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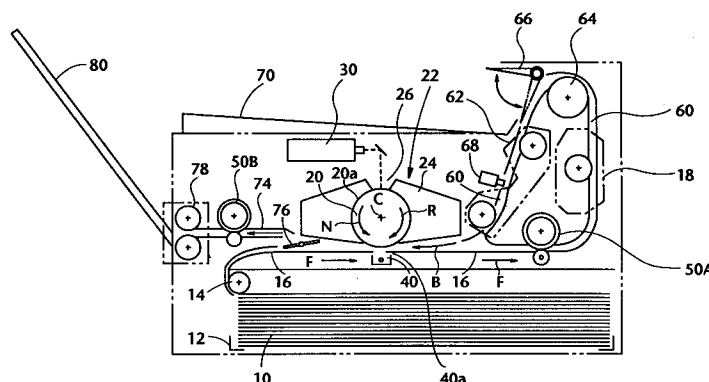
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(54) **Electrophotographic printer capable of printing on both sides of a sheet of paper.**

(57) The invention relates to an electrophotographic printer which can make printing first on the front side of a sheet of paper and then on the back side of the same sheet with conformity between the front and back sides in the head-bottom arrangement of the printed images. The printer has a photoreconductive drum which can be rotated both in a normal direction and in the reverse direction, an exposure unit to produce electrostatic latent images on the drum surface, first developing means for developing the latent images with a toner when the drum is rotating in the normal direction, second developing means for developing the latent images with a toner when the drum is rotating in the reverse direction, a transfer

unit for transferring the developed images to a sheet of paper, and first and second fixing means which are oppositely arranged with respect to the transfer unit. For printing on the front side of the paper sheet, the sheet is passed through the transfer unit in a first direction toward the first fixing means while the drum is rotating in the normal direction. For printing on the back side of the sheet, the sheet is further conveyed by a returning route which turns so as to reverse the sheet and extends to the transfer unit, and, while the drum is rotating in the reverse direction, the reversed and returned sheet passes through the transfer unit in the opposite second direction toward the second fixing means.

FIG. 1**EP 0 636 951 A2**

This invention relates to an electrophotographic printer which can perform printing on both sides of a sheet of recording medium such as paper.

In conventional electrophotographic printers a photosensitive drum having a photoconductive layer on the cylindrical surface rotates on its center axis in a predetermined direction. In the printing process electrostatic latent images are produced on the photoconductive surface of the rotating drum, and the latent images are developed into visible images with a toner. Then a sheet of paper is forwarded so as to make contact with the rotating drum at a location where an image transfer means is provided, and the toner images on the drum surface is transferred onto the front side of the paper. After that the transferred images are fixed to the paper by application of heat.

To successively perform printing on the back side of the paper sheet it is necessary to convey the sheet from the fixing station to the paper inlet of the image transfer means and reverse the sheet during this conveyance. In many cases the conveyor system for this purpose includes a switchback mechanism which has the advantage of being simple in construction. However, after the operation of the switchback mechanism the retrogressive movement of the paper sheet results in inversion of the head-bottom arrangement of the sheet. When the sheet is printed on both sides, the head of the page on the back side is at the back of the bottom of the front page. This is quite inconvenient for fastening similarly printed sheets of paper together.

As a solution for the above problem, JP 63-54060 A discloses an electrophotographic printer in which the direction of rotation of the photosensitive drum is temporarily reversed at the initial stage of the process of printing on the back side of a sheet of paper after printing on the front side. That is, while the drum is reversely rotated a train of imaging information is supplied to the drum surface until the formation of latent images for one page. During this operation the developing and image transferring treatments are suspended. After that the drum is rotated in the normal direction, and the developing and image transferring treatments are made in the usual way to accomplish printing on the reversed sheet of paper. This printer employs a switchback mechanism to reguide the paper sheet printed on the front side to the transfer unit, permitting inversion of the head-bottom arrangement of the sheet, but the inversion is compensated by the formation of latent images on the reversely rotating drum. When the paper sheet is printed on both sides the head of the page on the back side is just at the back of the head of the front page.

However, the printer of JP 63-54060 A is low in printing speed since the development of latent images and the transfer of the developed images to

paper are suspended while latent images for one page are formed on the reversely rotating photosensitive drum. As another disadvantage, it is impossible to freely reduce the diameter of the drum because the circumference of the drum needs to be longer than the length of the sheet of recording paper so that the drum surface can carry latent images for a full page. Besides, the employment of a switchback mechanism for retrogressive conveyance of paper sheets constitutes an obstacle to a reduction in size of the printer because the space necessary for the function of the switchback mechanism depends proportionally on the maximum length of paper sheets used in the printer.

It is an object of the present invention to provide an electrophotographic printer which can perform printing on both sides of a sheet of recording medium with conformity between the front and back sides in the head-bottom arrangement of the printed images and can be made relatively high in printing speed and relatively small in size.

An electrophotographic printer according to the invention comprises a photosensitive drum which has a photoconductive layer on its cylindrical surface and can be rotated on its center axis both in a predetermined normal direction and in the reverse direction, exposure means for producing electrostatic latent images on the cylindrical surface of the drum, first developing means for developing the latent images into visible images with a toner while the drum is rotating in the normal direction, second developing means for developing the latent images into visible images with a toner while the drum is rotating in the reverse direction, transfer means for transferring the developed images from the cylindrical surface of the drum to a sheet of recording medium, first fixing means for fixing the visible images transferred to the front side of a sheet of recording medium and second fixing means for fixing the visible images transferred to the back side of a sheet of recording medium. The first fixing means is spaced from the transfer means in a first direction which is normal to the center axis of the drum, and the second fixing means is spaced from the transfer means in a second direction opposite to the first direction. The printer further comprises first conveying means for conveying a sheet of recording medium by a sheet forwarding route which extends in the aforementioned first direction to pass through the transfer means and the first fixing means to allow the sheet of recording medium to pass through the transfer means in the first direction while the drum is rotating in the normal direction, second conveying means for conveying a sheet of recording medium by a sheet returning route which starts from an end of the sheet forwarding route, turns so as to re-

verse the sheet of recording medium under conveyance and then extends in the second direction to the transfer means to allow the reversed sheet of recording medium to pass through the transfer means in the second direction while the drum is rotating in the reverse direction, and a delivery passageway which extends from the transfer means in the second direction and passes through the second fixing means.

The printer according to the invention has two oppositely arranged fixing means, one for printing on the front side of a sheet of recording medium (usually paper) and the other for printing on the back side of the same sheet. After performing printing on the front side of the sheet by using the first developing means and the first fixing means, the sheet is returned to the transfer means by the sheet returning route which is curved so as to reverse the sheet and reverse the direction of movement of the sheet without using any switch-back mechanism. Therefore, the forward edge of the moving sheet remains unchanged. In compliance with the reversing of the direction of movement of the sheet toward the transfer unit, the direction of rotation of the photosensitive drum is reversed before forming images to be printed on the back side of the sheet (upper side of the reversed sheet), and this is accompanied by the switchover of the first developing means to the second developing means. Therefore, the head-bottom arrangement of the images printed on the back side of the sheet conforms with that on the front side.

In this printer the printing speed is relatively high because in printing on each side of a sheet of recording medium the formation of latent images, development of the latent images and the transfer of the developed images to the sheet can be performed continuously. Furthermore, the printer can be made relatively small in size because the diameter of the photosensitive drum can be reduced and also because the space necessary for the provision of the sheet forwarding and returning routes is smaller than in the case of using a switch-back mechanism.

Fig. 1 schematically shows the construction of an electrophotographic printer embodying the invention in an elevational sectional view;

Fig. 2 is an elevational view of a switching guide in a paper passageway in the printer of Fig. 1;

Fig. 3 is a perspective view of a package of an image setting unit used in the printer of Fig. 1; and

Fig. 4 shows the image setting unit in a sectional view taken along the line 4-4 in Fig. 3.

Fig. 1 shows an electrophotographic printer as an embodiment of the invention. The printer includes a paper cassette 12 containing a neat stack

of some sheets of recording paper 10. The paper sheets 10 can be drawn out one by one by a takeout roller 14.

The principal element of the printer is a photosensitive drum 20 which has a photoconductive layer 20a on the cylindrical surface. The drum 20 can be rotated on its center axis C which extends horizontally. Normally the drum 20 is rotated in the direction of arrow N, but according to the need the drum 20 can be rotated in the reverse direction indicated by arrow R.

Above the photosensitive drum 20 there is an exposure unit 30 to scan the photoconductive surface 20a of the drum 20 with a modulated laser beam to thereby produce electrostatic latent images on that surface 20a. Information for producing the latent images is supplied to a memory means (not shown) of the printer from, for example, a host computer. The printer has developing means (not shown in Fig. 1) for developing the electrostatic latent images into visible images with a toner. In this embodiment the photosensitive drum 20 and the developing means are installed in a casing 24 to constitute an image setting unit 22 as shown in Figs. 3 and 4. Outside the casing 24 and under the drum 20 there is an image transfer unit 40 to transfer the images developed on the drum surface 20a to a sheet of paper. A paper forwarding route 16 extends from the takeout roller 14 to the position of the transfer unit 40 to bring a sheet of paper into contact with the drum surface 20a right above the transfer unit 40. From the paper outlet 40a of the transfer unit 40 the paper forwarding route 16 further extends to a first fixing unit 50A. There is a paper conveying means 18 to convey each sheet of paper by the forwarding route 16.

Downstream from the first fixing unit 50A, the paper forwarding route 16 turns upward and connects with a paper returning route 60 which turns downward and extends to the paper outlet 40a of the image transfer unit 40. There is another paper conveying means 62 for the conveyance of each paper sheet by the returning route 60. The paper returning route 60 is used to perform printing on both sides of a sheet of paper. The end part of the forwarding route 16 and the returning route 60 are curved such that the paper sheet makes a 180-degree turn across a horizontal plane, and as a result the paper sheet is reversed before it is returned to the transfer unit 40. In this printer the paper sheet makes no retrogressive movement. When it suffices to make printing on one side of a paper sheet, a switching guide 66 is moved into an open position (as shown in solid line in Fig. 1) to break the returning route 60 and allow the paper sheet to be passed to an intermediary delivery tray 70 by a guide roller 64. A paper sensor 68 is provided to the returning route 60 at a location

downstream from the switching guide 66 to detect the passage of a paper sheet at that location. Along the paper forwarding route 16 and the returning route 60, the distance from the transfer unit 40 to the position of the paper sensor 68 is made longer than the maximum length of paper sheets 10 to be used in this printer in order to accomplish reversing of every paper sheet.

Referring to Figs. 3 and 4, in the casing 24 of the image setting unit 22 the photosensitive drum 20 is disposed in a central section. The top face of the casing 24 is formed with a slit 26 which is parallel to the center axis C of the drum 20, and the exposure unit 30 is arranged so as to project a laser beam onto the cylindrical, photoconductive surface 20a of the drum 20 through the slit 26. For producing images to be printed on the front side of a sheet of paper 10 which is moving in the direction of arrow F along the paper forwarding route 16, a first charger 28A and a first developing means 32A are arranged against the cylindrical surface of the drum 20 at a suitable angular distance. Preceding to the operation of the exposure unit 30 the first charger 28A makes a corona discharge by which the photoconductive surface 20a of the drum 20 is uniformly negatively charged. After that the exposure unit 30 scans the charged surface of the drum 20 with a modulated laser beam to form electrostatic latent images by selective dissipation of the negative charges. The first developing means 32A has a toner container 34 containing a toner 36, a stirring paddle 38 and a developing sleeve 42. The toner 36 is negatively charged by friction caused by the rotation of the stirring paddle 38 and applied to the surface of the rotating drum 20 by the sleeve 42. The toner 36 adheres to the drum surface 20a only in the areas of the electrostatic latent images where negative charges are absent, whereby the latent images are developed into visible toner images. The developing sleeve 42 is retractable so as to stay detached from the drum 20.

Right above the image transfer unit 40 the bottom of the casing 24 is formed with a slit 44 by which the cylindrical surface 20a of the drum 20 is locally exposed. Therefore, the paper sheet 10 makes contact with the surface 20a of the rotating drum 20. From the back side of the paper 10 the transfer unit 40 applies positive charges to the drum surface 20a to transfer the toner images from the drum surface to the paper.

There is a first cleaning means 46A between the transfer unit 40 and the first charger 28A. The cleaning means 46A includes a cleaning brush 48 for removing residual toner from the drum surface 20a and a discharging lamp 52 for dissipation of residual electric charges from the drum surface 20a. The brush 48 is pivoted to an inner part of the casing 24 and can be held either in contact with

the drum surface 20a or detached from the drum. The lamp 52 is located outside the casing 24 and projects light onto the drum surface 20a through a slit 54 in the casing 24.

For producing images to be printed on the back side of the paper sheet 10 which is reversed and returned to the position of the transfer unit 40 by the paper returning route 60 and is moving in the direction of arrow B, the image setting unit 22 has a second charger 28B and a second developing means 32B. With respect to a vertical plane P containing the center axis C of the photosensitive drum 20, the first and second chargers 28A and 28B are arranged symmetrical, and the first and second developing means 32A and 32B are arranged symmetrical. The second charger 28B has the same function as the first charger 28A. The second developing means 32B is identical with the first developing means 32A in construction and function. That is, the second developing means 32B has a toner container 34 containing a toner 36, a stirring paddle 38 and a developing sleeve 42. Between the transfer unit 40 and the second charger 28B there is a second cleaning means 46B which includes a cleaning brush 48 and a discharging lamp 52 similarly to the first cleaning means 46A.

Referring again to Fig. 1, the printer has a second fixing unit 50B which is located on the opposite side of the first fixing unit 50A with respect to the photosensitive drum 20 and the transfer unit 40, and a paper delivery passageway 74 extends from the transfer unit 40 to the second fixing unit 50B. There is a junction of the paper delivery passageway 74 with the paper forwarding route 16, and at the junction there is a switching guide 76. As shown in Fig. 2, the switching guide 76 takes position A to block the delivery passageway 74 when a paper sheet is to be sent from the cassette 12 to the transfer unit 40 by the paper forwarding route 16 and takes position B when the paper sheet returned by the returning route 60 is to be passed to the second fixing unit 50B. The delivery passageway 74 further extends from the second fixing unit 50B to paper delivering rollers 78 in front of a paper delivery tray 80.

As to the aforementioned memory means for temporary storage of information for producing latent images, it is preferable to employ a memory means with a capacity sufficient to store information for both sides of a paper sheet as a precaution against accidental interruption of the printing process at the last stage of making printing on the back side.

In this printer special care is taken for the dissipation of heat since the printer has two sets of heat fixing units 50A, 50B.

The printer of Fig. 1 operates in the following way to make printing first on the front side of a sheet of paper and then on the back side of the same sheet.

For printing on the front side of a paper sheet 10 the photosensitive drum 20 is rotated in the direction of arrow N, and the paper sheet is forwarded in the direction of arrow F toward the transfer unit 40 while the switching guide 76 takes the position A in Fig. 2. The discharging lamp 52 of the first cleaning means 46A is operated to remove residual electric charges from the photoconductive surface 20a of the drum 20, and then the first charger 28A is operated to negatively charge the drum surface 20a. Then the exposure unit 30 is operated to produce electrostatic latent images on the drum surface 20a while the first developing means 32A is operated to develop the latent images with the toner 36, and the developed images are transferred to the front side of the paper sheet 10 by the operation of the transfer unit 40. After that residual toner is removed from the drum surface 20a by the cleaning brush 48 of the first cleaning means 46A. During this process the second charger 28B, the stirring paddle 38 of the second developing means 32B and the discharging lamp 52 of the second cleaning means 46B are not operated, and the developing sleeve 42 of the second developing means 32B and the cleaning brush 48 of the second cleaning means 46B are kept detached from the drum surface 20a.

Then the paper sheet is passed to the first fixing unit 50A to heat fix the images on the front side of the paper sheet. By the operation of the paper conveying means 18 and 62 the paper sheet follows the paper returning route 60 while the switching guide 66 is in the closed position. When the paper sheet, moving in the direction of arrow B, returns to the transfer unit 40 the paper sheet is already reversed. That is, the upper side of the paper sheet moving in the direction B is the back side of the sheet.

Printing on the paper sheet moving in the direction B is performed in the following way.

As the paper sensor 68 detects the passage of the paper sheet along the returning route 60, a controller (not shown) of the printer commands the photosensitive drum 20 to rotate in the reverse direction indicated by arrow R. At the same time the second charger 28B, the second developing means 32B and the second cleaning means 46B begin to operate. The discharging lamp 52 of the second cleaning means 46B is used to remove residual electric charges from the surface 20a of the drum 20, and the second charger 28B is used to negatively charge the drum surface 20a. Then the exposure unit 30 is operated to produce electrostatic latent images on the drum surface 20a

while the second developing means 32B is operated to develop the latent images with the toner 36, and the developed images are transferred to the back side (now upper side) of the paper sheet 10 by the operation of the transfer unit 40. After that residual toner is removed from the drum surface 20a by the cleaning brush 48 of the second cleaning means 46B. During this process the first charger 28A, the stirring paddle 38 of the first developing means 32A and the discharging lamp 52 of the first cleaning means 46A are not operated, and the developing sleeve 42 of the first developing means 32A and the cleaning brush 48 of the first cleaning means 46A are held detached from the drum surface 20a. The switching guide 76 is in the position B in Fig. 2 in order to pass the paper sheet from the transfer unit 40 to the second fixing unit 50B by the paper delivery passageway 74. The images on the back side of the paper sheet are heat fixed by the second fixing unit 50B, and the paper sheet is ejected into the delivery tray 80.

Thus, in performing printing on the back side of the paper sheet after printing on the front side the direction of movement of the paper sheet is reversed, and the direction of rotation of the photosensitive drum 20 is also reversed, and the reversing is accompanied by the switchover of the first set of charger 28A, developing means 32A and cleaning means 46A to the oppositely arranged second set of charger 28B, developing means 32B and cleaning means 46B. Therefore, the head-bottom arrangement of the printed images on the back side of the paper conforms with that on the front side. In this printer the printing time required for each sheet of paper can be shortened because in printing on each side of the paper the formation of latent images, development of the latent images and the transfer of the developed images can be performed continuously. The printer can be made relatively small in size because the diameter of the photosensitive drum 20 can be reduced and also because the total length of the paper forwarding and returning routes necessary for reversing the paper sheet is relatively short.

Claims

1. An electrophotographic printer which can perform printing on both sides of a sheet of recording medium, the printer comprising:

a photosensitive drum which has a photoconductive layer on its cylindrical surface and can be rotated on its center axis both in a predetermined direction and in the reverse direction;

exposure means for producing electrostatic latent images on the cylindrical surface of

said drum;

first developing means for developing said latent images into visible images with a toner while said drum is rotating in said predetermined direction;

second developing means for developing said latent images into visible images with a toner while said drum is rotating in said reverse direction;

transfer means for transferring the visible images from the cylindrical surface of said drum to a sheet of recording medium;

first fixing means for fixing the visible images transferred to the front side of a sheet of recording medium, the first fixing means being spaced from said transfer means in a first direction which is normal to the center axis of said drum;

second fixing means for fixing the visible images transferred to the back side of a sheet of recording medium, the second fixing means being spaced from said transfer means in a second direction opposite to said first direction;

first conveying means for conveying a sheet of recording medium by a sheet forwarding route which extends in said first direction to pass through said transfer means and said first fixing means to allow the sheet of recording medium to pass through said transfer means in said first direction while said drum is rotating in said predetermined direction;

second conveying means for conveying a sheet of recording medium by a sheet returning route which starts from an end of said sheet forwarding route, turns so as to reverse the sheet of recording medium under conveyance and then extends in said second direction to said transfer means to allow the reversed sheet of recording medium to pass through said transfer means in said second direction while said drum is rotating in said reverse direction; and

a delivery passageway which extends from said transfer means in said second direction and passes through said second fixing means.

2. An electrophotographic printer according to Claim 1,

comprising an intermediary delivery means for delivering the sheet of recording medium passed from said first fixing means when it suffices to make printing only on the front side of the sheet.

3. An electrophotographic printer according to Claim 1 or 2,

comprising a sensor to detect the exis-

tence of a sheet of recording medium on said sheet returning route and provide a signal to rotate said drum in said reverse direction.

4. An electrophotographic printer according to Claim 1, 2 or 3,

comprising a switchable guide which is provided at a junction of said delivery passageway with said sheet forwarding route to block said delivery passageway when a sheet of recording medium is to be passed in said first direction to said transfer means and block said sheet forwarding route when a sheet of recording medium is to be passed to said second fixing means.

5. An electrophotographic printer which can perform printing on both sides of a sheet of recording medium, the printer comprising:

a photosensitive drum which has a photoconductive layer on its cylindrical surface and can be rotated on its center axis both in a predetermined direction and in the reverse direction;

first charging means for uniformly charging the cylindrical surface of said drum while said drum is rotating in said predetermined direction;

second charging means for uniformly charging the cylindrical surface of said drum while said drum is rotating in said reverse direction, which is arranged symmetrical with said first charging means with respect to a plane containing the center axis of said drum;

exposure means for producing electrostatic latent images on the uniformly charged cylindrical surface of said drum by selective dissipation of the electric charges;

first developing means for developing said latent images into visible images by application of a toner while said drum is rotating in said predetermined direction;

second developing means for developing said latent images into visible images by application of a toner while said drum is rotating in said reverse direction, the second developing means being arranged symmetrical with said first developing means with respect to said plane;

transfer means for transferring the visible images from the cylindrical surface of said drum to a sheet of recording medium;

first cleaning means for removing residual toner and residual charges from the cylindrical surface of said drum while said drum is rotating in said predetermined direction;

second cleaning means for removing residual toner and residual charges from the

cylindrical surface of said drum while said drum is rotating in said reverse direction, the second cleaning means being arranged symmetrical with said first cleaning means with respect to said plane;

first fixing means for fixing the visible images transferred to the front side of a sheet of recording medium, the first fixing means being spaced from said transfer means in a first direction which is normal to the center axis of said drum;

second fixing means for fixing the visible images transferred to the back side of a sheet of recording medium, the second fixing means being spaced from said transfer means in a second direction opposite to said first direction;

first conveying means for conveying a sheet of recording medium by a sheet forwarding route which extends in said first direction to pass through said transfer means and said first fixing means to allow the sheet of recording medium to pass through said transfer means in said first direction while said drum is rotating in said predetermined direction;

second conveying means for conveying a sheet of recording medium by a sheet returning route which starts from an end of said sheet forwarding route, turns so as to reverse the sheet of recording medium under conveyance and then extends in said second direction to said transfer means to allow the reversed sheet of recording medium to pass through said transfer means in said second direction while said drum is rotating in said reverse direction; and

a delivery passageway which extends from said transfer means in said second direction and passes through said second fixing means.

6. An electrophotographic printer according to Claim 5, wherein each of said first and second developing means comprises a toner stirring means and a toner applying sleeve which makes contact with the cylindrical surface of said drum and can be kept retracted and detached from said drum.

7. An electrophotographic printer according to Claim 5 or 6, wherein each of said first and second cleaning means comprises a discharging lamp and a toner removing brush which makes contact with the cylindrical surface of said drum and can be kept detached from said drum.

8. An electrophotographic printer according to Claim 5, 6 or 7,

comprising an intermediary delivery means for delivering the sheet of recording medium passed from said first fixing means when it suffices to make printing only on the front side of the sheet.

9. An electrophotographic printer according to any one of claims 5 to 8, comprising a sensor to detect the existence of a sheet of recording medium on said sheet returning route and provide a signal to rotate said drum in said reverse direction.

10. An electrophotographic printer according to any one of claims 5 to 9, comprising a switchable guide which is provided at a junction of said delivery passageway with said sheet forwarding route to block said delivery passageway when a sheet of recording medium is to be passed in said first direction to said transfer means and block said sheet forwarding route when a sheet of recording medium is to be passed to said second fixing means.

FIG. 1

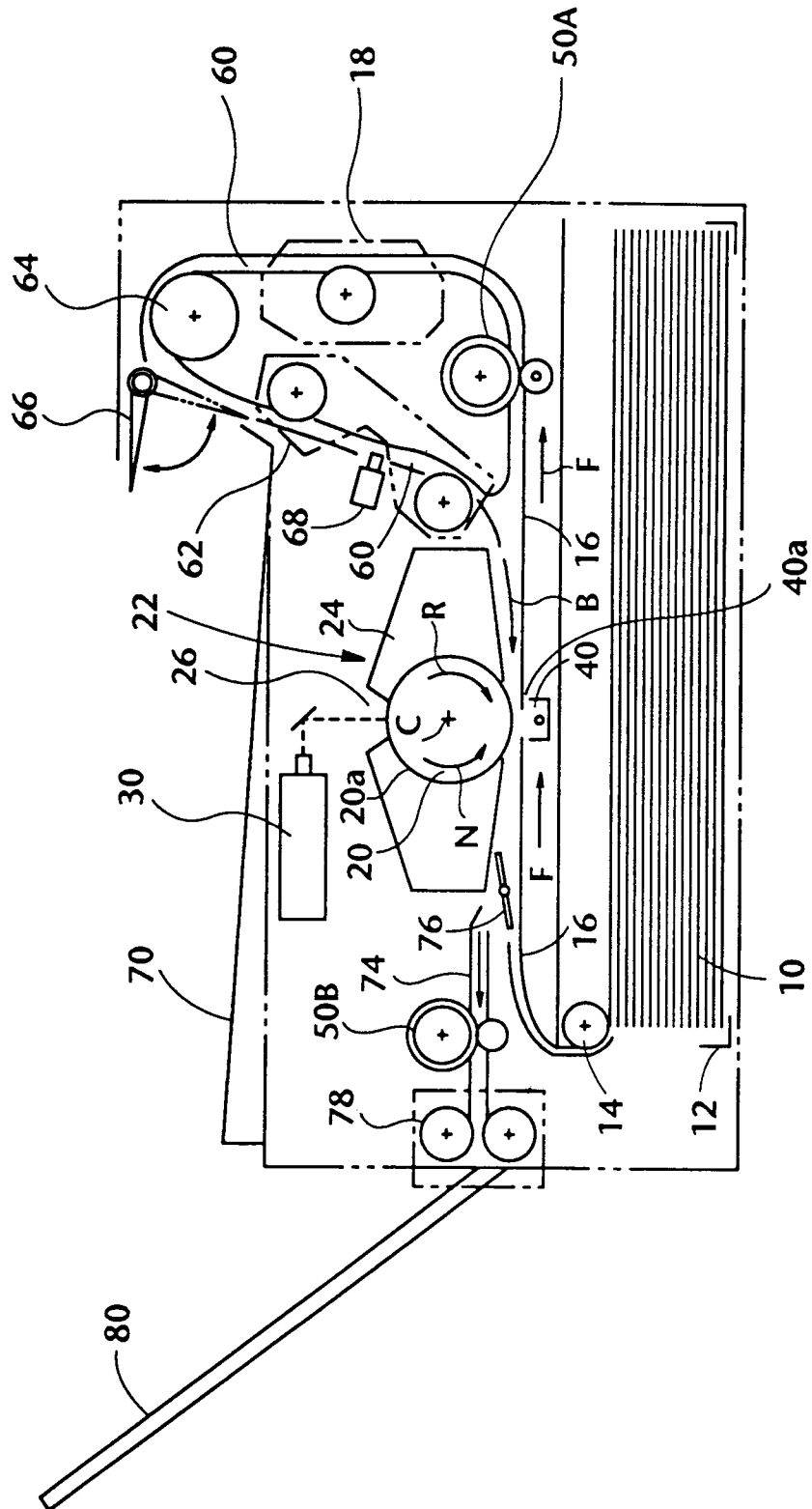


FIG. 2

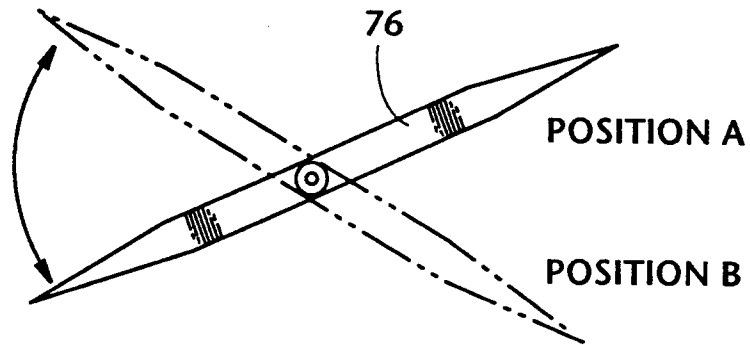


FIG. 3

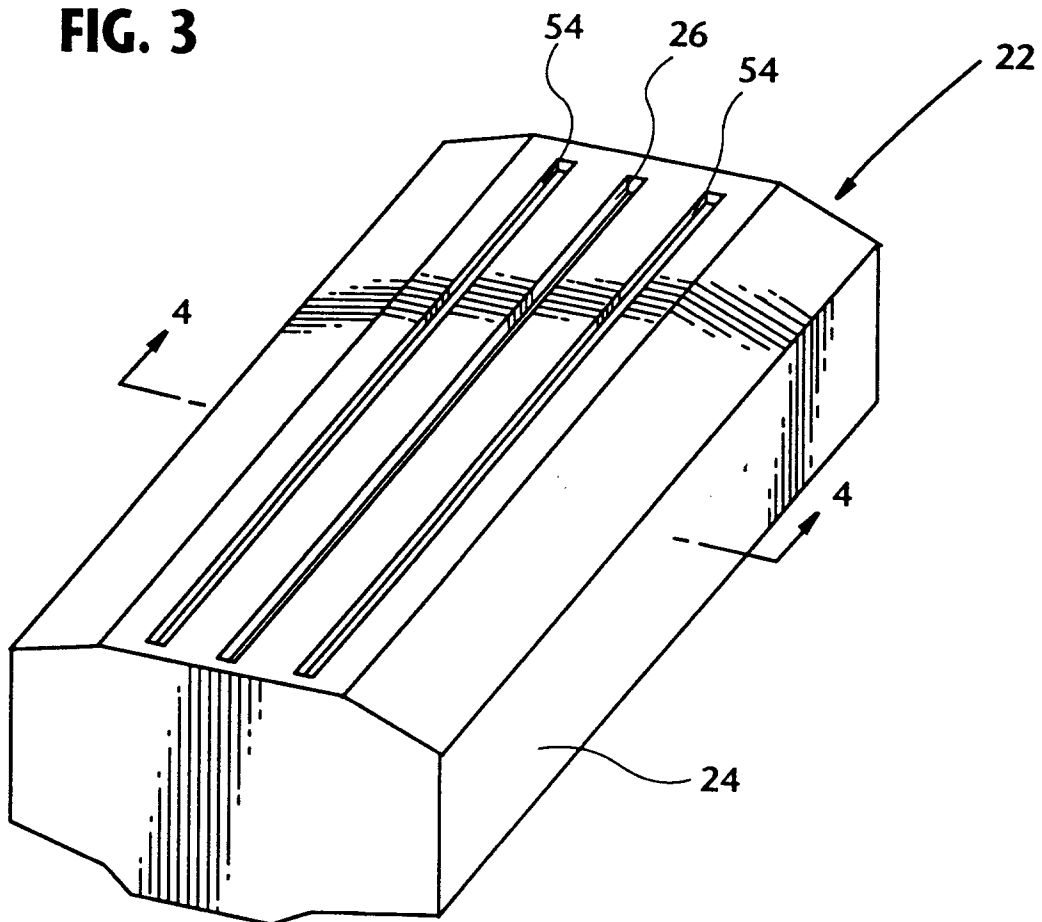


FIG. 4

