Title: SHEET L-INVERTER

Abstract: An inverter for taking separate sheets of printing media from a starting location in a printer or copier and conveying the sheets to an ending location in an inverted orientation, the inverter comprising: a) one or more conveying elements capable of simultaneously moving a plurality of the sheets along a continuous path in space, starting from the starting location and ending in the ending location while inverting the sheets; and b) one or more holders capable of confining the sheets substantially to the path the whole time that the sheets are moving; wherein the path is helical in at least one region.
Sheet 1-Inverter

Field of the Invention

The field of the invention is inverters for printers and copiers.

Background of the Invention

A wide variety of mechanisms exist for inverting paper (or other printing media, herein after referred to as paper) in printers and copiers. Paper is inverted, for example, between printing the first side and the second side of the paper, when two-sided printing is done, as well between copying the first side and the second side of a page in a copier with two-sided copying.

Printers can either print on separate sheets of paper drawn from a stack, or on a continuous roll of paper, known in the industry as a web. Generally, different methods are used for inverting sheets and for inverting a web. Sheets can be inverted individually, one after the other. A web, on the other hand, is inverted continuously. When moving sheets through a printer, each sheet is in contact with a roller or another mechanism which moves it. When moving a web through a printer, it is sufficient to have a mechanism pulling the end of the web, and this will draw the rest of the web behind it. Because of these differences, existing printers generally print either sheets or a web, but the same printer cannot be used for both.

A mechanism commonly used for inverting a web is an L-inverter. An L-inverter has a circular cylinder, oriented with its axis in the plane of the incoming paper, but oriented at a 45 degree angle to the direction of motion of the incoming paper. The paper wraps half of a helical turn around the cylinder, and leaves the cylinder inverted from its original orientation, and travelling in a direction perpendicular to its incoming direction of motion.

If it is desired to have the web leave the inverter travelling in the same direction as it was travelling when it entered the inverter, then two L-inverters and a simple cylinder can be combined to form an X-inverter. In an X-inverter, the web first goes through a first L-inverter, then wraps half a turn around a reversing cylinder and returns back toward the first L-inverter, but above or below it. A second L-inverter, located above or below the first L-inverter, receives the web from the reversing cylinder, and changes its direction by 90 degrees so that it travels in the same direction, and optionally even in the same plane, as the paper coming into the first L-inverter, and inverted from its original orientation. The cylinders of the two L-inverters have axes oriented in directions 90 degrees apart from each other (although the two axes are not in the same plane), making an X as seen from above, so this device is called an X-inverter.

Generally, some or all of the cylinders used in the L and X-inverters are stationary such that motion is provided by the tension on the web.

Summary of the Invention
An aspect of some embodiments of the invention concerns adapting an inverter of the kind that is usually used for inverting a web, for example an L-inverter, so that it can be used for inverting separate sheets. Optionally, the same inverter can then be used for either webs or sheets.

Two features are present in a web inverter to allow it to be used for sheets. First, since each sheet is to be moved individually, one or more conveying elements are added along a path that the paper follows, so that each sheet is in contact with at least one conveying element as it travels along the path, keeping all the paper moving at the desired speed in the desired direction. Second, holding elements are added along the path, to keep each sheet of paper substantially confined to the path as the paper moves along the path. In the case of a web, keeping the web confined to the path is typically accomplished by having a solid surface against one side of the web at places where the web bends around, for example the cylinder in the case of an L-inverter, and applying tension to the web at the beginning and end of the path. In the case of separate sheets, tension applied to one sheet of paper is not felt by the other sheets, so additional elements are used to confine the paper to the path.

In some embodiments of the invention, pinch rollers situated on the periphery of one or more of the cylinders are used to move the paper and to hold it to the path. For example, each pair of rollers comprises a motor-driven drive roller which moves the paper, and an idler roller which holds the paper against the drive roller. The nip between the pair of rollers is situated at or near the surface of the cylinder. In the case of an X-inverter, the reversing cylinder is optionally used as a drive roller. However, there are also pinch rollers oriented helically around the cylinders of the L-inverters, or around the single cylinder in the case of a single L-inverter. Note that simply rotating the cylinder of an L-inverter on its axis will not cause the paper to move in the desired direction, since the paper is supposed to go in a helical path around the cylinder, with a component of motion along the cylinder, as well as a component of motion around the cylinder.

In other embodiments of the invention, there is a belt, which moves the paper along the path, and pinch rollers, or pinch balls, which hold the paper against the belt. In still other embodiments, there are two belts, and the paper is held between them. In both these cases, a return path is provided for each belt to go back to the beginning of the path, or to the part of the path that the belt covers. In some of these embodiments, the belts are used only in the places where the paper is bending around a curve, for example at the cylinder of the L-inverter. This simplifies the problem of returning the belt to the beginning. Other means, known to the art, are
optionally used to move the paper, and to hold the paper against the path, in the straight sections of the path, and at the reversing roller in the case of an X-inverter.

Optionally, some elements are used both for moving and holding the sheets.

The invention is not limited to L-inverters and X-inverters. Other L-shaped inverters or X-shaped inverters, differing in their configuration from the L-inverters and the X-inverter shown in Fig. 1, are optionally used. For example, in an L-shaped inverter, the direction of motion of the paper need not change by 90 degrees, but optionally changes by a different angle. Many different combinations of cylindrical or conical surfaces, not necessarily circular cylinders and cones, but also cylinders and cones of other convex shapes, or even non-convex shapes, may be used to invert a web, or sheets of paper.

There is thus provided, in accordance with an exemplary embodiment of the invention, an inverter for taking separate sheets of printing media from a starting location in a printer or copier and conveying the sheets to an ending location in an inverted orientation, the inverter comprising:

a) one or more conveying elements capable of simultaneously moving a plurality of the sheets along a continuous path in space, starting from the starting location and ending in the ending location while inverting the sheets; and

b) one or more holders capable of confining the sheets substantially to the path the whole time that the sheets are moving;

wherein the path is helical in at least one region.

Optionally, the path does not turn to the left or right with respect to any plane tangent to the surface of the sheets.

Optionally, the holders are arranged so as not to exert substantial tangential stresses on the sheets when said holders confine the sheets substantially to the path.

Optionally, successive sheets follow substantially the same path, and are oriented in substantially a same orientation at a given location in the path.

Optionally, the helical path is along a circular cylindrical surface in at least part of the at least one regions where the path is helical.

Optionally, the circular cylindrical surface and the helical path along it comprise an L-shaped inverter.

Optionally, the circular cylindrical surface and the helical path along it comprise an L-inverter.

Optionally, there are at least two L-shaped inverters with axes oriented at different angles.
Optionally, two of the at least two L-shaped inverters with axes oriented at different angles comprise an X-inverter.

In an embodiment of the invention, the conveying elements comprise at least one drive roller tangent to the surface of the sheets as they move along the path at a location in one of the at least one regions where the path is helical, and oriented at the pitch of the direction of motion of the sheets at said location.

Optionally, the at least one drive roller comprises a plurality of drive rollers tangent to the surface of the sheets in one of the at least one regions where the path is helical, said drive rollers being spaced closely enough together so that each sheet is always in contact with at least one of the drive rollers as said sheet traverses said region.

Optionally, the holding elements comprise at least one pinch roller, tangent to the surface of the sheets at a location where one of the at least one drive rollers is tangent to the surface of the sheets, but on the other side of the sheets from said drive roller, such that said pinch roller and said drive roller form a nip at said location, through which the sheets pass as they move along the path.

Optionally, the at least one pinch roller is an idler roller, oriented in the same direction as the drive roller with which it forms a nip.

Alternatively or additionally, the holding elements comprise at least one pinch ball, tangent to the surface of the sheets at the location that one of the at least one drive rollers is tangent to the surface of the sheets, but on the other side of the sheets from said drive roller, such that said pinch ball and said drive roller form a nip at said location, through which the sheets pass as they move along the path.

In an embodiment of the invention, the conveying elements comprise a conveyer belt, having along its length a conveying portion, the outer surface of which coincides with the path over at least part of one of the at least one regions where the path is helical, and which conveying portion moves the sheets along said part of the path.

Optionally, the holding elements comprise at least one pinch ball, tangent to the outer surface of the conveying portion of the conveyer belt, such that said pinch ball and said outer surface form a nip through which the sheets pass as they move along the path.

Alternatively or additionally, the holding elements comprise at least one pinch roller, tangent to the outer surface of the conveying portion of the conveyer belt, and substantially aligned with the direction of motion of said conveying portion, such that said pinch roller and said outer surface form a nip through which the sheets pass as they move along the path.
Optionally, the conveyer belt also has, along its length, a return portion, which does not coincide with the path, the conveyer belt thereby forming a closed loop.

Optionally, there are also conveyer belt tensioning elements which hold the conveyer belt taut.

Optionally, the tensioning elements include a first cylindrical roller which the belt wraps around non-helically where the conveying portion of the belt becomes the return portion, and a second cylindrical roller which the belt wraps around non-helically where the return portion of the belt becomes the conveying portion.

Optionally, the conveyer belt tensioning elements prevent the return portion of the conveyer belt from rubbing against the conveying portion of the conveyer belt.

Additionally or alternatively, the conveyer belt tensioning elements comprise at least one conveyer belt drive roller around which the conveyer belt wraps, and which causes the conveyer belt to move, whereby the conveying elements also comprise said conveyer belt drive roller.

Additionally or alternatively, the conveyer belt tensioning elements comprise at least one conveyer belt idler roller around which the conveyer belt wraps.

Optionally, said part of the path follows a circular cylindrical surface, and the tensioning elements comprise an inner cylindrical rod located inside said circular cylindrical surface, around which rod the return portion of the conveyer belt wraps helically.

In an embodiment of the invention, the holding elements comprise a second belt, having along its length a conveying portion, the outer surface of which presses against the outer surface of the conveying portion of the conveyer belt, over an extended contact region of the said part of the path, thereby keeping the sheets pressed between the conveyer belt and the second belt as the sheets move along said part of the path.

Optionally, the second belt moves at substantially the same speed and in the same direction as the conveyer belt in said contact region.

Optionally, the second belt also has, along its length, a return portion, which does not coincide with the path, the second belt thereby forming a closed loop.

Optionally, there are also second belt tensioning elements which hold the second belt taut.

Optionally, the second belt tensioning elements include a first outer cylindrical roller which the second belt wraps around non-helically where the conveying portion of the second belt becomes the return portion, and a second outer cylindrical roller which the second belt wraps around non-helically where the return portion of the second belt becomes the conveying portion.
Optionally, the second belt tensioning elements prevent the return portion of the second belt from rubbing against the conveying portion of the second belt.

Additionally or alternatively, the second belt tensioning elements comprise at least one second belt drive roller around which the second belt wraps, and which causes the second belt to move, whereby the conveying elements also comprise said second belt drive roller.

Additionally or alternatively, the second belt tensioning elements comprise at least one second belt idler roller around which the second belt wraps.

Optionally, said part of the path follows a circular cylindrical surface, and the tensioning elements comprise an outer rod located outside said circular cylindrical surface, around which outer rod the return portion of the second belt wraps helically.

In an embodiment of the invention, the inverter is also adapted for conveying a web of printing media from the starting location to the ending location in an inverted orientation, and the drive rollers are capable of being decoupled from their drives, thereby becoming idler rollers, when the inverter is used for conveying the web.

Optionally, the inverter is also used for conveying a web of printing media from the starting location to the ending location in an inverted orientation, wherein the conveying elements comprise a drive roller at the ending location, and other conveying elements, and the other conveying elements are capable of being inactivated when the inverter is used for conveying the web.

There is further provided, in accordance with an exemplary embodiment of the invention, a method of inverting separate sheets of printing media in a printer or copier, the method comprising:

a) simultaneously moving a plurality of the sheets along a continuous path in space, starting from the starting location and ending in the ending location while inverting the sheets; and

b) confining the sheets substantially to the path the whole time that the sheets of paper are moving;

wherein the path is helical in at least one region.

There is further provided, in accordance with an exemplary embodiment of the invention, a method of inverting either separate sheets of printing media or a web of printing media in a same inverter in a printer or copier, the method comprising:

a) driving at least one intermediate conveying element when using the inverter for separate sheets;
b) using the at least one intermediate conveying elements to simultaneously move a plurality of the sheets along a continuous path in space, starting from a starting location and ending in an ending location while inverting the sheets;

c) confining the sheets substantially to the path the whole time that the sheets of paper are moving;

d) freeing the intermediate conveying elements when using the inverter for the web;

e) using an end conveying element located at the end location to pull the web along the path; and

f) keeping the web under tension while the end conveying element is pulling it.

BRIEF DESCRIPTIONS OF THE DRAWINGS

Exemplary embodiments of the invention are described in the following sections with reference to the drawings. The drawings are generally not to scale and the same or similar reference numbers are used for the same or related features on different drawings.

Fig. 1 is a perspective view of a generic sheet X-inverter showing the path of the sheets, according to any of several different exemplary embodiments of the invention;

Fig. 2 is a perspective view of a sheet L-inverter, according to an exemplary embodiment of the invention;

Figs. 3A, 3B and 3C are perspective views of a sheet L-inverter, according to exemplary embodiments of the invention different from that shown Fig. 2, each using a single belt with a different return path; and

Fig. 4 is a perspective view of a sheet L-inverter, according to another exemplary embodiment of the invention, using two belts.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Fig. 1 shows the path of the sheets of paper in an X-inverter, similar to the web path in prior art X-inverters used for inverting a continuous web of paper. A feeder 102 feeds sheets of paper 104 onto an impression roller 106, where an image is printed on one side of each sheet by a known mechanism such as electrophotography, lithography, ink-jet, or any other printing mechanism. Another roller 108 brings the paper down to the level of a first sheet L-inverter 110, to which it is transferred by a conventional mechanism (not shown). The L-inverter comprises a cylinder whose axis is oriented at a 45 degree angle to the direction of motion of the paper, which inverts the paper and changes its direction of motion by 90 degrees, sending the paper off to the left. The paper is then inverted again by a cylinder 112, which sends the paper back in the direction it came from, but raises it up to the level of a second sheet L-inverter 114. L-inverter
114 is also a cylinder, whose axis is oriented at an angle of 45 degrees to the path of the paper. It inverts the paper a third time, and sends it off to the left, in the same direction that the paper was moving when it entered first L-inverter 110. The net result of L-inverters 110 and 114, and cylinder 112, is that the paper is travelling in the same direction as it was at the beginning, but it is inverted. This combination of L-inverters and roller is called an X-inverter, since the two L-inverters, with axes oriented at right angles to each other, looks like an X when seen from above. The paper is then taken up by a second impression roller 116, where it is printed on the other side (the side which was not printed by impression roller 106), and sent by roller 118 to a finisher 120. Transfer between the cylinders and to and from the impression rollers is by any conventional means.

It should be understood that while the mechanism in Fig. 1 is described with respect to a continuous flow of paper sheets or web, this is not a necessity. As in conventional web and sheet printing systems, multiple impressions may be made at each printing station, involving intermittent feeding of paper sheets (or stop-go action of the web), and/or multiple rotations of the impression roller, with transfer through the L or X-inverter taking place when one side of a sheet is ready for transfer to the next station.

Optionally, there is no roller 108, and the paper goes directly from first impression roller 106 to L-inverter 110. Optionally, there is no roller 118, and the paper goes directly from second impression roller to finisher 120. In Fig. 1, because of the configuration of the X-inverter, roller 108 is used so that the paper will end up at the same elevation when entering impression roller 116 as it had when leaving impression roller 106. If instead, for example, the paper wrapped around L-inverters 110 and 114 in the other direction, going downward, but still went upward when wrapping around roller 112, then, depending on the diameters of the L-inverters and roller 112, the paper could end up at the end of the X-inverter at the same elevation that it had when it started, and roller 108 would not be needed in order to have the two impression rollers at the same level.

If used for a continuous web of paper, as in the prior art, the configuration shown in Fig. 1 would not need any additional rollers in order to keep the paper confined to the path shown, and to keep the paper moving. It would be sufficient, for example, to keep the web under tension, along the path shown in Fig. 1, and/or to have a motor driving one of the rollers.

However, with separate sheets, some means is needed to keep the paper on the path, and to keep it moving. Along the straight sections of the path, conventional drive and pinch rollers or belts are optionally used for this purpose, spaced closely enough together that the sheet is always in contact with a drive roller, or at least is out of contact with a drive roller for a short
enough distance that momentum carries it to the next drive roller, or some other means such as moving air carries the sheet to the next drive roller. However, conventional drive and pinch rollers will not serve to keep the paper confined to the L-inverters. Simply turning the first or second L-inverter on its axis will not work, because the path shown in Fig. 1 includes a component of motion parallel to the axis of the cylinder in each L-inverter, and rotating the cylinder will not provide this axial component of motion to the sheet. It is noted that in conventional L-inverters at least, rollers 110 and 114 do not rotate.

Optionally, the paper path is different from the paper path shown in Fig. 1. For example, the paper need not be travelling in the same direction when it leaves the inverter as it had when it entered the inverter. So, for example, there is optionally only a single L-inverter, or L-shaped inverter, instead of an X-inverter, and the second impression roller is oriented at 90 degrees to the first impression roller, or the two impression rollers are oriented in the same direction, but some other means is used to change the orientation of the paper after leaving the L-inverter. Optionally, one or more L-shaped inverters is oriented at an angle other than 45 degrees to the direction of motion of the paper, and the paper leaves the L-shaped inverter with its direction of motion changed by an angle other than 90 degrees. For example, there are three L-shaped inverters, each changing the direction of motion of the paper by 120 degrees. However, no L-shaped inverter is oriented at an angle of 90 degrees to the direction of motion of the paper, or it would be an ordinary cylinder, not an L-shaped inverter, and ordinary drive and pinch rollers could be used to keep the paper moving around it. Any number of such ordinary cylinders are, optionally, used in combination with L-shaped inverters, as is the case, for example, with cylinder 112 in Fig. 1, but there is at least one place where the path of the paper is helical for some distance, as it is at the L-inverters in Fig. 1.

The paper need not travel around such a helical path for half a turn, as it does at each of the L-inverters in Fig. 1. Optionally, the paper travels around an L-shaped inverter for less than half a turn, or more than half a turn. In general, the paper would then not be oriented in the same direction at input and output, and optionally the paper later goes less than half a turn, or more than half a turn, around additional L-shaped inverters, in order to bring its orientation back to substantially the starting orientation, but inverted. Optionally, one or more L-shaped inverters are conical rather than cylindrical. In this case, the paper would also, in general, not be oriented in the same direction after going around such an L-shaped inverter, even if it went half a turn around, and optionally, some combination of one or more additional conical L-shaped inverters, or cylindrical L-shaped inverters oriented at an appropriate angle with the path taking an appropriate fraction of a turn, later brings the paper back to the starting orientation.
Using L-shaped inverters with surfaces that have zero geodesic curvature, such as cylindrical and conical surfaces, has the potential advantage that the paper can be made to conform to the surface, by holding elements, without buckling, creasing, stretching, or tearing. In some embodiments of the invention, as described below for Fig. 2, there is no physical surface associated with the L-shaped inverter, but a set of holding elements, for example pinch rollers, still keeps the paper confined substantially to a virtual surface. In either case, the condition of "zero geodesic curvature" means simply that the holding elements are arranged so that the paper, as it travels along the path, is not subject to substantial tangential stresses, which would tend to stretch, tear, buckle or crease the paper, in an attempt to force the paper to conform to a real or virtual surface with non-zero geodesic curvature.

Optionally, the L-shaped inverters, whether cylindrical or conical, do not have circular cross-sections, but cross-sections that are elliptical, or another shape. Preferably, however, the cross-sections do not have sharp corners, which could tear the paper, or crease or spindle it. Optionally, the cross-sectional shapes of the L-shaped inverters are convex, which has the potential advantage that it is easier to hold paper to the path. Alternatively, the cross-sections are concave in at least some places.

There are some limits to the possible paths that the paper takes through space. For example, a path similar to the conveyer belts used for carrying luggage at airports, which turn around corners, might be unsuitable for an inverter using a continuous web of paper, because the web might buckle, stretch or tear when it turned to the left or to the right in its own plane. Such a path could be used for separate sheets of paper without buckling, stretching or tearing, using various possible mechanisms for rotating the orientation and/or direction of motion of the paper in its own plane. The mechanisms shown for L-inverters in Figs. 2, 3 and 4 do not rotate the orientation or direction of motion of sheets of paper in their own plane, although mechanisms which do rotate the orientation and/or direction of motion of sheets of paper in their own plane are optionally used at other places in the printer or copier, before or after the paper is inverted.

Fig. 2 shows a close-up view of an L-inverter, for example, one of the L-inverters in Fig. 1, adapted to convey sheets. A sheet of paper 104 enters the L-inverter from the bottom, and travels on a helical path around a cylindrical surface 202. In order to keep the sheet of paper confined to surface 202, and in order to keep it moving, pairs of rollers are arranged along the paper path. Rollers 204 and 206 are the first pair in the path shown in Fig. 2, rollers 208 and 210 are the next pair, then rollers 212 and 214, and then rollers 216 and 218. Each pair of rollers optionally includes a drive roller and a pinch roller. Alternatively, some pairs of rollers do not
include a drive roller, but at any given point in the path, the paper is in contact with at least one pair of rollers that does include a drive roller. Alternatively or additionally, some of the pairs of rollers comprise two drive rollers. In each pair, one roller is inside the cylindrical surface, and one roller is outside. For example, rollers 204, 208, 212 and 216 are inside cylindrical surface 202, while rollers 206, 210, 214 and 218 are outside, such that the nip between the rollers is on cylindrical surface 202. The rollers are preferably oriented so that, as the paper passes through each pair of rollers, the paper moves in the proper direction along the helical paper path without substantial slippage between the paper and the roller surfaces.

Optionally, there are more or fewer than four pairs of rollers arranged around the paper path on surface 202. The rollers shown are all located near one edge of the paper, the edge that is initially on the right. Optionally, there are also pairs of rollers located near the left edge of the paper. Having rollers near both edges has the potential advantage that the paper may be less likely to turn to the left or the right, due to different forward forces acting on the left and right sides of the paper. Optionally, there are more than two rows of rollers, for example a row of pairs of rollers near the right edge of the paper, a row near the left edge of the paper, and a row in the middle. Alternatively, there is only one row of pairs of rollers located near the middle of the paper path, half way between the left and the right edges of the paper. However, the right edge of the paper reaches surface 202 before the middle of the paper does, so it is potentially advantageous to have a pair of rollers at the location of rollers 204 and 206, to pick up the paper as soon as it reaches surface 202.

Optionally, surface 202 is a solid surface, with openings to expose rollers 204, 208, 212 and 216, and any other rollers which are located inside the surface. Alternatively, surface 202 is only a mathematical construct, to show where the rollers are located in space, and there is no material surface there, but there are several rows of rollers, spaced closely enough together to keep the paper confined to surface 202. Alternatively, there is a solid structure along part of surface 202, to help keep the paper confined to the surface, but not along all of the surface.

Optionally, at least some of the idler pinch rollers are replaced by idler pinch balls. This has the potential advantage that it makes no difference which way pinch balls are aligned, while pinch rollers are generally aligned with the desired helical path of the paper, if it is desired to avoid slippage of the paper relative to the rollers when the paper moves along the desired path.

If the system shown in Fig. 2 is used for a web as well as for separate sheets, then optionally the drive rollers decouple from the motors driving them when the system is being used for a web, so that all the pinch rollers act as idler rollers, and the web is driven by a single drive roller pulling it at the end. This arrangement has the potential advantage that a single drive
roller at the end may drive the web more uniformly than a set of independent drive rollers along the length of the web.

Figs. 3A shows an L-inverter using a different mechanism for keeping sheets of paper moving along and confined to the desired helical paper path. A half-cylindrical shell 302 has a surface corresponding to the cylindrical surface that the paper travels on. A belt 304, following the path of the paper, is wrapped around a roller 306, then follows the helical path of the paper around half-cylinder 302, then wraps around another roller 308, then one and a half times around a smaller cylinder 310, with radius equal to one third of the radius of half-cylinder 302, located concentric with and inside half-cylinder 302, and returns to roller 306. Roller 306 or roller 308 optionally acts as a drive roller, moving belt 304, while the other of rollers 306 and 308 optionally is an idler roller. Rollers 306 and 308 are optionally crowned, to keep belt 304 centered. When paper 104 reaches the beginning of belt 304, below roller 306, the paper is caught in a nip between belt 304 and a pinch ball 312. The paper is then carried around half-cylinder 302 by belt 304, and the paper is held to the belt by a series of pinch balls 314, arranged along belt 304, optionally at close enough intervals so that there is always at least one pinch ball holding the paper to belt 304, and at close enough intervals so that, when the paper is going around the curved part of the path, the paper stays close enough to the belt so that it can be taken up by each pinch ball. Alternatively, in the flat part of the path where the paper is above the belt, near roller 308, the pinch balls are not spaced closely enough so that the paper is always held by at least one pinch ball, and gravity is used to hold the paper to the belt. At roller 308, the belt wraps back around to return to the beginning of the paper path, and the paper leaves the belt.

Optionally, cylinder 310 and half-cylinder 302 have low coefficients of friction with belt 304. Optionally, this is achieved by an air cushion between belt 304 and the surface of cylinder 310 and/or half-cylinder 302, produced by pushing air under pressure through small holes in the surface. Optionally, this is also done for other cases, described below, where a belt wraps helically around a cylindrical surface.

Fig. 3A shows belt 304 situated along one edge of the paper, the edge that is on the right side at the beginning of the belt. Optionally, there is more than one belt in parallel, for example there is also a belt, similar to belt 304, situated along the opposite edge of the paper, or there is only one belt but it is wider, covering more of the width of the paper, or all of the width of the paper. In the case of a wide belt, there are optionally two or more rows of pinch balls holding the paper to the belt. Optionally, one or more of the pinch balls are replaced by pinch wheels, each pinch wheel oriented in the direction of motion of the paper.
Having belt 304 wrap one and a half turns around cylinder 310, but only half a turn around half-cylinder 302, and making cylinder 310 have one third the radius of half-cylinder 302, allows the conveying part of the belt to be aligned with the return part of the belt, both before and after the helical portion of the belt. Such alignment allows the belt to wrap around cylindrical rollers 306 and 308 without sliding axially. This has the potential advantage that either roller 306 or roller 308 or both can be used to drive belt 304, without any slipping, for example by keeping a high coefficient of friction between the belt and the rollers, or by using sprockets.

There are many other ways to arrange the return path of belt 304 so that the conveying part of the belt and the return part are aligned both before and after the helical portion. Two examples are shown in Figs. 3B and 3C. These drawings differ from Fig. 3A only in the return path of belt 304. The conveying part of 304, which conveys the paper around the L-inverter, is the same in all three drawings.

In Fig. 3B, the return part of belt 304, after wrapping around roller 308, wraps half a turn helically around cylinder 316, which sends the belt off to the side at an oblique angle. The belt then wraps half a turn helically around cylinder 318, which is oriented with its axis parallel to cylinder 316. The belt is now travelling in the same direction as it was when it came around roller 308, but displaced laterally. The lateral displacement is such that, when the belt wraps half a turn around cylinder 310, it ends up aligned with the conveying part of the belt. The orientation of cylinders 316 and 318 need not be the same as the orientation of cylinder 310 and half-cylinder 302, and the diameters of cylinders 316 and 318 need not be the same as each other, or the same as the diameter of cylinder 310. The radius of cylinder 310 need not be one third the radius of half-cylinder 302, as it is in Fig. 3A, but the lateral displacement that cylinders 316 and 318 give to the belt is related to the radius of cylinder 310 and the radius of half-cylinder 302.

In Fig. 3C, there is no small cylinder 310 concentric with half-cylinder 302, but there are two small cylinders 320 and 322, oriented at different angles, which the return part of belt 304 wraps around helically. Cylinders 320 and 322 are located and oriented in such a way that the return part of belt 304 is aligned with the conveying part of belt 304, both before and after the conveying part of belt 304 wraps helically around half-cylinder 302. Optionally, depending on the location of cylinders 320 and 322, half-cylinder 302 is solid rather than a shell.

Optionally, belt 304 is not wrapped half a turn around rollers 306 and 308, but less than half a turn around one or both of them, and the return part of belt 304 is not parallel to the conveying part of the belt, near one or both of rollers 306 and 308. As long as belt 304 takes a
non-helical path around rollers 306 and 308, then belt 304 can still go around the rollers without slipping, and we still describe the return part of belt 304 as “aligned” with the conveying part of belt 304, adjacent to the rollers.

Many other ways of handling the return path of belt 304, while keeping the return part aligned with the conveying part of the belt at both ends, will be apparent to those skilled in the art. Optionally, the return part of belt 304 is aligned with the conveying part only at one end, for example only at the end which has a drive roller, and at the other end, the idler roller is replaced with a cylinder which the belt goes around helically.

Fig. 4 shows an L-inverter with a belt 304, as in Figs. 3A, which is wrapped one and half times around cylinder 310 in its return path. Alternatively, the return path shown in Figs. 3B or 3C, or one of many other possible return paths, is used instead for belt 304 in Fig. 4. However, pinch balls 314 in Fig. 3A are replaced in Fig. 4 by an outer belt 402, and the paper is held between belt 304 and outer belt 402 as it goes around the L-inverter. Outer belt 402 begins at roller 404, adjacent to roller 306, and follows the paper path around half-cylinder 302, pressing against belt 304 with enough force to hold the paper against belt 304. After going around half-cylinder 302, outer belt 402 leaves contact with belt 304, and wraps around another roller 406, and returns back along the paper path, but further away from half-cylinder 302. Outer belt 402 then makes half a helical half-turn around a cylinder 508, which is oriented parallel to half-cylinder 302 but with its axis generally not directly above the axis of half-cylinder 302, and wraps around rollers 510, 512, and 514, finally returning to roller 404. Note that, depending on the position and diameter of cylinder 508, relative to half-cylinder 302, outer belt 402 need not wrap one and a half times around cylinder 508, as belt 304 does around cylinder 310, in order to make the return part of outer belt 402 align with the conveying part of outer belt 402, at both ends. Alternatively, cylinder 508 is the same diameter as cylinder 310 and located directly above cylinder 310, and outer belt 402 does wrap one and a half turns around cylinder 508. Many other possible return paths for outer belt 402 will be apparent to one skilled in the art, and taking into account the remarks above about belt 304.

In Figs. 2, 3A-3C, and 4, the half-cylinders need not be 180 degrees of a cylinder. They can be less than or greater than 180 degrees, depending partly on how much of the cylinder the paper path follows, and they need not be parts of circular cylinders, but optionally are surfaces of other shapes. The return path of the belt or belts need not be held even approximately a uniform distance away from the part of the belt that is conveying the paper, but could take a variety of different paths. A potential advantage of not letting the return path get too far away from the paper conveying part of the belt is that the entire belt will not take up too much space.
A potential advantage of not letting the return path get too close to the paper conveying part is that the two parts of the belt will not rub against each other, possibly causing wear or damage. A possible advantage of using a return path that allows the belt to be kept under tension is that the belt may be less likely to accidentally come off the rollers.

In the inverter shown in Fig. 4, optionally the speed of the belts is set by a motor driving only one of the belts, for example belt 304, and the other belt, in this case belt 402, is driven by a motor whose speed is variable and sensitive to the torque exerted on the motor by belt 402. This arrangement has the potential advantage that the belts will not slide against each other, possibly smudging the image on the paper, but will move at the same speed. Alternatively, one of the belts is not driven by its rollers at all, but has only idler rollers which allow it to be pulled along by the other belt. Alternatively, a single motor is connected to a drive roller for each belt, and the two belts are kept moving at the same speed by means of gears, or sprockets, or any other means known to the art for synchronizing two drive rollers. Alternatively, there are separate motors driving the two belts, but they are kept synchronized electrically, so that the belts move at the same speed.

The inverters shown in Figs. 3A, 3B, 3C, and 4, like the inverter shown in Fig. 2, are potentially usable for either a web or individual sheets. If used for a web, optionally the web is driven by a drive roller pulling the web at its end, and the belt or belts have only idler rollers. Alternatively, the belt or belts have their own drive roller or drive rollers, but the belt drive rollers are driven by motors which have variable speed and are sensitive to torque, so that the belt or belts move at the same speed as the web is being pulled. Alternatively, it is the drive roller at the end of the web which has variable speed and sensitivity to torque, so that it moves at whatever speed is needed to keep the web under a desired tension as the web is moved by the belt or belts. Alternatively, the pinch balls in Figs. 3A-3C, or the outer belt in Fig. 4, is disengaged from belt 304 when a web is used, and, with nothing pressing the web against belt 304, the web slides along belt 304. Alternatively or additionally, belt 304, at least, is moved to the side when a web is used, or belt 304 remains in the same position but the paper path is moved to the side, so that the web goes directly over cylinder 302 without touching belt 304.

As used herein, except where explicitly otherwise limited, the term helical or helical motion means a path along a surface that is not along the minimum local radius of curvature, and includes helical motion along a non-circularly cylindrical surface.

As used herein, except where explicitly otherwise limited, the term “tangent to the surface” of a sheet of printing media, means “tangent to either the front surface or the back surface” of the sheet, but excludes the case of tangent only to an edge of the sheet.
As used herein, "L-shaped inverter" includes, but is not limited to, an L-inverter. The term L-inverter is defined as an L-shaped inverter with a 90 degree change in path direction. The term L-shaped inverter may also include inverters in which the change in direction is more or less than 90 degrees. Similarly, as used herein, "X-shaped inverter" includes, but is not limited to, an X-inverter. The term X-inverter is defined as an X-shaped inverter comprising two L-inverters, with their axes oriented 90 degrees apart. The term X-shaped inverter may also include inverters which comprise two L-shaped inverters, not necessarily L-inverters, and inverters in which the axes of the two L-shaped inverters are oriented at angles that differ by more or less than 90 degrees.

Although this description and the claims refer sometimes to paper, the invention may also be used with any other printing media, and the claims cover the apparatus and the method when any printing media is used. The invention has been described in the context of the best mode for carrying it out. It should be understood that not all features shown in the drawings or described in the associated text may be present in an actual device, in accordance with some embodiments of the invention. Furthermore, variations on the method and apparatus shown are included within the scope of the invention, which is limited only by the claims. Also, features of one embodiment may be provided in conjunction with features of a different embodiment of the invention. As used herein, the terms "have", "include" and "comprise" or their conjugates mean "including but not limited to."
1. An inverter for taking separate sheets of printing media from a starting location in a printer or copier and conveying the sheets to an ending location in an inverted orientation, the inverter comprising:
   a) one or more conveying elements capable of simultaneously moving a plurality of the sheets along a continuous path in space, starting from the starting location and ending in the ending location while inverting the sheets; and
   b) one or more holders capable of confining the sheets substantially to the path the whole time that the sheets are moving;
   wherein the path is helical in at least one region.

2. An inverter according to claim 1, wherein the path does not turn to the left or right with respect to any plane tangent to the surface of the sheets.

3. An inverter according to claim 1 or claim 2, wherein the holders are arranged so as not to exert substantial tangential stresses on the sheets when said holders confine the sheets substantially to the path.

4. An inverter according to any of the preceding claims, wherein successive sheets follow substantially the same path, and are oriented in substantially a same orientation at a given location in the path.

5. An inverter according to any of the preceding claims, wherein the helical path is along a circular cylindrical surface in at least part of the at least one regions where the path is helical.

6. An inverter according to claim 5, wherein the circular cylindrical surface and the helical path along it comprise an L-shaped inverter.

7. An inverter according to claim 6, wherein the circular cylindrical surface and the helical path along it comprise an L-inverter.

8. An inverter according to claim 6, wherein there are at least two L-shaped inverters with axes oriented at different angles.
9. An inverter according to claim 8, wherein two of the at least two L-shaped inverters with axes oriented at different angles comprise an X-inverter.

10. An inverter according to any of the previous claims, wherein the conveying elements comprise at least one drive roller tangent to the surface of the sheets as they move along the path at a location in one of the at least one regions where the path is helical, and oriented at the pitch of the direction of motion of the sheets at said location.

11. An inverter according to claim 10, wherein the at least one drive roller comprises a plurality of drive rollers tangent to the surface of the sheets in one of the at least one regions where the path is helical, said drive rollers being spaced closely enough together so that each sheet is always in contact with at least one of the drive rollers as said sheet traverses said region.

12. An inverter according to claim 10 or claim 11, wherein the holding elements comprise at least one pinch roller, tangent to the surface of the sheets at a location where one of the at least one drive rollers is tangent to the surface of the sheets, but on the other side of the sheets from said drive roller, such that said pinch roller and said drive roller form a nip at said location, through which the sheets pass as they move along the path.

13. An inverter according to claim 12, wherein the at least one pinch roller is an idler roller, oriented in the same direction as the drive roller with which it forms a nip.

14. An inverter according to any of claims 10-13, wherein the holding elements comprise at least one pinch ball, tangent to the surface of the sheets at the location that one of the at least one drive rollers is tangent to the surface of the sheets, but on the other side of the sheets from said drive roller, such that said pinch ball and said drive roller form a nip at said location, through which the sheets pass as they move along the path.

15. An inverter according to any of claims 1-9, wherein the conveying elements comprise a conveyer belt, having along its length a conveying portion, the outer surface of which coincides with the path over at least part of one of the at least one regions where the path is helical, and which conveying portion moves the sheets along said part of the path.
16. An inverter according to claim 15, wherein the holding elements comprise at least one pinch ball, tangent to the outer surface of the conveying portion of the conveyer belt, such that said pinch ball and said outer surface form a nip through which the sheets pass as they move along the path.

17. An inverter according to claim 15 or claim 16, wherein the holding elements comprise at least one pinch roller, tangent to the outer surface of the conveying portion of the conveyer belt, and substantially aligned with the direction of motion of said conveying portion, such that said pinch roller and said outer surface form a nip through which the sheets pass as they move along the path.

18. An inverter according to any of claims 15-17, wherein the conveyer belt also has, along its length, a return portion, which does not coincide with the path, the conveyer belt thereby forming a closed loop.

19. An inverter according to claim 18, and including also conveyer belt tensioning elements which hold the conveyer belt taut.

20. An inverter according to claim 19, wherein the tensioning elements include a first cylindrical roller which the belt wraps around non-helically where the conveying portion of the belt becomes the return portion, and a second cylindrical roller which the belt wraps around non-helically where the return portion of the belt becomes the conveying portion.

21. An inverter according to claim 19 or claim 20, wherein the conveyer belt tensioning elements prevent the return portion of the conveyer belt from rubbing against the conveying portion of the conveyer belt.

22. An inverter according to any of claims 19-21, wherein the conveyer belt tensioning elements comprise at least one conveyer belt drive roller around which the conveyer belt wraps, and which causes the conveyer belt to move, whereby the conveying elements also comprise said conveyer belt drive roller.

23. An inverter according to any of claims 19-22, wherein the conveyer belt tensioning elements comprise at least one conveyer belt idler roller around which the conveyer belt wraps.
24. An inverter according to any of claims 19-23, wherein said part of the path follows a circular cylindrical surface, and the tensioning elements comprise an inner cylindrical rod located inside said circular cylindrical surface, around which rod the return portion of the conveyer belt wraps helically.

25. An inverter according to any of claims 15-24, wherein the holding elements comprise a second belt, having along its length a conveying portion, the outer surface of which presses against the outer surface of the conveying portion of the conveyer belt, over an extended contact region of the said part of the path, thereby keeping the sheets pressed between the conveyer belt and the second belt as the sheets move along said part of the path.

26. An inverter according to claim 25, wherein the second belt moves at substantially the same speed and in the same direction as the conveyer belt in said contact region.

27. An inverter according to claim 25 or claim 26, wherein the second belt also has, along its length, a return portion, which does not coincide with the path, the second belt thereby forming a closed loop.

28. An inverter according to any of claims 25-27, and including also second belt tensioning elements which hold the second belt taut.

29. An inverter according to claim 28, wherein the second belt tensioning elements include a first outer cylindrical roller which the second belt wraps around non-helically where the conveying portion of the second belt becomes the return portion, and a second outer cylindrical roller which the second belt wraps around non-helically where the return portion of the second belt becomes the conveying portion.

30. An inverter according to claim 28 or claim 29, wherein the second belt tensioning elements prevent the return portion of the second belt from rubbing against the conveying portion of the second belt.

31. An inverter according to any of claims 28-30, wherein the second belt tensioning elements comprise at least one second belt drive roller around which the second belt wraps, and
which causes the second belt to move, whereby the conveying elements also comprise said second belt drive roller.

32. An inverter according to any of claims 28-31, wherein the second belt tensioning elements comprise at least one second belt idler roller around which the second belt wraps.

33. An inverter according to any of claims 28-32, wherein said part of the path follows a circular cylindrical surface, and the tensioning elements comprise an outer rod located outside said circular cylindrical surface, around which outer rod the return portion of the second belt wraps helically.

34. An inverter according to any of claims 10-14, 22 or 31, also adapted for conveying a web of printing media from the starting location to the ending location in an inverted orientation, wherein the drive rollers are capable of being decoupled from their drives, thereby becoming idler rollers, when the inverter is used for conveying the web.

35. An inverter according to any of the preceding claims, also used for conveying a web of printing media from the starting location to the ending location in an inverted orientation, wherein the conveying elements comprise a drive roller at the ending location, and other conveying elements, and the other conveying elements are capable of being inactivated when the inverter is used for conveying the web.

36. A method of inverting separate sheets of printing media in a printer or copier, the method comprising:

a) simultaneously moving a plurality of the sheets along a continuous path in space, starting from the starting location and ending in the ending location while inverting the sheets; and

b) confining the sheets substantially to the path the whole time that the sheets of paper are moving;

wherein the path is helical in at least one region.

37. A method of inverting either separate sheets of printing media or a web of printing media in a same inverter in a printer or copier, the method comprising:
a) driving at least one intermediate conveying element when using the inverter for separate sheets;

b) using the at least one intermediate conveying elements to simultaneously move a plurality of the sheets along a continuous path in space, starting from a starting location and ending in an ending location while inverting the sheets;

c) confining the sheets substantially to the path the whole time that the sheets of paper are moving;

d) freeing the intermediate conveying elements when using the inverter for the web;

e) using an end conveying element located at the end location to pull the web along the path; and

f) keeping the web under tension while the end conveying element is pulling it.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B65H15/00 B65H23/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 3 548 783 A (KNAPP LOWELL W) 22 December 1970 (1970-12-22) column 1, line 3 -column 2, line 35; figures</td>
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Lemmen, R
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