87 to the frame 78 and at the opposite side is held by suitable catches 88 which catches may be manually operated so as to disengage the same and allow the frame 84 and board 82 to swing downwardly from the frame 78 when said frame 78 is in its horizontal position. When the frame 84 swings down to an open slanting position it rests against the stop or ledge 89 projecting from one of the auxiliary brackets 73, said slanting angle being such as to give the maximum clearance between the frame 84 and glass 78, while at the same time not sufficient to let the copy slide down under the action of gravity. This sliding action is also resisted or counteracted by the nature of the felt covering 85. In Fig. 15 the spring board 82 is shown as solid, but where it is desirable to use the device for copying lantern slides or for making positives from negatives, or for other purposes the middle section of the spring board is cut out and filled with a nest of adapters to hold the various standard sizes of plates. When not in use the adapters are removed and the opening closed by an exact fitting block of felt covered wood. Of course it is evident that if desired an extra spring board for exclusive use in transmitted light is provided and exchanged whenever desired with the regular copyboard illustrated in Fig. 15.

In Figs. 4 and 10 particularly will be seen an arrangement of scales which for the purpose of description are called posterior and anterior scales, the scale 21 being the posterior scale and the scale 22 being the anterior scale. The anterior scale 22 is arranged on a shelf 90 extending alongside of the track 3 and either rigidly secured thereto or formed integral therewith. This shelf and arm 14 are both grooved for receiving the respective members 19 and 20 which carry the scale strips 21 and 22. It will be noted also that the scale 22 has the lines inclined in one direction, while scale 21 has the lines inclined in another direction. Each of these scales is provided with an arrow adjacent its outer end as shown in Fig. 10 which reacts with the respective rulers 91 and 92 so that the scales may be adjusted whenever necessary, and when adjusted are locked in position by the set screws 93 and 94. Each of the scales 21 and 22 is provided with an indicator 95 which is rigidly fastened to a bar 96 slidably mounted in a grooved member 97 which grooved member is rigidly secured to the front frame 7. A number of graduations 98 are provided on the member 97 and a single indicating line 99 is provided on bar 96 so that the proper adjustment of the bar 96 and the indicators 95 may be secured and when secured the parts are locked against accidental shifting by the set screw 100. Each of the indicators is provided with enlargements at the outer end having an opening whereby there is formed a frame 101 for each indicator and in which frame is provided a transparent member 102 having lines 103 and 104 formed thereon at right angles to each other, the line 103 being arranged longitudinally of the scales. The transparent member 102 is of the same width as the respective scales so that the relative position of the lines 103 and 104 with respect to the scales may be seen at any time. When correctly attached the two indicating windows or frames 101 will be held above their respective scales 21 and 22 and almost in touch therewith, while the centers of each window (intersections of horizontal and vertical lines) correspond with the center lines of each scale. By shifting the crossbar or plate 96 to the right or left the indicating courses are also shifted and the amount of lateral shift for both scales must be absolutely uniform to secure the desired result.

The scales 21 and 22 are graduated in accordance with the focal distance of the lens which is used on the camera, the scale 22 indicating the position of the lens relative to the copyboard or image to be photographed in making a picture of any prescribed size within certain limits, and the scale 21 being graduated to indicate the position of the camera ground glass 50 in focusing the camera for the several positions of the lens, the graduations on the two scales indicating the proper position of the lens and ground glass respectively to take a full sized picture, the image being preferably designated 100 and the graduations for each scale on the 100 mark extending to zero toward the copyboard and at a suitable distance within the focal limits of a camera to the opposite side of the 100 mark. After the scales are applied to the camera and it is desired to set the camera to take a picture of a print or other configuration on the copyboard of any relative size the camera body is moved along the tracks 2 and 3 until the indicator 95 over the scale 22 is in registry with the proper graduation on said scale 22. This places the lens at the required distance from the image. The frame 5 is then adjusted until the scale

21 shows the same number through the indicator window on the indicator 95 as is shown through the window from scale 22. The camera therefore is always in focus when identical ratio numbers on both scales are opposite and on a line with each other (disregarding the slant of the graduation lines) and it is through this fact that the operator can in a moment's time verify his camera position.

Referring to Figs. 11 and 12 a part of a posterior scale will be seen and also an anterior scale will be seen, namely, the scales 21 and 22 as illustrated in Fig. 10. In Figs. 25 and 26 diagrams are shown illustrating certain actions of light rays which illustrate the reason why certain of the lines on the scales 11 and 12 are arranged at an angle. Briefly stated this angle is provided to take care of the difference in the focus produced by different sized openings of the diaphragm and to cause the usual fuzzy edges to be eliminated to as large an extent as possible.

Every lens is more or less a compromise in which some superior quality in one direction has been sacrificed and others emphasized in order to make the lens best adapted for the work intended. The remnants or traces of aberrations, more or less conspicuous, are inherent in all lenses. In process work, where almost to the exclusion of everything else, two dimensional objects are dealt with, the qualities of the lens with regard to rectilinear drawing, flatness of field, color correction, and critical definition over a large field, are severely tested while high power is immaterial. Without going into the theory of spherical aberration, lenses afflicted with it cause the axial rays to focus in a different plane from the marginal rays (see Fig. 26). From this it will be seen that the lens gives one focus with a large diaphragm opening and another focus with a small diaphragm opening. The size of the image is also affected. If focused to a definite size at a full opening, then stepped down and re-focused, the size will be larger or smaller according to whether the lens is over or under corrected, and in order to bring the image on the ground glass back to the right size, the position of the lens must be changed. The problem deepens when we proceed from aberrations on the axis to those of oblique rays, principally astigmatism and curvature of field. Both are closely related and produce the phenomenon that rays of light coming from a plane surface are not united in a plane surface again, such as the ground glass represents but in a saucer shaped surface. If focused in the optical axis, the corners are fuzzy and vice versa. This is illustrated in a rough way in Fig. 25.

A focusing scale based on the focus of the axial rays will be longer, have its critical definition in the center and will blur the edges of large sized negatives. Contrary, a scale based on the focus for oblique rays, will be shorter, cover a larger area, but want in critical definition, while the image sizes in both cases remain correct. Even in cases where high priced anastigmats are used large negatives could not be made with the scales without impairing corner definitions, though sizes and central definitions of negatives, were critical. From the above it will be clear that the whole question of focusing scales is closely involved in problems of lens construction even to the extent that it may be correctly stated: the better the lens, the better the scale.

It is obvious to assume that if one scale cannot combine all conditions for correct focusing, two scales will be better or a combination of two scales into one, or a combination of three scales, only simplicity of the original scale is lost. Under the present invention the solution arrived at has been the completion of a scale with slanting lines as indicated in Figs. 10, 11 and 12. These scales represent a combination of a number of scales with the aid of simple adjustable indicators so as to adapt itself to the greater or lesser state of correction of the lens.

Allowing for a maximum difference of $\frac{1}{16}''$ in focal length of an 18″ lens and proportionately more or less for a longer or shorter foci, the displacement of the graduation lines from the normal at natural size for the anterior scale will be twice $\frac{1}{16}''$, at half size three times $\frac{1}{16}''$, and so on $\frac{1}{16}''$ more for every amplification until at seven times reduction the displacement becomes $\frac{1}{2}''$. For the posterior reducing scale the displacement at natural size amounts likewise to $\frac{1}{8}''$ and becomes less until at zero it is $\frac{1}{16}''$.

In Figs. 11 and 12 the slope of the graduation lines away from the normal is indicated for every full per cent. of reduction. With these two scales arranged as shown in Fig. 10 it becomes necessary to register the camera position, not on a whole graduation line, but on a point of it formed by the intersection of the perpendicular indicating line 104 with a slanting graduation line. The image will not be altered at whatever height along one graduation line we register the camera by shifting line 103 upon the movement of the bar or plate 96 as long as the same height is used on both the anterior scale 22 and the posterior scale 21. This shifting will not change the size, but will alter the definition. From this it will be evident that the functions of the indicators 95 are two-fold, namely, to register over the whole length of the scale and at the same time along the height of one line which later requires a movement of the plate 96.

If in consequence of accident or if due to corrosion of the glass surfaces, it is necessary to repair or polish the lens then it is almost

a foregone conclusion that the scales have become useless when used as found in the cameras now on the market. Polishing a lens means altering its focal length and consequently the preparing of a new scale to agree with the focal length. According to the present arrangement of slanting lines and other features of the scale shown in Fig. 10 and the arrangement of the bar 96 and indicators 95, preparing an entirely new scale is unnecessary as the adjustment of the indicators 95 will bring the scale again in harmony with the lens.

I claim:

1. A process camera comprising a plurality of tracks, a camera body provided with a front frame and a rear frame, supporting wheels mounted on said camera body engaging said tracks, means controllable at the will of the operator for independently moving the front and rear frames of said camera body, means for locking said frames together so that they will move in unison, and a copy holder connected with said tracks and provided with means for holding a copy always in the same position relative to the track regardless of the thickness of the copy.

2. A process camera comprising a camera body, a track therefor, said camera body being formed with rear and front frames, each of said frames carrying a shaft and a traction wheel for each of said tracks, a ball bearing member for supporting said shafts on the respective frames, a balancing arm connected to each of said frames, a traction wheel arranged on each of said arms at an appreciable distance from the traction wheels on the respective shafts, manually actuated means for rotating said shafts for independently shifting said frames, means for locking said frames together so that they will move as a unit, means presenting a copyboard adjacent the end of said track, and a system of scales and indicators coacting with said copyboard and the camera body for focusing the camera body and producing a correct size reproduction.

3. A process camera comprising a track structure, a camera body mounted to move over said track structure, a copyboard arranged adjacent one end of said track structure, a chart carried by said camera body adjacent the lens formed with lines indicating proper diaphragm openings, and an arm connected to the iris diaphragm of the camera formed with ratio graduations coacting with the lines on the chart whereby the correct opening may be secured moving the arm to the desired point on said chart.

4. A process camera comprising a track structure, a copyboard arranged adjacent the track structure, a stationary scale positioned adjacent said track structure, a camera body mounted on said track structure formed so that the front and rear frames are movable independently, a pair of traction members carried by each of said frames engaging said track structure, an arm rigidly secured to each of said frames and extending toward said copyboard, a traction wheel carried by each of said arms whereby there is a three point support for each of said frames, a scale carried by the arm connected with the rear frame, and an indicator for each of said scales carried by the front frame.

5. A process camera of the character described comprising a track structure, a copyboard arranged adjacent the track structure, a camera body arranged to move back and forth over the track structure, the rear and front frames of said camera body being independently movable, a scale rigidly secured to said rear frame and extending parallel with said track structure, a second but stationary scale arranged parallel to the first mentioned scale, and an indicator carried by said front frame for each of said scales, said indicators being connected together to move a unit in a direction transversely of the scale.

6. A process camera comprising a track structure, a camera body mounted to reciprocate on said track structure, a stationary scale arranged parallel with said track structure with the graduations on a slant, a scale connected rigidly to the rear frame of said camera body and extending parallel with the first mentioned scale, said second mentioned scale having the graduations at an opposite angle to the graduations of the first mentioned scale, an indicator for each of said scales, said indicators being in alinement transversely of said track structure, and means for mounting both of said indicators on the front frame of said camera body, said means including a bar rigidly secured to the indicators and movable in a direction transversely of the track structure, said scales having numbers thereon arranged according to a predetermined formula whereby when the same number is positioned opposite each of the indicators the camera is in focus.

7. In a process camera a camera body formed with front and rear frames independently movable, a bar rigidly connected with the rear frame and extending past the front frame, a tubular member mounted on said front frame, a rotatable bar carried by said arm and extending loosely through said tubular member and means for moving said bar so as to pitch the tubular member and thereby lock the two frames together.

8. In a process camera, a camera body formed with front and rear frames independently movable, a bar connected rigidly with the rear frame and extending past

the front frame, a bar rotatably mounted on said arm, said bar substantially rectangular in cross section with two of the surfaces arc-shaped, a tubular member rigidly secured to said front frame, said tubular member fitting over said bar and formed with an elliptical bore, said bore in cross section having the major axis of greater length than the width of said bar at its widest point and a minor axis of less length than the width of said bar at its greatest width and manually actuated means for turning said bar and thereby causing the same to pinch against said tube substantially in line with the minor axis thereof, whereby the front and rear frames are locked together so as to move as a single unit.

9. In a process camera of the character described a camera body formed with independently movable front and rear frames, a pair of supporting wheels for each frame, an arm rigidly secured to each frame, a sliding bracket arranged on each of said arms, means for locking each of said brackets any point along the respective arms and a traction wheel mounted in each of said brackets whereby there is provided a three point support for each of said frames.

10. In a process camera of the character described a camera body provided with front and rear frames, a pair of brackets arranged on said rear frame, a rod extending through said brackets, a ground glass frame and a pair of guide plates secured to said ground glass frame, each of said plates being formed with a straight groove having an offset at one end, said rod extending through said groove, said groove being arranged in a vertical position when the ground glass is in an operative position, said frame and guide plates being movable upwardly and then horizontally over said rear frame and guided by said rod, said rod fitting into said offset portion of said grooves when the ground glass frame is moved to its extreme position on top of said rear frame.

11. A process camera of the character described comprising a camera body, provided with front and rear frames, four shutters arranged in said rear frame and normally positioned to overlap a pair of supporting members for each two shutters, said supporting members being independently rotatable so as to independently shift said shutters and manually actuated means arranged exteriorly of said frame for shifting said shutters, said means being formed with indicators indicating the position of said shutters.

12. In a process camera of the character described a camera body formed with front and rear frames, an upper and a lower rod extending into said rear frame, a tubular member surrounding each of said rods and extending part of the distance from said frame, a shutter rigidly secured to each of said rods and to each of said tubular members and manually actuated means connected with said rods and said tubular members for shifting the position of said shutters, said manually actuated means being positioned exteriorly of said rear frame.

13. In a process camera of the character described a camera body formed with front and rear frames, a plurality of shutters arranged in said rear frame, means connected with said shutters and extending to a point exteriorly of the frame for independently shifting the position of said shutters and a weight arranged on each shutter for normally holding the respective shutters in either of two positions.

14. In a process camera comprising a camera body, a track and a copyboard arranged adjacent one end of said track, said copyboard comprising a pair of supports, a frame pivotally mounted on said supports and adapted to swing from a vertical to a horizontal position, a transparent member carried by said frame, a clamping board for pressing a copy against the rear surface of said transparent member, a clamping frame surrounding said clamping board, a plurality of anchor bolts extending through said frame and said board, springs acting on said bolts and on said board for clamping the board resiliently in place and means for connecting said clamping frame with the frame carrying the transparent member.

15. In a process camera of the character described a supporting track, a copyboard adjacent one end of said camera, a camera body mounted to reciprocate on said track, a bar connected with the iris diaphragm of said camera body whereby the diaphragm may be moved to secure the proper opening and a chart arranged adjacent said lever formed with rulings indicating the various openings necessary for different vocal lengths and different percentages of reductions or enlargements.

16. In a process camera of the character described a camera body provided with front and rear frames, a track on which said body reciprocates, a stationary scale arranged alongside of said track formed with diagonal graduations, a second scale connected with the rear frame of said camera body and arranged parallel with the first mentioned scale but with the graduations arranged at the opposite angle, an indicator for each of said scales, each of said indicators having a window with cross lines arranged therein, said lines being at right angles to each other with one line parallel to the longitudinal center of the respective scales, means for rigidly securing said indicators together and means for guiding the scales in a back and forth movement at right angles to the general direction of said scales whereby the

center of said cross lines on either indicator may be positioned above any point on any of said diagonal lines on the respective scales for compensation for an aberration of the lens of said camera body.

17. In a process camera of the character described a camera body, a track structure on each, a camera body first slidingly mounted on the scale carried by said track structure indicating the position of the camera lens to make a photograph of an image located at a prescribed distance of any required appropriate size within certain limits, a scale carried by the rear frame of said camera body graduated to indicate the position of the camera ground glass in focusing the camera for the several positions of the lens and an indicator carried by the front frame of said camera body traversing said scales, said indicators being in transverse alinement.

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