Dec. 6, 1927. 1,651,648

O. VON GRUBER

DEVICE FOR PROCESS WORK AND THE LIKE

Filed Oct. 3, 1925 5 Sheets-Sheet 1

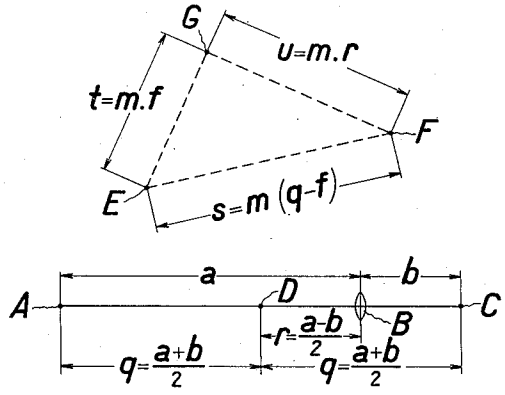


Fig. 1

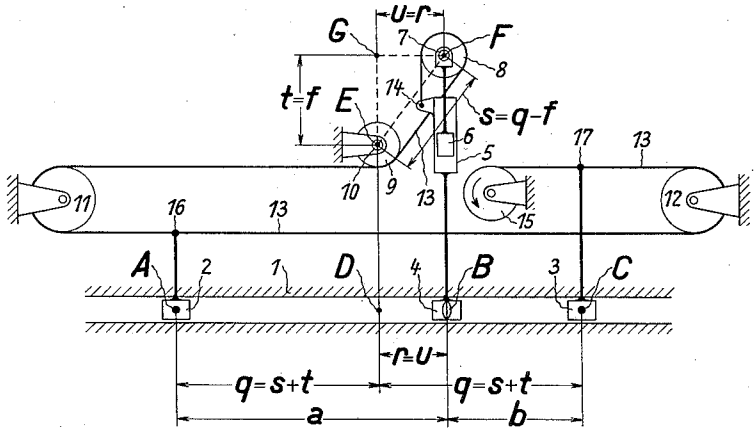


Fig. 2

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Filed Oct. 3, 1925 5 Sheets-Sheet 2

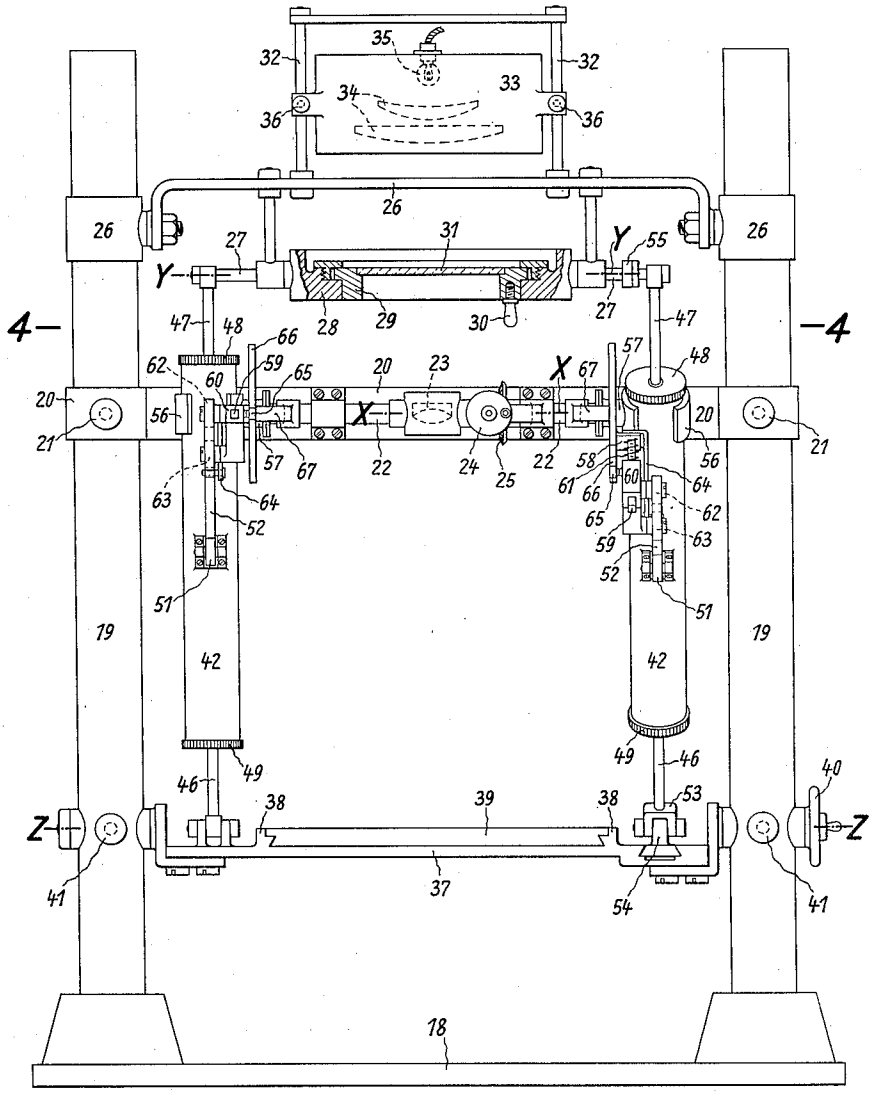


Fig. 3

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Filed Oct. 3, 1925 5 Sheets-Sheet 3

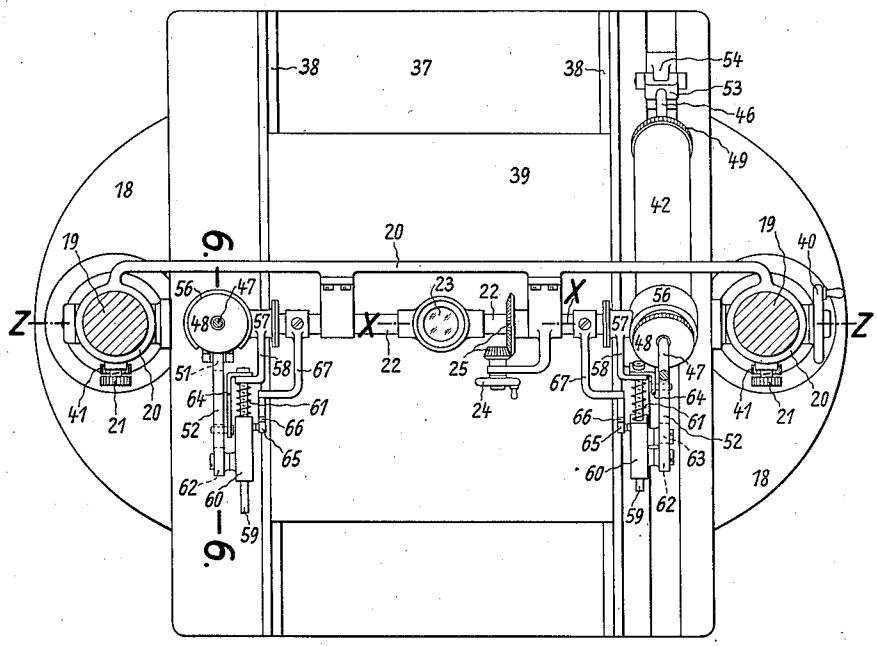


Fig. 4

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DEVICE FOR PROCESS WORK AND THE LIKE

Filed Oct. 3, 1925 5 Sheets-Sheet 4

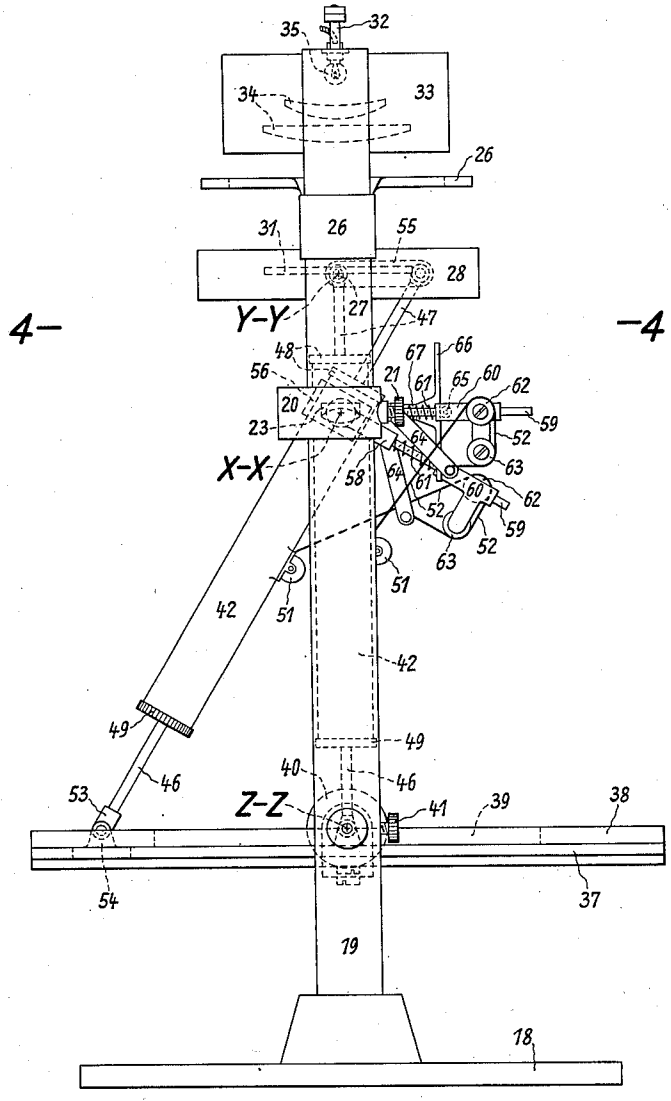


Fig. 5

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DEVICE FOR PROCESS WORK AND THE LIKE

Filed Oct. 3, 1925 5 Sheets-Sheet 5

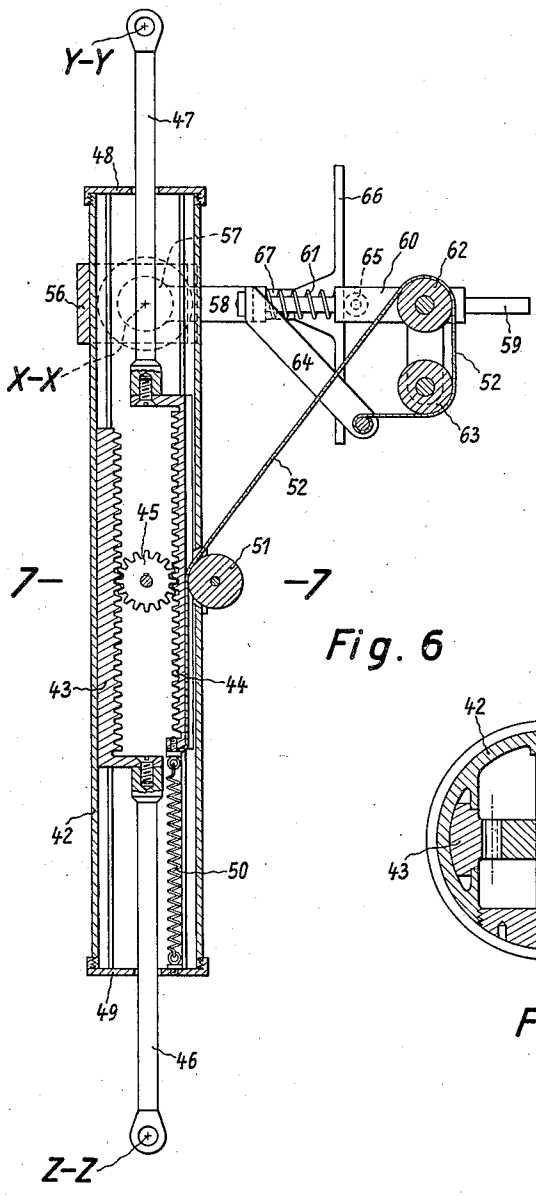


Fig. 6

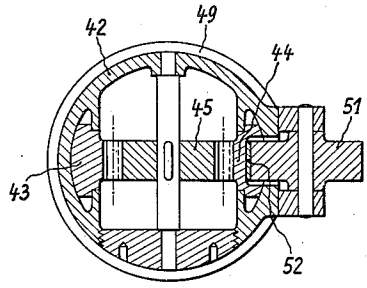


Fig. 7

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Patented Dec. 6, 1927. 1,651,648

UNITED STATES PATENT OFFICE.

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DEVICE FOR PROCESS WORK AND THE LIKE.

Application filed October 3, 1925, Serial No. 60,187, and in Germany October 7, 1924.

The present invention relates to a device for solving the equation

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f},$$

usually known as lens equation. Devices of this kind have been repeatedly suggested already. The invention provides a new device of this kind which is of simplified construction and at the same time not subjected to the supposition that the focal length f is invariable. According to the invention the new device contains three parts, which are displaceable relatively to each other in one and the same direction, and two members which are likewise displaceable relatively to each other. All parts and members are so coupled to each other that the distances (q and r) of the point which bisects the distance apart of the two outer ones of the said three parts, from one of these two parts and from the middle one of the said three parts are in such proportion to each other as the total of the distance apart (s) of the said two members and the component (t), which this distance (s) has perpendicular to the direction of displacement of these two members, is to the component (u) which this distance has in this direction of displacement, so that the following equation holds good:

$$\frac{q}{r}=\frac{s+t}{u}.$$

By so constructing such a device that the said two members, beside in the above mentioned direction, are also adjustable relatively to each other perpendicular to this direction, it is possible to consider different values of f.

For the purpose of a particularly simplified construction it is advisable to make such an arrangement that in the said last-mentioned equation the numerators and denominators have equal values ($q=s+t$ and $r=u$).

A suitable constructional form of the device is attained if the said two members be constructed as circular discs and if the relative coupling of the members and parts be effected by a draw-organ (band or the like). Another suitable constructional form can be attained if the said two members be constructed as toothed wheels and if the relative coupling of the members and parts be effected by means of a gearing. Besides, the combination of a draw-organ and a gearing or the use of friction gearings affords simplified constructional forms.

The new device may be used to particular advantage for rectifying apparatus in order to always keep the plate to be imaged, the plate to be made and the objective at the proper distance from each other. If in a rectifying apparatus a device according to the invention be used in such a way that one of the said three parts of the device represents the plate to be imaged, a second the plate to be made and the third the objective of the rectifying apparatus, it is possible, if only one of the said two members be displaceable perpendicular to the above mentioned direction of displacement of the members, to automatically maintain the distance-equation

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f}$$

in a simple way by coupling the objective in such a way to the said displaceable member that a rotation of the objective entails a displacement of the said member perpendicular to the aforesaid direction of displacement of the members.

In an entirely automatic rectifying apparatus the distance-equation

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f}$$

for a pair of points must, on the one hand, be automatically maintained and it must, on the other hand, be automatically seen to that the image plane, imaging plane and principal plane of the objective (supposing the simplest case of the two principal points coinciding) intersect in a common line. (For simplicity I have refrained here from considering the case of the two principal points having a distance differing from zero. Even to this case the invention may be applied without particular difficulty.) To these two conditions entirely corresponds the condition that the equation

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f}$$

must simultaneously be maintained for two

pairs of points. This latter condition can be fulfilled in a simple way by suitably uniting two devices according to the invention in each of which one of the three parts represents the plate to be imaged, a second the plate to be made and the third the objective of the rectifying apparatus, in each of which the said two members are, beside in the above mentioned direction of displacement, displaceable perpendicular to this direction and in each of which devices the arrangement is such that a rotation of the objective entails a displacement of the said two members relatively to each other perpendicular to the said direction of displacement of the members.

Particularly suitable constructional conditions may be attained if the said direction of displacement of the two members coincides with the direction of displacement of the sliding carriages.

Fig. 1 is destined to show the line of thought of the invention, A representing an object point which is imaged into the point C by means of an objective B of the focal length f. The distances of the objective B from the object point A and the image point C are denoted by a and b respectively. D is that point which lies on the connecting line of A and C and has from A and C the same distance

$$q=\frac{a+b}{2}.$$

The distance of the point D from the objective B is denoted by r, where

$$r=\frac{a-b}{2}.$$

The relative position of the points A, C, D, and the objective B is determined by the equation

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f}$$

which with

$$\frac{a+b}{2}=q \text{ and } \frac{a-b}{2}=r$$

may be transferred into the equation

$$(q-f)^2-r^2=f^2.$$

By the values $(q-f)$, r and f are therefore determined a right-angled triangle with $(q-f)$ as hypotenuse and with r and f as cathetus.

E and F denote two points which have a distance $s=m(q-f)$ from each other, m representing a constant of proportion. The position of a third point G relatively to E and F is so chosen that a right-angled triangle is determined in which E F represents the hypotenuse and in which the cathetus E G and F G have the values $t=m.f$ and $u=m.r$.

From the right-angled triangle E F G readily follows with the said designations of the sides that the equation holds good

$$s^2-u^2=t^2,$$

or

$$m^2.(q-f)^2-m^2.r^2=m^2.f^2.$$

This deduction shows that the distance-equation

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f}$$

may be automatically maintained if the points A, C, D, E and F and the objective B be so coupled to each other that the equation always holds good

$$\frac{AD}{BD}=\frac{CD}{BD}=\frac{EF+EG}{FG},$$

i. e. with the said designations the equation

$$\frac{q}{r}=\frac{m(q-f)+mf}{mr}=\frac{s+t}{u}.$$

It is a matter of course that the coupling will be the most simplified if the factor of proportion m, having in the drawing the value 2, receives the value 1, if therefore the equations hold good $q=s+t$ and $r=u$, and if, furthermore, F G be parallel to A C, E G being then perpendicular to A C.

Fig. 2 diagrammatically shows a constructional example corresponding to this simplest case. Along a joint guide 1, which is assumed to appertain to the stand (not shown in the drawing) of the device, there are displaceably disposed three sliding carriages 2, 3 and 4, of which 4 carries an objective of the focal length f whose optical axis is parallel to the direction of displacement of the sliding carriages, whilst 2 and 3 carry a punctiform mark each A and C respectively, lying on the objective axis. The sliding carriage 4 carries in addition a guide 5 along which a sliding carriage 6 is straightguided in such a way that its direction of displacement is perpendicular to that of the sliding carriages 2, 3 and 4. This sliding carriage 6 carries a shaft 7 whose axis is perpendicular to the plane, determined by the directions of displacement of the sliding carriages 2, 3, 4 and 6 and upon which there is loosely rotatably disposed a roller 8. A second loose roller 9 of the same diameter as the roller 8 rests on a shaft 10 which is so fixed on the stand of the device as to be parallel to the shaft 7. Two additional rollers 11 and 12 of like diameter are rotatably disposed on the stand of the device in such a way that, on the one hand, their axes of rotation are parallel to those of the shafts 7 and 10 and that, on the other hand, the plane, determined by their axes of rotation is parallel to the direction of displacement of the sliding carriages 2, 3 and 4 and has from the axis of rotation of the

roller 9 a distance which is equal to the total of the radius of this roller 9 and that of the roller 11 increased by the thickness of a steel band 13. The latter is laid over the rollers 8, 9, 11 and 12 and at 14 fixed on the guide 5, whereby 14 has such a position that that part of the band lying between 14 and the roller 8, is parallel to the direction of displacement of the sliding carriage 6. The band 13 rolls over a spring drum 15 whose spring action takes place in the arrow direction shown and which is rotatably supported on the stand of the device in such a way that its axis of rotation is parallel to the axis of rotation of the various rollers and that the part of the band, lying between it and the roller 12, is parallel to the direction of displacement of the sliding carriages 2, 3 and 4. At the steel band 13 acts the sliding carriage 2 at a point 16 and the carriage 3 at a point 17. Thereby the arrangement is as follows. The distance E F ($=s$) of the axes of rotation of the rollers 9 and 8 is equal to the difference in the distance q, which each of the marks A and C has from the bisecting point D of the connecting line from A to C, and to the focal length f of the objective B. Moreover, the component F G ($=u$), falling into the direction of displacement of the sliding carriages 2, 3 and 4, of the distance E F is equal to the distance r of the principal point of the objective B from the point D, while the component E G ($=t$), falling into the direction of displacement of the sliding carriage 6, of the distance E F is equal to the focal length f. Besides, the points of application 16 and 17 of the sliding carriages 2 and 3 respectively, at the steel band 13 have from the plane, placed through D and perpendicular to the direction of displacement of the sliding carriages 2, 3 and 4, the same distance q which D has from the marks A and C.

The described arrangement rests upon that case in which the position of the bisecting point relatively to the stand is invariable, and the distance-equation holds good

$$\frac{1}{a}+\frac{1}{b}=\frac{1}{f},$$

where a and b denote the distance of the principal point of the objective B from the mark A and C respectively. By the adjustment of one of the three sliding carriages 2, 3 and 4 along the guide 1 the position which is required owing to the band-coupling for the two other carriages for fulfilling the distance-equation for any values altered of a and b (an alteration being, of course, only possible within the limits required by the construction) is exactly prescribed and it is only necessary to keep the band tightly stretched. By adjusting the sliding carriage 6 other values of f may also be considered; the distance-equation is correctly fulfilled for each adjusted f with tightly stretched band. For simplicity the scales useful for practical purposes have been dispensed with in the drawing. For instance, it would be suitable to use a scale along the guide 5 with which coacts an index of the sliding carriage 6, in order to indicate the focal length f adjusted at any one time, and a scale along the guide 1 with which coacts an index each of the sliding carriages 2, 3 and 4. The difference of the values indicated by the indices of the sliding carriages 2 and 4 would then yield the magnitude of a and the difference of the values indicated by the indices of the sliding carriages 3 and 4 the magnitude of b.

In the position of the sliding carriages 2, 3, 4 and 6 adjusted in Fig. 2, the following values hold good:

$f=18$	$q=40,5$	$s=22,5$
$a=54$	$r=13,5$	$t=18$
$b=27$		$u=13,5$

Fig. 1 is a diagram illustrating graphically the principles on which the invention is based.

Fig. 2 is a diagrammatic view in side elevation of a simple construction utilizing these principles.

Figs. 3 to 7 show in a constructional example a rectifying apparatus according to the invention which contains two inversors, each of which is based upon the said simplest case that $q=s+t$ and $r=u$. Fig. 3 is an elevation, Fig. 4 a plan and Fig. 5 a side-view, whilst Figs. 6 and 7 are partial sections on an enlarged scale.

A base-plate 18 carries two parallel pillars 19. Along these two pillars is displaceably disposed a sliding carriage 20 which is fixable by means of two set-screws 21 relatively to the pillars and on which by means of two pivots 22 an objective 23 is supported rotatably about an axis X—X in such a way that its optical axis describes during the rotation a plane which is perpendicular to the plane through the axes of the two pillars 19. In order to be able to rotate the objective 23 is used a hand wheel 24 whose rotations are transmitted to the one of the two pivots 22 by means of a pair of bevel wheels 25. Along the two pillars 19 is further displaceably disposed a sliding carriage 26 on which by means of two pivots 27 a frame 28 is rotatably disposed in such a way that its axis of rotation Y—Y is parallel to the axis of rotation X—X of the objective 23 and lies with this axis of rotation in a plane which is parallel to the directions of displacement of the sliding carriages 20 and 26. In the frame 28 a ring 29 is rotatably disposed in such a way that its axis of rotation intersects the axis of rotation Y—Y of the frame in a perpendicular direction. With the aid of a handle 30 it is possible to rotate the

ring in the frame 28. A plate to be imaged 31 can be inserted into this ring 29 in such a way that it is perpendicular to the axis of rotation of the ring and that its sensitive surface contains the axis of rotation Y—Y of the frame 28. On the sliding carriage 26 are fixed two guide bars 32 which are parallel to the pillars 19 and along which there is displaceably disposed a casing 33, containing on the one hand a condenser 34 and on the other hand a source of light 35. By means of two set screws 36 it is possible to fix this casing on the guide bars 32. On the pillars 19 is rotatably supported a plate 37 in such a way that its axis of rotation Z—Z is parallel to the axis of rotation X—X of the objective 23 and lies with the axes of rotation X—X and Y—Y in one and the same plane. The plate 37 contains two guide bars 38 for the purpose of being able to connect a drawing board 39 to the plate and to conveniently exchange this drawing board for a dark slide with a photographic plate. Moreover the drawing board must be of such construction that its drawing surface contains the axis of rotation Z—Z, while the dark slide must be so designed that the sensitive surface of the photographic plate contains this axis of rotation. In order to be able to rotate the plate 37 a hand wheel is used. For fixing the plate in any desired position relatively to the pillars there are used two set-screws 41.

The frame 28 with the plate to be imaged 31, the objective 23 and the plate 37 with the drawing board 39 and the dark slide containing a photographic plate respectively, are coupled to each other by two devices, each of which is constructed as follows (see Figs. 6 and 7). In a tube 42 two racks 43 and 44 are displaceably disposed in the longitudinal direction of the tube. A toothed wheel 45 which is rotatably supported in the tube 42 in such a way that its axis of rotation is equidistant from both tube-ends engages in this rack in such a way that its rotation entails a relative motion of the racks in opposite directions. The rack 43 is so connected to a rod 46 and the rack 44 to a rod 47 that the axes of the two rods 46 and 47 coincide with the axis of the tube 42. At its ends the tube 42 is closed by lids 48 and 49 respectively, through which pass the two rods 46 and 47. A draw-spring 50, acting upon the rack 44 and the lid 49, tends to continuously draw the rack 44 towards the lid 49 and thus to attain a reduction of the relative distance of the two rods 46 and 47. A roller 51 is rotatably supported on the tube 42 in such a way that its axis of rotation is parallel to the axis of rotation of the toothed wheel 45 and lies with this axis of rotation in a plane which is perpendicular to the axis of the tube 42. The diameter of this roller 51 is such that a steel band 52 running over the roller and being fixed with its one free end on the rack 44, is parallel to the tube axis with that part which lies between the roller and the fixing. Besides the place where the band 52 is fixed on the rack is so chosen that a tension exerted on the band outside the tube 42 is opposed to the tensile force of the spring 50.

The one of the two devices of the above described construction is linked with its rod 46 to the plate 37 in such a way that the link axis is, on the one hand, parallel to the axis of rotation of the appertaining wheel 45 and intersects the axis of the appertaining wheel 42 and coincides, on the other hand, with the axis of rotation Z—Z of the plate 37, while the rod 47 of the device is linked on the one pivot 27 of the frame 28 in such a way that the link axis is, on the one hand, parallel to the axis of rotation of the appertaining wheel 45 and intersects the axis of the appertaining tube 42 and coincides, on the other hand, with the axis of the pivot 27 and therefore with the axis of rotation Y—Y. The other device is rotatably supported with a fork 53, disposed at the free end of its rod 46, on a sliding carriage 54 displaceable on the plate 37, the direction of displacement of which carriage is perpendicular to the axis of rotation Z—Z and parallel to the drawing surface of the drawing board 39, in such a way that its axis of rotation is, on the one hand, parallel to the axis of rotation of the appertaining wheel 45 and intersects the axis of the appertaining tube 42 and is, on the other hand, parallel to the axis of rotation Z—Z and lies in that drawing surface. This device is rotatably supported with its rod 47 on a crank 55 in such a way that its axis of rotation is, on the one hand, parallel to the axis of rotation of the appertaining wheel 45 and intersects the axis of the appertaining tube 42 and is, on the other hand parallel to the axis of rotation Y—Y. This crank is wedged with the other pivot 27 of the frame 28 in such a way that the axis of rotation of the rod 47 lies with the axis of this pivot and therefore with the axis of rotation Y—Y in the plane of the layer of the plate to be imaged 31.

On the tube 42 of each of the devices is displaceably disposed in the direction of the tube axis a bush 56 provided with a tube 57 whose axis perpendicularly intersects the axis of the bush and engages in the appertaining pivot 22 of the objective 23, so that a displacement of the sliding carriage 20 along the pillars 19 entails a displacement of the bush along the appertaining tube 42. In order that the appertaining roller 51 will not impede the displacement of the bush, the same is provided with a longitudinal slit of sufficient width. The tube 57 of each device is provided with an arm 58 on which

is fixed a square rod 59, serving as a guide bar of a sliding carriage 60, which is disposed to be displaceable along this bar in such a way that its direction of displacement is perpendicular to the plane determined by the tube axis and the axis of the appertaining bush 56, and which is connected to the arm 58 by a spring 61 which continuously tends to draw the sliding carriage towards the arm 58. On the sliding carriage 60 of each device two rollers 62 and 63 of the same diameter as the appertaining roller 51 are rotatably supported in such a way that their axes of rotation are parallel to that of the appertaining roller 51 and determine a plane which is parallel to the axis of the appertaining tube 42, the roller 62 having such a position that its axis of rotation lies with the axis of rotation X—X in a plane perpendicular to the axis of the appertaining tube 42. The steel band 52 of each condenser, fixed with its one free end on the rack 44, runs in the manner shown (see particularly Figs. 5 and 6) over the appertaining rollers 51, 62 and 63 and is fixed with its other free end on a holder 64 rigidly connected to the arm 58. The sliding carriage 60 of each device also carries a third roller 65 which is rotatably supported in such a way that its axis of rotation lies with that of the appertaining roller 62 and the axis of rotation X—X in one and the same plane, that it is thereby parallel to the axis of rotation of the roller 62 and has a distance from the same which is equal to the distance of the axis of rotation of the appertaining roller 51 from the axis of rotation of the appertaining toothed wheel 45. This roller 65 bears with its surface facing the appertaining tube 57 against a straight rail 66 which is fixed on an arm 67, rigidly connected to the appertaining pivot 22, in such a manner that it is parallel to the optical axis of the objective 23 and that its surface adjoining the roller 65 has from the axis of rotation X—X a distance which is equal to the focal length of the objective 23, reduced by the radius of the roller 65.

When using the device it is necessary to place on the drawing board 39 a drawing sheet on which are traced four known points of the plate 31 to be rectified with a proper relative position in their plan projection on the scale required for the rectified photo.

By means of trials, wherein the following manipulations are to be made over and over again:

1. Rotating the plate by the hand wheel 40,

2. Rotating the objective by the hand wheel 24,

3. Rotating the plate to be imaged 31 in its plane by the handle 30,

4. Displacing the sliding carriage 20 along the pillars 19 and

5. Adjusting the drawing sheet in its plane.

The device is to be adjusted in such a way that the projection of the said four points of the plate to be imaged on the drawing sheet coincides with the four points traced. If such be the case, it is necessary to fix the sliding carriage 20 by means of the set-screws 21 and the plate 37 by means of the set-screws 41 and to adjust the casing 33 with the condenser 34 and the source of light 35 relatively to the guide bars 32 in such a way that the source of light is imaged into the objective 23. In this position the casing 33 is to be fixed on the guide bars 32 by means of the set-screws 36. If thereupon the drawing board 39 be replaced by a dark slide with a photographic plate, the photo made of the plate to be imaged represents the rectified photo.

I claim:

1. A process work apparatus, containing a fundamental body, a holder adapted to receive a pattern, another holder adapted to receive process work to be made, and an objective disposed between the two holders, the two holders and the objective being disposed on the fundamental body displaceably relatively to each other in one and the same direction, the apparatus further containing a carrier, a toothed wheel rotatably disposed on the carrier, two racks displaceably disposed on the carrier and engaging in the toothed wheel at opposite sides, each of these racks being connected with one of the two holders, two circular discs disposed on the carrier rotatably and displaceably relatively to each other in the said direction, a draw organ wound round these discs, means for coupling this draw organ with one of the said racks so as to impart to the rack, with a displacement of the discs relatively to each other, a displacement equal to the rate of change of the distance apart of the discs, and means for coupling the discs with the objective so as to impart to the objective, with a displacement of the discs relatively to each other, a displacement of the same amount.

2. A process work apparatus, containing a fundamental body, a holder adapted to receive a pattern, another holder adapted to receive process work to be made, and an objective disposed between the two holders, the two holders and the objective being disposed on the fundamental body displaceably relatively to each other in one and the same direction, the apparatus further containing a carrier, a toothed wheel rotatably disposed on the carrier, two racks displaceably disposed on the carrier and engaging in the toothed wheel at opposite sides, each of these racks being connected with one of the two holders, two circular discs, one of these discs being rotatably mounted on the carrier, a

slide displaceably disposed on the objective in a direction perpendicular to the direction of displacement of the two holders and the objective relatively to each other, the other disc being rotatably mounted on this slide, a draw organ wound round these discs, and means for coupling this draw organ with one of the said racks so as to impart to the rack, with a displacement of the discs relatively to each other, a displacement equal to the rate of change of the distance apart of the discs.

3. A process work apparatus, containing a fundamental body, a holder adapted to receive a pattern, another holder adapted to receive process work to be made and an objective disposed between the two holders, three bodies, each for carrying one of the holders and the objective respectively, these three bodies being disposed on the fundamental body displaceably relatively to each other in one and the same direction, each of the two holders and the objective being rotatably disposed in the appertaining carrying body about an axis, the three axes of rotation being perpendicular to the said direction and lying in one and the same plane, the apparatus further containing a carrier, a toothed wheel rotatably disposed on the carrier, two racks displaceably disposed on the carrier and engaging in the toothed wheel at opposite sides, each of these racks being connected with one of the two holders, two circular discs, one of these discs being rotatably mounted on the carrier, a slide displaceably disposed on the body carrying the objective in a direction perpendicular to the direction of displacement of the said three bodies relatively to each other, the other disc being rotatably mounted on this slide, means for coupling the objective with this slide in such a manner, that a rotation of the objective imparts to this slide a displacement perpendicular to the direction of displacement of the said three bodies relatively to each other, a draw organ wound round these discs, and means for coupling this draw organ with one of the said racks so as to impart to the rack, with a displacement of the discs relatively to each other, a displacement equal to the rate of change of the distance apart of the discs.

4. A process work apparatus, containing a fundamental body, a holder adapted to receive a pattern, another holder adapted to receive process work to be made, and an objective disposed between the two holders, three bodies, each for carrying one of the holders and the objective respectively, these three bodies being disposed on the fundamental body displaceably relatively to each other in one and the same direction, each of the two holders and the objective being rotatably disposed in the appertaining carrying body about an axis, the three axes of rotation being perpendicular to the said direction and lying in one and the same plane, the apparatus further containing two carriers, each of these carriers containing a toothed wheel rotatably disposed on the carrier, two racks displaceably disposed on the carrier and engaging in the toothed wheel at opposite sides, each of these racks being connected with one of the two holders, each of these carriers further containing two circular discs, one of these discs being rotatably mounted on the carrier, two slides displaceably disposed on the body carrying the objective in a direction perpendicular to the direction of displacement of the said three bodies relatively to each other, the other disc of each carrier being rotatably mounted on one of these slides, means for coupling the objective with these slides in such a manner, that a rotation of the objective imparts to each of these slides a displacement perpendicular to the direction of displacement of the said three bodies relatively to each other, each of these carriers further containing a draw organ wound round the two appertaining discs, and means for coupling this draw organ with one of the two appertaining racks so as to impart to the rack, with a displacement of the appertaining discs relatively to each other, a displacement equal to the rate of change of the distance apart of the discs.

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