

# PATENT SPECIFICATION (11)

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## (54) IMPROVEMENTS IN AND RELATING TO COPYING APPARATUS

(71) We, AGFA-GEVAERT AKTIENGES-  
 ELLSCHAFT, a body corporate organised  
 according to the laws of the Federal  
 Republic of Germany, of Leverkusen,  
 5 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  
 10 following statement:—

The invention relates to copying apparatus  
 and to an optical projection system for  
 copying apparatus.

15 It has previously been proposed to employ  
 an optical projection system in which an  
 original to be copied is imaged strip-by-strip  
 onto a copy support by means of an  
 objective arrangement moved relative to the  
 20 original, the objective arrangement consist-  
 ing of several individual lens systems  
 arranged adjacent to one another, each of  
 which comprises at least two components  
 with positive optical power and in each of  
 25 which an intermediate image is formed in  
 an intermediate image plane situated  
 between the components, and the individual  
 images supplementing one another to  
 produce a total image which is at least free  
 from gaps.

30 A projection system of that kind, which is  
 referred to hereinafter as a grid objective, is  
 the subject of German Patent 1,203,115, for  
 example.

35 The invention provides copying apparatus  
 which comprises means for supporting an  
 original to be copied, means for supporting  
 a record support, and an optical projection  
 system for strip-by-strip imaging of the  
 40 original onto the record support, the original  
 supporting means and the optical projection  
 system being arranged for relative move-  
 ment, the optical projection system com-  
 prising a grid objective (as hereinbefore  
 45 defined) wherein at least one component of  
 each individual lens system comprises a  
 mirror lens (as hereinafter defined of posi-  
 tive optical power.

The term "mirror lens" is used herein to  
 mean a component in which an optical lens

50 element is so arranged in the immediate  
 vicinity of a mirror surface that the projec-  
 tion ray path passes through a refracting  
 surface of the lens element twice.

55 The use of mirror lenses allows the bend-  
 ing of the light ray path so that the  
 structural dimensions can be reduced, even  
 in those cases where the use of separate  
 deflecting mirrors is impossible because the  
 light ray path is so short. This is quite  
 60 often the case with the grid objective which  
 by its nature is bound to be short in con-  
 struction. In theory, of course, it is possible  
 with the grid objective to reduce the optical  
 structural length as required, and a cor-  
 65 responding number of lens systems could  
 then be arranged in a row in order to  
 obtain a sufficiently large exposure field in  
 spite of the reduction of the individual  
 elements. This procedure, however, easily  
 70 gives rise to difficulties with regard to the  
 introduction of the light necessary for pro-  
 jection. The use according to the invention  
 of mirror lenses offers the possibility of  
 further reduction, without difficulties arising  
 75 with regard to the construction of the  
 illumination means.

In addition, it may also be desirable for  
 reasons of image inversion to interpolate a  
 a further mirror into a projection system  
 which is in itself already short enough, that  
 80 is, a projection system which is already too  
 short for a separate deflecting mirror to be  
 built in. In this way the projection system  
 already mentioned, which by its very nature  
 produces an image the right way round  
 85 after transfer printing under the conditions  
 prevailing in copying apparatus for the imag-  
 ing of non-transparent originals, for  
 example, in the indirect electrophotographic  
 process, can be converted into a system for  
 90 direct imaging the right way round. It is  
 then suitable for use in all copying processes  
 which work without an intermediate record  
 support, for example the direct electro-  
 95 photographic process, photo-copying and the  
 diazo process.

A further advantage of the combination  
 according to the invention of the positive

projection element with a mirror element consists in that with a relatively weakly curved lens surface through which the light ray path passes twice, it is possible in this way to obtain relatively high refraction powers. This is particularly significant in the case of grid objectives, in which the projection elements generally consist of strips which are injection-moulded in one piece from transparent plastics since with weakly curved lens elements any errors in shape have less effect.

Accordingly, the invention makes it possible to provide a projection system using a grid objective which is space saving and can also offer high optical quality whilst using optical components which are simple to produce.

The arrangement may be such that the individual images of the objectives overlap one another or exactly supplement one another without overlapping so that in either case a total image is formed free from gaps. Also, on account of the relative movement of the copy support, for the formation of a total image free from gaps, the projection through a row of lenses need not be free from gaps if several rows arranged one behind the other are provided and the image gaps of one row are closed by the images from lenses of further rows staggered in relation to the lenses of this row.

A field lens strip may be provided in a known manner in the intermediate image plane. Interference with the intermediate image by optical components can be avoided, however, if two field lens strips are arranged one on each side of the intermediate image plane.

According to an advantageous embodiment of the invention, the projection ray path may be folded in a Z-shape by means of two mirror lens strips arranged between an original surface and a record support surface.

In another advantageous embodiment of the invention, a mirror lens strip is provided to act as the field lens strip. If in this case the mirror lens strip acting as the field lens strip is arranged between an original surface and a record support surface substantially parallel thereto, and there is supported in front of it a double row lens strip in which the two rows of lenses are so arranged in relation to the field lens strip that each row has a different part of the light ray path mirrored in the field lens strip pass through it, whilst the two parts of the light ray path passing through the lens strip run approximately parallel to the original and the record support, and a mirror is provided which deflects the two parts of the light ray path towards the original and the record support in each case, an arrangement can be produced in a simple and space-saving manner

for direct imaging of originals the right way round on a record support which is itself photosensitive, as is the case for example with ZnO process, a diazo process or a silver diffusion process. The double row lens strip is preferably bent by double the angle by which each of the two parts of the light ray path deviates from the original surface or the record support surface, so that the light passes through the lenses approximately parallel to the axis.

In a further advantageous embodiment of the invention, the light ray path between the original surface and the record support surface is folded in a Z-shape by means of a field lens strip backed by a mirror surface, a lens strip backed by a mirror surface, and a lens strip combined with this mirror lens strip. This embodiment produces a projection arrangement which images the right way round after transfer printing, and is therefore suitable for a copying process which works with intermediate imaging, in which arrangement the two positive projection elements of the system lie on a strip, so that temperature fluctuations or the like occurring during operation can have only a minimal effect on the imaging quality.

A particularly compact arrangement of the projection system according to the invention can be produced if the light ray path between the original surface and the record support surface is folded four times by means of a double row mirror lens strip, a field lens strip backed by a mirror, and a deflecting mirror.

The lens elements which are injection-moulded in transparent plastics are advantageously provided with moulded-in aperture diaphragms of opaque plastics material.

The invention also provides an optical projection system suitable for use in the copying apparatus of the invention.

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 is a section through a portion of a first form of copying apparatus according to the invention having a projection arrangement with two lens strips backed by a mirror;

Figure 2 shows a similar arrangement to Figure 1 but with a divided field lens strip;

Figure 3 is a section through a portion of a third form of copying apparatus having a projection arrangement with a field lens strip backed by a mirror;

Figure 4 is a section through a portion of a fourth form of copying apparatus having a projection system in which both a projection lens strip and a field lens strip is backed by a mirror;

Figure 5 is a section through a portion

of a fifth form of copying apparatus having a light ray path which is bent four times; and

Figure 6 shows a lens strip with a moulded-in aperture diaphragm.

Referring to the accompanying drawings and initially to Figure 1, an original carriage 2 is supported on an apparatus frame 1 so that it is movable in a longitudinal direction A. The carriage 2 carries a transparent plate 3 on which can be placed an original 4 to be copied. The original 4 is moved in the direction of the arrow A during the projection operation and illuminated by means of a lamp 6 arranged in a reflector 5.

Arranged in the apparatus frame 1 there are lens strips 7 and 9 which are injection-moulded in one piece from plastics material and carry lens surfaces 7a and 9a of positive refractive power which are each backed by a mirror layer 8 and 10. The lens strip 7 images the original 4 moving in the direction of the arrow A into an intermediate projection plane  $G^1$ , where the image of the original is taken up by the lens strip 9 and projected onto a surface, moving in the direction of an arrow B, of a copying cylinder 12 which is supported on a spindle 16 and is provided with a photosensitive layer 11. In this way, a 1:1 projection of the original is produced strip-by-strip on the above-mentioned photosensitive layer. The cylinder 12 may for example form the intermediate copy support of an indirect electrophotographic apparatus, on which a latent image, which can be inked with electroscopically attractable toner, is produced by the exposure.

In the intermediate image plane  $G^1$  there is arranged in a known manner a field lens strip 13 with field lens surfaces 13a and 13b of positive refraction power, which image the outlet pupil of the lenses 7a of the strip 7 onto the inlet pupil of the lenses 9a of the strip 9, and thus ensure the transmission of the beams furthest from the axis, so that each individual channel of the projection system is enabled to project over a relatively large angle. Also in a known manner, due to the intermediate projection which takes place in the plane  $G^1$ , the images of the individual channels can be combined again in the actual projection plane to form a gapless or even overlapping image, since after a double image inversion they adjoin one another again in the right direction.

In order to avoid scattered light and to define the limits of the projection strips, the field lens strip 13 is housed in a rectangular tube 14 which allows the light to pass through only in the region of the slit-like diaphragms 14a and 14b. In addition, between the original plane and the record support plane a light-blocking floor 15 is

inserted, which also has only slit-like passage apertures 15a and 15b.

According to Figure 2, with conditions otherwise corresponding to Figure 1, a field lens strip 17, 18 with positive lens surfaces 17a, 18a, respectively, is arranged on each side of the intermediate image plane  $G^1$  in the tube 14. The double field lens strip 17, 18 has approximately the same effect as the single field lens strip 13, but liberates the region of the intermediate image plane  $G^1$  so that the intermediate image produced therein cannot be disturbed either by striae formed in the lens body or by scratches or dust particles on a lens surface.

In Figure 3, a tube 21 in which a slit diaphragm 22 is drawn is arranged between the original carriage 2, 3 and a transport cylinder 19 for a photosensitive sheet 20. The tube 21 has slit-like openings 21a, 21b on one side. A double row lens strip 23 which carries two rows of lens elements 23a and 23b, respectively, is inserted in the tube 21. The lens strip 23 is bent so that its lenses 23a and 23b have the main beams of the light ray path pass through them parallel to the axis in each case.

A field lens strip 24 with positive lens elements 24a backed by a mirror layer 25 is also arranged in the tube 21. Outside the tube 21 deflecting mirrors 26 and 27 are also provided which deflect the light ray path towards the original 4 and the photosensitive copy support 20. With this arrangement, owing to the three mirror surfaces involved in the projection process, a correct-sided image is produced without a transfer on the copy support 20, where it can be developed and fixed.

In Figure 4, the original 4 is imaged by means of a double row lens strip 28, with the intermediate imaging in the intermediate plane  $G^1$  being effected by means of the lens surfaces 28a and 28b, whilst the projection of the intermediate image onto the photosensitive layer 11 is effected by means of the lens surfaces 28c backed by a mirror surface 29. The lens surfaces 31a of a field lens strip 31, which are backed by a mirror surface, 30, act as field lenses. The screening of the photosensitive layer 11 from scattered light, and the definition of the projection strip are again effected by means of an intermediate floor 15 in which there is an exposure slit 15c.

According to Figure 5, the actual projection into the intermediate image plane  $G^1$  and onto the photosensitive surface 11 is carried out by means of a double lens strip 32 which has two rows of lenses 32a and 32b, each backed by a mirror surface 33 and 34. In addition, a field lens strip 36 with lens surfaces 36a backed by a mirror surface 35, and a deflecting mirror 37 are provided, which together with the mirror surfaces 33

and 34 bend the light ray path four times, so that a very space-saving projection system is produced. Scattered light is again excluded by means of an intermediate floor 15 provided with an exposure slit 15c.

Figure 6 shows a single lens strip 40 of transparent plastics which is injection-moulded over a diaphragm body 41 made of opaque plastics material. The lens body 40 is provided with pairs of lenses 40a and 40b. In the region of the lenses 40a, 40b, the opaque diaphragm body 41 is in each case provided with a diaphragm aperture 41a which is field in with the transparent material of the lens strip 40 and forms the aperture diaphragm for the optical channel running between the lenses 40a and 40b. This aperture diaphragm could of course also be used in the region of a field lens backed by a mirror surface.

#### WHAT WE CLAIM IS:—

1. Copying apparatus which comprises means for supporting an original to be copied, means for supporting a record support, and an optical projection system for strip-by-strip imaging of the original onto the record support, the original supporting means and the optical projection system being arranged for relative movement, the optical projection system comprising a grid objective (as hereinbefore defined) wherein at least one component of each individual lens system comprises a mirror lens (as hereinbefore defined) of positive optical power.

2. Copying apparatus as claimed in claim 1, wherein the grid objective comprises a row of lens systems, and corresponding members of each lens system are formed in respective strips extending the length of the row.

3. Copying apparatus as claimed in claim 2, wherein a field lens strip is provided in the intermediate image plane of the row of lens systems.

4. Copying apparatus as claimed in claim 2, wherein two field lens strips are arranged one on each side of the intermediate image plane of the row of lens systems.

5. Copying apparatus as claimed in any one of claims 2 to 4, which comprises two mirror lens strips and wherein the projection light ray path is folded into a substantially Z-shaped path by means of the two strips arranged between an original and a record support.

6. Copying apparatus as claimed in claim 3 in which a mirror lens strip is provided to act as the field lens strip.

7. Copying apparatus as claimed in claim 6, wherein the mirror lens strip acting as the field lens strip is arranged between an original surface and a record support surface substantially parallel to the original surface, and there is supported in front of it a double row lens strip in which the two rows of lenses are so arranged in relation to the field lens strip that one row transmits light passing from the original to the field lens strip and the other row transmits light passing from the field lens strip to the record support with the two parts of the light ray path passing through the respective rows of the double row lens strip running approximately parallel to the original surface and the record support surface; and wherein two mirrors are provided one of which deflects the light ray path from the original surface along one of the said parts of the light ray path and the other of which deflects the other said part of the light ray path towards the record support surface.

8. Copying apparatus as claimed in claim 7, wherein the planes of the optical axes of the two rows of lenses of the double row lens strip form an angle that is double the angle which each of those two planes forms with the original surface or the record support surface.

9. Copying apparatus as claimed in claim 3 wherein the light ray path between the original and the record support is folded in a Z-shape by means of a "mirror lens" strip acting as a field lens and a further mirror lens strip and wherein the grid objective comprises a further lens strip combined with the said further mirror lens strip.

10. Copying apparatus as claimed in claim 3, wherein the light ray path between the original and the record support is folded four times by means of a double row mirror lens strip, a field lens strip backed by a mirror, and a deflecting mirror.

11. Copying apparatus as claimed in any one of claims 1 to 10, wherein at least some of the lens elements are formed by injection-moulding from transparent plastics and are provided with moulded-in aperture diaphragms made of opaque plastics material.

12. Copying apparatus substantially as hereinbefore described with reference to, and as shown in, any one of Figures 1 to 5 of the accompanying drawings.

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and 34 bend the light ray path four times, so that a very space-saving projection system is produced. Scattered light is again excluded by means of an intermediate floor 15 provided with an exposure slit 15c.

Figure 6 shows a single lens strip 40 of transparent plastics which is injection-moulded over a diaphragm body 41 made of opaque plastics material. The lens body 40 is provided with pairs of lenses 40a and 40b. In the region of the lenses 40a, 40b, the opaque diaphragm body 41 is in each case provided with a diaphragm aperture 41a which is field in with the transparent material of the lens strip 40 and forms the aperture diaphragm for the optical channel running between the lenses 40a and 40b. This aperture diaphragm could of course also be used in the region of a field lens backed by a mirror surface.

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2. Copying apparatus as claimed in claim 1, wherein the grid objective comprises a row of lens systems, and corresponding members of each lens system are formed in respective strips extending the length of the row.

3. Copying apparatus as claimed in claim 2, wherein a field lens strip is provided in the intermediate image plane of the row of lens systems.

4. Copying apparatus as claimed in claim 2, wherein two field lens strips are arranged one on each side of the intermediate image plane of the row of lens systems.

5. Copying apparatus as claimed in any one of claims 2 to 4, which comprises two mirror lens strips and wherein the projection light ray path is folded into a substantially Z-shaped path by means of the two strips arranged between an original and a record support.

6. Copying apparatus as claimed in claim 3 in which a mirror lens strip is provided to act as the field lens strip.

7. Copying apparatus as claimed in claim 6, wherein the mirror lens strip acting as the field lens strip is arranged between an original surface and a record support surface substantially parallel to the original surface, and there is supported in front of it a double row lens strip in which the two rows of lenses are so arranged in relation to the field lens strip that one row transmits light passing from the original to the field lens strip and the other row transmits light passing from the field lens strip to the record support with the two parts of the light ray path passing through the respective rows of the double row lens strip running approximately parallel to the original surface and the record support surface; and wherein two mirrors are provided one of which deflects the light ray path from the original surface along one of the said parts of the light ray path and the other of which deflects the other said part of the light ray path towards the record support surface.

8. Copying apparatus as claimed in claim 7, wherein the planes of the optical axes of the two rows of lenses of the double row lens strip form an angle that is double the angle which each of those two planes forms with the original surface or the record support surface.

9. Copying apparatus as claimed in claim 3 wherein the light ray path between the original and the record support is folded in a Z-shape by means of a "mirror lens" strip acting as a field lens and a further mirror lens strip and wherein the grid objective comprises a further lens strip combined with the said further mirror lens strip.

10. Copying apparatus as claimed in claim 3, wherein the light ray path between the original and the record support is folded four times by means of a double row mirror lens strip, a field lens strip backed by a mirror, and a deflecting mirror.

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