The controller then manipulates a zero-backlash actuator so as to control the transverse position of the web.

SUMMARY

Although with known techniques the transverse position of the web can be controlled to a high tolerance, it is not possible to control both the transverse position of the web at a selected point along the web path and control the angular orientation of the web at that point. For some applications, control of the angular orientation as well would be very desirable. ~~The~~ Embodiments of the present invention generally ~~relates~~ relate to a method and an apparatus for controlling a moving web. More specifically, embodiments of the present invention ~~relates~~ relate to a web guide apparatus having the ability to control both the lateral position of the web at a control location (chosen position along the web path), as well as the web's angular orientation at the control location.

It has now been determined that it is possible to control both the transverse position of a moving web at the same time and at the same place along the web path where the angular orientation of the web is also controlled. This is accomplished in part by providing a steering roller that has the ability to move with two degrees of freedom. Such control ~~is~~ may be of great advantage when, e.g. the web is about to be patterned with very fine features that are positioned in registration with other features on the web.

~~Hence, in one embodiment~~In accordance with one aspect of~~,~~ the invention, ~~resides in~~ there is provided an apparatus for steering a web comprising: a web path comprising at least one steering roller and an exit roller, each having a mount; wherein the at least one steering roller has an axis of rotation and wherein the mount for the at least one steering roller can pivot and/or translate the axis of rotation with a total of two degrees of freedom; an array comprising a plurality of position sensors for monitoring the position of the web; a controller connected to the array for determining the lateral position and angular orientation of the web; and two actuators operably connected to the at least one steering roller for positioning the steering roller to control the angular orientation and the lateral position of the web at a particular point along the web path.

In some convenient embodiments, the apparatus is such that the web path has one steering roller and the mount for that steering roller can pivot in the requisite two degrees of freedom. In other convenient embodiments, the apparatus is such that the web path has a first and a second steering roller, and the mounts for the first and second steering rollers can each pivot in a first and a second degree of freedom, respectively.

In some convenient embodiments, the first degree of freedom is a yaw angle around a yaw-axis perpendicular to the surface of the web at a predetermined point. Further, in some

convenient embodiments the second degree of freedom is a roll angle around a roll-axis parallel to the surface of the web at the predetermined point or possibly at different predetermined point.

While an array having a plurality of position sensors is needed, some convenient embodiments include four sensors. This is because the relevant equations for controlling the web transverse position and angular orientation require four boundary conditions for an exact solution.

~~In another embodiment, the invention resides in~~In accordance with another aspect of the present invention, there is provided a method of steering a web comprising: providing a plurality of position sensors adjacent to the web; calculating the angular orientation and lateral position of the web by solving more than one position equation using a general solution for the lateral dynamics of a moving web; moving a steering roller about a yaw-axis perpendicular to the surface of the web; moving the steering roller about a roll-axis parallel to the surface of the web; and guiding the web to a chosen position along a web path downstream of the steering roller.

Those skilled in the art will more fully understand the nature of the invention upon consideration of the remainder of the disclosure, including the Detailed Description, the Examples, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only, and is not intended as limiting the broader aspects of the present disclosure, which broader aspects are embodied in the exemplary construction.

FIG. 1 is a perspective schematic view of a web steering apparatus according to the prior art, illustrating certain limitations on its performance;

FIG. 2 is a perspective schematic view of a web steering apparatus according to one embodiment of the present invention;

FIG. 3 is a perspective schematic view of the web steering apparatus system of FIG. 2 with one positioning of an array of position sensors;

FIG. 4 is a perspective schematic view of the web steering apparatus of FIG. 2 with an alternate positioning of an array of position sensors;

FIG. 5 is a perspective schematic view of an alternate embodiment of the web steering apparatus;

FIG. 6 is a perspective schematic view of another alternate embodiment of the web steering apparatus;

FIG. 7 is a front view of a particular embodiment of the web steering apparatus;

FIG. 8 is a side view of the web steering apparatus of FIG. 7;

FIG. 9 is a cross-section side view of the web steering apparatus taken along section lines 9-9 of FIG. 7;