

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN AND RELATING TO COPYING APPARATUS

(71) We, AGFA-GEVAERT AKTIEN-GESELLSCHAFT, a body corporate organised according to the laws of the Federal Republic of Germany, of Leverkusen, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to copying apparatus. In copying apparatus in which an original is projected stripwise on to a copy support by means of a lens arrangement displaced relative to the original, it has previously been proposed for the lens arrangement to consist of several groups of lenses arranged in rows next to one another, in each case transversely to the direction of movement. Each group incorporates at least two members, which two members combined have positive refracting power, and an intermediate image plane is positioned between the members. At least two rows of groups of lenses are provided which rows are positioned one behind the other in the direction of movement.

An exposure system of this kind, referred to in the following for short as a screen lens, in which the individual images provided by the individual groups of lenses complement one another and form a complete image, is the subject of the German Patent Specification No. 1 203 115. In order to increase the light output of the system, in this process the individual images may join together or overlap, both transversely to the direction of movement and also in the direction of movement. As shown, for example, in U.S. Patent Specification No. 3,655,284, in so doing, it is possible for two and more rows of groups of lenses to lie one behind the other in the direction of movement of the copy support, so that every image point of the copy support is exposed more than once during its passage through the exposure device. As a result of this multiple exposure of the individual image areas, it is possible to obtain high throughout speeds. In addition, by means of multiple exposure, possible differences in the exposure strength between the groups of lenses and also between the centre and the edge of the individual groups of lenses can be compensated more easily. This is particularly the case if, as

can also be seen from the above-quoted U.S. Patent Specification, the groups of lenses of the individual rows of lenses are so laterally offset with respect to one another that, viewed in the direction of movement of the copy support, the groups of lenses of one row of lenses are arranged in the gaps between the groups of lenses of the other row of lenses.

In contrast of these advantages of the screen lens formed by several rows of groups of lenses, is the disadvantage that complete exposure of an individual image point has in the past carried out in several stages staggered with respect to one another in terms of time. If, in the process, the movements of the original and copy support are not synchronised with one another so as to be completely free of oscillation, it is possible for projection to take place by means of each of the individual rows of lenses at a variable relative position of original and copy support, as a result of which multiple contours appear on the copy. Multiple contours of this kind pose still more problems than continuous blurring which would occur with an individual exposure extending over a comparatively long period of time. It has therefore been found that for a screen lens equipped with several rows of lenses, greater expenditure must be envisaged for the drive means in the case of the original and copy support than would be necessary in the case of a conventional lens with an associated exposure strip of comparable width.

The invention provides copying apparatus which comprises means for supporting an original, means for supporting a copy support, and exposure means for stripwise projection of an image of an original onto a copy support, the original supporting means and the exposure means being arranged for relative movement, the exposure means comprising a plurality of groups of lens elements, each group comprising at least two lens elements, which together have positive refracting power, arranged with an intermediate image plane between them, the groups being arranged in at least two rows extending transversely to the direction of relative movement and the rows being spaced apart in the direction of relative movement, and the exposure means also comprising deflection means positioned in the path of the central ray through at least one group,

the arrangement being such that the distance between the or each central ray passing through the deflection means and a central ray of a group of a row adjacent to it is decreased in the direction of relative movement in the region of the surface of an original on the original supporting means and in the region of the surface of a copy support on the means for supporting a copy support.

With this arrangement, because the distance between central rays of groups of adjacent rows is decreased by the deflection means compared to their separation in a system without such deflection means, the interval of time between exposure of an image point by each of those groups is also decreased.

Advantageously, the plane containing the central ray of each group of a row intersects the plane containing the central ray of each group of an adjacent row in the region of the surface of an original and in the region of the surface of a copy support.

Exposure can then take place simultaneously through all the rows of lenses, so that even in the case of an extremely unstable drive means, the individual partial images are not displaced to either side, and double contours on the finished copy can be avoided. In spite of this, it is possible to concentrate the light from several rows of lenses on each image area, it being possible also for these rows of lenses to have, as hitherto, groups of lenses offset with respect to one another in order to compensate differences in brightness.

The deflection means may comprise one or more transparent prisms. For example, a prism may be arranged in the region of the intermediate image plane so as to deflect the paths of the central rays of at least one row of lenses towards the common axial plane of all the rows of lenses. Alternatively, one prism may be arranged in the path of rays of at least one row of lenses on the side of the original and a further prism on the side of the copy support, which prisms deflects the paths of the central rays towards the common axial plane of all the rows of lenses.

According to another embodiment of the invention, the deflection means comprises a cylindrical lens so positioned at, or adjacent to, the intermediate image plane that its central axis coincides with the common axial plane of all the rows. This cylindrical lens arranged in the vicinity of the intermediate image plane acts simultaneously in one direction as a field lens, without it being possible for it to develop at this point the distorting action otherwise caused by cylindrical lenses.

In a further advantageous embodiment of the invention, the deflection means comprises at least one mirror so arranged in the paths of rays between an original and a copy support as to deflect the paths of rays of the groups of each row in such a manner that the planes of the central rays of the rows intersect in the

region of the surface of an original and of the surface of a copy support.

In a further advantageous embodiment, each group comprises at least one spherical wedge lens element, which also forms the deflection means.

Several forms of copying apparatus constructed in accordance with the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a section through an exposure device according to the invention with a deflecting prism arranged in the region of the intermediate image plane;

Figure 2 shows an arrangement with one prism arranged on the side of the original and one on the side of the copy;

Figure 3 shows cylindrical lenses arranged in the region of the intermediate image plane;

Figure 4 shows two deflection mirrors inserted in the path of rays;

Figure 5 shows a view of one lens securing bar from above; and

Figure 6 shows the use of spherical wedge lenses for deflections the paths of rays.

Referring to the accompanying drawings, in Figure 1, in an apparatus housing 1 a copying drum 3 is mounted, which drum has a light-sensitive layer, for example, a photo-conductive selenium layer 2, and which is arranged to rotate during the copying process in the direction of the arrow A. On the upper side of the housing 1, a slide 5 for the original, provided with a transparent supporting plate 4, is arranged so as to be displaceable, by means of which slide an original 6, for example, a book or a piece of writing, can be moved over the apparatus in the direction of the arrow B. In a manner known *per se* and not shown, the slide 4, 5 for the original is so driven in synchronisation with the copying cylinder that its speed of movement in the direction of the arrow B corresponds exactly to the surface speed of the copying cylinder 2, 3 in the direction of the arrow A.

In order to illuminate the original 6, two rod-shaped lamps 9 and 10 are provided, arranged one in each reflector 7 and 8. Between the reflectors 7 and 8, a tube 11 of substantially rectangular cross-section is arranged in which two screen lens securing bars 12 and 13 and a screened field lens securing bar 14 are accommodated. The lens securing bars 12, 13, and 14 each carry two rows of lens elements 12a, 12b, 13a, 13b, 14a, 14b, respectively, which, as is shown in Figure 5 for the securing bar 12 of the screen lens, are so offset with respect to one another that, viewed in the direction of movement A, B of the projecting system relative to the copying cylinder 2, 3 or the original 6, the lens elements 12b are positioned in the gaps between the lens elements 12a, as a result of which the recording surface 2, moved through under the lens

securing bars 12, 13 and 14, undergoes a largely uniform exposure.

In addition, in the tube 11, a prism 15 is secured, which has two faces 15a and 15b angled relative to the base of the prism, of which one is assigned to the group of lenses 12a, 13a, 14a and the other to the group of lenses 12b, 13b, 14b. The two prism faces 15a and 15b are so angled with respect to one another that the central rays belonging to the groups of lenses a and b are so deviated in the region of the intermediate image plane g that they intersect both at a point G on the surface of the original 6 lying on the transparent plate 4 and also at a point g" on the surface of the copy support 2 while they run in the intermediate image plane through the two separate projecting points G₁' and G₂'. Of course, the rows a and b of lenses must be so arranged on their securing bars 12, 13 and 14 that their centres lie on these central rays.

With this arrangement, the plane of the original is projected upright in the direction of relative movement onto the plane of the copy support, and projection and exposure of every image point G" is carried out at the same time, so that even if comparatively serious vibrations occur in the geared connection between the slide 6 for the original and the copying cylinder 2, 3, this need not result in multiple projection of the point G. In spite of this, this point may contain light from two or more rows of lenses, so that it is possible both for light from several rows of lenses to accumulate on the individual image point and also for the intensity of exposure to be laterally compensated very effectively as a result of the laterally displaced arrangement of the groups of lenses of successive rows of lenses. In this arrangement an imperceptible transition, in particular at the edges of the image field of the individual groups of lenses, can be obtained more easily than would be possible in arrangements with only a single lens securing element, in which it would be necessary to provide image field diaphragms considerably more precisely set one to another. The setting of the image field diaphragms becomes less important the more rows of lenses for exposure of an image point are arranged one behind the other.

If in the above-described arrangement more than two rows of lenses are connected one behind the other, the prism 15 must have a number of prism surfaces suitably angled with respect to one another corresponding to the number of rows of lenses, instead of the two prism surfaces 15a and 15b. In order to keep within reasonable limits the lack of sharpness which might result from the fact that the individual image fields run at a specific angle to the recording surface as a result of the deviation of the central rays, inclined at the angle α , relative to the direction perpendicular to the said surface, also in the region of intermediate image plane g an intermediate image diaphragm

16 is provided which borders on these individual image fields. Moreover, in known manner, an intermediate image diaphragm of this type also serves in the case of the cylindrical recording carrier, shown in the drawings, to keep within the limits prescribed by the depth of sharpness of the projecting system, the deviation of the image field of the lens elements from the curve of the cylinder surface, the image field being substantially even or at most curved about the centre of the lenses, and also serves to prevent irradiation into adjacent groups of lenses.

In Figure 2 the deviation of the central rays of the rows of lenses is carried out in conditions otherwise identical to those in Figure 1, in an optically advantageous manner by means of two deflecting prisms 17 and 18 which are arranged symmetrically to the entire projecting system, in each case between the outer lens securing bar of the system and the original or copy plane, which prisms have prism surfaces 17a, 17b, 18a, 18b.

In the arrangement according to Figure 3, in the intermediate image plane g a cylindrical lens 19 is arranged. This cylindrical lens which is positioned in the centre of the system, in the conditions illustrated in which original and copy are projected successively by means of two identical lens systems 12 and 13 on the scale 1:1, has a focal length corresponding to a quarter of the distance between the plane of the original and plane of the copy, and thus projects the point G to the point G" in relation to the central rays of the rows of lenses. The pictorial projection of the point G to the point G" through the lens group 12a and 12b, and 13a, 13b respectively, is not affected adversely by the cylindrical lens 19 because the lens is located relative to this system in the intermediate projection plane in which it simply can display the action of a field lens.

In spite of the presence of the cylindrical lens 19 in the intermediate image plane g, it is possible as hitherto to attach field lens securing bars 20, 21 in the region of this intermediate image plane g, which in the known manner have a focal length corresponding in total approximately to a quarter of the distance between the two lens securing bars 12 and 13, and thus project the lens elements 12a and 12b onto the lens elements 13a and 13b. Spherical field lenses of this kind also do not produce any great distortion of the actual projection even if they are not positioned exactly in the intermediate image plane. In addition to a change in the total focal length of the system, the partial images might be displaced to either side, this displacement being easily compensated by appropriate adaptation of the focal lengths or by adaptations of the screen distances of the lens securing bars 12 and 13. In any case, displacement of the image is not noticed if, as in the case of the embodiment according to Figure 3, two identical field lens securing bars are

arranged symmetrically to the intermediate image plane *g*.

In Figure 4 a transparent support plate 22 is inserted in an opening 1*a* of the housing 1 of the apparatus. An original 25 in sheet form is transported in the direction of the arrow B over this transparent support plate 22 by means of transport rollers 23 and 24. The transport speed in the direction of the arrow B is again so adjusted by means of the gear connection (not shown) that it corresponds to the peripheral speed of the copying cylinder 2, 3 in the direction of the arrow A. The original 25 is pressed during its passage past the transparent support plate 22 by means of a pressure plate 26, which is under the action of two pressure springs 27 and 28. The exposure of the original is carried out by means of two light tubes 9 and 10 arranged in reflectors 29 and 30.

Projection of the original 25 onto the copying cylinder 2, 3 is carried out again by means of lens securing bars 12 and 13 attached in a tube 11 of substantially rectangular cross-section, a field lens securing bar 14 and an intermediate image diaphragm 17 being provided.

Upstream and downstream of the tube 11 is arranged a deflecting mirror 31 and 32, respectively, which in each case has two mirror surfaces 31*a*, 31*b*, 32*a*, 32*b*, angled with respect to one another. The mirror surfaces are at such an angle with respect to one another that the central rays of the rows of lenses *a* and *b* passing through the points *G*₁' and *G*₂' intersect at the points *G* and *G*'.

Finally, according to Figure 6, concentration of the axial planes of the projection through the individual groups of lenses to the points *G* and *G*' is effected by the projection system containing lens securing bars 33 and 34 with de-centred spherical lens elements or spherical wedge lenses 33*a*, 33*b*, 34*a*, 34*b*. For this, the field lens securing bar 14 contains, as in the case of Figure 2, normal, that is centres, spherical lens elements.

Of course, on the other hand, it would be possible for the cylindrical field lens securing bar 19 according to Figure 3, together with the associated spherical field lens securing bars 20 and 21, to be replaced by a single field lens securing bar with spherical wedge lenses of the type of the bars 33 and 34 in Figure 6.

WHAT WE CLAIM IS:—

1. Copying apparatus which comprises means for supporting an original, means for supporting a copy support, and exposure means for stripwise projection of an image of an original onto a copy support, the original supporting means and the exposure means being arranged for relative movement, the exposure means comprising a plurality of groups of lens elements, each group comprising at least two lens elements, which together have positive refracting power, arranged with an intermediate image plane between them, the groups

being arranged in at least two rows extending transversely to the direction of relative movement and the rows being spaced apart in the direction of relative movement, the exposure means also comprising deflection means positioned in the path of the central ray through at least one group, the arrangement being such that the distance between the or each central ray passing through the deflection means and a central ray of a group of a row adjacent to it is decreased in the direction of relative movement in the region of the surface of an original on the original supporting means and in the region of the surface of a copy support on the means for supporting a copy support.

2. Copying apparatus as claimed in claim 1, wherein the plane containing the central ray of each group of a row intersects the plane containing the central ray of each group of an adjacent row in the region of the surface of an original and in the region of the surface of a copy support.

3. Copying apparatus as claimed in claim 1 or claim 2, wherein the deflection means comprises one or more prisms.

4. Copying apparatus as claimed in claim 3, wherein the prism or one of the prisms is arranged in the region of the intermediate image plane so as to deflect the paths of the central rays of the groups of at least one row towards the common axial plane of all the rows.

5. Copying apparatus as claimed in claim 3, wherein one of the prisms is arranged in the paths of the rays of the groups of at least one row on the side of the original supporting means and a further one of the prisms is arranged on the side of the copy supporting means, the prisms being so arranged as to deflect the paths of the central rays of the groups of the row towards the common axial plane of all the rows.

6. Copying apparatus as claimed in claim 1 or claim 2, wherein the deflection means comprises a cylindrical lens so positioned at, or adjacent to, the intermediate image plane that its central axis coincides with the common axial plane of all the rows.

7. Copying apparatus as claimed in claim 1 or claim 2, wherein the deflection means comprises at least one mirror so arranged in the path of rays between an original and a copy support as to deflect the paths of rays of the groups of each row in such a manner that the planes of the central rays of the rows intersect in the region of the surface of an original and in the region of the surface of a copy support.

8. Copying apparatus as claimed in claim 1 or claim 2, wherein each group comprises at least one spherical wedge lens element, which also forms the deflection means.

9. Copying apparatus substantially as hereinbefore described with reference to, and as

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arranged symmetrically to the intermediate image plane g.

In Figure 4 a transparent support plate 22 is inserted in an opening 1a of the housing 1 of the apparatus. An original 25 in sheet form is transported in the direction of the arrow B over this transparent support plate 22 by means of transport rollers 23 and 24. The transport speed in the direction of the arrow B is again so adjusted by means of the gear connection (not shown) that it corresponds to the peripheral speed of the copying cylinder 2, 3 in the direction of the arrow A. The original 25 is pressed during its passage past the transparent support plate 22 by means of a pressure plate 26, which is under the action of two pressure springs 27 and 28. The exposure of the original is carried out by means of two light tubes 9 and 10 arranged in reflectors 29 and 30.

Projection of the original 25 onto the copying cylinder 2, 3 is carried out again by means of lens securing bars 12 and 13 attached in a tube 11 of substantially rectangular cross-section, a field lens securing bar 14 and an intermediate image diaphragm 17 being provided.

Upstream and downstream of the tube 11 is arranged a deflecting mirror 31 and 32, respectively, which in each case has two mirror surfaces 31a, 31b, 32a, 32b, angled with respect to one another. The mirror surfaces are at such an angle with respect to one another that the central rays of the rows of lenses a and b passing through the points G_1' and G_2' intersect at the points G and G".

Finally, according to Figure 6, concentration of the axial planes of the projection through the individual groups of lenses to the points G and G" is effected by the projection system containing lens securing bars 33 and 34 with de-centred spherical lens elements or spherical wedge lenses 33a, 33b, 34a, 34b. For this, the field lens securing bar 14 contains, as in the case of Figure 2, normal, that is centres, spherical lens elements.

Of course, on the other hand, it would be possible for the cylindrical field lens securing bar 19 according to Figure 3, together with the associated spherical field lens securing bars 20 and 21, to be replaced by a single field lens securing bar with spherical wedge lenses of the type of the bars 33 and 34 in Figure 6.

WHAT WE CLAIM IS:—

1. Copying apparatus which comprises means for supporting an original, means for supporting a copy support, and exposure means for stripwise projection of an image of an original onto a copy support, the original supporting means and the exposure means being arranged for relative movement, the exposure means comprising a plurality of groups of lens elements, each group comprising at least two lens elements, which together have positive refracting power, arranged with an intermediate image plane between them, the groups

being arranged in at least two rows extending transversely to the direction of relative movement and the rows being spaced apart in the direction of relative movement, the exposure means also comprising deflection means positioned in the path of the central ray through at least one group, the arrangement being such that the distance between the or each central ray passing through the deflection means and a central ray of a group of a row adjacent to it is decreased in the direction of relative movement in the region of the surface of an original on the original supporting means and in the region of the surface of a copy support on the means for supporting a copy support.

2. Copying apparatus as claimed in claim 1, wherein the plane containing the central ray of each group of a row intersects the plane containing the central ray of each group of an adjacent row in the region of the surface of an original and in the region of the surface of a copy support.

3. Copying apparatus as claimed in claim 1 or claim 2, wherein the deflection means comprises one or more prisms.

4. Copying apparatus as claimed in claim 3, wherein the prism or one of the prisms is arranged in the region of the intermediate image plane so as to deflect the paths of the central rays of the groups of at least one row towards the common axial plane of all the rows.

5. Copying apparatus as claimed in claim 3, wherein one of the prisms is arranged in the paths of the rays of the groups of at least one row on the side of the original supporting means and a further one of the prisms is arranged on the side of the copy supporting means, the prisms being so arranged as to deflect the paths of the central rays of the groups of the row towards the common axial plane of all the rows.

6. Copying apparatus as claimed in claim 1 or claim 2, wherein the deflection means comprises a cylindrical lens so positioned at, or adjacent to, the intermediate image plane that its central axis coincides with the common axial plane of all the rows.

7. Copying apparatus as claimed in claim 1 or claim 2, wherein the deflection means comprises at least one mirror so arranged in the path of rays between an original and a copy support as to deflect the paths of rays of the groups of each row in such a manner that the planes of the central rays of the rows intersect in the region of the surface of an original and in the region of the surface of a copy support.

8. Copying apparatus as claimed in claim 1 or claim 2, wherein each group comprises at least one spherical wedge lens element, which also forms the deflection means.

9. Copying apparatus substantially as hereinbefore described with reference to, and as

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shown in, any one of Figures 1 to 4 in combination with Figure 5 of the accompanying drawings, or Figure 6 of the accompanying drawings.

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