March 2, 1965 J. D. ROBERTSON 3,171,579

SHEET GUIDING AND WIDTH CONTROL APPARATUS

Filed Aug. 22, 1963

3 Sheets-Sheet 1

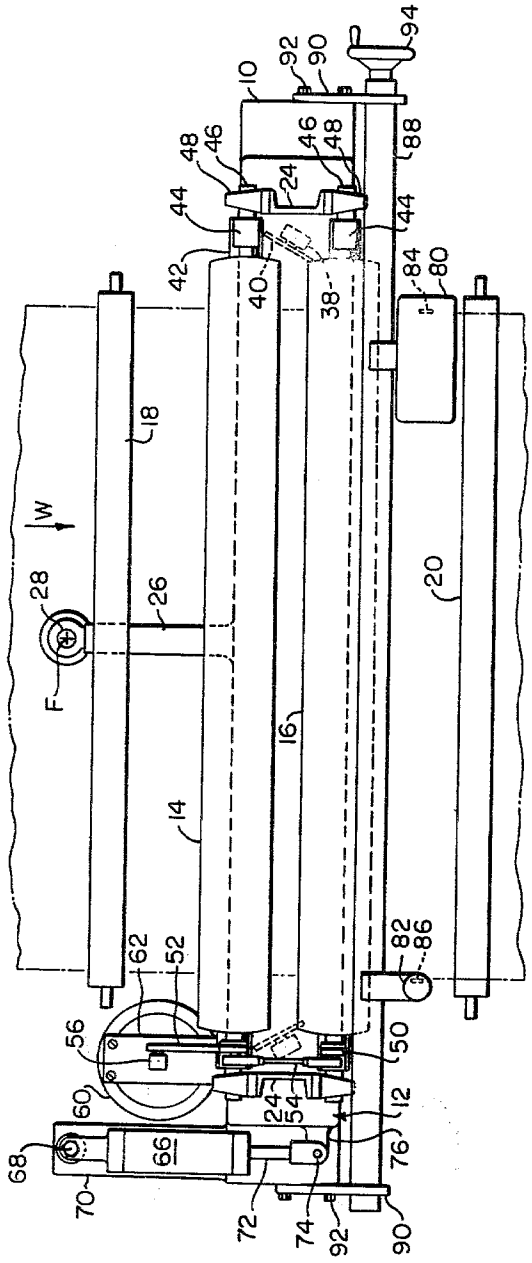


FIG. 1

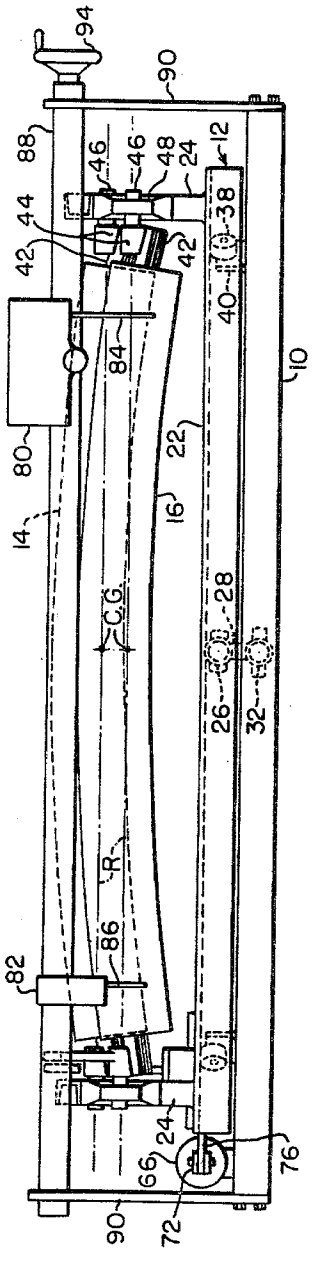


FIG. 2

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FIG. 3

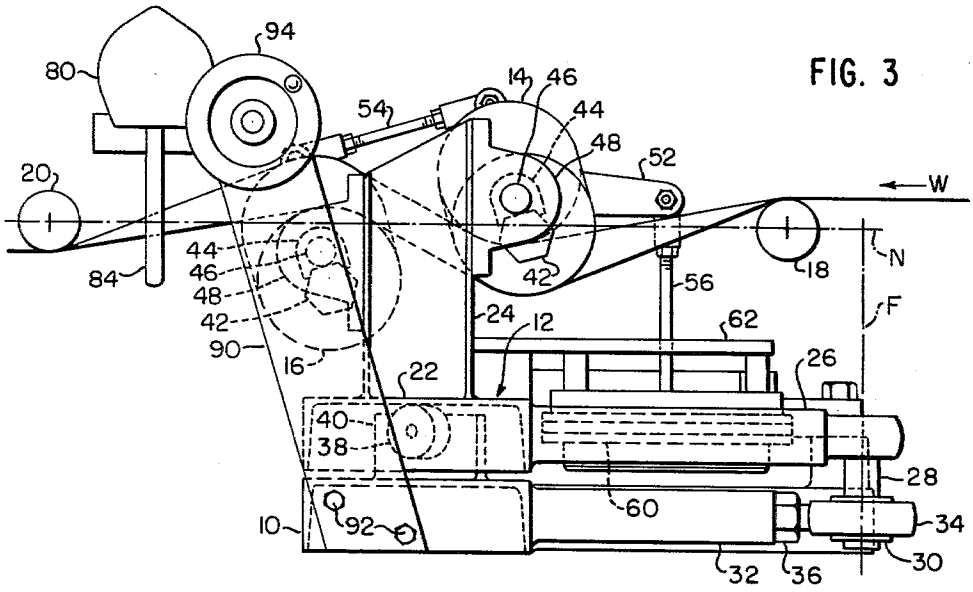
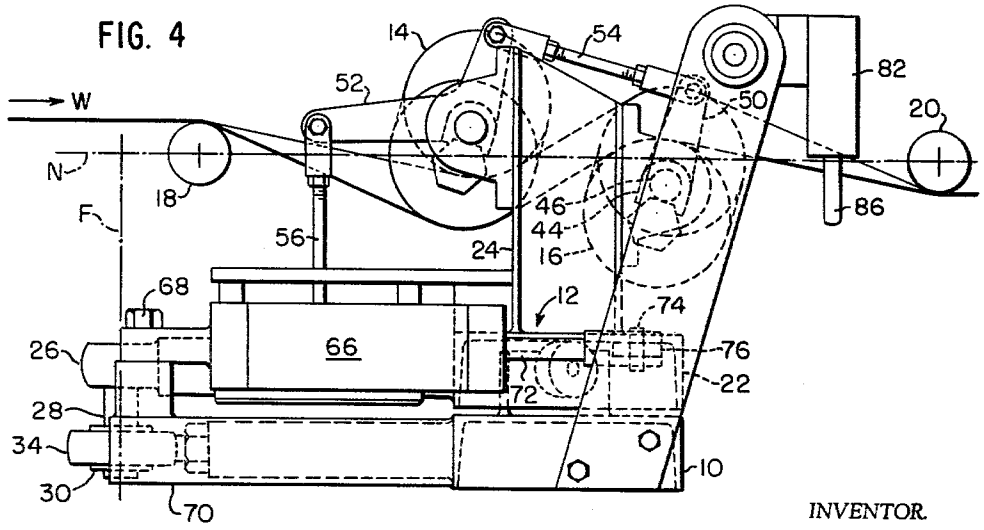


FIG. 4



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FIG. 6

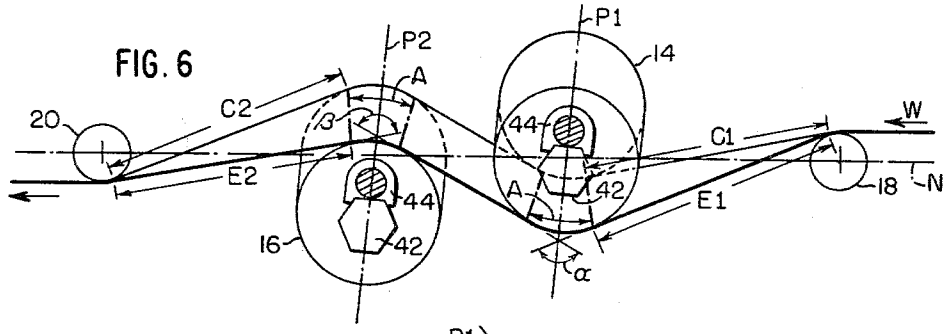


FIG. 7

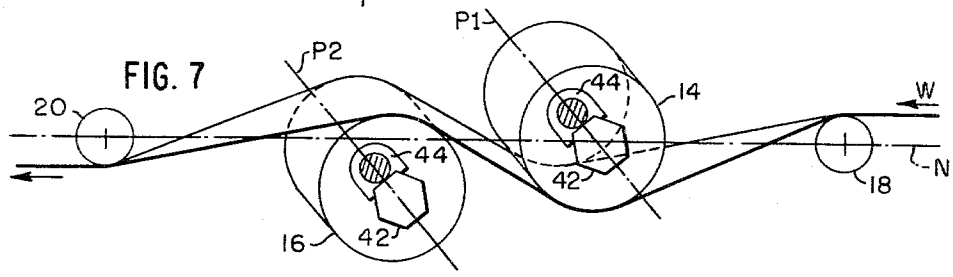
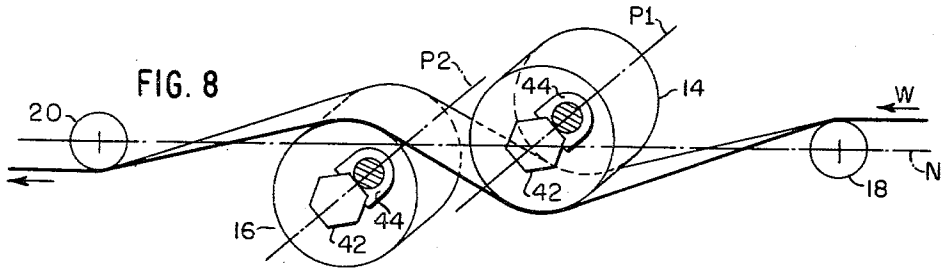


FIG. 8



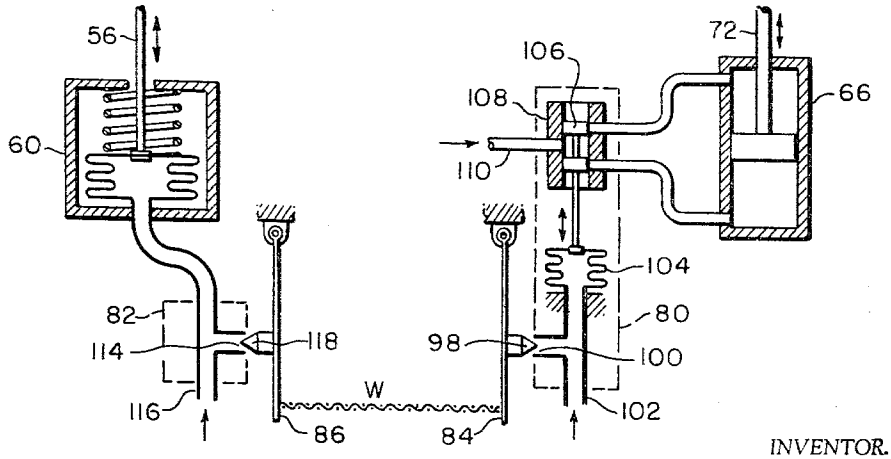


FIG. 5

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United States Patent Office 3,171,579
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3,171,579

SHEET GUIDING AND WIDTH CONTROL APPARATUS

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Filed Aug. 22, 1963, Ser. No. 303,757
8 Claims. (Cl. 226—23)

The present invention relates to an improvement in sheet guiding and width control apparatus of a type disclosed and claimed in U.S. Patent No. 2,722,415 to George B. Wood, Jr., et al., issued November 1, 1955, on "Sheet Guiding Apparatus," and assigned to the inventor of the present application. More particularly, the invention is concerned with apparatus of a type shown in FIGURES 5 and 6 of that patent, which include means for controlling the width of a traveling sheet, as well as means for guiding the sheet in a predetermined path. According to the patent, a sheet traveling between parallel spaced rolls is engaged by an intermediate guiding roll, which is mounted for movement transversely of the direction of sheet travel, and also for tilting movement in a plane generally parallel to the common plane of the parallel rolls. Transverse movement of the guiding roll carries the sheet quickly back to a predetermined path when it wanders, and tilting movement tends to maintain the sheet in the proper path once it has been re-positioned there.

According to an embodiment as disclosed in FIGURES 5 and 6 of the patent, the width of the web is also controlled by the same apparatus, by forming the guiding roll with a planar longitudinal curvature and mounting it for angular adjustment. By appropriately adjusting the position of the curved roll with respect to the web, which is wrapped over an arcuate portion of the roll surface, the web may be expanded or contracted in width, according to a well-known principle. A sheet encountering the roll on its concave side and leaving on its convex side will be laterally expanded, while a reversed relationship will produce contraction. The degree of width alteration can be varied between a null and either maximum by rotating the roll to intermediate angular positions, the determining factors being the relative lengths of the longitudinal arcs of encounter and departure of the roll with the sheet, and the tangent of the projection of the end angle of the roll axis onto a plane which is normal to the plane passing through the roll axis in its neutral position.

While this apparatus is effective for guiding and width control, I have found that when the curved roll is in positions other than those providing maximum expansion or contraction for a given arc of contact, i.e., with the plane of curvature of the roll lying perpendicular to the plane bisecting the arc about which the roll is wrapped by the sheet, there is a tendency to introduce bowed distortions in the sheet. That is, the length of travel of the central and edge portions of the sheet becomes unequal, tending to cause rectilinear transverse elements of the sheet to become bowed with their central portions lagging or leading their end portions.

It is the primary object of the present invention to provide an improved sheet guiding and width control apparatus which affords substantially independent guiding and width control of a travelling sheet, without sheet distortion. It is a further object to provide an improved apparatus of increased effectiveness for guiding and width control, which at the same time features reduced complexity. It is another object to provide such an apparatus with means for maintaining uniform longitudinal path lengths for all portions of a sheet passing through the

apparatus, regardless of its guiding and width control movements. Further objects and advantages of the invention will become apparent as the following description proceeds.

Briefly stated, according to a preferred embodiment, the invention may be carried out in part by providing, intermediate a pair of parallel spaced abutments or rolls which are preferably of straight cylindrical form, and which lie in a common plane, a pair of longitudinally curved rolls, having planar curvature of their axes of symmetry. These planar curvatures are parallel and bowed in a common direction, and the rolls are drivingly interconnected for equi-angular adjustment of the location of their curvatures about parallel rectilinear axes which subtend the axes of symmetry of the curved rolls, so as to maintain this relationship. Further, the curved rolls are positioned with their rectilinear axes symmetrically spaced with respect to the common plane of the parallel abutments, for serial wrapping by a sheet, passing between the abutments, about equal arcuate segments of each curved roll. The path lengths of all longitudinal elements of the traveling sheet are thereby maintained substantially equal regardless of the angular positions of the curved rolls, and this insures against sheet distortion. Both of the curved rolls act in the same fashion upon the sheet, according to their angular position, to expand or contract the sheet cumulatively.

The curved rolls are mounted in a frame which is in turn supported for angular adjustment about an axis which is perpendicular to the common plane of the spaced abutments, for guiding the traveling sheet by moving the rolls bodily in a direction transverse to the direction of sheet travel, to carry the sheet quickly to its proper path, and at the same time tilting the rolls to retain the sheet in the proper path. In a preferred embodiment, the frame is generally of a T-shape, including a transverse support member for the rolls, and an arm extending perpendicularly to the support member for mounting at a pivotal axis located centrally of the width of the sheet. The pivotal axis of the frame is spaced from both rolls in the direction of the source of the traveling sheet, so that the lateral and tilting movements of each roll take place in a sense to aid one another in guiding the sheet to the proper path. This arrangement is advantageous in that substantially equal path lengths of sheet travel are maintained in the central and edge portions of the sheet, regardless of the angular position of the frame; distortion is thereby prevented.

The apparatus is completed by the provision of control means for positioning the frame to guide the sheet in response to deviations from a predetermined path, and further control means for angularly positioning the curved rolls to regulate the expansion of the sheet in response to deviations from a predetermined width. In a preferred form, these control means are respectively responsive to the positions of the opposite edges of the sheet, as this is a convenient parameter for determining sheet width as well as sheet position. To offset the consequent tendency of control movements of either control means to affect the other and thus induce instability, their control characteristics should differ; in a preferred form, the guiding control means adjusts the frame position at a rate dependent on edge position error, while the width control means adjusts the roll positions to an extent dependent on the opposite edge position error.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which I regard as my invention, it is believed that a clearer understanding may be gained from the following

detailed description of a preferred embodiment thereof, referring to the accompanying drawing, in which:

FIG. 1 is a plan view of a preferred embodiment of the apparatus;

FIG. 2 is a view in front elevation;

FIG. 3 is an end view;

FIG. 4 is an opposite end view;

FIG. 5 is a schematic view of control means of the apparatus; and

FIGS. 6, 7 and 8 are diagrammatic end views of curved rolls of the apparatus, showing various adjusted relationships to a traveling sheet.

In the preferred form of the invention shown in the drawings, the sheet guiding and width control apparatus is organized upon a stationary base **10**, upon which is pivotally mounted a frame generally designated at **12**, which in turn supports a pair of longitudinally curved rolls **14, 16** for serial engagement with a traveling sheet W. The curved rolls **14, 16** are arranged to be wrapped by the traveling web about equal arcuate segments, intermediate a pair of spaced parallel abutments **18, 20** which lie in a common plane N, and may be stationarily or rotatably supported in a suitable frame (not shown) in fixed relation to the base **10**. These abutments serve to guide the traveling sheet to and from the curved rolls, and to wrap the sheet about equal arcuate segments thereof.

The frame **12** includes a channel member **22** and a pair of upstanding bearing brackets **24** forming a support for the curved rolls, and a floating arm **26** which extends opposite to the direction of sheet travel, that is, toward the source of sheet supply. The frame is pivoted for swivelling movement about an axis F, which is substantially perpendicular to the common plane of the abutments **18, 20**, by means of a pivot shaft **28** extending rightangularly from the floating arm **26**, and mounted in a thrust bearing **30** which is supported by a fixed arm **32** extending from the base **10**. For alignment of the pivotal axis, the bearing **30** is supported in an eye of a threaded stud **34**, which is threadedly engaged in the arm **32** and secured by a locknut **36**. The frame carrying the rolls **14** and **16** is thus mounted for pivotal movement about the axis F for guiding the web. The frame and rolls are supported with respect to the base **10** additionally by means of a pair of rollers **38**, which are rotatably mounted upon upstanding brackets **40** welded to the base **10**, and bear against the lower surface of the channel **22** to guide the frame in its pivotal movement.

The longitudinally curved rolls **14** and **16** are of a well-known type, rotatably supported by means of longitudinally-spaced internal bearings (not shown) upon hexagonal curved shafts **42**. Each of these shafts has a longitudinal curvature lying in a plane **P1** or **P2** (see FIGS. 6–8). The rolls are mounted for angular adjustment of these planes of curvature about rectilinear axes R, which pass substantially through the centers of gravity CG of the respective rolls. The rectilinear axes R thus subtend the axes of symmetry of the rolls, lying in the planes P1 and P2, at points lying intermediate the ends of the rolls. To mount the rolls for rotation on the axes R, the ends of the axes **42** are secured, as by welding, to pairs of offset brackets **44**, which are formed with trunnions **46** rotatably supported by bearing blocks **48** in the frame **12**. The axles **42** are thus supported in parallel relation, that is, with the rectilinear axes R defined by the trunnions **46** lying parallel. It should be noted that in the preferred embodiment, the rectilinear axes of the rolls are symmetrically spaced with respect to the common plane N of the abutments **18** and **20** and each equidistant from the adjacent one of the abutments, so that the sheet W wraps about equal arcuate segments of each of the curved rolls.

The curved rolls are drivingly interconnected by means of a linkage which maintains their planes of curvature P1 and P2 in parallel relation, with the curvatures of the rolls being bowed in the same direction of these planes; the linkage is such as to adjust the rolls equi-angularly, thus to maintain this relationship as the rolls are adjusted. The linkage includes a crank **50** fixed to a bracket **44** of the roll **16** (FIG. 4), a bell-crank **52** affixed to a bracket **44** of the roll **14**, an adjustable interconnecting link **54** which drivingly connects the cranks **50** and **52** with equal lever arms, and an actuating rod **56** connected to the bell-crank **52** for positioning the rolls. To drive the linkage, a single-acting pneumatic diaphragm or motor **60**, having spring return means (not shown), is connected to the actuating rod **56**, and is mounted in the frame **12** by means of a bracket **62** secured thereto.

The angular position of the frame **12** and thus of the rolls **14** and **16** about the pivot **28** is adjustable by means of a double-acting pneumatic motor **66**, which is pivotally secured by a machine screw **68** in an extension **70** of the base **10**. A bifurcated actuating rod **72** of the motor is pivotally connected at **74** with an ear **76**, formed in an end of the frame channel member **22**.

Angular displacement of the frame **12** from the neutral position shown alters the path of the traveling sheet in a manner essentially similar to that of the apparatus of the afore-mentioned Patent No. 2,722,415. The lateral bodily movement of both rolls quickly carries the sheet transversely to a proper path; while the concomitant tilting of the rolls parallel to the common plane of the abutment **18** and **20** holds the sheet in this new path against forces tending to displace it, because the reaction on the sheet as it passes over the tilted rolls tends to bring longitudinal elements of the sheet into perpendicular relationship to the rectilinear axes of the rolls. The two distinct effects of bodily movement and of tilting of the rolls act to bring the sheet quickly to a new path, and to prevent it from subsequently crawling along the rolls back toward its original path. The effect of these movements on the sheet is distributed between the two rolls so that the action is comparatively gentle and gradual.

At the same time, the width of the sheet may be altered by its passage over the curved rolls, depending upon the angular positions of their planes of curvature P1 and P2 with respect to the sheet. This action is illustrated in FIGS. 6, 7 and 8. The rolls are shown in a neutral position in FIG. 6, being that position in which the parallel planes P1 and P2 bisect the equal angles of wrap α and β of the sheet about the rolls **14** and **16**, respectively. Because the sheet engages and leaves each roll along curvilinear arcs A which are of identical length, there is no lateral contraction or expansion of the sheet.

Because of the geometrical relation of the rolls, there is no tendency to introduce bowed distortion into the sheet. The path lengths of central portions of the sheet from the abutment **18** to the abutment **20** are substantially equal to those of the edge portions of the sheet. Specifically, the path length C1 of a central element of the sheet is greater than the path length E1 of an edge element between the abutment **18** and the curved roll **14**, but this difference is mullified by an inverse relationship between the path lengths C2 and E2 of the span extending from the roll **16** to the abutment **20**. In the position of FIG. 6, therefore, substantially no alteration of the sheet takes place as it passes through the apparatus.

In FIG. 7, the curved rolls are shown turned to a position for expanding the sheet, in which the web wraps equal arcuate sectors of the roll surfaces which are passing from the concave toward the convex condition, and are therefore being expanded laterally. The sheet is correspondingly expanded by the expansion of the roll surfaces, as well as by the tendency of the sheet to pass in perpendicular relation to the local direction of the curved axes of symmetry of the rolls. Again, the path lengths of all longitudinal elements of the web through the apparatus are substantially equal, as will be apparent from an inspection of the drawing, so that distortion is avoided.

In FIG. 8, the planes of curvature of the rolls are

turned in an opposite sense, so that the sheet wraps equal arcuate sectors of each roll which are passing from the convex toward the concave condition and are therefore contracting, with the result that the sheet is correspondingly contracted laterally. Again, however, the uniformity of path length of all longitudinal elements of the sheet is maintained, so that there is substantially no distortion of the sheet.

The improved apparatus thereby overcomes the sheet distortion arising from the use of a curved roll in a sheet guider for carrying out independent width control in the same apparatus, as disclosed by the aforementioned U.S. Patent No. 2,722,415. At the same time the improved apparatus maintains substantially independent guiding and width control functions, through separate angular adjustability of the frame and the curved rolls.

The positioning of these independently adjustable means by the motors 60 and 66 is carried out under the control of separate sheet edge-position sensors at the opposite edges of the sheet. These control means include, as shown in FIGS. 1–4, an edge-guiding sensing head 80 and a width-control sensing head 82, which have fingers 84 and 86, respectively for bearing upon and thereby sensing the positions of the opposite edges of the traveling sheet. The heads are supported in a transverse support tube 88, which is mounted upon the base 10 by means of arms 90 fixed to opposite ends of the base by machine screws 92. A lead screw having opposite threads at either end (not shown) extends internally of the tube and is connected with a hand wheel 94; the sensing heads are provided with traveling nuts (not shown) engaging the lead screw, and the tube is longitudinally slotted for connection of the heads with the traveling nuts, so that rotation of the hand wheel 94 adjusts the lateral position of the sensing heads in opposite directions to adapt them for any desired width of sheet material.

A preferred control system is shown schematically in FIG. 5. The edge-guiding sensing head 80 is connected to control the motor 66 and thus position the frame 12 angularly for guiding the sheet, while the width-control sensing head 82 is connected to control the motor 60 and thus position the rolls angularly for expanding or contracting the sheet.

The control actions of the sensing heads 80 and 82 are interdependent, in that a corrective action performed by either produces an effect upon the web which may modify the position of the sensing finger of the other control head. In order that the control system may be more stable, it is preferred to utilize sensing heads having differing control characteristics. Specifically, the edge-guiding sensing head 80 is arranged to apply a rate of guiding correction, rather than a total correction, which is proportional to the extent of an edge position error detected by the finger 84. The width-control sensing head 82, on the contrary, is arranged to provide a width correction of a value proportional to the extent of a width error detected by the finger 86.

To this end, the finger 84 bears a valve member 98 which regulates the rate of release of compressed air through an orifice 100 from a conduit 102, supplied with compressed air at a controlled flow rate from a suitable source. The pressure obtaining in a bellows 104 thereby depends upon the position of the finger 84; a valve member 106 of a four-way valve 108 is connected to the bellows to control the rate of flow to opposite ends of the double-acting motor 66, from a conduit 110 connected to a suitable source of compressed air under a regulated flow rate, in response to the extent of an edge position error. The rate of movement of the actuating rod 72, and the rate of pivotal movement of the frame 12, is thus controlled in proportion to the amount of the edge position error.

In the width-control sensing head 82, the rate of escape of compressed air from an orifice 114 in a conduit 116 is controlled by the position of a valve member 118

fixed to the sensing finger 86. The conduit 116 is supplied with compressed air under a regulated flow rate from a suitable source, and the position of the finger 86 thereby determines the pressure established within the single-acting spring return bellows or motor 60, to set the position of the actuating rod 56 in direct relation to the position of the finger 86. The extent of width correction applied by the curved rolls is consequently proportional to the amount of a deviation in width of the sheet from a predetermined value.

It will be understood that the guiding action effected by pivotal movement of the frame, and the width control action effected by angular adjustment of the curved rolls, are not inherently interdependent. However, sheet edge detection is a highly convenient means for determining the sheet width, as well as for sensing the sheet position, and the resulting interdependence of control is acceptable in actual practice, provided that the control characteristics of the two systems are such that the interaction does not result in instability.

While I have described a preferred embodiment of my invention by way of illustration, it will be understood by those skilled in the art that various changes and modifications may be made therein without departing from the true spirit and scope of the invention, which I therefore intend to define in the appended claims without limitation to details of the foregoing embodiment.

What I claim is:

1. Sheet guiding and width control apparatus for acting on a traveling sheet, comprising: a frame; a pair of curved rolls each having an axis of symmetry longitudinally curved in a plane, each of said rolls being mounted in said frame for angular adjustment of the curvature thereof about a rectilinear axis subtending its curved central axis, the rectilinear axes of said rolls being parallel; said rolls being disposed transversely of the direction of sheet travel for serial wrapping of said sheet about equal arcuate segments of said rolls; said frame being supported for angular adjustment about an axis to move said rolls transversely of the direction of sheet travel and to tilt said rolls for guiding said traveling sheet, while maintaining equal path lengths of sheet travel in the central and edge portions of said sheet through said apparatus; and linkage means drivingly interconnecting said rolls, together with motive means constructed and arranged for actuating said linkage means for equi-angular adjustment of said rolls to maintain said curvatures thereof in parallel relation and bowed in the same direction, such that said rolls may be angularly adjusted, independently of angular adjustment of said frame, to control the width of the traveling sheet while maintaining equal path lengths of sheet travel in the central and edge portions of said sheet through said apparatus.

2. Sheet guiding and width control apparatus for acting on a traveling sheet, comprising: two substantially parallel spaced abutments having axes of symmetry lying in a common plane for serially engaging the traveling sheet; a frame; a pair of curved rolls each having an axis of symmetry longitudinally curved in a plane, each of said rolls being mounted in said frame for angular adjustment of the curvature thereof about a rectlinear axis subtending its curved central axis, the rectilinear axes of said rolls being parallel; said rolls being disposed transversely of the direction of sheet travel between said abutments for serial wrapping of said sheet about equal arcuate segments of said rolls; said frame being supported for angular adjustment about an axis substantially perpendicular to said common plane and spaced from said rolls in the direction of the source of said traveling sheet, to move said rolls transversely of the direction of sheet travel and to to tilt said rolls in a plane parallel to said common plane for guiding said traveling sheet, while maintaining equal path lengths of sheet travel in the central and edge portions of said sheet through said apparatus; and means drivingly interconnecting said rolls for

equi-angular adustment to maintain said curvatures thereof in parallel relation and bowed in the same direction, such that said rolls may be angularly adjusted, independently of angular adjustment of said frame, to control the width of the traveling sheet while maintaining equal path lengths of sheet travel in the central and edge portions of said sheet through said apparatus.

3. Sheet guiding and width control apparatus as recited in claim 2, in which said frame comprises a unitary T-shaped structure including a roll support member extending transversely of the sheet and an arm extending perpendicularly from the center of said roll support member in the direction of the source of said traveling sheet, together with roller means supporting the ends of said roll-support member remote from said arm for movement of said frame about said perpendicular axis.

4. Sheet guiding and width control apparatus as recited in claim 2, in which said rectilinear axes of said rolls are symmetrically spaced with respect to said common plane of said spaced abutments.

5. Sheet guiding and width control apparatus for acting on a traveling sheet, comprising: two substantially parallel spaced abutments having axes of symmetry lying in a common plane for serially engaging the traveling sheet; a frame; a pair of curved rolls each having an axis of symmetry longitudinally curved in a plane, each of said rolls being mounted in said frame for angular adjustment of the curvature thereof about a rectilinear axis subtending its curved central axis, the rectilinear axes of said rolls being parallel and lying in a common plane; said rolls being disposed transversely of the direction of sheet travel between said abutments for serial wrapping of said sheet about equal arcuate segments of said rolls; said frame being supported for angular adjustment about an axis substantially perpendicular to said common plane and spaced from said rolls in the direction of the source of said traveling sheet, to move said rolls transversely of the direction of sheet travel and to tilt said rolls in a plane parallel to said common plane for guiding said traveling sheet, while maintaining equal path lengths of sheet travel in the central and edge portions of said sheet through said apparatus; guiding control means responsive to displacement of said sheet from a predetermined path for angularly adjusting said frame to return the sheet to the predetermined path; means drivingly interconnecting said rolls for equi-angular adjustment to maintain said curvatures thereof in parallel relation and bowed in the same direction, such that said rolls may be angularly adjusted, independently of angular adjustment of said frame, to control the width of the traveling sheet while maintaining equal path lengths of sheet travel in the central and edge portions of said sheet through said apparatus; and width control means responsive to deviations of said sheet from a predetermined width for angularly adjusting said rolls to return the sheet to the predetermined width.

6. Sheet guiding and width control apparatus as recited in claim 5, in which said guiding and width control means are constructed and arranged to sense the locations of the opposite edges of the web, respectively, to determine the lateral position and width of the sheet, said guiding and width control means having substantially different response characteristics to prevent control instability and oscillation from being caused by the interaction of either control means on the other through displacement of both sheet edges as said frame and rolls are adjusted by said control means to guide and alter the width of the sheet.

7. Sheet guiding and width control apparatus as recited in claim 5, in which said guiding control means is constructed and arranged to adjust the angular position of said frame at a rate proportional to the extent of a displacement of an edge of said sheet from a predetermined lateral position, and said width control means is constructed and arranged to adjust the angular positions of said rolls in an amount proportional to the extent of a displacement of an edge of said sheet from a predetermined lateral position.

8. Sheet guiding and width control apparatus for acting on a traveling sheet, comprising: two substantially parallel spaced abutments having axes of symmetry lying in a common plane for serially engaging the traveling sheet; a frame comprising a unitary T-shaped structure including a roll-support member extending transversely of the sheet and an arm extending perpendicularly from the center of said roll support member in the direction of the source of said traveling sheet; a pair of curved rolls each having an axis of symmetry longitudinally curved in a plane, each of said rolls being mounted in said frame for angular adjustment of the curvature thereof about a rectilinear axis subtending its curved central axis, the rectilinear axes of said rolls being parallel and lying in a further plane; said rolls being disposed transversely of the direction of sheet travel between said abutments and positioned with said rectilinear axes symmetrically spaced with respect to said common plane, for serial wrapping of said sheet about equal arcuate segments of said rolls; said arm of said frame being supported for angular adjustment about an axis substantially perpendicular to said common plane and spaced from said rolls in the direction of the source of said traveling sheet, to move said rolls transversely of the direction of sheet travel and to tilt said rolls in a plane parallel to said common plane for guiding said traveling sheet; roller means supporting the ends of said roll-support member remote from said arm for movement of said frame about said perpendicular axis; guiding control means including a sheet edge-position sensor, and motive means under control of said sensor and drivingly connected with said frame for guiding the sheet; means drivingly interconnecting said rolls for equi-angular adjustment to maintain said curvatures thereof in parallel relation and bowed in the same direction, such that said rolls may be angularly adjusted, independently of angular adjustment of said frame, to control the width of the traveling sheet; and width control means including a further sheet edge-position sensor, and motive means under control of said further sensor and drivingly connected with said roll interconnecting means for controlling the width of the sheet.

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