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(71) Applicant: **IMPERIAL CHEMICAL INDUSTRIES PLC**
London SW1P 3JF (GB)

(72) Inventors:
- **Whaley, Gregory J.**
  Woodbury, Minnesota 55125 (US)
- **Mazar, Scott Thomas**
  Inver Grove Heights,Minnesota 55076-1510 (US)
- **Teter, James R.**
  Minneapolis, Minnesota 55409 (US)

(74) Representative: **Price, Anthony Stuart et al**
Frank B. Dehn & Co.,
European Patent Attorneys,
179 Queen Victoria Street
London EC4V 4EL (GB)

(54) Method and apparatus for dye sublimation transfer printing

(57) A modulated scanning laser beam (5) heats selected regions on a dye donor sheet (1) mounted on a roller (2) to cause dye therein to sublime and cross an gap (10) to condense onto a receiver sheet (3) mounted on a support bed (4) to form an image therein. The gap (10) is provided by scanning the beam (5) at a point offset from the point A where the donor sheet (1) and receiver sheet (3) contact. The donor and receiver sheets may exchange positions. The roller (2) may be replaced by a rod lens through which the beam (5) passes. In this case, the sheet adjacent the rod lens may be spaced from the rod lens at the point where the beam (5) exits the rod lens, e.g. by spacer tape on the surface of the lens. In a further embodiment, the sublimation gap between the donor and receiver sheets is provided by a flanged roller.

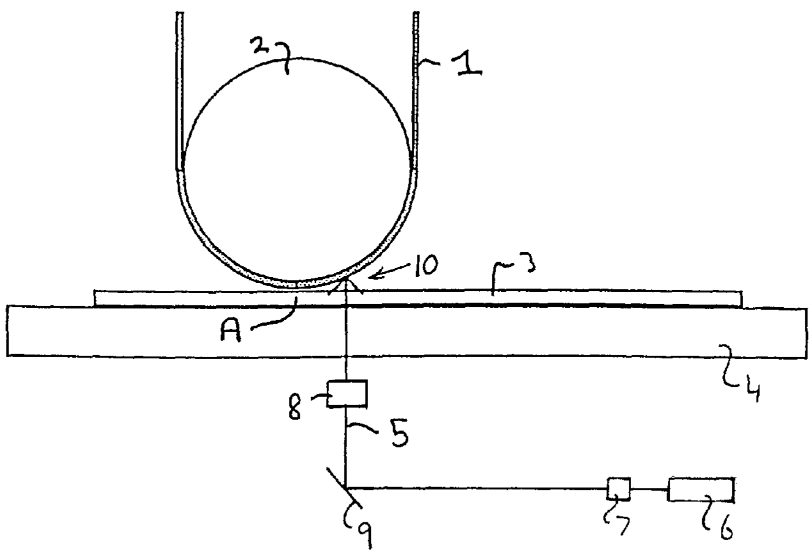

Fig. 1

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Description

The present invention relates to a method and apparatus for dye sublimation transfer printing.

In laser-based dye diffusion thermal transfer printing, a dye donor sheet and a receiver sheet (or other such dye donor and receiver elements) are held in intimate contact with one another, and selected regions of the dye sheet are heated by a modulated scanning laser beam. This causes dye from the selected regions to diffuse into the receiver sheet to form a corresponding image therein.

An alternative method of transfer printing is by sublimation. This is the method of interest in the present invention. In sublimation transfer, there is an gap of typically a few microns between the donor and receiver sheets. Heating of the donor sheet causes the dye to enter the vapour phase. The dye then crosses the gap, and condenses onto the relatively cool surface of the receiver sheet.

In a laser system, sublimation transfer requires less energy for a given amount of dye transfer than does diffusion transfer (due to the fact that only the dye sheet requires heating), and is less prone to image defects caused by dust particles between the donor and receiver sheets (In diffusion transfer, dust particles cause separation of the donor and receiver elements over an area much larger than that of the particles themselves, and so, even if very small, prevent proper diffusion).

Typically, the gap for sublimation transfer is provided by spacer particles, such as microbeads, mounted in the surface of the donor and/or receiver sheets.

US-A-4876235 discloses a system in which spacer particles are provided in the receiver sheet, and US-A-5283224 disclose a system in which spacer particles are provided on the surface of a dyesheet.

A problem with spacer particles, however, is that they absorb and reflect the laser light, and can give the final print a mottled appearance. They can also interfere with the transfer of the dye because of direct blockage of the dye and because of the large thermal mass of the spacer particles. They can further cause local distortions of the surface of the coating again leading to irregularities in the print.

Spacer particles are particularly unsuitable for printing 35 mm slides, as these are viewed under high magnification, and so any defects in the print, for example where dye is obstructed by the spacer particles, is also magnified.

US-A-5291218 discloses a system in which spacer particles are not used. Instead, the receiver element is provided with a pair of spacer rails at either side thereof, and a vacuum hold down is used to maintain a stable gap.

The present invention aims to provide an improved method and apparatus for sublimation transfer printing which also not require the use of spacer particles, and so can avoid the above problems.

Viewed from one aspect, the present invention provides a method of dye sublimation transfer printing, in which a dye donor element and a dye receiver element are brought into contact with one another at least at one point, and in which sublimation transfer occurs at a point offset from the contact point, the elements being separated by a gap at the offset.

The invention also provides apparatus for dye sublimation transfer printing, including means for supporting a dye donor element and a dye receiver element in contact with one another at least at one point, and means for causing sublimation transfer of dye from the donor element to the receiver element at a point which is offset from this contact point, the donor and receiver elements being separated by a gap at the offset.

By the invention, the donor and receiver elements are accurately positioned with respect to one another through their contact, whilst a gap is provided by causing transfer at a point offset from the contact. The invention thus provides a simple and inexpensive method of providing a consistent gap between the elements without the need for spacer particles and their accompanying disadvantages.

The gap may be of any suitable size, and may be of the sizes found in prior art sublimation transfer systems. It has been found that gap sizes of between about 8 and about 20 microns provide good results, although gap sizes outside of this range are also possible.

As an example of the invention, a dye transfer print system may typically comprise a dye donor sheet on a flat support plate held in contact with a receiver sheet mounted on a roller, so that the donor sheet makes a line contact with the receiver sheet along the length of the roller. In the prior art, a scanned focused laser spot would have heated the donor sheet at selected points along the line contact, so that dye from the selected areas would either diffuse into the receiver sheet if no spacer particles were used to provide a gap, or would sublime into the receiver sheet if spacer particles were used.

In contrast, by the present invention, the focused laser spot does not scan the donor sheet at its point of contact with the receiver sheet, but scans along a line of the donor sheet parallel to but offset slightly from the line contact. At this offset point, the donor sheet is out of contact with the receiver sheet, and so a small gap exists, which allows for sublimation transfer.

Any suitable arrangement may be used to mount the donor and receiver elements in contact with one another.

In a preferred form, the donor or receiver element is mounted on or passes about an arcuate surface, such as that of a roller. The periphery of for example the roller may provide a good guide path for the element to follow. Also, the roller may rotate to feed the donor and receiver elements through the sublimation point.

In a preferred embodiment, one element may be mounted on a roller and the other on a flat support bed against which the roller is held so as to produce a line contact between the elements at the nip of the roller and flat bed. A laser beam may be used to sublime the dye, and a focused laser spot may be scanned along a line parallel to the line of the nip but offset slightly therefrom, so that there is a gap between the donor and receiver elements at the scan line. The use of a flat support bed is particularly advantageous for ready-mounted 35 mm slides, as they are rigid.

The support bed or the roller may be transparent to the laser light, so that the light may pass through the one or the other to the donor element.

If the support bed is transparent, then the laser may be mounted on the opposite side of the donor and receiver elements from the roller. In this case, the receiver element may be mounted on the bed if it also is transparent to the laser light (if not transparent, it could prevent the light from reaching the donor element). Suitably transparent receiver elements may be, for example, 35 mm slides and overhead projector transparencies.

A transparent support bed and receiver element allows the laser beam to be focused into the front of the donor sheet to generate heat exactly where it is needed, as opposed to passing the beam through the back of the donor element, in which case a greater depth of the donor element is heated.

A further alternative is to use a rod lens, of for example glass. This may act both to hold the donor and receiver elements in contact, and to focus for example a laser beam onto the donor element at the offset. Preferably, the rod lens is used with a flat support bed, the donor and receiver elements contacting at the pinch of the lens and bed.

The rod lens may be rotated as in a roller type arrangement, or may be fixed against rotation.

Where a rod lens is used, a laser beam may pass through the lens at an angle offset from the normal of the support bed opposite which the lens is mounted, so that the lens focuses the laser beam at a position offset from the nip of the lens and support bed.

The use of a rod lens is also advantageous in facilitating the use of inexpensive but powerful multimode laser diodes, which have output beams with high and low divergences in orthogonal axes. Thus, the rod lens can focus a laser diode beam into a dye sheet in the low divergence axis of the beam, whilst, for example, a cylindrical lens may be used upstream of the rod lens for focusing the beam in its high divergence axis. This arrangement allows the beam focus in both axes to remain within the dye sheet during the whole of the scan, without the need for complicated and expensive corrective optics such as an fθ lens.

Where a rod lens is used with for example a dye sheet adjacent thereto, constructive and destructive interference can occur at the interface between the two, producing Newton rings. This can lead to variations in the power transmitted to the dyesheet, and, hence, variations in the print density in the receiver sheet. This problem may be solved by for example providing the lens with an anti-reflective coating and/or the dyesheet with an anti-reflective backcoating. In a preferred embodiment, however, the problem is solved by providing a gap between the lens and the element mounted about the lens, e.g. a dye sheet, at the point where the light exits the lens. The separation of for example the dye sheet from the lens provides an interface of non-parallel surfaces, and this, coupled with for example a convergent laser beam of poor coherence, such as a multimode laser diode, reduces the interference effects.

The provision of a gap to prevent interference effects may also be applied to embodiments where for example a transparent receiver sheet is adjacent the rod lens, or where a transparent roller or other transparent apparatus is used to mount the donor or receiver element.

The gap between the rod lens and for example a dye sheet may be provided in any suitable manner. Preferably, the gap is at least about 25 microns.

The gap between the lens and dye sheet may be formed for example by positioning a guide roller for the dye sheet (mounted to one side of the rod lens), in such a manner as to guide the dyesheet between the lens and a support bed at a shallow angle to the support bed, so that a suitable gap is formed between the dyesheet and the lens, and between the dyesheet and a receiver sheet on the support bed.

In another embodiment, spacer means may be provided on the rod lens. The spacer means may be provided either to one side of the dye transfer point or on opposite sides of the transfer point, or the spacer means may have an aperture therein at the transfer point. In each case, the spacer means provides an area adjacent thereto on the surface of the lens at which the dye sheet is spaced from the lens. The spacer means may for example take the form of tape which may for example comprise standard adhesive tape or any other suitable tape, or a thin piece of any suitable material mounted on the surface of the lens.

A still further method of obtaining a gap between the rod lens and the donor or receiver element adjacent thereto is to provide a groove along the length of the rod lens (e.g. by machining or moulding) at the point where the beam exits the lens. The width of the groove should be large enough to accommodate the width of the beam at that point, and the bottom of the lens should be formed as a final focusing surface chosen so as to obtain a sharp focus of the beam into the dye donor element, which passes across the top of the groove.

Instead of using a rod lens in the inventive printing apparatus, a cylindrical lens could be used in a similar manner.

In a further alternate embodiment for providing the sublimation gap between the donor and receiver elements, both the donor and receiver elements could pass about an arcuate surface, such as that of a roller, one upon the other, so that they contact one another against the periphery of e.g. the roller about an arc thereof. The elements are preferably held in tension, and are preferably guided by one or more guide rollers either side of the main roller. Again, a laser beam may be used to sublime the dye. If the laser beam is on the opposite side of the donor and receiver to the roller/arcuate surface, then the donor should be between the laser and the receiver, unless the receiver is transparent to the laser light. The arcuate surface could also be provided in other ways, and the roller could for example be replaced by a rod lens or a cylindrical lens.

In general, the separation of the donor and receiver elements will be greater, the further the offset is from the point of contact, at least over a small distance from the point of contact. Therefore, it is possible to vary the gap size by relative movement of the sublimation point and the contact point. For example, in one embodiment, a focused laser spot may be moved relative to the nip of a roller and support bed to vary the gap size. Alternatively, if the receiver and the donor pass about rollers under tension, one or more of the rollers may be moved so as to cause the donor and receiver to contact one another along a greater or lesser arc of the roller, thereby moving the end point of the contact area of the two elements closer to or further from for example a fixed laser spot scan position. This embodiment therefore allows the gap size to vary without having to move the sublimation point, e.g. the laser spot scan position.

In practice, in any of the above embodiments, the offset is chosen to produce a desired image pixel size (for a given laser spot size), rather than a desired gap size, the pixel size being a function of the gap size, because the dye spreads out as it travels across the gap. Typical gap widths may be between about 8 and about 20 microns, although other sizes are possible. The sublimation process is quite robust, tolerating significant variations. If the gap is less than 8 microns, however, then the probability of solid welding (and therefore sticking) between a dye sheet and receiver sheet may increase, leading to catastrophic printing failure. A gap larger than 20 microns may lead to a mottling effect on the print due to physical mechanisms where the sublimed dye tends to aggregate.

The offset may be either before the point where the donor and receiver elements contact, during the approach of the elements to each other, or after contact, during their separation. The latter may have the advantage that the donor and receiver do not touch one another after transfer, and so there are no problems with regard to for example smearing of the transferred dye.

As well as the accurate provision of a gap by having the donor and receiver elements contact one another and by offsetting the transfer from the contact point, the invention as said above also provides an excellent way of varying the gap by varying the offset. This latter point is an invention in itself, and is not limited to systems in which the donor and receiver elements contact one another. For example, in a system in which one of the donor and receiver elements is mounted on a flat surface, and the other is mounted about a platen roller, the roller may have flanges at its ends, which contact the flat surface or element mounted thereon to define the gap. In such a system, it would be thought conventional to transfer dye at the point of closest approach of the donor element to the receiver element. By the present invention, however, the transfer may be carried out at a point offset from this closest approach in order to provide a desired gap distance or image pixel size. Thus, the offset may allow the gap to be varied. It may be also that the flanges may provide a rough gap distance, with the offset providing fine tuning.

The invention therefore extends to a method of dye sublimation transfer printing in which sublimation transfer occurs from a dye donor element to a dye receiver element at a point offset from a point at which the donor and receiver elements are at their closest to each other. The invention further provides apparatus for dye sublimation transfer printing, including means for supporting dye donor and receiver elements, and means for causing sublimation transfer of dye from the donor element to the receiver element at a point which is offset from a point at which the donor and receiver elements are closest to each other.

The above arrangement of a flanged platen roller is itself an advantageous way of providing a gap without spacer particles, and, from a further aspect, the invention provides dye sublimation transfer printing apparatus, in which a dye donor element or a dye receiver element is mounted on a platen roller, with the other of the donor or receiver elements mounted on a flat support, the platen roller being flanged at or towards its ends, with the flanges contacting the flat support, or the element mounted thereon, so as to define a gap between the two elements.

The invention also extends to a method of dye sublimation transfer printing, in which a dye donor element or a dye receiver element is mounted on a roller having flanges at or towards its ends, which define a gap between the elements.

In this aspect of the invention, the thickness of the element about the roller should be carefully controlled, as it affects the size of the gap. This is also true of the element on the flat support, unless the flanges contact the element itself rather than its support, in which case the element's thickness does not affect the gap.

Overall, the provision of sublimation transfer printing systems which do not need the use of spacer particles is especially advantageous in fields in which the images are magnified before viewing, so that even small flaws in the image are visible, e.g. 35 mm slides.

Although mention has mainly been made of the use of a laser beam to heat the dye donor element, any suitable method of causing sublimation may be used, including the use of heating elements or ultrasound, and instead of a laser beam, such as from a laser diode, it would also be possible to use for example LEDs.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a side elevation of a first embodiment of the invention;
Figure 2 shows a side elevation of a second embodiment of the invention;
Figure 3 shows a side elevation of a third embodiment of the invention;
Figure 4 shows a more detailed view of the Fig. 3 embodiment in the region of the nip;
Figure 5 shows a variation on the embodiment of Figure 3;
Figure 6 shows a more detailed view of a further variation on the embodiment of Figure 3 in the region of the nip;
Figure 7 shows a further variation on the embodiment of Figure 3; and
Figures 8 and 9 show respectively front and side elevations of a fourth embodiment of the invention.

Referring to Fig. 1, a dye donor ribbon 1 passes about a platen roller 2, and is held in contact with a dye receiver sheet 3 mounted on a flat support plate 4. The donor ribbon 1 and receiver sheet 3 contact one another at a point A, along the length of the roller 2, i.e. at the nip of the roller 2 and plate 4.

The support plate 4 and receiver sheet 3 are transparent to a laser beam 5 to allow the beam 5 to reach the donor ribbon 1. For example, the plate 4 may be made of glass and the receiver sheet 3 may be a transparency for an overhead projector or a 35 mm slide.

The dye donor ribbon 1 and receiver sheet 2 may of course take any other suitable form, and may comprise any standard dye and receiver ribbons/sheets provided that the dyesheets are designed to absorb laser radiation.

A typical dyesheet/ribbon may comprise a polyester base material of for example 23 microns which supports a dye donor layer of dye, a binder and an infrared absorber. The binder locks the dye and infrared absorber together and onto the base material, and the infrared absorber absorbs the laser energy and converts it to heat thereby causing the dye to sublime out of the dye sheet and condense onto the receiver sheet.

A typical receiver sheet may comprise a polyester base material of for example 75 microns which supports a dye receiver layer of a suitable resin for absorbing the sublimed dye.

Various such dye and receiver sheets are well-known in the art.

The laser beam 5 may be produced by any suitable source, such as a laser diode source 6, and may be scanned and focused using any suitable system. Fig. 1 shows schematically a standard scanning arrangement comprising collimating and focusing optics 7,8 and a galvanometer mirror 9, the optics 8 being a standard fθ lens which corrects the focus of the beam 5 to scan such that the ultimate focal spot position will be proportional to the mirror deflection angle.

In contrast to the prior art, a focused spot of the laser beam 5 is not scanned across the dye sheet 1 at A, where the ribbon and sheet contact one another, but is aimed at the dye ribbon 1 a small distance away from A, where the ribbon 1 and sheet 3 are apart. This provides a gap 10 at the point of transfer. As the donor ribbon 1 and the receiver sheet 3 are held firmly together between the roller 2 and support plate 4, they are accurately positioned with respect to one another, and so the gap 10 is accurately maintained.

An image is produced in the receiver sheet 3 line-by-line by moving the receiver sheet 3 and donor ribbon 1 relative to the focused spot of the laser beam 5 as the spot scans across the width of the donor ribbon 1. The output of the laser source 6 is modulated so that the beam 5 heats selected regions of the donor ribbon 1 during each scan to cause dye from those regions to sublime, cross the gap 10, and condense onto the relatively cool receiver sheet 3. The system could work either with the platen roller 2 and laser scan position fixed, whilst the support plate 4 moves, or with the roller 2 and beam 5 moving in tandem over a fixed plate 4. In both cases, the roller 2 may rotate to forward fresh regions of the donor ribbon 1 and reduce friction.

Transfer may take place at an offset which is either before or after the contact of the donor ribbon 1 with the receiver sheet 3.

A colour image may be formed by passing the receiver sheet 3 through the system multiple times, each time with a different colour donor ribbon 1, for example of yellow, magenta and cyan, or by using a single donor ribbon which has regions of different colour along its length or width.

The focused spot of laser beam 5 and the roller 2 may be relatively movable so that the amount of offset of the laser scan from the point of contact of the donor ribbon 1 with the receiver sheet 3 may be varied to thereby vary the width of the gap 10. In practice, the offset would be varied until a desired image pixel size was produced in the receiver, the pixel size being related to the gap width because the sublimed dye spreads out as it is transferred. Typically, the gap size could be between about 8 and about 20 microns, although other gap sizes are possible as are used in for example prior art sublimation systems.

Fig. 2 shows a second embodiment, in which the receiver sheet 3 is wound about a platen roller 2. The dye donor ribbon 1 is mounted in tension between a pair of guide rollers 11, 12, and is held by the rollers 11, 12 in contact with the receiver sheet 3 about a portion of the platen roller 2. As in the first embodiment, the focused spot of laser beam 5 does not scan over the donor ribbon 1 where the ribbon 1 contacts the receiver sheet 3, but rather at a point offset therefrom, where the ribbon 1 and sheet 3 are apart to provide the required gap 10 for sublimation transfer. A stepper motor 13 may be provided to rotate the roller 2 and advance the receiver sheet 3 by one line after each scan.

In this embodiment, the gap 10 between the donor ribbon 1 and receiver sheet 3 can be varied by moving roller 12 to the left or right, rather than by having to move the scan position of the spot of laser beam 5. By moving the roller 12 to the left in Fig. 2, the donor ribbon 1 contacts the receiver sheet 3 for a greater distance about the platen roller 2, and so the offset of the focused spot of beam 5 from the last point of contact of the elements is reduced, thereby reducing the width of the gap 10. Moving the roller 12 to the right produces the opposite result.

An arrangement similar to that described in the second embodiment was put into practice using a 75 μm receiver ribbon 3 which, in this case, was stuck to a metal platen roller 2 of 50 mm diameter. A dye donor ribbon 1 of 23 μm thickness was held in contact with the receiver ribbon 3 by a rubber roller 11 operating against a clutch to maintain tension. The donor ribbon 1 passed over a second rubber roller 12 50 mm away from the point at which the donor ribbon 1 lost contact with the receiver ribbon 3.

A laser beam 5 of 810 nm wavelength was focused onto the donor ribbon 1 at the point at which the separation between the donor ribbon 1 and the receiver ribbon 3 gave a gap 10 of 5 μm. The beam 5 was the combined output from two SDL-5422 150 mW lasers 6 and was measured as 105 mW at the point of absorption by the IR absorbers in the dye coat of the donor ribbon 1. The laser spot size was 20 μm, and this spot was scanned parallel to the axis of the platen roller 2 at the 5 μm gap offset by a galvanometer mirror 9. After each line was printed, the platen 2 was rotated by a stepper motor 13 to advance the receiver ribbon 3 by one line.

By controlled modulation of the laser beam, images were printed on the receiver ribbon 3. A uniform area of cyan was printed giving an optical density on transmission of 1.57 as measured using a Sakura PDA 65 densitometer.

Figs. 3 and 4 show a third embodiment, which is similar to the first but uses a glass rod lens 14 instead of a rotating platen roller 2. The laser beam 5 is focused by this lens 14 into the donor ribbon 1, which passes about the lens' periphery, thereby causing dye 15 to sublime onto the receiver sheet 3. The centre axis 5a of the optical path of the laser beam 5 is at an angle α to the normal 4a of the support plate 4, so that the glass rod lens 14 focuses the beam 5 to a point B on the donor ribbon 1 offset from the point of contact C of the donor ribbon 1 with the receiver sheet 3. The donor ribbon 1 may be moved past the lens 14 by spools 16 and 17.

This embodiment does not require the support plate 4 or receiver sheet 3 to be transparent to the laser beam 5, and utilises less parts, as the glass rod lens 14 acts both to hold the dyesheet 1 in contact with the receiver sheet 3, and to focus the laser beam 5 into the dyesheet 1 at the offset. This provides a compact arrangement. Further, the offset and so the size of the gap 10 may be varied by varying the angle α of the laser beam 5 with respect to the normal 4a.

With final focusing being achieved through the rod lens 14, the arrangement facilitates the use of a multimode diode laser beam 5 with the multimode (low divergence) axis normal to the longitudinal axis of the lens 14.

Thus, in a typical arrangement, the laser beam 5 may be provided by a multimode laser diode 6, which produces a beam 5 having a high divergence axis and a low divergence axis. The beam 5 is first collimated by a collimating lens 18 and converged in its high divergence axis by a cylindrical lens 19 so as to come to a focus in that axis at the dye sheet 1. The beam 5 is then deflected by a scanning mirror 9, such as a galvanometer mirror or a rotating polygon mirror, so as to scan the beam 5 along the length of the rod lens 14 and across the width of the dye sheet 1, the rod lens 14 focusing the beam 5 in its low divergence axis onto the dyesheet 1.

The rod lens 14 itself may be of standard design, well-known in the art. Preferably, however, it is made from a higher than usual refractive index glass, so that it brings the beam 5 to a focus at a point which is closer to its surface than it would be for a rod lens made of standard glass, such as BK7, i.e. to a point within the dye sheet 1 mounted on its periphery.

A problem which may be encountered in the use of a rod lens system is that interference may occur at the interface between the dye sheet 1 and the rod lens 14, producing Newton rings and leading to variations in the power transmitted to the dyesheet 1 and, hence, variations in the print density of the image on the receiver sheet 3. To overcome this, the dyesheet 1 may be spaced from the surface of the rod lens 14 at least in the region of the dye transfer, at the point where the beam 5 exits the lens 14. This gap is preferably at least about 25 microns.

The spacing between the lens and the dye sheet may be produced in any suitable manner. In one method, the position of the guide roller 17 is chosen so that the gap between the lens 14 and the dye sheet 1, and the gap between the dye sheet 1 and the receiver sheet 3 are of suitable sizes.

A further alternative for producing a gap between the dyesheet 1 and rod lens 14 is to provide spacer means on the lens itself. Figs. 5 and 6 show the use of such spacer means, especially for use where the rod lens 14 does not rotate.

In Fig. 5, spacer tape 20, comprising any suitable tape, such as standard adhesive tape, typically from about 20 to about 50 microns thick, is provided on the surface of the rod lens 14 to one side of the point B at which the laser beam 5 exits the rod lens 14 (alternatively, a thin piece of any suitable material may be provided on the surface of the lens 14). The tape 20 causes the dyesheet 1 to be spaced from the rod lens 14 in the region between the end of the spacer tape 20 and the nip of the rod lens 14 and support bed 4.

In Fig. 6, spacer tape 20 is provided either side of the point B where the laser beam 5 exits the lens 14.

Fig. 7 shows a further alternative method of achieving the gap, in which the rod lens 14 has a groove 21 machined or moulded along its length. The bottom 22 of the groove 21 is formed so as to provide a final focusing surface for the beam 5, to focus the beam into the dyesheet 1, which passes across the top of the gap. The gap width should be wide enough to accommodate the width of the beam 5 at that point.

All of the above embodiments provide systems for dye sublimation transfer printing, in which spacer particles are not needed in the donor or receiver to produce the gap, so that the mottling these particles normally produce in the final print can be avoided. This is especially advantageous in the case of prints which are magnified for viewing, such as 35 mm slides.

It should be noted that the gaps shown in the figures are somewhat exaggerated, and that they will typically be of the order of microns in width, e.g. between 8 and 20 microns. Also, care should be taken to avoid fluting of the donor or receiver (i.e. ripples produced in a sheet when it is under tension). This may be achieved for example by having a short distance between guide rollers, and ensuring that their axis are accurately aligned.

A fourth embodiment shown in Figs. 8 and 9 is somewhat different to the previous embodiments, in that it does not require an offset to produce a gap. The embodiment is similar to Fig. 1, except that the platen roller 2 has flanges 23 at each end which contact with the receiver sheet 3 to define the gap 10. Although an offset is not necessary, it may still be used to vary the width of the gap, so that for example the same platen roller may be used to provide different sizes of gap. An offset may also provide a fine tuning to the desired width of the gap, so that the tolerances of the flanges may be reduced.

An advantage of this system is that the donor and receiver sheets/ribbons never contact. This prevents any deformation of dye previously deposited by a previous print pass in colour printing. A possible disadvantage of this system is that the thickness of the donor ribbon must be well controlled in order to maintain a consistent gap. If the donor ribbon thickness increases, then the gap between the surface of the donor ribbon and the receiver sheet decreases, and vice versa.

In the system shown, the flanges 23 run on the periphery of the receiver sheet 3, so that the thickness of the receiver sheet 3 does not affect the width of the gap 10. It would however also be possible to contact the flanges 23 directly with the support plate 4, in which case the thickness of the receiver sheet should be closely controlled also.

The above embodiments are only examples of how the present invention may be put into practice, and various alternatives are also possible. For example, the positions of the donor and receiver sheets/ribbons may be reversed in the above embodiments, although this may require various other changes to the systems to ensure that the laser beam may reach the donor ribbon/sheet, e.g. by using appropriately transparent parts. Also, instead of a roller, any other suitable arcuate surface may be used, and instead of a rod lens, a cylindrical lens could be used. Further, the dye sublimation may be carried out by any suitable means other than a laser, e.g. by using LEDs or focusable forms of energy other than light.

Claims

1. A method of dye sublimation transfer printing, in which a dye donor element and a dye receiver element are brought into contact with one another at at least one point, and in which dye is transferred to the receiver element at a point offset from this point of contact, the donor and receiver elements being separated by a gap at the offset point.

2. The method of claim 1, wherein one of the donor or receiver elements is mounted on or passes about an arcuate surface.

3. The method of claim 1, wherein one of the donor or receiver elements is mounted on or passes about a roller.

4. The method of claim 3, wherein one element is mounted on the roller and the other is mounted on a flat support bed, the elements being held in contact between the roller and the bed to provide the point of contact.

5. The method of claim 4, wherein a laser beam is used to heat the donor element to cause dye transfer, and wherein the flat support bed is transparent to laser light.

6. The method of claim 5, wherein the receiver element is mounted on the flat support bed, and is also transparent to laser light.

7. The method of claim 3, wherein both the donor element and the receiver element pass about the roller one upon the other, the elements being tensioned to be held against a portion of the periphery of the roller.

8. The method of claim 1, wherein a laser beam is used to heat the donor element to cause dye transfer, and wherein the beam is focused into the dye donor element using a cylindrical lens.

9. The method of claim 1, wherein a laser beam is used to heat the donor element to cause dye trans-

fer, and wherein the beam is focused into the dye donor element using a rod lens.

10. The method of claim 9, wherein the rod lens rotates.

11. The method of claim 9 or 10, wherein the laser beam is produced by a laser diode, and wherein the rod lens is used to focus the low divergence axis of the beam onto the donor element.

12. The method of claim 11, wherein said laser diode comprises a multimode laser diode.

13. The method of claim 9, 10, 11 or 12, wherein a gap is provided between the element adjacent to the rod lens and the rod lens, at the point where the laser beam exits the rod lens.

14. The method of claim 13, wherein the gap is provided by spacer means mounted on the rod lens.

15. The method of claim 14, wherein the spacer means comprises tape or a piece of suitably thin material mounted on the lens.

16. The method of any preceding claim, wherein the receiver element comprises a transparency.

17. The method of claim 16, wherein the receiver element comprises a slide transparency or overhead projector transparency.

18. Apparatus for dye sublimation transfer printing, including means for supporting a dye donor element and a dye receiver element in contact with one another at at least one point, and means for causing sublimation transfer of dye from the donor element to the receiver element at a point which is offset from the point of contact, the donor and receiver elements being separated by a gap at the offset.

19. The apparatus of claim 18, wherein an arcuate surface is provided about which one or both of the elements is mounted or passes.

20. The apparatus of claim 18, wherein a roller is provided about which one or both of the elements is mounted or passes.

21. The apparatus of claim 18, wherein a laser source is provided for providing a laser beam to heat the donor element, and wherein a cylindrical lens is provided for focusing the laser beam onto the donor element.

22. The apparatus of claim 18, wherein a laser source is provided for providing a laser beam to heat the donor element, and wherein a rod lens is provided for focusing the laser beam onto the donor element.

23. The apparatus of claim 22, wherein the rod lens rotates.

24. The apparatus of claim 22 or 23, wherein the laser source is a laser diode, and wherein the rod lens focuses the low divergence axis of the beam from the rod lens into the donor element.

25. The apparatus of claim 24, wherein the laser diode is a multimode laser diode.

26. The apparatus of claim 22, 23, 24 or 25, wherein spacer means are provided for spacing the donor or receiver element adjacent to the rod lens from the surface of the rod lens at the point where the laser beam exits the rod lens.

27. The apparatus of claim 26, wherein the spacer means is mounted on the rod lens.

28. The apparatus of claim 27, wherein the spacer means comprises a thin piece of material or tape provided on the surface of the rod lens.

29. A method of dye sublimation transfer printing in which a dye donor element and a dye receiver element are made to approach and or recede from each other, and in which sublimation transfer occurs at a point offset from the point at which the donor and receiver elements are at their closest to each other.

30. The method of claim 29, wherein the donor and receiver elements contact one another at their closest point.

31. Apparatus for dye sublimation transfer printing, including means for supporting dye donor and dye receiver elements so that they approach and/or recede from each other, and means for causing sublimation transfer of dye from the donor element to the receiver element at a point which is offset from the point at which the donor and receiver elements are closest to each other.

32. A system for dye sublimation transfer printing, in which a dye donor element or a dye receiver elements is mounted on a substantially flat surface, and the other element is mounted about a roller, the roller having flanges towards or at its ends, which contact the flat surface or the element mounted thereon to define a gap between the two elements.

33. A method of dye sublimation transfer printing, in which a gap is provided between a dye donor element and a dye receiver element by flanges at or towards the ends of a roller supporting one of these elements.

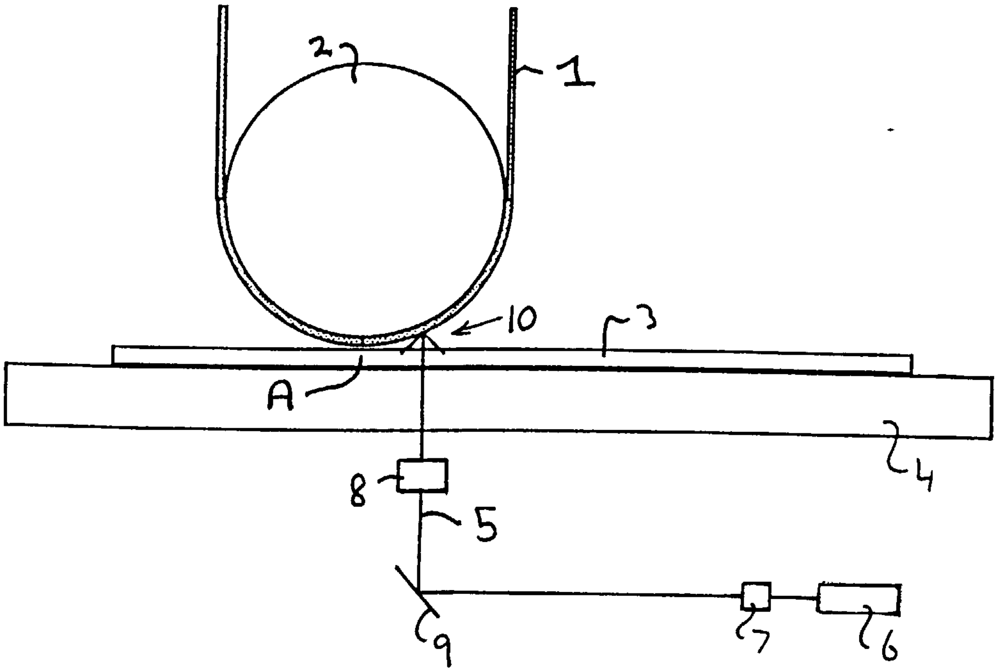

Fig. 1

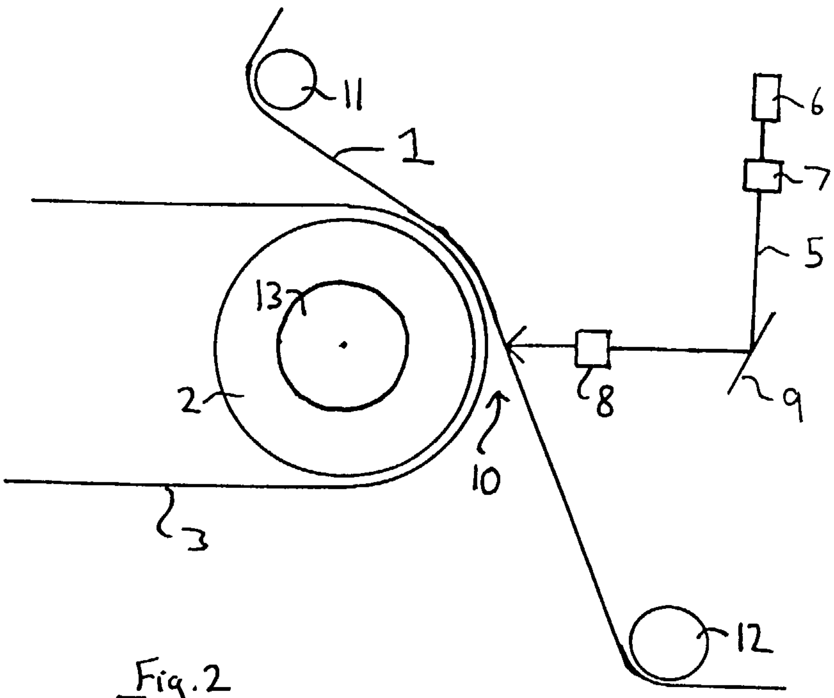

Fig. 2

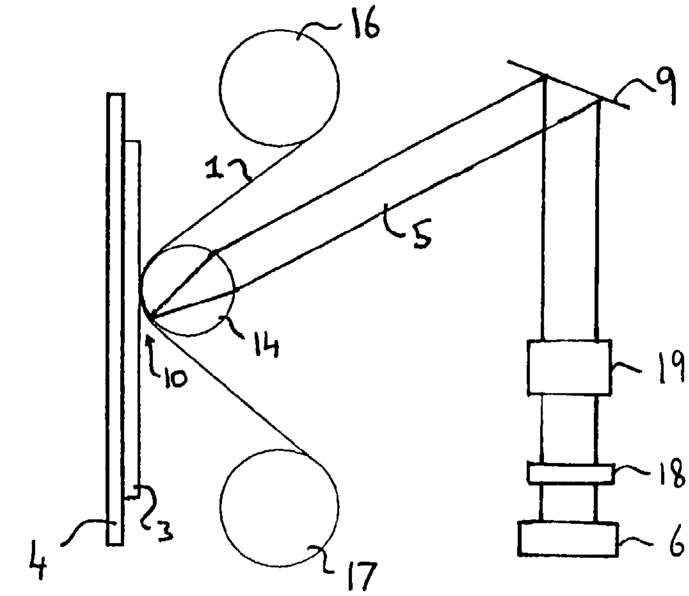

Fig. 3

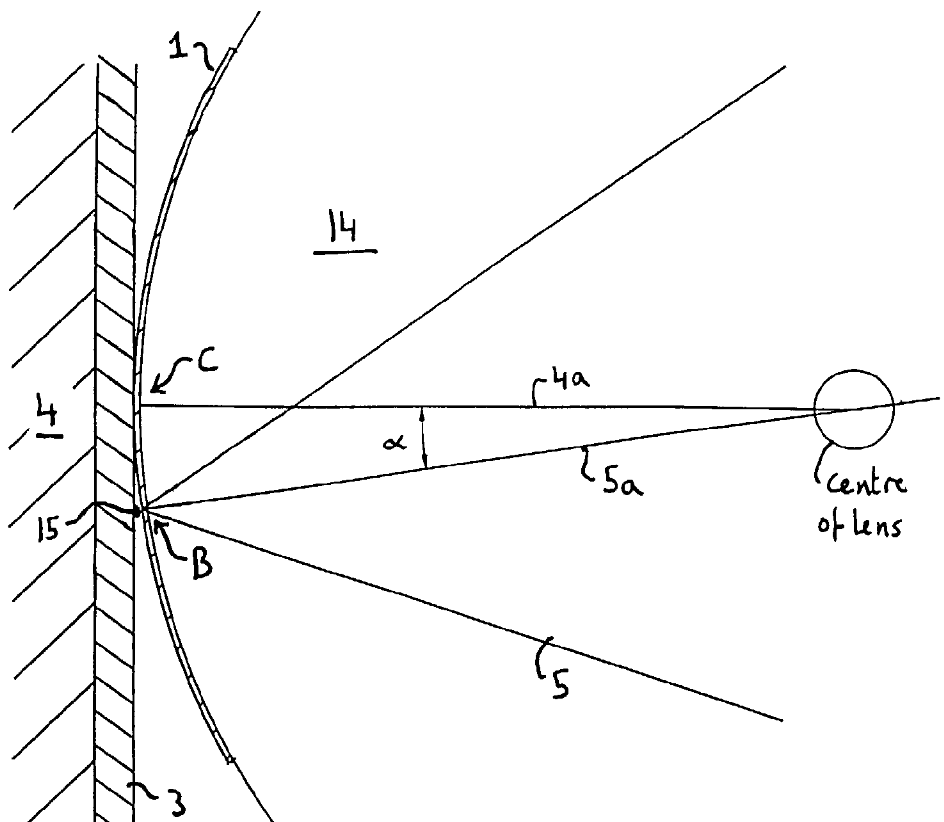

Fig. 4

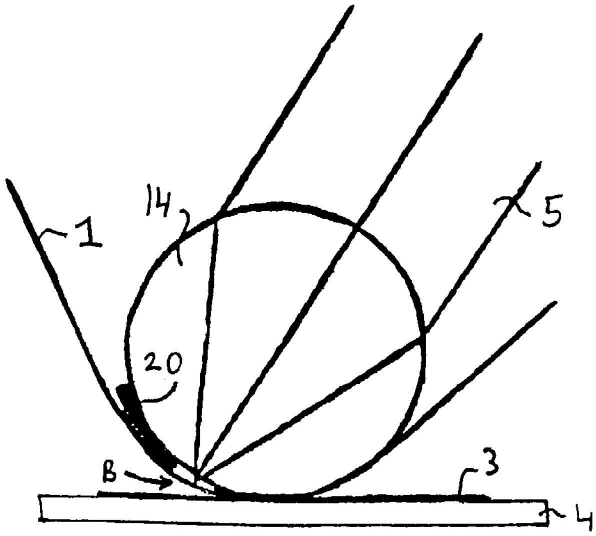

Fig. 5

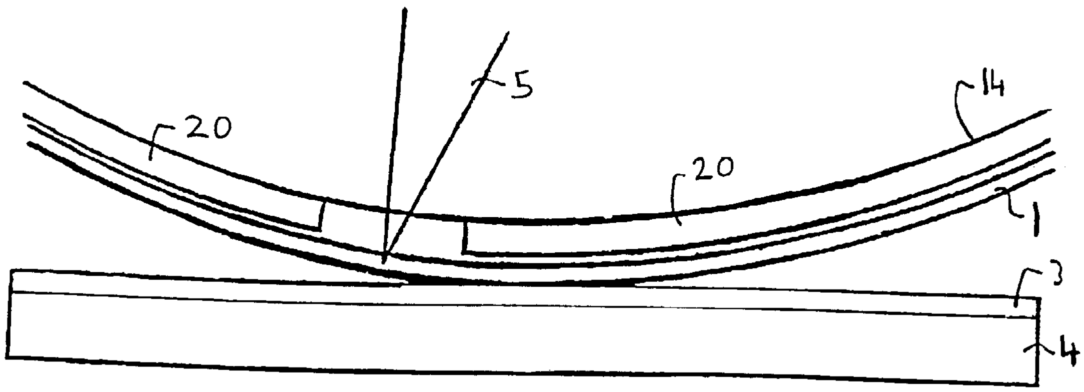

Fig. 6

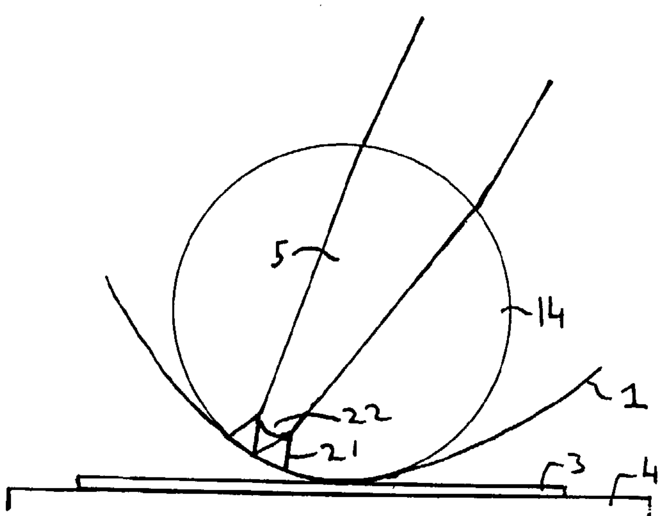

Fig. 7

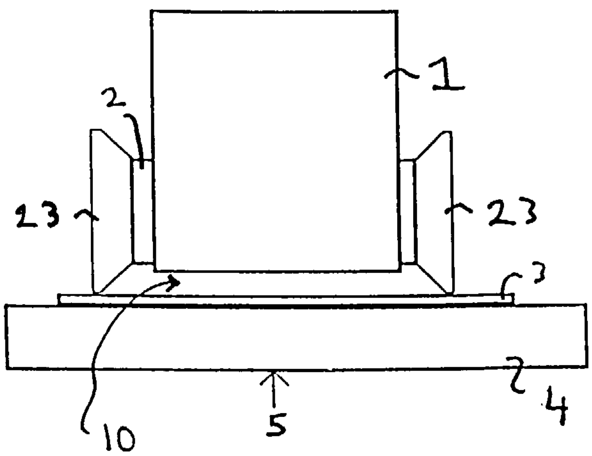

Fig. 8

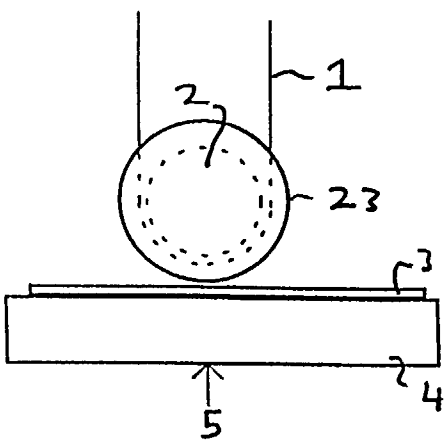

Fig. 9