

Jan. 20, 1970

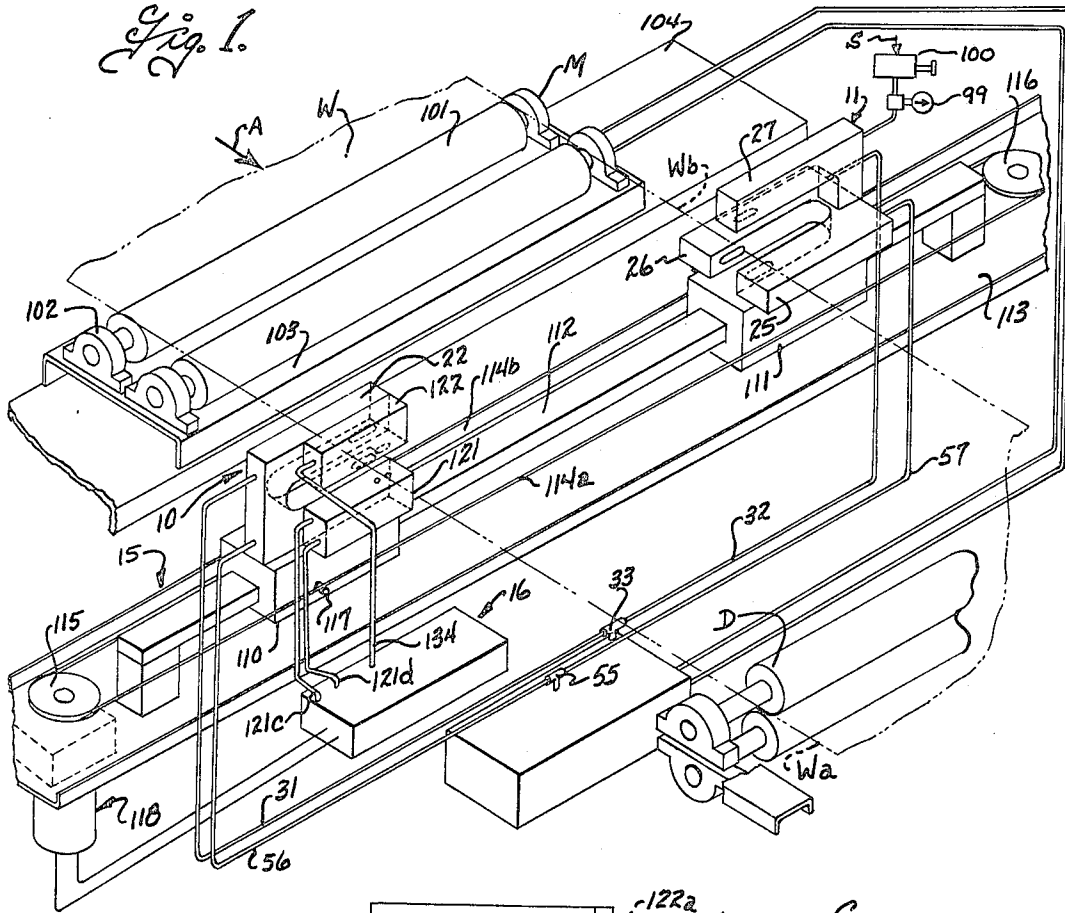
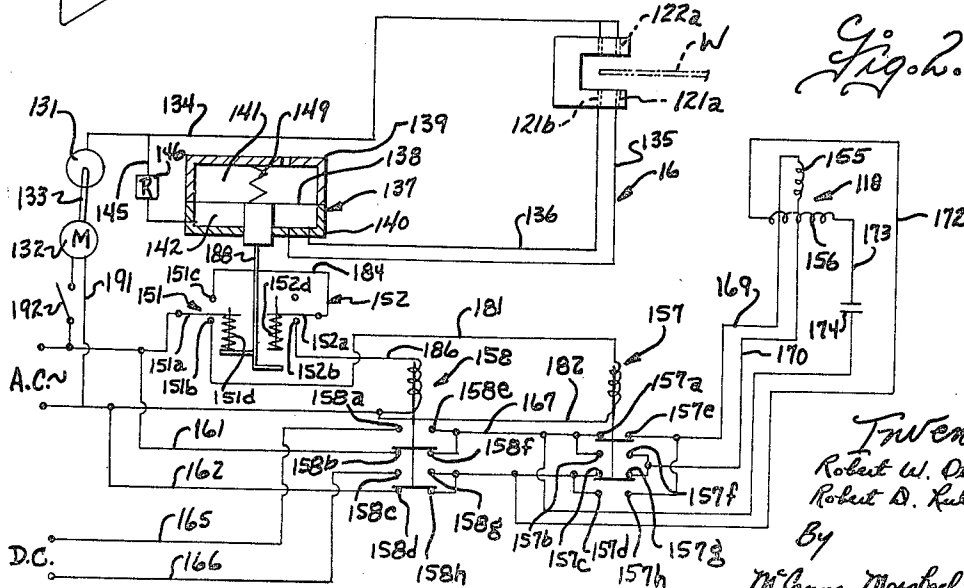
R. W. OTT, JR., ET AL

3,490,674

WEB ALIGNMENT APPARATUS

Filed March 25, 1968

3 Sheets-Sheet 1



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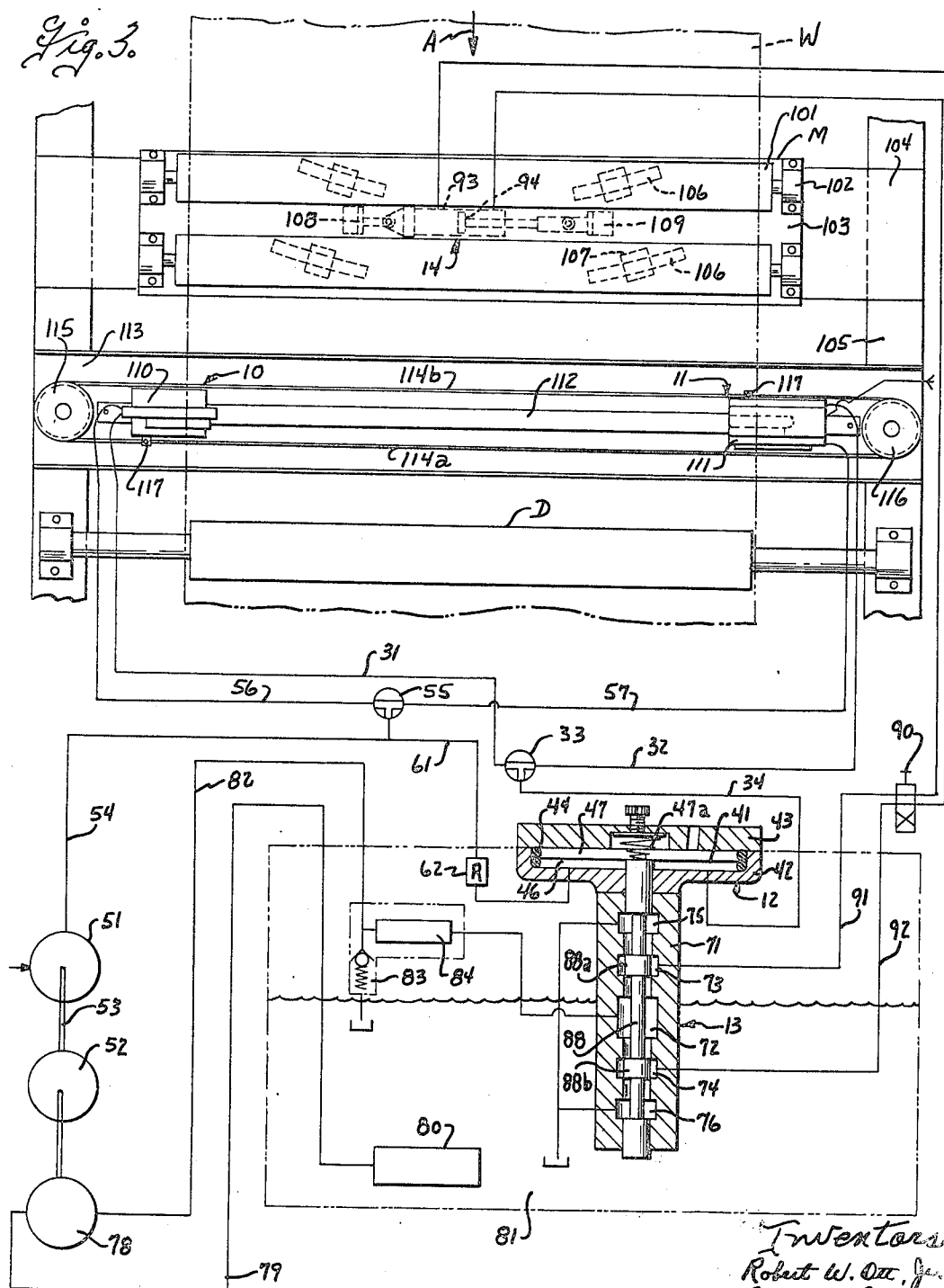
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WEB ALIGNMENT APPARATUS

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3 Sheets-Sheet 2



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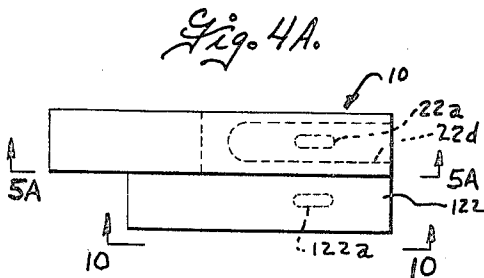
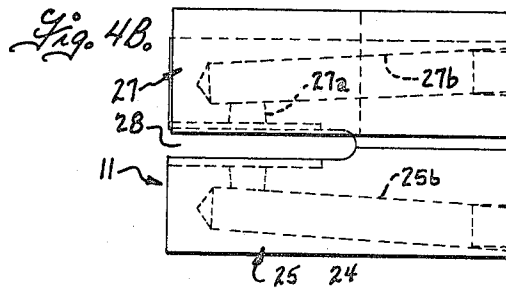
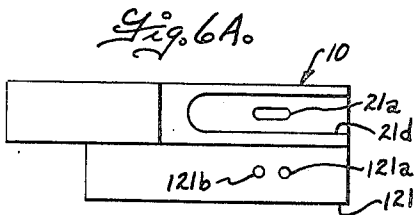
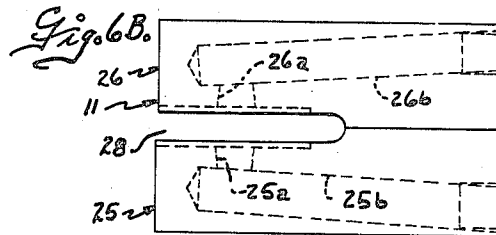
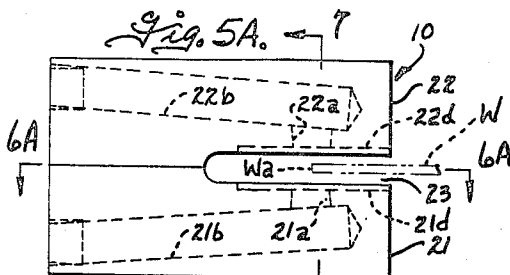
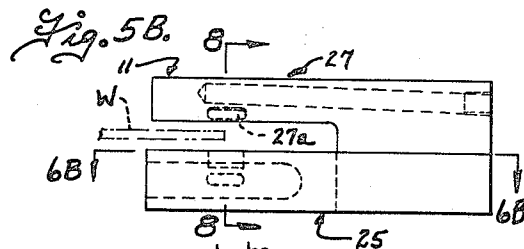
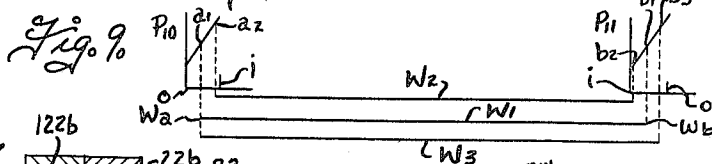
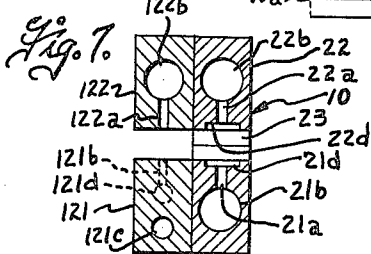
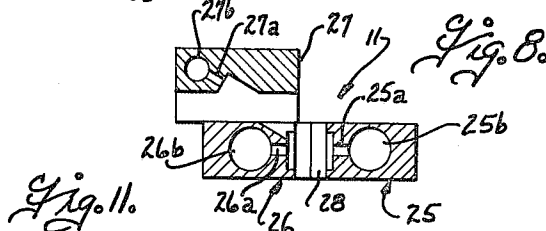
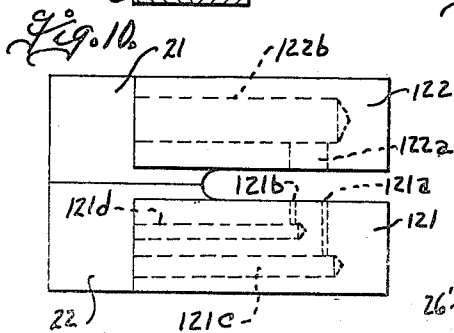
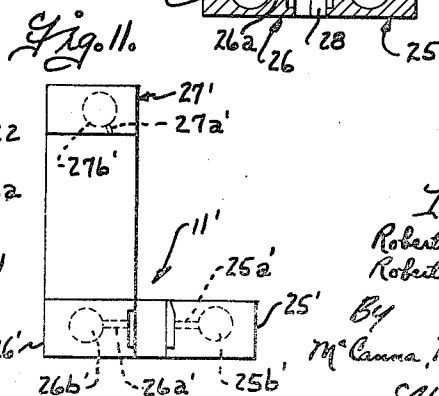
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WEB ALIGNMENT APPARATUS

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3 Sheets-Sheet 3



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3,490,674

WEB ALIGNMENT APPARATUS

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U.S. Cl. 226—19

17 Claims

ABSTRACT OF THE DISCLOSURE

A web alignment apparatus having two pneumatic web edge detectors at opposite edges of the web constructed so that one edge detector produces an inverted signal, that is, a signal that varies oppositely in magnitude with relation to the signal produced by the other detector for a like increase or decrease in the spacing of the respective web edge from the center-line path. The pneumatic signals from the two detectors are combined to average the same, and the average signal used to operate a control device to effect shifting of the web in a direction to correct any deviation of the web center-line from the desired center-line path. The inverted signal web edge detector has one transmitting orifice for directing a first air stream toward a sensing orifice and a second transmitting orifice for directing a second air stream across the web edge and crosswise of the first orifice, and the inverted signal web edge detector can be used in a single edge web guide apparatus for wide gap sensing and also for sensing webs of foraminous material.

BACKGROUND

In many installations requiring control of the lateral position of a travelling web, it is sufficient to use a web alignment apparatus which senses only one edge of the travelling web and which operates a mechanism for relatively shifting the web and a device which performs an operation on the web in a direction to maintain that one web edge in a preselected path relative to the device. However, in some installations, for example, in printing presses for paper, textiles and the like, it is desirable if not essential to maintain the web and the device which operates thereon in centered relation to each other. If the web has a uniform width, a web alignment apparatus that senses only one web edge can be used to maintain the web centered with relation to the device that operates on the web. However, if the web has a variable width, guiding by only one web edge will not adequately maintain the web center-line with relation to the device which operates on the web. Accordingly, in installations in which webs of varying widths must be maintained centered in relation to a device that operates on the web, it has heretofore been proposed to use a center-line type web alignment apparatus. In general, previous pneumatic type center-line web alignment apparatus employed a pair of like pneumatic web edge detectors for sensing the position of opposite edges of the web and a pair of pressure-responsive devices each arranged to measure the pressure signal produced by a respective one of the web edge detectors.

SUMMARY OF THE INVENTION

The pneumatic type center-line web alignment apparatus of the present invention includes a pair of pneumatic web edge detectors for sensing the position of op-

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posite edges of the web and a single pressure-responsive device for responding to the pressure signals of both web edge detectors and for operating a centering means to relatively shift the web and a device which operates on the web in a direction to correct any deviation of the web center-line from the desired center-line path. The pneumatic web edge detectors are arranged so that one produces a pressure signal that is inverted relative to the signal produced by the other, that is, the signals produced by the two web edge detectors vary oppositely in magnitude for a like increase or decrease of the spacing of the respective web edge from the center-line path. The signals from the two web edge detectors are then combined in a manner to produce a resultant pressure signal, that is, the average of the two detector signals, and the resultant or average signal is applied to a single pressure-responsive device. The average signal remains substantially constant at a preselected value when both web edges move either outwardly or inwardly like amounts, and the average signal increases and decreases from the preselected value when the web center-line deviates respectively to one side or the other of the center-line path.

The invention also includes an improved inverted signal web edge detector having one transmitting orifice for directing a first air stream toward a sensing orifice and a second transmitting orifice for directing a second air stream across the web edge and crosswise of the first air stream and which can be advantageously used in single edge web alignment apparatus for wide gap sensing and for sensing foraminous materials.

An important object of this invention is to provide a pneumatic type center-line web alignment apparatus having a pair of pneumatic web edge detectors for sensing the positions of opposite edges of the web and a single pressure-responsive device for responding to the pressure signals from both web edge detectors.

A more particular object of this invention is to provide a pneumatic-type web center-line alignment apparatus in which the web edge detector for one web edge is arranged to produce a pneumatic signal that is inverted with relation to the pressure signal produced by the web edge detector for the other web edge, whereby the pressure signals from the two web edge detectors, when averaged, will remain substantially constant when the spacing of both web edges increases or decreases like amounts, and will respectively increase or decrease in value in accordance with deviations of the web center-line from one side or the other of the desired center-line path.

A further object of this invention is to provide a web alignment apparatus which can be operated both as a web center-line alignment apparatus and a single edge web alignment apparatus without change in construction or adjustment of the pressure-responsive device.

Another object of this invention is to provide a pneumatic web alignment apparatus having an improved web edge detector which is capable of operating and producing a substantially linear signal with large web-to-detector spacing; which can be used to sense the edge of a wide range of materials from relatively light foraminous materials to heavy imperforate materials; and which can be used to sense the border line between a second material laminated onto a relatively wider web of foraminous material.

These, together with other objects and advantages of this invention, will become apparent as the following

description proceeds when taken in connection with the accompanying drawings.

DRAWINGS

FIGURE 1 is a diagrammatic view in perspective illustrating a pneumatic-type web center-line alignment apparatus embodying the present invention;

FIG. 2 is a schematic diagram of a detector position control system for controlling the lateral position of the pair of web edge detectors in the web center-line alignment apparatus shown in FIG. 1;

FIG. 3 is a schematic view illustrating a pneumatic and hydraulic control system applied to the center-line control apparatus of FIG. 1;

FIGS. 4A and 4B are top plan views of the two web edge detectors for sensing the position of opposite side edges of the web;

FIG. 5A is a sectional view taken on the plane 5A—5A of FIG. 4;

FIG. 5B is a side elevational view of the web edge detector of FIG. 4B;

FIG. 6A is a horizontal sectional view taken on the plane 6A—6A of FIG. 5A;

FIG. 6B is a horizontal sectional view taken on the plane 6B—6B of FIG. 5B;

FIG. 7 is a transverse sectional view taken on the plane 7—7 of FIG. 5A;

FIG. 8 is a transverse sectional view taken on the plane 8—8 of FIG. 5B;

FIG. 9 is a graph illustrating the manner in which the pressure signals P_{10} and P_{11} for the two different web edge detectors vary with different web edge positions;

FIG. 10 is a view of the web edge detector taken on the plane 10—10 of FIG. 4A; and

FIG. 11 is an end elevational view of a modified web edge detector for wide gap sensing.

The web alignment apparatus of the present invention is generally adapted for controlling the lateral position of a longitudinally travelling web W with relation to a device D for performing an operation on the web to maintain the web in a preselected relation to the device which operates on the web. The web W is shown in phantom in FIGS. 1 and 3, and the device D for performing an operation on the web is diagrammatically illustrated as a pair of rolls, it being understood that the device can be any of a number of different instrumentalities such as a printing mechanism; a cutting or scoring mechanism; a web rewind roll; a web folder, etc. It is common in web guiding mechanisms to mount the device D in a laterally fixed relation to the frame of the machine, or apparatus employing the web alignment apparatus and to provide a web shifting mechanisms designated M for laterally shifting the web relative to the frame and to the device D in a direction to maintain the web in a preselected relation to the device D that operates on the web. In the embodiment shown, the web shifting mechanism M comprises a web guide roller arrangement which engages the web and which is movable to laterally shift the web. It is to be understood, however, that the web shifting mechanism M could, alternatively, be a web unwind roll which is laterally movable to laterally shift the web. Moreover, while it is common practice to mount the device D that operates on the web in laterally fixed relation to the frame and to shift the web relative to the device, it is contemplated that the device D itself can be made laterally movable relative to the frame and the web alignment apparatus utilized to shift the device D relative to the frame to cause the device to follow the lateral movements of the web.

In the preferred embodiment of the web alignment apparatus illustrated in the drawings, the apparatus includes first and second web edge detectors 10 and 11 mounted adjacent relatively opposite edges of the web W for sensing the lateral positions of the opposite web edges; a pressure-responsive device 12 for responding to signals

of both web edge detectors; and a control system 13 for reversibly controlling the application of power to a centering mechanism 14 to relatively shift the web W and the device D that operates on the web in a direction to correct deviations of the web center-line from the center-line path. As used herein, the phrase "web center-line" refers to an imaginary line medially between the web edges, and the phrase "center-line path" refers to an imaginary path centered with relation to the device D that operates on the path. The web edge detectors are of the pneumatic type, and one web edge detector is arranged so that it produces a pressure signal that is inverted relative to the signal produced by the other for a like increase or decrease in the spacing of the respective web edge from the center-line path, and pressure signals from the two web edge detectors are averaged and applied to the pressure-responsive device 12 so that the pressure applied to the pressure-responsive device remains substantially constant at a preselected value when both web edges move either outwardly or inwardly like amounts from the center-line path, and the average signal increases and decreases from the preselected value when the web center-line deviates respectively to one side or the other of the center-line path. The web edge detectors 10 and 11 are advantageously mounted for adjustment laterally of the center-line path in a manner to maintain the two detectors spaced relatively equal distances from the center-line path to accommodate webs of different widths. While the web edge detectors can be arranged for manual adjustment laterally of the center-line path, a power-operated detector shifting mechanism 15 is preferably provided for moving the two detectors equally in opposite directions relative to the center-line path, and an automatic detector position control system 16 arranged to control operation of the detector shifting mechanism to move the detectors outwardly and inwardly relative to the center-line path when the web edges respectively move outwardly and inwardly.

The pneumatic web edge detector 10 is best shown in FIGS. 4A, 5A and 6A and comprises first and second nozzle members 21 and 22 having inner end portions thereof laterally spaced apart to define a web receiving gap 23 therebetween. The gap 23 between the nozzle members is made sufficiently wide to accommodate limited movement of the web in a direction normal to the plane thereof and, in order to minimize air consumption, the gap is preferably made as small as possible, consistent with accommodating the usual movement of the web in a direction normal to its plane, as is well understood in the art. One of the nozzles such as the first nozzle 21 has a transmitting orifice means 21a arranged to direct an air stream across the gap 23, and the other or second nozzle 22 has a sensing orifice means 22a positioned in the air stream from the transmitting nozzle. As best shown in FIG. 5, passages 21b and 22b are formed in the nozzle members 21 and 22 to communicate with the respective orifice means 21a and 22a. The transmitting and sensing nozzle means are arranged to produce a pressure signal at the sensing nozzle means that varies in magnitude at a preferably uniform rate over a preselected range of movement of the respective web edge and, for this purpose, the transmitting and sensing orifice means are elongated in a direction laterally of the web edge so that the transmitting nozzle means 21a transmits a sheet-like air stream across one edge of the web W toward the sensing nozzle means 22a, which sheet-like air stream is variably interrupted by the edge of the web W as it moves laterally across the air stream. In the preferred embodiment illustrated, the transmitting and receiving nozzle means are in the form of elongated slots as shown in FIGS. 4A and 6A, it being understood that a series of small apertures arranged in a row laterally of the web edge may be used to provide laterally elongated orifice means. The air streams from several small openings will tend to flare outwardly and merge to effectively provide a continuous sheet-like air stream. In order to prevent blocking of either the transmitting

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orifice means or the sensing orifice means in the event of excessive web movement in a direction normal to its plane, the first and second nozzle members are preferably provided with grooves 21d and 22d, respectively, in the registering faces thereof, which grooves intersect the respective nozzle means and preferably open at the inner ends of the nozzle members.

The sensing orifice means should have a length, measured in a direction laterally of the web edge, which approximates the preselected range of movement of the web edge to be sensed. However, the stream from the transmitting orifice expands as it moves away from the transmitting orifice so that the effective cross section of the air stream increases with distance from the transmitting orifice. Thus, while it is preferable to have the length of the transmitting orifice approximate the range of movement of the web edge to be sensed, when the gap between the transmitting orifice and the web is small, it is possible to use relatively shorter transmitting orifices for larger gaps and even round apertured transmitting orifices for very large gaps. The pressure signal produced by the web edge detector 10 at the sensing orifice 22a will vary from a maximum when the air stream from the orifice means 21a is uninterrupted to a minimum when the web edge moves inwardly and substantially completely across the orifice means. This variation in the pressure signal from the web edge detector 10 with different web edge positions is graphically shown at P₁₀ in FIG. 9, wherein it is seen that the pressure signal is at a maximum when the web edge Wa is at an inner position *i* adjacent the inner edge of the sensing orifice means and that the pressure P₁₀ decreases to a minimum when the web edge is at an outer position *o* adjacent the outer edge of the sensing orifice means.

The other web edge detector 11 is best shown in FIGS. 4B, 5B and 6B and is arranged to produce a pressure signal designated P₁₁ in FIG. 9, that is, inverted with relation to the pressure signal P₁₀ produced by the detector 10, for corresponding changes in the position of the respective web edge with relation to the center-line path. For this purpose, the web edge detector 11 includes a first nozzle member 25, a second nozzle member 26 and a third nozzle member 27. The first and second nozzle members 25 and 26 are positioned at one side of the web W while the third nozzle member 27 is positioned at the relatively opposite side of the web. The first and second nozzle members 25 and 26 are preferably made substantially the same as the first and second nozzle members 21 and 22 of the detector 10 so as to have like characteristics. Thus, the nozzle members 25 and 26 have inner end portions which are spaced apart to define a gap 28 therebetween, preferably having a width substantially equal to the gap 23. Nozzle member 25 has a transmitting orifice means 25a arranged to direct an air stream across the gap, and nozzle member 26 has a sensing orifice means 26a positioned in the stream from the orifice 25a. The transmitting orifice means 25a and the sensing orifice means 26a are also elongated in a direction laterally of the web edge Wb and are preferably shaped and dimensioned similar to the corresponding orifices 21a and 22a in the first-mentioned web edge detector 10. The orifice means 25a and 26a respectively communicate with passages 25b and 26b in the nozzle members 25 and 26, and the sensing orifice means 26a is operative to produce a pressure signal correlative with the uninterrupted portion of the sheet-like air stream transmitted from the transmitting orifice means 25a.

The third nozzle member 27 is mounted at the side of the web opposite the nozzle members 25 and 26 and has a second transmitting orifice means 27a arranged to direct an air stream across the web edge and crosswise of the air stream from the first orifice means 25a. The second orifice means 27a is connected to a passage 27b, and the orifice means 27a is arranged to transmit an air stream which, in the region where it passes the web edge, is at least as wide as the desired range of movement of the

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web edge to be sensed. In the embodiment shown in FIGS. 4B and 5B, the orifice means 27a is in the form of an elongated slot, it being understood that the orifice means 27a could also be formed by a plurality of individual holes arranged in a line laterally of the web edge and such that the air streams from the individual openings would merge as they leave the orifice means to form the desired sheet-like air stream. The air stream from the orifice means 27a is directed cross-wise of the air stream from the orifice means 25a and is arranged in a manner hereinafter described to normally interrupt the first air stream from the transmitting orifice means 25a to the sensing orifice means 26a. As the web edge Wb moves outwardly across the air stream from the orifice means 27a, the web edge progressively interrupts the second air stream so that interruption of the first air stream is progressively decreased. Thus, as the web edge moves outwardly relative to the second detector 11, the magnitude of the pressure signal designated P₁₁ in FIG. 9 at the sensing orifice means 26a progressively increases from a minimum when the web edge is at an inner position designated *i* adjacent the inner edge of the second transmitting orifice means, to a maximum when the web edge extends completely across the transmitting orifice means 27a.

The magnitude of the pressure signals P₁₀ and P₁₁ produced at the sensing orifices of the web edge detectors 10 and 11, respectively, thus vary oppositely in magnitude for a like increase or decrease in the spacing of the respective web edge from the center-line path. By proportioning the first and second orifice means 25a, 26a and the gap 28 therebetween of the detector 11 substantially the same as the first and second orifice means 21a and 22a and gap 23 of the detector 10, it has been found that the rate of change in the signal pressure for the two nozzles for a given change in web spacing can be made substantially the same, although the senses of the change in pressures P₁₀ and P₁₁ are relatively opposite. Stated otherwise, the slope of the signal pressure versus web edge position curves shown in FIG. 9 can be made substantially the same with one pressure P₁₀ decreasing in magnitude as the web edge Wa moves outwardly and the other signal pressure P₁₁ correspondingly increasing as the opposite web edge Wb moves outwardly.

As previously described, the second transmitting orifice means 27a is arranged to transmit a second air stream crosswise of the first air stream from the orifice means 25a. The second transmitting orifice means 27a can be arranged to direct the air stream at substantially right angles to the first air stream so as to deflect the first air stream in proportion to the uninterrupted part of the second air stream, as shown in the nozzle arrangement of FIG. 1. Somewhat improved sensitivity is achieved, however, if the second air stream from the orifice means 27a is directed toward the transmitting orifice means 25a as shown in FIG. 8. It is also highly advantageous in guiding foraminous materials, especially lightweight woven materials, to direct the second air stream from the orifice 27a at an acute angle to the plane of the travelling web and preferably inclined in a direction longitudinally of the travelling web, hereinafter sometimes referred to as a longitudinally acute angle. The web edge detector 11 can also be adapted for wide gap sensing as shown at 11' in FIG. 11, by increasing the spacing between the third nozzle member 27' and the first and second nozzle members 25' and 26', with a corresponding increase in the pressure applied through the transmitting passage 27b' to the second transmitting nozzle means 27a'. The first transmitting nozzle means 25a' and passage means 25b' and the first sensing nozzle means 26a' and passage means 26b' can be the same as previously described for nozzle members 25 and 26. As shown in FIG. 11, the nozzle means 27a' is preferably directed toward the first transmitting nozzle means 25a'. While it is preferable to laterally elongate the second transmitting orifice, when the gap between the second transmitting orifice and the web is small,

because of the lateral expansion of the air stream, the second transmitting orifice 27b' can be made substantially narrower than the range of movement of the web edge to be sensed, and a single round apertured orifice can be used in detectors having large gaps of, for example, four or six inches.

Since the pressure signals P_{10} and P_{11} from the web edge detectors 10 and 11 respectively vary oppositely in magnitude for a like increase or decrease in the spacing of the respective web edge from the center-line path, the pressure signals P_{10} and P_{11} can be combined and averaged to produce a resultant signal that remains substantially constant at a preselected magnitude when both web edges move outwardly or inwardly like amounts. As shown in FIGS. 1 and 3, the sensing orifices 22a and 26a are connected through preferably flexible tubes 31 and 32 respectively, to a T-fitting 33 and conduit 34 to the common pressure-responsive device 12. The tubes and fittings are selected to have a sufficiently large flow passage, for example $\frac{3}{8}$ " or more to minimize pressure dip in the tubes. The signal applied to the common pressure-responsive device is thus the average of the pressure signals P_{10} and P_{11} from the web edge detectors 10 and 11. The detectors 10 and 11 are preferably constructed and arranged so that when substantially equal pressures are applied to the transmitting orifices 21a and 25a, the web edge detector 10 will produce a preselected intermediate pressure signal designated a , when the web edge W_a is centered relative to the sensing orifice 22a, which is substantially equal to the intermediate pressure signal b_1 produced by the web edge detector 11, when the other web edge W_b is substantially centered with respect to the sensing orifice 26a. Thus, when opposite edges of the web are centered with respect to the detectors 10 and 11, respectively, as diagrammatically shown by web W_1 in FIG. 9, the detectors 10 and 11 will produce pressure signals P_{10} and P_{11} respectively having magnitudes a_1 and b_1 , and the average of these two signals, that is, $a_1 + b_1/2$ will be substantially equal to the preselected intermediate value a_1 . If the web edges move inwardly like amounts relative to the center-line path, for example, inwardly as shown by the web W_2 in FIG. 9, web edge detector 10 will produce a pressure signal P_{10} having a magnitude a_2 that is higher than the magnitude a_1 while the other detector 11 will produce a pressure signal P_{11} having a magnitude b_2 that is somewhat lower than the intermediate value b_1 . However, the average of the two pressure signals, that is, $a_2 + b_2/2$ will be substantially equal to the preselected intermediate value a_1 . Similarly, if both web edges move outwardly like amounts, the average of the two pressure signals from the detectors 10 and 11 will remain substantially equal to the intermediate value a_1 . However, if one web edge is spaced a relatively farther distance from the center-line path than the other web edge, as diagrammatically shown by web W_3 in FIG. 9, then the average of the two signals will be either greater or less than the value a_1 , depending on the direction of deviation of the web center-line from the center-line path. The web W_3 is shown as having one edge centered with respect to the detector 10 to produce a pressure signal having a value a_1 while the other web edge is spaced outwardly relative to the center of the detector 11 to produce a pressure signal having a value b_3 . The average of these two pressure signals, that is, $a_1 + b_3/2$ is greater than the intermediate value a_1 and will operate the pressure-responsive device 12 accordingly. Conversely, if the web edge sensed by detector 10 is spaced further outwardly from the center-line path than the other web edge, the average of the two signals will be less than the value a_1 .

The pressure-responsive device 12 and control apparatus 13 are advantageously of the type disclosed in the co-pending application of Robert W. Ott, Ser. No. 618,102, filed Feb. 23, 1967, entitled "Web Edge Sensing and Control apparatus." As diagrammatically shown in FIG. 3, the pressure-responsive device 12 comprises a diaphragm

41 clamped between diaphragm housing members 42 and 43 and sealed thereto as by seal rings 44. The diaphragm housing members define chambers 46 and 47 at opposite sides of the diaphragm.

A common air supply is advantageously provided for the transmitting orifices 21a and 25a in the detector heads 10 and 11 and, as diagrammatically shown in FIG. 3, the air pressure is supplied by a constant pressure supply preferably in the form of a centrifugal air pump 51 driven by a motor 52 through shaft 53. As disclosed in the aforementioned application, the centrifugal air pump will produce an outlet pressure which is substantially constant and having a magnitude dependent upon the size of the centrifugal air pump and the speed of operation. The pump outlet is connected through a conduit 54 and a T-fitting 55 through conduits 56 and 57 leading to the nozzles 21 and 25, respectively. As previously described, the sensing orifices 22a and 26a are connected together through conduits 31 and 32 and T-fitting 33 to average the fluid pressure signals of the two detectors, and the average signal is applied through conduit 34 to the pressure-responsive device 12. In the form shown, the conduit 34 communicates with the diaphragm chamber 46 to apply the average pressure to the underside of the diaphragm 41, and diaphragm chamber 47 is vented to atmosphere. In order to prevent ingestion of foreign material into the sensing openings, air under a relatively lower pressure than that supplied to the transmitting orifices is preferably supplied to the sensing orifices to maintain a slight outflow of air. For this purpose, the outlet of the air pump 51 is connected through a conduit 61 and flow restrictor 62 to the diaphragm chamber 46 for flow through the diaphragm chamber and out through conduit 34 to the sensing orifices of the two detector heads. The size of the flow restrictor 62 is selected so that the pressure supplied to the sensing orifices is substantially lower than the pressure supplied to the transmitting orifices, and just sufficient to maintain a slight outflow of air through the sensing orifices. Air under pressure is supplied to the passage 27b for flow through the second orifice means 27a. In the form shown, air is supplied from an external source such as the plant air supply S through a regulator 100 to the second transmitting orifice 27a. The regulator is preferably of the adjustable type to enable adjustment of the second transmitted air stream in accordance with the spacing between the second orifice means 27a and the first air stream and the type of material being sensed. A gauge 99 may be provided to indicate the air pressure supplied to the transmitting orifice and to facilitate adjustment of the regulator. Alternatively, if the gap between transmitting orifice 27a and transmitting orifice 25a is small, allowing use of a low pressure stream, then air pressure for orifice 27a can be obtained from the air pump 51.

The control apparatus 13 which is operated by the pressure-responsive detector 12 may be of any conventional construction. However, in the present embodiment, the control apparatus 13 comprises an hydraulic four-way reversing valve including a valve casing 71 having an inlet chamber 72, first and second control chambers 73 and 74, and outlet chambers 75 and 76 adjacent opposite ends of the casing. Fluid under pressure is supplied to the inlet chamber 72 from an hydraulic pump 78 having its inlet connected through a line 79 and filter 80 to a reservoir 81, and its outlet connected through a line 82, relief valve 83 and filter 84 to the inlet chamber 72.

A valve member 88 is connected to the diaphragm 41 to reversibly control the flow of hydraulic fluid to the control chambers 73 and 74. As shown, the valve has spaced valve elements 88a and 88b operative in the neutral position shown to close off communication between the control chambers and both the inlet and outlet chambers. As the valve element moves upwardly, it allows the inlet chamber 72 to communicate with the control chamber 73 and simultaneously communicates

the control chamber 74 with one of the outlet chambers 76. When the valve member moves downwardly from the position shown, it communicates the control chamber 73 with an outlet 75 and simultaneously communicates control chamber 74 with the inlet chamber 72. Fluid under pressure is thus reversibly supplied to the control chambers 73 and 74 and these chambers are connected through hydraulic lines 91 and 92 to the centering mechanism 14, herein shown in the form of a double-acting hydraulic cylinder 93 and piston 94.

As previously described, the web centering mechanism M can be of any suitable construction and is herein shown in the form of a web guide roller assembly of the type disclosed in the copending application of Robert W. Ott, Jr., Ser. No. 530,074, filed Feb. 25, 1966, for "Web Guide Apparatus." In general, the mechanism M includes one or more web guide rolls 101 rotatably supported by bearings 102 on a movable roll support structure 103. A stationary support structure 104 is mounted on the main frame 105. Arcuate guideways such as arcuate guide bars 106 (FIG. 3) are mounted on one of the support structures such as the stationary support structure 104, and followers 107 are mounted on the other or movable support structure 103 to slidably support the movable support structure for movement in a direction lengthwise of the guide bars 106. The guide bars 106 are conveniently in the form of arcuate members having a common center to support the movable roll support structure 103 and the web engaging rollers 101 for movement in an arcuate path. The web centering means 14 is interconnected between the stationary and movable support structures and, in the form shown, the cylinder 93 is connected by a bracket 108 to the stationary support structure 104, and the piston has its rod connected by a bracket 109 to the movable support structure 103. Thus, as the cylinder and piston of the centering means 14 is respectively extended and retracted, the movable roll support structure is respectively moved to the left and to the right from its centered position and is simultaneously tilted with respect to the longitudinal path of movement of the web to thereby correct the path of travel of the web.

The web edge detectors 10 and 11 are mounted for adjustment laterally of the center-line path to accommodate webs of varying widths and, as diagrammatically shown in FIG. 1, the detectors 10 and 11 are mounted as by guides 110 and 111 respectively on a guideway 112 for sliding movement in a direction laterally of the web. The guideway 112 is conveniently in the form of a guide bar mounted on a support base 113 secured to the frame structure 105. Provision is made for controlling the relative movement of the detectors 10 and 11 to maintain the same spaced relatively equal distances from the center-line path, and in the embodiment shown, this means is in the form of an endless cable entrained over pulleys 115 and 116 adjacent opposite ends of the support structure 113 with opposite runs of the cables designated 114a and 114b connected to the guides 110 and 111, respectively, as by a connector 117. The cable thus operates to equalize movement of the web edge detectors in relatively opposite directions. While the web edge detectors can be manually adjusted to accommodate webs of widely different widths, an automatic detector adjusting means is preferably provided. In the embodiment shown, this adjusting means includes a reversible motor 118 and a detector position control system 16, best shown in FIG. 2. The detector position control system includes a means for sensing the position of at least one edge of the web. In order to avoid interference with the operation of the web center-line alignment apparatus, a separate edge detector is advantageously employed and, in the form shown, comprises a transmitting nozzle 122 and a sensing nozzle 121. The transmitting and sensing nozzles 122 and 121 can be located adjacent either side of the

web and, in the form shown, are mounted on the transmitting and sensing nozzles 21 and 22, respectively. The transmitting nozzle 122 includes a transmitting orifice means 122a, and the sensing nozzle includes a sensing orifice means advantageously in the form of two separate orifices designated 121a and 121b laterally spaced apart a distance no greater than the lateral width of the elongated sensing orifice means 122a. The transmitting orifice means 122a is arranged to direct air toward the sensing orifice means 121a and 121b, and the transmitting orifice means can be in the form of separate transmitting orifices directed toward a respective one of the sensing orifices or, as shown, in the form of an elongated orifice arranged to direct a sheet of air toward the two sensing orifices. The transmitting orifice 122a is connected to a passage means 122b, and the sensing orifices 121a and 121b are respectively connected to passages 121c and 121d.

In the form shown in FIG. 2, air under pressure is supplied from a constant pressure supply source such as a centrifugal air pump 131 herein shown driven by a motor 132 through a shaft 133. The outlet of the air pump 131 is connected through a conduit 134 to the transmitting orifices means 122a. The sensing orifices means 121a and 121b are connected through separate conduits 135 and 136 to pressure-responsive detecting means. While separate pressure-responsive detectors such as a diaphragm or bellows could be employed, a single pressure-responsive detector apparatus 137 is disclosed herein. This detector apparatus includes a diaphragm 138 and diaphragm housings 139 and 140 which define diaphragm chambers 141 and 142 at opposite sides of the diaphragm. The diaphragm chambers 141 is vented to atmosphere, and the conduits 135 and 136 are connected to the other chamber 142 to apply fluid pressure to the underside of the diaphragm 138. In order to inhibit ingestion of foreign material in the sensing orifices 121a and 121b, air under a relatively low pressure is supplied to the sensing orifices. As shown, air under pressure is supplied from the outlet of the pump 131 through conduit 145 and flow restrictor 146 to the chamber 142 for flow through conduits 135 and 136 to the sensing orifices. The flow restrictor is selected in accordance with the pressure applied to maintain a relatively lower pressure at the sensing orifices than at the transmitting orifices and preferably just sufficient to maintain a slight outflow of air through the sensing orifices. When a web W is interposed between the transmitting orifices 122a and both sensing orifices 121a and 121b, the air pressure in the chamber 142 is reduced to a minimum determined by the air pressure maintained by flow restrictor 146, and a spring 149 is provided to urge the diaphragm to a position as shown in FIG. 2 under these pressure conditions. When one of these sensing orifices 121b is uncovered, the pressure in chamber 142 will be increased a predetermined amount, and when the other sensing orifices 121a is also uncovered, the pressure in chamber 142 will rise to a second level. The control 16 for the detector shifting means is arranged to reversibly operate the motor 118 to move the detector heads inwardly when both sensing orifices 121a and 121b are uncovered; to interrupt movement of the heads when the sensing orifice 121a is covered; and to move both sensing heads outwardly when both orifices 121a and 121b are covered.

The motor 118 herein shown is a reversible induction motor having first and second motor windings 155 and 156 which can be reversed by reversing the phase of the voltage applied to one of the windings relative to the other winding. This is achieved through a reversing relay 157 which reverses the connections to one of the motor windings relative to the other motor winding. Dynamic braking is also advantageously employed, and this is achieved through the use of a second or braking relay 158 operable to apply a DC "braking" current to the motor to stop the same.

As schematically shown in FIG. 2, power from an AC

supply source is applied through AC supply conductors 161 and 162 to contacts 158b and 158d of braking relay 158, and DC power is applied from a DC source through DC supply conductors 165 and 166 to relay contacts 158a and 158c. The output contacts 158e, 158f and 158g, 158h of the braking relay are connected through conductors 167 and 168 to the input contacts 157a, 157b and 157c, 157d respectively of the reversing relay. One end of the motor windings 155 is connected through a conductor 169 to relay contacts 157e and 157h, and the other end of the motor winding 155 is connected through a conductor 170 to the relay contacts 157f and 157g of the reversing relay 157. The other motor winding 156 is connected through conductors 172 and 173 to conductors 167 and 168, and a motor phasing capacitor 174 is provided in series as one of the conductors 173. The coil of reversing relay 157 is energized under the control of switch 151 operated by the pressure-responsive device 137 and, as shown, the switch 151 is a two-position switch and has an armature 151a and an overtravel actuator 151d. The armature 151a is normally positioned to engage a contact 151b connected through a conductor 181 to the coil for relay 157, the coil being otherwise connected through a conductor 182 to the AC power supply. The other contact 151c of switch 151 is connected through a conductor 184 to the movable armature 152a of switch 152. The armature 152a has an overtravel actuator 152d. The armature 152a is normally positioned to engage a contact 152b connected through a conductor 186 to the coil of braking relay 158. The diaphragm 138 of the pressure-responsive detector 137 has a switch operator 188 connected thereto arranged to operate switches 151 and 152 in a predetermined sequence. The pump drive motor 132 is energized from the AC supply through conductor 191 and a switch 192, as diagrammatically shown in FIG. 2. The switch operator 188 is so arranged that when the pressure in chamber 142 is at a minimum, as occurs when the web W blocks flow from the transmitting orifice 122a to the receiving orifices 121a and 121b, the switches 151 and 152 are in the positions shown engaging contacts 151b and 152b, respectively. Under these conditions, relay 157 is energized, and relay 158 is deenergized and are positioned as shown in FIG. 2. Power is thus supplied through contacts 158b, 158f and 158d, 158h to one of the motor windings 156 and through contacts 157a, 157e and 157c, 157g to the other motor winding 155 to drive the motor in one direction, that is, a direction to shift the web edge detectors outwardly. As the web edge detectors move outwardly relative to the web edge, the sensing orifice 121b is uncovered so that the air stream from the transmitting orifice 122a increases the pressure at the sensing orifice 121b and correspondingly raises the pressure in the detector chamber 142 to an intermediate value. The diaphragm 138 then operates to raise the switch operator 188 sufficient to move the armature 151a out of engagement with contact 151b and into engagement with contact 151c. This deenergizes reversing relay 157 and establishes a circuit to switch 152 to thereby energize the coil of braking relay 158. When the coil of braking relay 158 is energized, the armature is raised to disconnect the AC supply conductors 161 and 162 and connect the DC supply conductors 165 and 166 to the contacts 158e and 158h. DC current is then applied to both motor windings 155 and 156 to provide dynamic braking of the detector positioning motor 118. When the web edge moves inwardly to also uncover the inner sensing orifice 121a, the transmitting orifice 122a increases the pressure at both sensing orifices 121a and 121b and causes the pressure in the chamber 142 to rise to an upper value. The diaphragm 138 then moves the armature to its fully raised position to move the armature 152a out of engagement with contact 152b. The overtravel actuator 151d of the switch 151 allows the upward movement of the operator 188 while maintaining the switch armature 151a in engagement with contact 151c. Under these conditions, braking relay 158 is deenergized to disconnect the

DC supply from the motor windings and to reconnect the AC supply to the motor windings through contacts 158f and 158h. However, since the reversing relay coil 157 is also deenergized under these conditions, the AC power supplied to the winding 155 is reversed in relation to that supplied to the winding 156 to thereby reverse the direction of rotation of the detector positioning motor 118 and move the detectors inwardly.

OPERATION

From the foregoing, it is thought that the operation and construction of the device will be readily understood. The web edge detectors 10 and 11 produce pressure signals that vary in accordance with the position of the respective web edges Wa and Wb with the signal produced by the first web edge detector 10 decreasing as the first web edge Wa moves outwardly relative to the center-line path while the signal produced by the second detector 11 increases as the second web edge Wb moves outwardly relative to the center-line path. The average of the two pressure signals P_{10} and P_{11} will remain substantially constant at a preselected value so long as both web edges are spaced the same distance from the center-line path. However, if the web edges are spaced relatively unequal distances from the center-line path such that the center-line of the web is offset to the left of the center-line path as viewed in FIG. 3, then the average of the pressure signals will decrease while if, the center-line of the web is offset to the right of the center-line path, the average of the pressure signals will increase.

The tension on the spring 47a for the pressure-responsive detector 12 is adjusted so as to position the valve member in its neutral position shown in FIG. 3 when the average of the pressure signals P_{10} and P_{11} is equal to an intermediate value a_1 . Under these conditions, the control 13 will maintain the centering mechanism 14 in its neutral position. However, if the web center-line deviates to the left or the right, the average of the pressure signals P_{10} and P_{11} will correspondingly decrease or increase to respectively move the valve member 88 upwardly and downwardly from its neutral position. An increase in the average of pressures P_{10} and P_{11} indicating a shift of the web center-line to the right as viewed in FIG. 3 will cause the valve member 88 to move upwardly and apply pressure through control port 73 to the right side of the piston 94 to cause the piston to move to the left and correspondingly move the web engaging rollers 101. The rollers 101 thus shift laterally and are canted in a direction to urge the web toward the left to correct the deviation of the web center-line from the center-line path. Conversely, if the web deviates to the left as viewed in FIG. 3, the average of the pressure signals P_{10} and P_{11} will decrease and operate the control 13 to move the centering device 14 in a direction to shift the web toward the right. The web edge detectors are preferably located at the outlet side of the web guide and, when the web center-line again returns to the desired center-line path, the control 13 is returned to its neutral position.

Since the pressure-responsive device 12 is operated by the average of the pressures P_{10} and P_{11} at the two web edge detectors, and since this average is the same as the signal produced by the web edge detector 10 when the web edge is centered with respect to the detector 10, it is possible to use the web alignment apparatus as a single web edge guide by merely cutting off the signal from the web edge detector 11. As diagrammatically shown in FIG. 3, the T-couplings 33 and 55 could be made in the form of three-way valves which are operative in the position shown to connect both web edge detectors to the air supply 51 and pressure-responsive detector 12. However, the three-way valves are movable to a second position to connect only one or the other of the web edge detectors to the air supply and pressure-responsive device 12. Since the web edge detector 11 produces a signal that is inverted

with relation to the signal produced by detector 10, it is necessary to reverse the hydraulic connections to the centering device 14 if the web edge detector 11 is used alone as a single edge web guide. A reversing valve 90, diagrammatically shown in FIG. 3, can be provided to reverse the hydraulic connections to the centering device, under these conditions.

The detector positioning apparatus operates automatically to move the web edge detectors outwardly and inwardly as the web edge respectively increases and decreases. In order to inhibit hunting, it is preferable to make the speed of response of the web edge detector positioning system slightly slower than that of the web alignment control system previously described. When both sensing orifices 121a and 121b of the detector positioning system are covered by the web, the pressure in the chamber 142 of the pressure-responsive device is at a minimum, and switch 151 operates to energize reversing relay 157 and deenergize braking relay 158. Under these conditions, AC power is supplied through braking relay 158 directly to one winding 156 of the motor 118 and reversely through relay 157 to the other winding 155 of motor 118. This energizes the motor 118 in a direction to move the web edge detectors outwardly. When the web edge is in a mid-position covering only the inner sensing port 121a, the pressure in chamber 142 is at an intermediate value and moves switch 151 to a raised position, thereby deenergizing the reversing relay 157 and applying power through switch 152 to the braking relay 158. DC braking current is then applied to both the motor windings 155 and 156 to stop the motor. If both sensing orifices 121a and 121b are uncovered, the pressure in chamber 142 rises to an upper value and causes the operator 188 to open the switch 152. Under these conditions, both relays 157 and 158 are deenergized to thereby apply AC power to both windings 155 and 156 without reversing the connections to winding 155 so as to drive the motor 118 in a direction to cause the web edge detectors to move inwardly.

What is claimed as new is:

1. In an apparatus for maintaining the centerline of a longitudinally travelling web of varying width in a preselected center-line path relative to a device for performing an operation on the web, said apparatus including two pneumatic web edge detectors mounted at relatively equal distances from the center-line path adjacent relatively opposite edges of the web for sensing the lateral positions of opposite web edges relative to the center-line path, one of said pneumatic web edge detectors being constructed and arranged to produce a first fluid pressure signal that decreases in magnitude at a predetermined rate as one web edge moves outwardly relative to said one detector and similarly increases in magnitude as said one web edge moves inwardly relative to said one detector, the other of said pneumatic web edge detectors being constructed and arranged to produce a second fluid pressure signal that decreases in magnitude at substantially said predetermined rate as the other web edge moves inwardly relative to said other detector and similarly increases in magnitude as said other web edge moves outwardly relative to said other detector, control means including a pressure-responsive operator, conduit means connected to both web edge detectors and to said pressure-responsive operator for averaging the first and second fluid pressure signals and for applying said average of said first and second signals to said pressure-responsive operator whereby the pressure applied to said pressure-responsive operator remains substantially constant at a preselected value when the center-line of the web is coincident with said center-line path and increases and decreases from said preselected value when the center-line of the web deviates respectively to one side and the other side of the center-line path, and centering means operated by said control means for relatively shifting the web and the device in a direction to cor-

rect deviations of the web center-line from the center-line path.

2. An apparatus according to claim 1 wherein each of said web edge detectors includes a sensing orifice means and a transmitting orifice means for directing air streams toward their respective sensing orifice means, one of said web edge detectors having a cross-jet transmitting orifice means for directing an air stream crosswise of the air stream from the transmitting orifice means on that web edge detector.

3. An apparatus according to claim 1 wherein a first one of said web edge detectors includes a first sensing orifice means located at one side of the web and a first transmitting orifice means located at the other side of the web for directing a first air stream across one edge of the web toward the first sensing orifice means, a second one of said web edge detectors includes a second sensing orifice means, a second transmitting orifice means for directing a second air stream toward said second sensing orifice means, and a third transmitting orifice means for directing a third air stream across the other edge of the web and crosswise of the second air stream, said conduit means being connected to both said first and second sensing orifice means.

4. An apparatus according to claim 3 including common means for supplying air to said first and second transmitting orifice means.

5. An apparatus according to claim 3 wherein said third transmitting orifice means is constructed and arranged in relation to said second transmitting orifice means to direct said third air stream toward said second transmitting orifice means.

6. An apparatus according to claim 3 wherein said third transmitting orifice means is constructed and arranged in relation to said second transmitting orifice means to direct said third stream at a longitudinally acute angle relative to the plane of the travelling web.

7. An apparatus according to claim 3 wherein said third transmitting orifice means is constructed and arranged in relation to said second transmitting orifice means to direct said third stream at a longitudinally acute angle to the plane of the travelling web and toward said second transmitting orifice means.

8. An apparatus according to claim 1 including reversibly operable detector shifting means for moving said two web edge detectors equally in relatively opposite directions relative to the center-line path, and means responsive to the position of at least one web edge for operating said detector shifting means to move the web edge detectors outwardly and inwardly relative to the center-line path when the web edges respectively move outwardly and inwardly relative to the center-line path.

9. An apparatus according to claim 1 including reversibly operable detector shifting means for moving said two web edge detectors equally in relatively opposite directions relative to the center-line path, sensing means including at least one web edge sensor for detecting the lateral position of at least one of the web edges, said one web edge sensor being mounted for lateral movement with one of said web edge detectors, and means responsive to said sensing means for operating said detector shifting means to move the web edge detectors outwardly and inwardly relative to the center-line path when the web edges respectively move outwardly and inwardly relative to the center-line path.

10. In an apparatus for maintaining the center-line of a longitudinally travelling web of varying width in a preselected center-line path relative to a device for performing an operation on the web, first and second pneumatic web edge detectors mounted relatively equal distances from the center-line path for respectively sensing the lateral positions of first and second edges of the travelling web relative to the first and second detectors, said first pneumatic web edge detector being constructed and

arranged to produce a first pneumatic signal having a preselected magnitude when the first web edge is in a mid-position relative to the first detector and which first signal respectively increases and decreases at a predetermined rate from said preselected magnitude in response to inward and outward shifting of the first web edge from its mid-position relative to the first detector, said second pneumatic web edge detector being constructed and arranged to produce a second pneumatic signal having substantially said preselected magnitude when the second web edge is in a mid-position relative to the second detector and which second signal respectively decreases and increases at substantially said predetermined rate from said preselected magnitude in response to inward and outward shifting of the second web edge from its mid-position relative to said second detector, centering means for relatively shifting said web and said device, movable control means for said centering means, a pressure-responsive operator for positioning said control means in a neutral position when the pressure applied thereto is equal to said preselected magnitude, conduit means connected to both web edge detectors and to said pressure-responsive operator for averaging said first and second signals and for applying the average of said first and second signals to said pressure-responsive operator whereby the average of said first and second signals remains at substantially said preselected magnitude when both the first and second web edges shift like amounts either outwardly or inwardly from their mid-positions and the average of said first and second signals respectively decreases and increases in response to shifting of the web center-line toward said first and toward said second detectors to thereby move the control means for the centering means in a direction to correct the deviation of the web center-line from the center-line path.

11. In an apparatus for maintaining the center-line of a longitudinally travelling web of varying width in a preselected relation to a device for performing an operation on the web, said apparatus including:

- (a) a first web edge detector mounted adjacent one edge of the web and having a first sensing orifice means and a first transmitting orifice means at relatively opposite sides of the web, said first transmitting orifice means directing a first air stream across said one web edge toward the first sensing orifice means,
- (b) a second web edge detector mounted adjacent the other edge of the web and having a second sensing orifice means and a second transmitting orifice means located at one side of the web, said second transmitting orifice means directing a second air stream toward said second sensing orifice means, said second detector including a third transmitting orifice means at the other side of the web for directing a third air stream across the other edge of the web and crosswise of said second air stream,
- (c) control means responsive to the fluid pressure conditions at said first and second sensing orifice means for relatively shifting said web and said device in a direction to correct deviations of the web center-line from the center-line path.

12. An apparatus according to claim 11 wherein said control means includes a pressure-responsive operator and conduit means communicating said first and second sensing orifice means with each other and with said pressure-responsive operator to average the pressures at said first and second sensing orifice means and apply the average pressure to said pressure-responsive operator.

13. In an apparatus for maintaining the center-line of a longitudinally travelling web of varying width in a preselected relation to a device for performing an operation on the web,

- (a) a first web edge detector mounted adjacent one edge of the web and including a first pneumatic transmitter and a first pneumatic sensor located at

relatively opposite sides of the web, said first pneumatic transmitter including a first transmitting orifice means elongated in a direction transverse to said one web edge and arranged to transmit a first sheet-like air stream across the web edge toward the first sensor, said first pneumatic sensor including a first sensing orifice means elongated in a direction transverse to said one web edge for sensing the first air stream to produce a first pressure signal proportional in magnitude to the uninterrupted portion of the first air stream and which decreases as the one web edge moves outwardly relative to the center-line path and progressively interrupts said first air stream, (b) a second web edge detector mounted adjacent the other edge of the web and including a second pneumatic transmitter and a second pneumatic sensor located at one side of the web and a third pneumatic transmitter located at the other side of the web, said second pneumatic transmitter including a second transmitting orifice means elongated in a direction transverse to the web edge and arranged to transmit a second sheet-like air stream toward said second pneumatic sensor, said second sensor including a second sensing orifice means elongated in a direction transverse to said second web edge for sensing said second air stream to produce a second pressure signal proportional in magnitude to the uninterrupted portion of the second air stream, said third transmitter including a third transmitting orifice means at said other side of the web and elongated in a direction transverse to said other web edge to transmit a third sheet-like air stream across said other web edge and crosswise of said second air stream to normally interrupt the latter, said other web edge as it moves outwardly relative to the center-line path progressively interrupting said third air stream and correspondingly decreasing interruption of said second air stream whereby the second pressure signal progressively increases as the web edge moves outwardly, pressure-responsive control means, conduit means connected to said first and second sensing orifice means and to said pressure-responsive control means to average the first and second pressure signals and apply the average of said signals to said control means, and centering means operated by said control means for relatively shifting the web and the device in a direction to correct deviations of the web from the center-line path.

14. In an apparatus for maintaining a longitudinally travelling web in preselected lateral position relative to a device for performing an operation on the web, a web edge detector mounted adjacent one edge of the web and including a first pneumatic transmitter and a first pneumatic sensor located at one side of the web, and a second pneumatic transmitter located at the other side of the web, said first pneumatic transmitter including a first transmitting orifice means arranged to transmit a first air stream from a location at said one side of said web towards said first pneumatic sensor at said one side of the web, said first pneumatic sensor including a first sensing orifice means for sensing the first air stream, said second transmitter including a second transmitting orifice means for transmitting a second air stream from a location at said other side of the web across said one web edge and crosswise of said first air stream, said one web edge variably interrupting said second air stream as said one web edge shifts laterally relative to the web edge detector and the uninterrupted portion of said second air stream variably interrupting said first air stream whereby to vary the pressure signal conditions at said sensing orifice correlative with the lateral position of said one web edge, and means responsive to the pressure signal condition at said sensing orifice for shifting the web and the device relative to each other in a direction to maintain the

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web in said preselected lateral position relative to the device.

15. An apparatus according to claim 14 wherein said second transmitting orifice means is arranged in relation to said first transmitting orifice means to direct said second air stream toward said first transmitting orifice means.

16. An apparatus according to claim 14 wherein said second transmitting orifice means is arranged to direct said second air stream at an acute angle relative to the plane of the travelling web.

17. An apparatus according to claim 14 wherein said second transmitting orifice means is arranged to direct said second air stream at a longitudinally acute angle

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relative to the plane of the travelling web and toward said first transmitting orifice means.

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