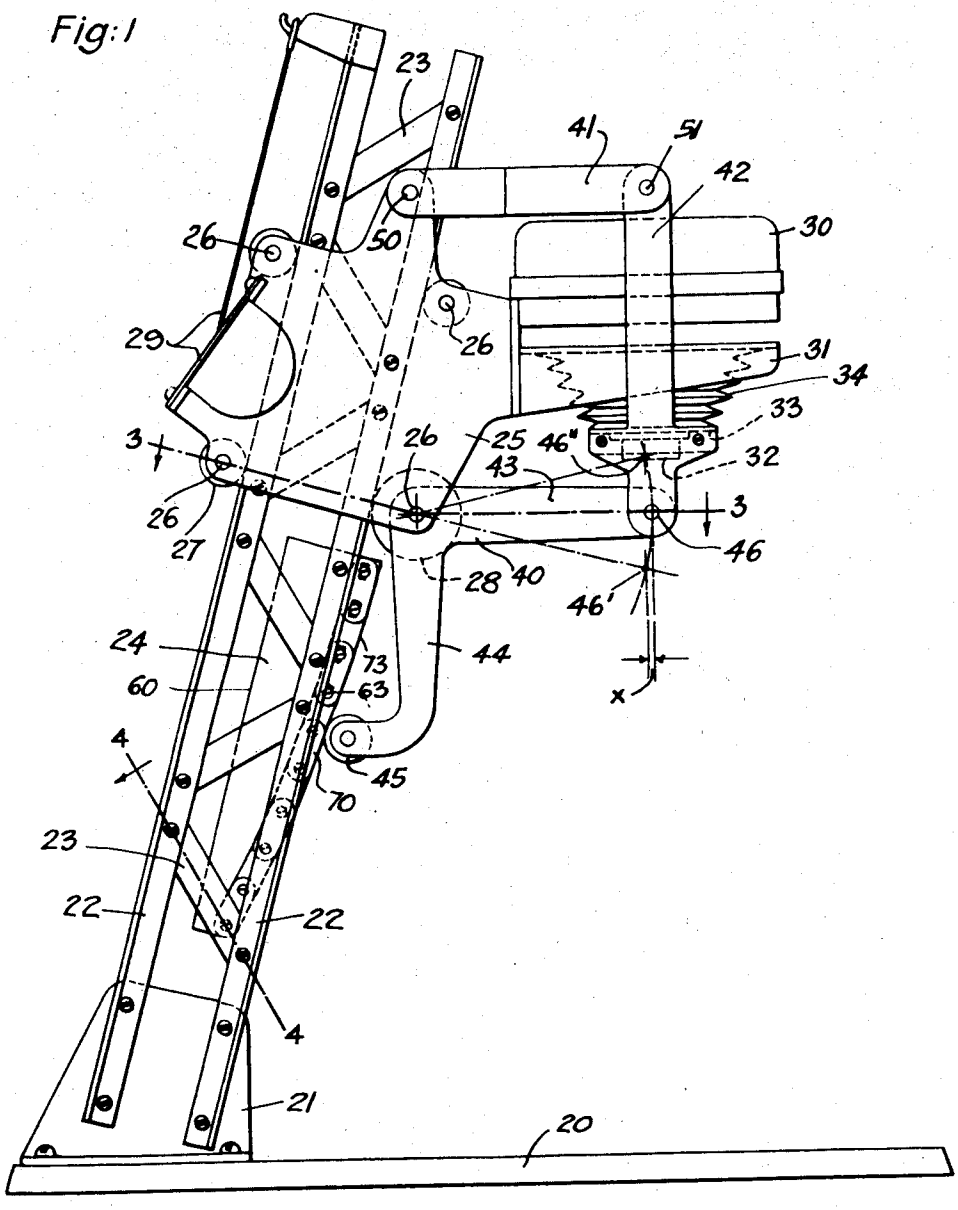
Nov. 4, 1947. A. SIMMON ET AL 2,430,252

AUTO-FOCUS ENLARGER

Filed May 1, 1945 4 Sheets-Sheet 1

Fig: 1



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AUTO-FOCUS ENLARGER

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Fig: 2

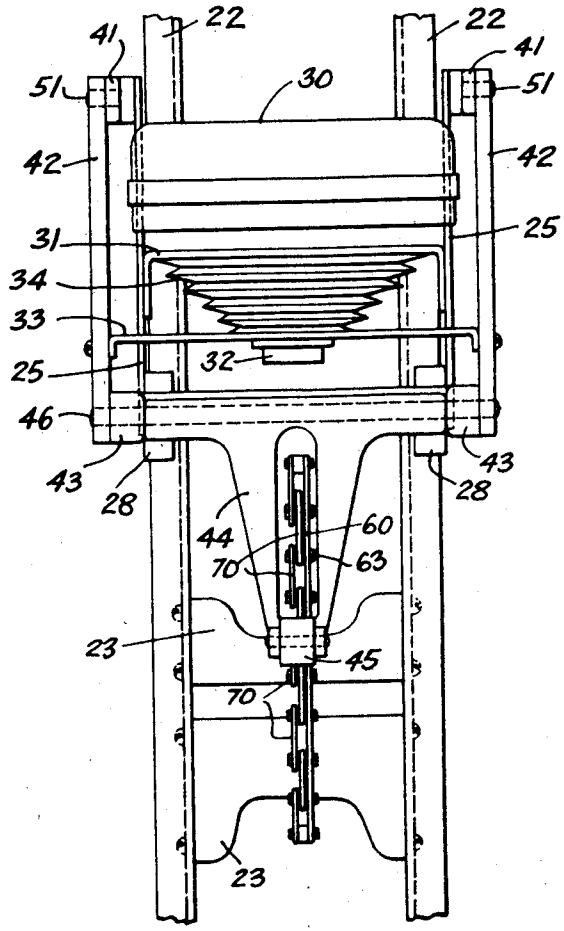

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Fig: 3

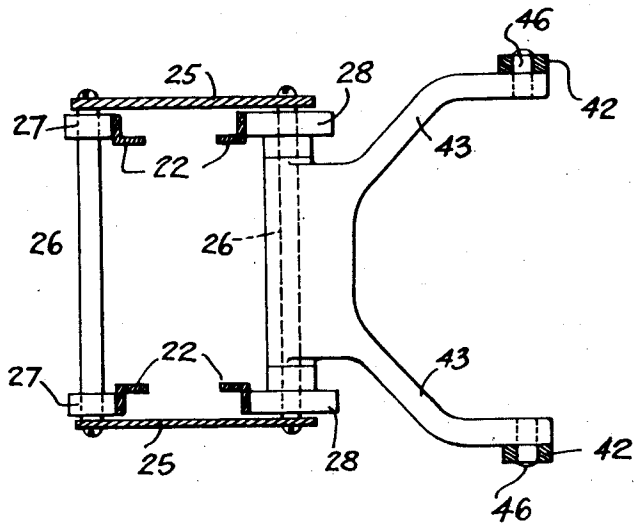

Fig: 4

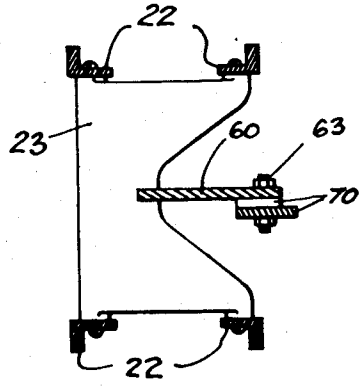

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Fig: 5

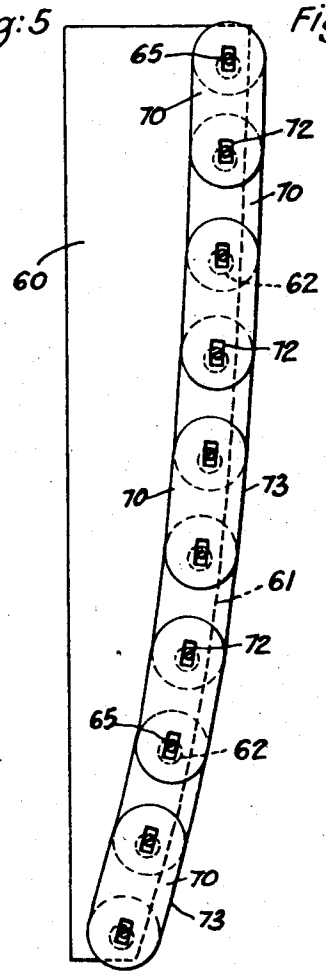

Fig: 6

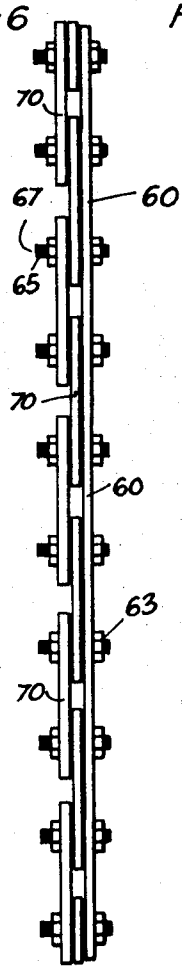

Fig: 7

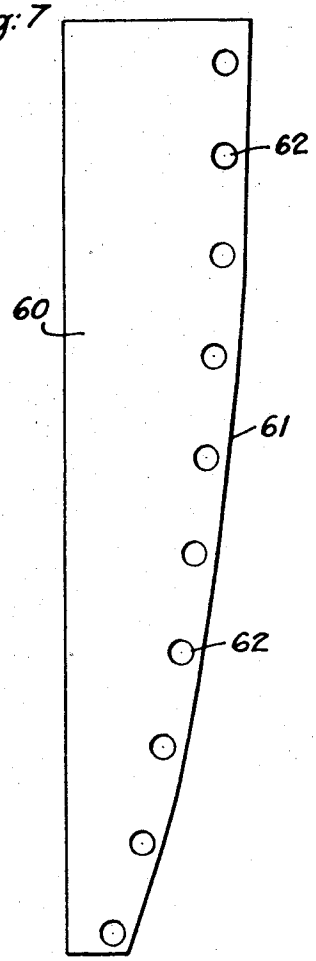

Fig: 8

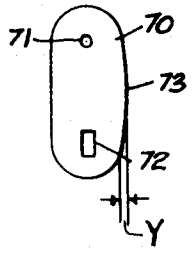

Fig: 9

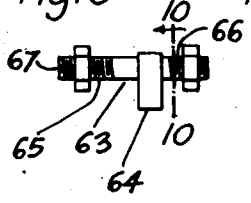

Fig: 10

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UNITED STATES PATENT OFFICE

2,430,252

AUTO-FOCUS ENLARGER

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Application May 1, 1945, Serial No. 591,366

4 Claims. (Cl. 88—24)

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This invention refers to an improved type of auto-focus enlarger. More particularly the object of this invention is an improved focusing mechanism and a cam of novel construction for an enlarger of the auto-focus type.

A preferred embodiment of our invention is shown in the attached drawings in which

Fig. 1 shows a side elevational view of the enlarger;

Fig. 2 is a fragmentary front elevational view of the same;

Fig. 3 is a cross-sectional view along the plane of line 3—3 in Fig. 1;

Fig. 4 is a cross-sectional view along the plane of line 4—4 in Fig. 1;

Fig. 5 is a side view of the cam which forms an important part of this invention;

Fig. 6 is a front view of the same;

Fig. 7 shows a baseplate of the cam assembly;

Fig. 8 is one of the sections of the composite cam;

Fig. 9 is an eccentric screw used for the adjustment of these sectional cam elements as will be explained later; and

Fig. 10 is a cross-sectional view along the plane of line 10—10 in Fig. 9.

Figs. 5 to 8 inclusive are drawn to a larger scale than Figs. 1 to 4 inclusive, and Figs. 9 and 10 to a still larger scale.

Like characters of reference denote similar parts throughout the several views and the following specification.

The enlarger consists of three principal parts, a base, a supporting structure, and a projector which can slide on this supporting structure.

The base comprises a baseboard 20 and a casting 21 which is fastened to this baseboard. The supporting structure consists of four steel angles 22 which are fastened to casting 21 and which are tied together and reinforced by diagonally arranged members 23. This supporting structure which forms the backbone of the enlarger may be arranged either vertically or, preferably, inclined at a slight angle as shown. Fastened to this supporting structure is a cam assembly 24 which will be described in detail later.

The projector consists of a projector carriage which supports all other projector elements, such as the lamphousing, the film stage, the lens and the focusing mechanism which supports the lens.

The projector carriage consists of two steel plates 25 which are bolted together by four bolts 26. These bolts serve at the same time as shafts for rollers 27 and 28. As can be seen, rollers 28 are larger than rollers 27 because in this manner

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additional clearance for the cam can be provided. The shaft on which rollers 28 revolve serves at the same time as a pivot for the main element of the focusing mechanism which will be described later. Fastened to the steel plate 25 are two steel springs 29 by means of which the entire projector assembly is counter-balanced so that it can be shifted on the supporting structure with ease and convenience.

Lamphousing 30 is essentially a sheet metal box of suitable shape and dimensions, adapted to receive a suitable source of light which illuminates the photographic negative. This source of light comprises preferably a number of fluorescent lamps which are contained within housing 30.

The film stage 31 is fastened to the projector carriage and is arranged immediately underneath the lamphousing. This film stage has, in a manner well known in the art, an aperture as large as the largest negative for which the enlarger has been designed. This negative is, during operation, supported by a negative or film holder which can be placed on the film stage 31 directly under the lamphousing 30. Since this filmholder does not form part of this invention and since filmholders adapted for this purpose are well known, it has been omitted and there is shown merely a gap or slot between lamphousing 30 and film stage 31 adapted to receive the filmholder.

The lens 32 is fastened to a horizontal plate 33. This plate is connected to the film stage by flexible but light-tight means, for example, by the conventional bellows 34 made of leather or similar material. Lens supporting plate 33 is in turn attached to the focusing mechanism about to be described.

The focusing mechanism consists of a main lever 40, two levers 41 and connecting links 42.

The main lever 40 swivels on shaft 26 and consists of two principal parts, part 43 which is substantially horizontal and part 44 which is substantially vertical. Part 42 is shaped fork-like as can be seen in Fig. 3, thereby avoiding interference with the light beam emanating from the enlarging lens 32. Part 44 is shaped as shown in Figs. 1 and 2 and supports the cam-following roller 45. The distances between pivots 26 and pivots 46 of the horizontal part 43 of lever 40 is the same as the distance between pivots 50 and 51 of part 41 and the distance between pivots 51 and 46 of part 42 is the same as the distance between the stationary pivot 26 of lever 40 and the stationary pivot 50 of lever 41. A parallelogram is thereby formed and any movement of the cam-follower 45 will cause a

slight rotary motion of lever 40 and thereby of lever 41 as well, and part 42 will move parallel to itself and perform a flat arc which approaches very nearly a straight vertical motion. For example, the point 46 may assume the two extreme positions 46' and 46'' as indicated in dotted lines in Fig 1. As can be seen, the lateral displacement X is very small since the horizontal part of the lever 40 is relatively long and the angle of rotation relatively small. In practice, it is possible to dimension these parts in such a manner that the displacement is no more than approximately ⅛'' which, of course, is quite negligible. Compared to the conventional straight line movement which comprises guide rods and other well known elements adapted to guide the lens in a straight line motion, this parallelogram movement has the important advantage of very low friction so that the cam-follower can follow the cam with ease and accuracy. It is very easy to make lever 40 one integral aluminum casting so that it can receive utmost rigidity without objectionable weight. Rigidity is very important since elastic deformation of this element would introduce undesired and unpredictable deviations in the lens position, thereby affecting the sharpness of the image projected on the baseboard.

It has been common experience with enlargers of the auto-focus type that it was relatively easy to manufacture the cam and other elements to obtain an image which was reasonably well defined, provided one's standards were not too high, but it has been impossible heretofore to obtain a degree of definition quite equal to the best obtainable by careful manual and visual focusing. The reason for this can be readily understood if one considers that lenses have rarely if ever the exact focal length they are supposed to have, and that small inaccuracies of the mechanical construction of the enlarger, for example in the supporting structure, will have exactly the same influence upon the performance of the enlarger as any inaccuracy of the cam itself. The supporting structure is usually made from pressed steel, such as shown, or from round tubing, and in either case deviations of .010'', or even more, are quite frequent. These deviations, which are not noticeable when focusing visually, are large enough to prevent the highest definition from being obtained with an enlarger of this type. While, in theory, it would be possible to use improved manufacturing methods to eliminate these inaccuracies, it appears doubtful whether this could be done at a price which is economically attractive. In order to overcome this difficulty a composite cam has been devised which permits the factory or the operator to use a point by point adjustment so that the performance of the enlarger becomes, for the first time, comparable to that of a manually and visually operated enlarger. This cam and its component parts are shown in detail in Figs. 5, 6, 7, 8, 9 and 10.

The cam has a supporting plate 60 shown in Fig. 7. This supporting plate has a front face 61 which follows approximately the correct cam shape. A number of holes 62 are provided and are adapted to receive eccentric screws 63. One of these eccentric screws is shown in enlarged dimensions in Figs. 9 and 10. Screw 63 comprises a central part 64 having a diameter as large as hole 62 and a length equal to the thickness of the supporting plate 60. Attached to this central part 64 are threaded parts 65 and 66 carrying each a conventional hexagonal nut. At least one of these threaded parts has a slot

67 by means of which the screw can be adjusted with the aid of an ordinary screwdriver. The cam itself consists of a relatively large number of small sectional cams 70, one of which is shown in Fig. 8. These cams are shaped similarly to the links of a chain. At one end each has a round hole 71 which fits over the threaded part 65 of the eccentric screw. A slot 72 of suitable dimensions is provided at the other end. The width of this slot equals the diameter of the threaded part 65. A slot on one end is necessary since the rotation of the eccentrics changes the distance between the screws 65 of two adjacent eccentrics. Each of the sectional cams 70 has a front face 73 which is curved, but the faces of all cams are not alike. The upper ones which control the lens position for relatively large magnifications are quite flat and, in fact, approach very nearly a straight line. The lower ones which control the lens position for small magnifications have an increasingly curved shape or, referring to Fig. 8, the dimension Y is almost zero for the top cams and becomes increasingly larger for the lower ones. The shape of the cams has been computed in such a way that, with the eccentrics in the mean position, all composite cams form a line which conforms to the theoretically computed shape of the cam. This shape can be computed very easily. If F is the focal length of the lens and the magnification factor M, the distance from the base of the enlarger to the optical center of the lens is always F $(1+m)$ and the distance from the optical center of the lens to the film is

$$F\left(1+\frac{1}{m}\right)$$

The operation of the enlarger can be easily understood from this description. The operator inserts the film into the enlarger and observes the image projected on the baseboard. As is well known, this observation can be facilitated by placing a white piece of paper or the like on the baseboard. The projector assembly can then be shifted vertically on the supporting structure until the magnification ratio is as desired, i. e., until the picture on the baseboard has the desired size. It is well known that the projector image becomes larger when the projector is moved upwards and that it becomes smaller when the projector is moved downwards. Since the front face of the composite cam has the shape which it theoretically should have, the image will be at least approximately sharp. If the enlarger structure were 100 percent accurate and if the lens would have precisely the focus for which the cam was computed, no further adjustment would be necessary. In practice, however, it will invariably be observed that the image will be sharper at some points than at others indicating that there are some unavoidable inaccuracies somewhere in the structure of the enlarger. Whenever the operator observes an inaccuracy of this type, he can improve the performance of the enlarger at this point by turning, with the aid of a screwdriver, the eccentric nearest the cam-following roller 45, thereby changing slightly the position of two adjacent ends of two sectional cams, until the image definition at this point is at its best. In this manner, the enlarger can be adjusted, not only at the two extreme points of the cam as heretofore provided in other enlargers, but at a large number of intermediate points. Since the distance between two eccentrics is quite small and, since the front face of the small cam intermediate

two eccentrics has the theoretically computed shape, any remaining deviation between two adjustable points will be a mere fraction of what it necessarily otherwise would be. It has been found that with a cam construction of this type, it is possible to improve the performance of an auto-focus enlarger to such an extent that there is no longer any measurable difference in quality between a picture printed with this enlarger and with a picture printed by a manually and visually focused enlarger.

It will be understood that the structure, as described above, is merely a preferred embodiment of the invention and that it may be freely changed in many respects without departing from the spirit of this invention. For example, instead of the supporting structure composed of steel angles and diagonal members, the conventional round tubing or other suitable type of supporting structure may be used. Likewise, the eccentrics described for adjusting the individual sectional cams are merely a preferred means of adjustment and other means, for example screws or the like, could very well be used should that appear desirable. Other possible modifications will readily appear to anybody skilled in the art.

What we claim as new, is:

1. In a photographic enlarger of the auto-focus type, comprising a flat base, a substantially vertical supporting structure mounted on said base, a cam assembly carried by said structure, a projector assembly comprising a carriage adapted to slide on said supporting structure in a substantially vertical direction, a lamphousing fastened to said carriage and including a source of light adapted to illuminate a photographic negative through an aperture in said housing, a film stage with an aperture, fastened to said carriage vertically beneath said lamphousing and adapted to support a photographic negative, a lens, and a lens supporting plate arranged vertically beneath said film stage, said lens adapted to project an enlarged image of said negative substantially into the plane of said flat base; a focusing mechanism controlling the position of said lens relative to said negative, the travel of said focusing mechanism being determined by the contour of said cam assembly, said cam assembly comprising a support, more than two relatively short sectional cams linked together in a chainlike manner carried by said support, and means to adjust each linkage point of said cams individually.

2. In a photographic enlarger of the auto-focus type, comprising a flat base, a substantially vertical supporting structure mounted on said base, a cam assembly carried by said structure, a projector assembly comprising a carriage adapted to slide on said supporting structure in a substantially vertical direction, a lamphousing fastened to said carriage and including a source of light adapted to illuminate a photographic negative through an aperture in said housing, a film stage with an aperture, fastened to said carriage vertically beneath said lamphousing and adapted to support a photographic negative, a lens, and a lens supporting plate arranged vertically beneath said film stage, said lens adapted to project an enlarged image of said negative substantially into the plane of said flat base; a focusing mechanism controlling the position of said lens relative to said negative, the travel of said focusing mechanism being determined by the contour of said cam assembly, said cam assembly comprising a base plate with a number of relatively large holes, a number of relatively short sectional cams, each having a relatively small hole near one end and a short narrow slot near the other end, a number of adjusting elements, each comprising two cylindrical parts which are eccentric with respect to each other, the first cylindrical part adapted to be received by the relatively large holes in said base plate, and having a diameter substantially equal to the diameter of said relatively large holes and a length substantially equal to the thickness of said base plate, the second cylindrical part adapted to engage the relatively small hole of one and the slot of another of two adjacent sectional cams, and having a diameter substantially equal to the diameter of said relatively small hole and being at least twice as long as the thickness of said sectional cams, each of these adjusting elements thereby adapted, upon being rotated, to adjust the position of two adjacent ends of two sectional cams relative to said base plate.

3. An auto-focus enlarger according to claim 1, the front faces of said sectional cams having contours of varying degrees of curvature, the one nearest to the enlarger flat base having the most pronounced curvature, the one farthest from the base having the least curvature, and intermediate cams having an intermediate degree of curvature substantially in inverse proportion to the distance of said intermediate cams from said base, the continuation of the front faces of all cams, when said means to adjust the linkage points of all cams are in their mean position, forming an unbroken line conforming to the theoretically computed shape of said cam, said means to adjust the linkage points serving merely to compensate for unavoidable inaccuracies in the dimensions of any of the component parts of the enlarger.

4. In a photographic enlarger of the auto-focus type, comprising a flat base, a substantially vertical supporting structure mounted on said base, an elongated cam carried by said structure, and a projector assembly comprising a carriage adapted to slide on said supporting structure in a substantially vertical direction, a lamphousing fastened to said carriage and including a source of light adapted to illuminate a photographic negative through an aperture in said housing, a film stage with an aperture, fastened to said carriage vertically beneath said lamphousing and adapted to support a photographic negative, a lens, and a lens supporting plate arranged vertically beneath said film stage, a hollow, substantially light-tight and extensible member having two ends, one end attached to the film stage and the other end attached to the lens supporting plate, said two ends adapted to be displaced relative to each other in a direction at right angles to the axis of the lens, said lens adapted to project an enlarged image of said negative substantially into the plane of said flat base; a focusing mechanism controlling the position of said lens relative to said negative comprising a main lever, at least one auxiliary lever and at least one connecting link, a first pivot fastened to said projector carriage and rotatably supporting said main lever, said main lever forming a substantially vertical leg, a cam-following roller carried by said leg in operative contact with said elongated cam, said main lever having another substantially horizontal leg, a second pivot at the end of said horizontal leg, a third pivot fastened to said projector carriage vertically above said first pivot of said main lever and rotatably supporting said auxiliary lever at one end, a fourth pivot at the other end of said auxiliary lever, the center distance between the third and fourth pivot of said auxiliary lever being

equal to the center distance between the first and second pivots of said main lever, said connecting link being rotatably supported at both ends by the second pivot of the main lever and by the fourth pivot of the auxiliary lever respectively, the center distance between the second and fourth pivot being equal to the center distance between the first and third pivot, said connecting link carrying said lens supporting plate with said lens, the straight lines connecting the centers of said four pivots forming a folding parallelogram, the folding angle being controlled by the position of the roller carried by one leg of said main lever, said roller being in contact with and following the contour of said elongated cam, thereby moving said connecting link, and therewith said lens supporting plate and said lens, in a flat arc closely approximating a straight vertical line, said elongated cam comprising a plurality of short sectional cams linked together, and means to adjust each linkage point of said short cams individually.

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