

Description

This invention relates generally to ink jet printing and more particularly to an improved ink jet printer having a constant heat flux evaporative dryer. This dryer provides uniform drying of ink on paper and is economical in construction.

In the past, paper output from an ink jet printer was either allowed to dry naturally without any special heating or drying schemes, or it was heated in a non-uniform manner, usually with a drying system which was not directly a part of the ink jet printer. See, for example, US-A-4095234 and US-A-4501072 for examples of non-uniform paper drying systems. In the case of the natural drying method, there is normally insufficient time elapse between ink printing and paper stacking or the like, thereby causing ink smearing to occur. In known non-uniform heating and drying systems, the non-uniform heat flux into the paper often produce hot spots in the paper, and this drying non-uniformity requires some type of compensation treatment for either the paper or the paper handling system or both.

Patent Abstracts of Japan, Kokai number 55-107490 discloses a method of drying the ink printed on paper in an ink jet printer. Ink printed on recording paper is dried by passing the paper around a dryer. A microwave generating tube generates microwaves inside the dryer which are reflected and absorbed by the drying of the ink.

Patent Abstracts of Japan, Kokai number 57-120447 describes an ink-jet recording device in which a far-infrared heater is fitted. A reflection board mounted at the back of the heater prevents the far-infrared rays from hitting any part other than the recording paper sheet.

The general purpose of this invention is to provide a new and improved paper handling and ink drying apparatus which is part of an ink jet printer, and an associated method of drying paper which overcomes the above disadvantages of the prior art.

According to the invention, there is provided an ink jet printer comprising : an input paper tray, an output paper collection tray, means for feeding paper from the input paper tray to an ink printing position where it receives ink from an adjacent ink jet printhead, to a drying position where the ink is dried by a heating means, and to a collection position where it is received by the output paper collection tray, said drying position including a heat-reflective curved surface around the inside of which the paper is passed ; characterised in that : the curved surface forms an approximate 180° arc ; and the heating means radiates heat uniformly to the curved surface.

The above objects, advantages and other novel features of this invention will become more readily apparent in the following description of the accompanying drawings.

Figure 1 is a schematic isometric view of an ink jet printer apparatus according to the invention and showing the 180° contoured drying area at the end of the printer.

Figure 2 is an elevation view looking into the right hand side of Figure 1 and showing paper movement from the input tray to the output tray.

Referring now to Figure 1, there is shown an ink jet printer which is designated generally 10 and includes an input paper collection tray 12 of rectangular construction and mounted on the front side of the printer 10. The input paper collection tray 12 is vertically aligned as shown with an output paper collection tray 14 to facilitate the front loading and front removal of both the unprinted and printed paper, respectively, from the printer 10.

The paper 16 in the input paper tray 12 is fed between a pair of pinch drive rollers 18 and 20 which are driven by a motor 22 located as shown on the left hand side of the printer.

The motor 22 drives a belt 23 which is connected to drive the horizontal shafts for both upper and lower sets of drive rollers as described herein in order to move the sheets of paper from the input tray 12 to the output tray 14 during an ink jet printing operation. The sheets of paper 16 are driven past the pinch drive rollers 18 and 20 and into a print area 24 beneath an ink jet printhead 26 located on the right side of the printer.

The ink jet paper tray 12, the drive rollers 18 and 20, the printhead 26, and the paper drive motor 22 are of conventional construction well known to those skilled in the thermal ink jet and related printing arts. These components are therefore shown schematically in the drawings and for sake of simplicity are not described in mechanical detail herein. However, for a further discussion of some of the mechanical construction details of paper drive means and associated transport mechanisms for an ink jet printhead, reference may be made to copending application Serial No. (PD 8554-176) of Steven O. Rasmussen et al entitled "LOW COST THERMAL INK JET PRINTER", assigned to the present assignee and incorporated herein by reference. Also, for a further discussion of many other aspects of thermal ink jet technology, reference may be made to the Hewlett Packard Journal, Vol. 36, No. 5, May 1985, also incorporated herein by reference.

Referring now to Figure 2, this elevation view shows by arrows 28 the path of paper movement as it exits the print area 24 beneath the ink jet printhead 26. This path extends along the inner contoured semi-cylindrical surface area 30 of a first or outer heat reflector 32. The paper path 28 continues to the uppermost region 34 of the heat reflector 32 and passes through a pair of output drive rollers 36 and 38 and into the output paper collection tray 14.

The paper drying system and apparatus of the present invention further includes an elongated

infrared heat source 40 which is positioned as shown adjacent a second or inner heat reflector 42. The inner heat reflector 42 includes an elongated trough portion 44 which has its longitudinal axis of symmetry coincident with the longitudinal central axis of the elongated infrared bulb 40. The flat surface of the inner reflector 42 lies in the same plane which contains the central axis of the infrared bulb 40, whose typical bulb diameter is between 0.635 and 0.9525 cm (0.25 and 0.375 inches). The bulb 40 has a filament 48 which extends along the central axis of the bulb 40, and the length of the bulb 40 is approximately 22.86 cm (9 inches), or slightly wider than the width of the paper 16. The tungsten filament 48 is designed to emit a uniform heat flux from end to end and is supported in an evacuated quartz tube. The spacing from the filament 48 to the second reflector 44 will typically be between 1.27 and 5.08 cm (0.5 and 2 inches). This infrared heater device 40 may be obtained from the General Electric Company of Schenectady, New York.

The reflectors 32 and 42 are fabricated of aluminum and are treated so as to have highly polished aluminum inside surfaces. These reflectors are also slightly wider than the width of the paper 16, or approximately 22.86 cm (9 inches) for a typical width of 21.59 cm (8.5 inches) for the paper 16. Typically, the distance from the filament 48 to the outer reflector 32 is in the range of 3.81 to 8.89 cm (1.5 to 3.5 inches), or comparable to the actual distances shown in Figure 2 of the drawings.

The infrared and visible radiation 50 from the filament 48 is transmitted from the right hand surface of the bulb 40 and directly through the paper 16, then to the interior surface 30 of the reflector 32 and then back through the paper 16. For infrared radiation 52 transmitted from the left hand surface of the bulb 40, the transmission path is from the filament 48 and directly to the semi-cylindrical surface 54 of the trough portion 44 of the reflector 42. This radiation 52 is then reflected back over its direct transmission path and passes directly as reflected radiation 56 in a direction as shown to the interior surface 30 of the first reflector 32.

The heat flux from the infrared bulb 40 will vary typically from zero up to 62 kJm^{-2} (40 joules per square inch) at the reflector 32, and these values correspond to a paper speed ranging from zero to 5.08 cms^{-1} (2 inches per second). The general relationship between the power input to the bulb filament 48 and the speed of the paper is established by the product of the power density, P , at the paper and the ink drying time, T . This product is equal to a constant at a constant humidity. Thus, if it takes 46.5 kWm^{-2} (30 watts per square inch) to dry the print in one second, then it will take approximately 6.51 kWm^{-2} (4.2 watts per square inch) to dry the print in seven seconds.

The paper entering the dryer as indicated by the lower arrow 28 will follow the semi-cylindrical contour

of the inner surface 30 of the first or outer reflector 32. The dynamic friction between the leading edge 60 of the paper 16 and the reflector 32 causes the paper to follow this contour along an approximate 180° surface path and to the output rollers 36 and 38 as indicated. The paper 16 which is ejected from the rollers 18 and 20 is sufficiently stiff so as to force the leading edge 60 of the paper 16 against the reflector surface 30 and hold it against this surface 30 during its motion along the 180° path as indicated. When the paper 16 is stacked in the output collection tray 14, it is stacked face down in the correct order with page 1 followed by page 2 by page 3 and so on.

The drive rollers 18 and 20 are typically made of urethane, whereas the drive rollers 36 and 38 are usually fabricated from silicone rubber because of the heat of the paper leaving the drying area.

In accordance with one advantage of the present invention, the per page processing speed was increased from 2 minutes per page using no dryer at all to 13 seconds per page using the uniform dryer described and claimed herein. This feature represents a speed performance increase of 923%. Using non-uniform drying techniques in the prior art, it has been possible to increase paper drying times to only approximately 30 seconds per page. This latter maximum attainable speed was limited by the fact that browning of paper occurred on paper jams (due to hot spots) where correspondingly higher non-uniform elevated temperatures were attempted in order to further increase the paper transport speed.

The axis of symmetry of the interior semi-cylindrical surface 30 of the first reflector 32 is also the longitudinal axis of the infrared filament 48. Thus, all direct radiation 50 emitted by the filament 48 and absorbed by the paper 16 travels over a constant radius from the infrared bulb 40 to the paper 16. Therefore, the heat flux 50 at the paper surface is uniform. On the other hand, the reflected radiation 52 which is transmitted first to the curved inner surface 54 of the reflective trough 44 is reflected off of this surface and travels a longer, but also constant, radius and produces a real image of the direct radiation pattern at the filament 48. This reflected radiation then follows the same radiation path as the path of the direct radiation 50. Thus, both the direct and reflected radiation from the IR bulb 40 produce a uniform heat flux over the 180° contoured inner surface area 30 over which the paper 16 travels along the path 28 and to the output paper collection tray 14.

Typically, the size and spacing of the various components of the printer are such that the trailing edge 58 of a cut sheet of paper 16 will be about half way out of the input tray 12 as its leading edge 60 is approaching the half way point 62 around the 180° contoured paper path 30. These trailing and leading edges 58 and 60 are also shown for the sheet of paper 16 as it continues its upward movement counterclock-

wise along the inner contoured surface 30 and through the output drive rollers 36 and 38 and into the output collection tray 14. In this fashion, the drying surface area may be minimized while insuring that the paper 16 is received by the output rollers 36 and 38 before leaving control of the input drive rollers 18 and 20.

Thus, there has been described a novel and extremely useful uniform paper drying method and apparatus for an ink jet printer. This apparatus is elegantly simple in construction and is particularly adapted for integration into conventional ink jet printing systems. Furthermore, this method and apparatus are reliable in the uniform paper drying operation, and such apparatus is economical to manufacture relative to some of the mechanically complex prior art paper handling and drying systems.

Various modifications may be made in the construction and operation of the above described embodiment without departing from the scope of this invention. For example, the materials and the exact shapes, sizes and geometries of the various components comprising the constant heat flux dryer may be changed and/or modified by those skilled in the art within the scope of the following appended claims.

Claims

1. An ink jet printer comprising :
an input paper tray (12),
an output paper collection tray (14),
means (18, 20 ; 36, 38) for feeding paper from the input paper tray to an ink printing position where it receives ink from an adjacent ink jet printhead (26), to a drying position (30) where the ink is dried by a heating means (40), and to a collection position where it is received by the output paper collection tray, said drying position including a heat-reflective curved surface (32) around the inside of which the paper is passed ; characterised in that :
the curved surface forms an approximate 180° arc ; and the heating means radiates heat uniformly to the curved surface.
2. A printer according to claim 1 wherein the input paper tray and output paper collection tray are disposed at opposite ends of the curved surface, one above the other.
3. A printer according to claim 1 or 2 which additionally comprises an inner reflector (42) mounted on the side of the heating means (40) opposed to said curved surface for reflecting heat from the heating means back to said curved surface.
4. A printer according to claim 3 wherein said heating means (40) is an elongated infrared bulb, and said inner reflector includes an elongated trough (44) therein positioned on one side of said bulb for reflecting radiation from said bulb toward said curved surface.

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5. A printer according to claim 4 wherein the longitudinal axes of said infrared bulb and said trough (44) and the axis of symmetry of said curved surface (32) all are coincident.

6. A method for drying paper in an ink jet printer comprising :

- providing an input paper tray (12) and an output paper collection tray (14) ;
- feeding paper from the input paper tray to an ink printing position ;
- feeding the paper to a drying position (30) including a heat-reflective curved surface (32) ;
- heating the paper in the drying position by heating means (40) ;
- feeding the paper to the output paper collection tray ; characterised by :
- passing the paper around an approximate 180° arc forming the heat-reflective curved surface ; and
- uniformly radiating heat to the heat-reflective curved surface to heat the paper in the drying position.

7. A method for drying paper according to claim 6, further comprising :

disposing the input paper tray and the output paper collection tray at opposite ends of the heat-reflective curved surface, one above the other.

8. A method for drying paper according to claim 6 or 7, further comprising :

- mounting an inner reflector (42) on the side of the heating means (40) opposite to the curved surface ; and
- reflecting heat from the heating means by the inner reflector back to the curved surface.

9. A method for drying paper according to claim 8 comprising :

- providing an elongated infrared bulb to heat the paper ; and
- positioning an elongated trough on one side of the bulb to provide the inner reflector (42) ; and
- reflecting radiation from the bulb by the elongated trough to the curved surface.

10. A method for drying paper according to claim 9, comprising positioning the infrared bulb and the trough so that their longitudinal axes are coincident with the axis of symmetry of the curved surface.

Patentansprüche

1. Tintenstrahldrucker mit
einem Eingabepapierblech (12),
einem Ausgabepapiersammelblech (14),
Mitteln (18, 20 ; 36, 38) zum Speisen von Papier vom Eingabepapierblech zu einer Tintendruckposition, wo das Papier Tinte von einem benach-

wise along the inner contoured surface 30 and through the output drive rollers 36 and 38 and into the output collection tray 14. In this fashion, the drying surface area may be minimized while insuring that the paper 16 is received by the output rollers 36 and 38 before leaving control of the input drive rollers 18 and 20.

Thus, there has been described a novel and extremely useful uniform paper drying method and apparatus for an ink jet printer. This apparatus is elegantly simple in construction and is particularly adapted for integration into conventional ink jet printing systems. Furthermore, this method and apparatus are reliable in the uniform paper drying operation, and such apparatus is economical to manufacture relative to some of the mechanically complex prior art paper handling and drying systems.

Various modifications may be made in the construction and operation of the above described embodiment without departing from the scope of this invention. For example, the materials and the exact shapes, sizes and geometries of the various components comprising the constant heat flux dryer may be changed and/or modified by those skilled in the art within the scope of the following appended claims.

Claims

1. An ink jet printer comprising :
an input paper tray (12),
an output paper collection tray (14),
means (18, 20 ; 36, 38) for feeding paper from the input paper tray to an ink printing position where it receives ink from an adjacent ink jet printhead (26), to a drying position (30) where the ink is dried by a heating means (40), and to a collection position where it is received by the output paper collection tray, said drying position including a heat-reflective curved surface (32) around the inside of which the paper is passed ; characterised in that :
the curved surface forms an approximate 180° arc ; and the heating means radiates heat uniformly to the curved surface.
2. A printer according to claim 1 wherein the input paper tray and output paper collection tray are disposed at opposite ends of the curved surface, one above the other.
3. A printer according to claim 1 or 2 which additionally comprises an inner reflector (42) mounted on the side of the heating means (40) opposed to said curved surface for reflecting heat from the heating means back to said curved surface.
4. A printer according to claim 3 wherein said heating means (40) is an elongated infrared bulb, and said inner reflector includes an elongated trough (44) therein positioned on one side of said bulb for reflecting radiation from said bulb toward said curved surface.

5. A printer according to claim 4 wherein the longitudinal axes of said infrared bulb and said trough (44) and the axis of symmetry of said curved surface (32) all are coincident.

6. A method for drying paper in an ink jet printer comprising :

- providing an input paper tray (12) and an output paper collection tray (14) ;
- feeding paper from the input paper tray to an ink printing position ;
- feeding the paper to a drying position (30) including a heat-reflective curved surface (32) ;
- heating the paper in the drying position by heating means (40) ;
- feeding the paper to the output paper collection tray ; characterised by :
- passing the paper around an approximate 180° arc forming the heat-reflective curved surface ;
- and
- uniformly radiating heat to the heat-reflective curved surface to heat the paper in the drying position.

7. A method for drying paper according to claim 6, further comprising :

- disposing the input paper tray and the output paper collection tray at opposite ends of the heat-reflective curved surface, one above the other.

8. A method for drying paper according to claim 6 or 7, further comprising :

- mounting an inner reflector (42) on the side of the heating means (40) opposite to the curved surface ; and
- reflecting heat from the heating means by the inner reflector back to the curved surface.

9. A method for drying paper according to claim 8 comprising :

- providing an elongated infrared bulb to heat the paper ; and
- positioning an elongated trough on one side of the bulb to provide the inner reflector (42) ; and
- reflecting radiation from the bulb by the elongated trough to the curved surface.

10. A method for drying paper according to claim 9, comprising positioning the infrared bulb and the trough so that their longitudinal axes are coincident with the axis of symmetry of the curved surface.

Patentansprüche

1. Tintenstrahldrucker mit
einem Eingabepapierblech (12),
einem Ausgabepapiersammelblech (14),
Mitteln (18, 20 ; 36, 38) zum Speisen von Papier vom Eingabepapierblech zu einer Tintendruckposition, wo das Papier Tinte von einem benach-



barten Tintenstrahldruckkopf (26) empfängt, zu einer Trocknungsposition (30), wo die Tinte mittels einer Heizvorrichtung (40) getrocknet wird, sowie zu einer Sammelposition, wo das Papier von dem Ausgabepapiersammel-

tablett übernommen wird, wobei die Trocknungsposition eine hitzereflektierende gekrümmte Oberfläche (32) aufweist, längs deren Innenseite das Papier gefördert wird, dadurch gekennzeichnet, daß

die gekrümmte Oberfläche im wesentlichen einen Winkel von 180° bildet und die Heizvorrichtung Wärme gleichförmig auf die gekrümmte Oberfläche strahlt.

2. Drucker nach Anspruch 1, bei dem das Eingabepapiertablett und das Ausgabepapiersammeltablett an entgegengesetzten Enden der gekrümmten Oberfläche übereinander angeordnet sind.

3. Drucker nach Anspruch 1 oder 2, der zusätzlich einen inneren Reflektor (42) aufweist, welcher auf derjenigen Seite der Heizvorrichtung (40) angeordnet ist, die entgegengesetzt der gekrümmten Oberfläche zum Reflektieren von Wärme von der Heizvorrichtung zurück auf die gekrümmte Oberfläche dient.

4. Drucker nach Anspruch 3, bei dem die Heizvorrichtung (40) eine langgestreckte Infrarotröhre umfaßt und der innere Reflektor eine langgestreckte Mulde (44) aufweist, die sich auf einer Seite der Röhre zum Reflektieren von Strahlung von der Röhre zu der gekrümmten Oberfläche befindet.

5. Drucker nach Anspruch 4, bei dem die Längsachsen der Infrarotröhre und der Mulde (44) und die Symmetrieachse der gekrümmten Fläche (32) zusammenfallen.

6. Verfahren zum Trocknen von Papier in einem Tintenstrahldrucker, bei dem

ein Eingabepapiertablett (12) und ein Ausgabepapiersammeltablett (14) vorgesehen werden ; Papier vom Eingabepapiertablett zu einer Tinten-

druckposition gespeist wird ; das Papier zu einer Trocknungsposition (30) einschließlich einer hitzereflektierenden gekrümmten Oberfläche (32) gespeist wird ;

das Papier in der Trocknungsposition durch eine Heizvorrichtung (40) erwärmt wird ;

das Papier zu dem Ausgabepapiersammeltablett gespeist wird ; gekennzeichnet durch

Fördern des Papiers um eine gebogenen Bahn von etwa 180°, welche die hitzereflektierende gekrümmte Oberfläche bildet, und gleichförmiges Strahlungsheizen der hitzereflektierenden Oberfläche zum Heizen des Papiers in der Trocknungsposition.

7. Verfahren zum Trocknen von Papier nach Anspruch 6, bei dem

das Eingabepapiertablett und das Ausgabepapiersammeltablett an entgegengesetzten Enden der hitzereflektierenden gekrümmten Oberfläche

übereinander angeordnet werden.

8. Verfahren zum Trocknen von Papier nach Anspruch 6 oder 7, bei dem

ein innerer Reflektor (42) auf der Seite der Heizvorrichtung (40) gegenüber der gekrümmten Oberfläche angeordnet wird und

Hitze von der Heizvorrichtung mittels des inneren Reflektors zurück zu der gekrümmten Oberfläche reflektiert wird.

9. Verfahren zum Trocknen von Papier nach Anspruch 8, bei dem

eine langgestreckte Infrarotröhre zum Heizen des Papiers vorgesehen wird und

eine langgestreckte Mulde auf einer Seite der Röhre positioniert wird, um den inneren Reflektor (42) zu bilden, und

Strahlung von der Röhre mittels der langgestreckten Mulde auf die gekrümmte Oberfläche reflektiert wird.

10. Verfahren zum Trocknen von Papier nach Anspruch 9, bei dem die Infrarotröhre und die Mulde

so positioniert werden, daß ihre Längsachsen mit der Symmetrieachse der gekrümmten Oberfläche zusammenfallen.

Revendications

1. Imprimante à jet d'encre comprenant :

un bac à papier d'entrée (12),

un bac collecteur de papier de sortie (14),

des moyens (18, 20 ; 36, 38) qui font avancer le papier du bac à papier d'entrée à une position

d'impression, où il reçoit de l'encre d'une tête d'impression (26) à jet d'encre adjacente, puis à

une position de séchage (30) dans laquelle l'encre est séchée par un moyen chauffant (40),

puis à une position collectrice, où il est reçu par le bac collecteur de papier de sortie, ladite position

de séchage comprenant une surface courbe (32) réfléchissant la chaleur, le long de la face

interne de laquelle passe le papier ; caractérisée en ce que :

la surface courbe forme un arc d'environ 180° ; et

le moyen chauffant rayonne la chaleur uniformément sur la surface courbe.

2. Imprimante selon la revendication 1, dans laquelle le bac de papier d'entrée et le bac collecteur de papier de sortie sont disposés aux extrémités opposées d'une surface courbe, l'un au-dessus de l'autre.

3. Imprimante selon la revendication 1 ou 2, qui comprend en supplément un réflecteur intérieur (42) monté sur le côté des moyens chauffants (40) en face de ladite surface courbe pour réfléchir la chaleur des moyens chauffants vers ladite surface courbe.

4. Imprimante selon la revendication 3, dans laquelle lesdits moyens chauffants (40) sont une



lampe à infrarouges de forme allongée ; et ledit réflecteur intérieur comprend un auget (44) de forme allongée qui est positionné sur un côté de ladite lampe pour réfléchir vers ladite surface courbe le rayonnement qui est émis par ladite lampe.

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5. Imprimante selon la revendication 4, dans laquelle les axes longitudinaux de ladite lampe à infrarouges et dudit auget (44), et l'axe de symétrie de ladite surface courbe (32) sont tous en coïncidence.

6. Procédé pour sécher le papier dans une imprimante à jet d'encre, consistant à :

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préparer un bac de papier d'entrée (12) et un bac collecteur de papier de sortie (14) ;

faire avancer le papier du bac de papier d'entrée à une position d'impression à l'encre ;

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faire avancer le papier à une position de séchage (30) qui comprend une surface courbe (32) réfléchissante de la chaleur ;

chauffer le papier dans la position de séchage à l'aide d'un moyen chauffant (10) ;

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faire avancer le papier au bac collecteur de papier de sortie ; caractérisé par les phases suivantes consistant à :

faire passer le papier le long d'un arc d'environ 180° qui forme la surface courbe réfléchissante de la chaleur ; et

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rayonner uniformément la chaleur vers la surface courbe réfléchissante de la chaleur pour chauffer le papier dans la position de séchage.

7. Procédé pour sécher du papier selon la revendication 6, comprenant en outre :

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disposer le bac de papier d'entrée et le bac collecteur de papier de sortie aux extrémités opposées d'une surface courbe réfléchissante de la chaleur, l'un au-dessus de l'autre.

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8. Procédé pour sécher du papier selon la revendication 6 ou 7, comprenant en outre les phases consistant à :

monter un réflecteur intérieur (42) sur le côté du moyen chauffant (40) qui est à l'opposé de la surface courbe ; et

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renvoyer la chaleur émise par le moyen chauffant du réflecteur intérieur vers la surface courbe.

9. Procédé pour sécher du papier selon la revendication 8, comprenant les phases consistant à :

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prévoir une lampe à infrarouges de forme allongée pour chauffer le papier ; et ;

positionner un auget de forme allongée sur un premier côté de la lampe pour former le réflecteur intérieur (42) ; et

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renvoyer le rayonnement issu de la lampe vers la surface courbe par réflexion sur l'auget de forme allongée.

10. Procédé pour sécher du papier selon la revendication 9, comprenant la phase consistant à positionner la lampe à infrarouges et l'auget de telle manière que leurs axes longitudinaux soient en coïncidence avec l'axe de symétrie de la surface courbe.

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