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APPARATUS FOR HANDLING A CONTINUOUS WEB OF MATERIAL

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FIG. 1

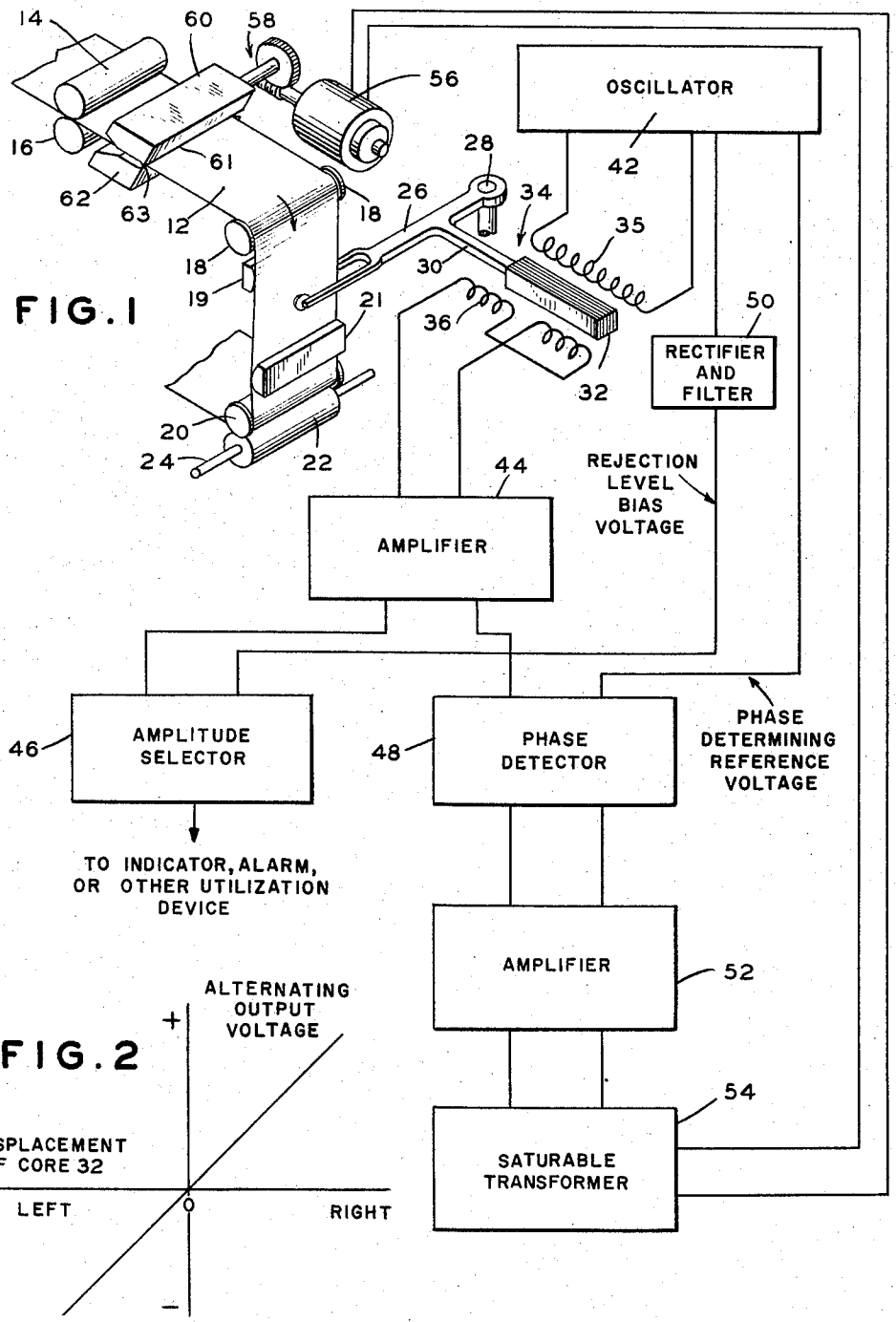
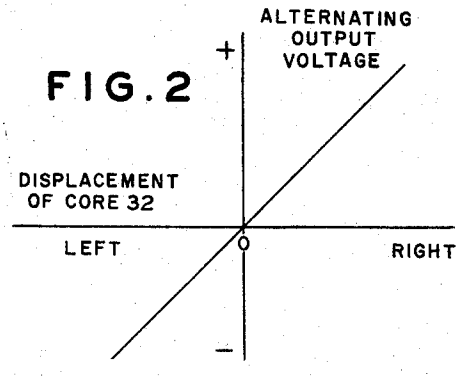


FIG. 2



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APPARATUS FOR HANDLING A CONTINUOUS WEB OF MATERIAL

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6 Claims. (Cl. 162—252)

This invention relates to an apparatus for continuously sensing and correcting curvature in a moving continuous sheet or web and for giving an indication when the curvature exceeds a predetermined tolerance.

In high speed data processing machines to which information may be fed on punched cards or the like, it is essential that the cards be flat and not have such curvature as would result in a stoppage of the processing machine. Such cards are prepared from continuous webs of suitable width which are fed through a high speed printing press and then are cut to provide individual printed cards. In such apparatus, the web is maintained under substantial tension as it passes through the card press and this tension is not relieved until the web has passed through the printing means of the press and is about to be cut. Apparatus has hitherto been provided for detecting excessive curvature in cards produced by such a card press in accordance with which the material was inspected for curvature after it had been relieved of tension. It has now been found that such apparatus can be substantially improved and this invention is directed to such improvement based upon the discovery that the web, even though moving at high speed under substantial tension, will, if normally curved when tensioned, retain a residual amount of curvature which may be accurately detected even though it is relatively small.

In an embodiment illustrated herein, provision is made to continuously monitor and correct any undesirable curvature present in a rapidly moving web of paper while the web is under substantial tension and before the curved portion of the web is fed into the printing and cutting means of a card manufacturing machine. The system also detects when the curvature exceeds a predetermined tolerance and provides an indication or signal for the rejection of such material. A forked lever arm, preferably with jeweled internal surfaces, is rigidly connected to the movable magnetic core of a linearly variable differential transformer. The web under tension is passed between the internal surfaces of the forked lever which acts like a clip exerting a low pressure on both sides of the web. With straight material passing through the sensing device the output voltage of the transformer is zero. Any curvature of the material in displacing the lever and the transformer core connected thereto results in a transformer output voltage which shows by its amplitude the degree of curvature and by its phase the direction of curvature. The amplitude of the transformer output voltage is used to produce an indication when the predetermined tolerance is exceeded, and the phase of the voltage is used to actuate a curvature correcting means through a servo system which controls the position of a pair of straightener bars.

A principal object of this invention is to detect an excessive amount of curvature in a web while the web is being fed rapidly under tension to a utilization means, such as a card printing and cutting apparatus, and to correct such curvature before the web material enters the utilization means.

Another object is to utilize a significant amount of residual curvature remaining in the web while it is taut to furnish an indication of excessive curvature, thereby affording opportunity to correct this excessive curvature before the sensed portion of the web is printed and cut.

A further object is to insure the detection of excessively large curvature even though it occurs in only a short length of the web, but to avoid unnecessary corrective action when the excesses of curvature are small and not of too long duration.

Other features, objects and advantages will appear from the following more detailed description of an illustrative embodiment of the invention, which will now be given in conjunction with the accompanying drawings in which

Figure 1 is a diagram, partly schematic and partly in block form, showing a system in accordance with the invention; and

Figure 2 is a graph useful in explaining the operation of the transformer shown in Figure 1.

A web **12** of material in sheet or filament form is fed or drawn from a supply reel or other source (not shown) and is led to a high speed processing device such as a printing press, fabricating machine, etc. (not shown). Web **12** may be paper or other material, the curvature of which is susceptible of substantial correction or elimination by the curvature correction means to be described. The web **12** passes between friction rolls **14, 16,** which may be spring biased, and over spaced rolls **18, 20,** the latter being juxtaposed to a drive or feed roll **22** having a drive shaft **24** adapted to be connected to the press drive. A pair of shoes **19, 21** are mounted intermediate rolls **18, 20** and fixed on opposite sides of the feed path so that the arcuate face of shoe **19** is presented to the back (as viewed in Figure 1) of the web **12** and shoe **21** to the front. Web **12** is in sliding contact with the faces of the shoes **19, 21** which establish a straight-line feed path. Thus, web **12** is maintained taut and under substantially constant tension. In accordance with the present invention it has been found that when such material as web **12** has excessive longitudinal curvature in an untensioned state, it displays a residual amount of curvature even when tensioned, as in the present instance, by a force of about 50 pounds. The curvature of the untensioned web material appears as a residual bowing of the tensioned web in one direction or the other perpendicular to the plane or line of a straight web which is detectable even with the web under relatively great tension. The shoes **19, 21** prevent any eccentricity of the rolls **18, 20** from disturbing or affecting the feed path. The degree of stiffness of the web may also affect the feed path because its stiffness may cause the web to bow outwardly when it passes around a roll, but with shoes **19** and **21** in the positions shown this bowing tendency of the web due merely to stiffness of the material is neutralized. Thus, bowing of the material between shoes **19, 21** is an indication of the amount and the direction of curvature in the untensioned material. A bifurcated lever **26,** which may have jeweled bearing surfaces for engaging the web, is pivotally mounted at **28** and is connected through arm **30** to the movable magnetic core **32** of a linearly variable differential transformer **34** having a primary winding **35** and a secondary winding **36,** with oppositely wound sections as indicated. Lever **26** is mounted between shoes **19, 21** so that web **12** passes between its arms with the latter lightly touching the opposite surfaces of the web. Lever **26** is mounted in any suitable way so as to be free to displace with any bowing of web **12** as may appear and correspondingly to shift magnetic core **32.** The core **32** is positioned between the primary winding **34** and the secondary winding **36** of the transformer, so that the

core 32 is capable of moderate motion substantially parallel to itself when the lever 26 moves about its pivot. Thus, forked lever 26 and core 32 follow any lateral displacement of the web 12.

An alternating current supply source such as an oscillator 42 is connected to the primary winding 35 and the secondary winding 36 is connected, preferably through an amplifier 44, to an amplitude selector 46 and a phase detector 48. The oscillator 42 is preferably voltage regulated and of high frequency, e.g., 20 kc. A rejection level bias voltage is supplied to the amplitude selector 46 from the oscillator 42 by means of a rectifier and filter unit 50. An alternating reference voltage is supplied from the oscillator 42 to the phase detector 48. The output of the phase detector 48 is connected to a differential amplifier 52 which is in turn, connected to a servomotor 56 preferably through a saturable transformer 54. The motor 56 is provided with a worm gear drive 58 through which the motor may cause to rotate two web straightener bars 60, 62. Straightener bars 60, 62 are juxtaposed to opposite sides of the web feed path so that the web 12 passes between them as it travels in the direction indicated from friction rolls 14, 16 toward roll 18.

As shown, bar 60, when operative, tends to bear downwardly upon the web and bar 62, when operative, tends to bear upwardly upon the web. Bars 60, 62 are each provided with a knife edge, as indicated at 61 and 63 respectively, which are respectively urged more or less against the upper and lower surfaces of the web depending upon the direction in which they are rotated by servomotor 56. As will be more fully pointed out, motor 56 rotates bars 60, 62 clockwise or counterclockwise, as viewed in Figure 1, depending upon the position assumed by lever 26 due to the curvature of the web 12 passing between its arms.

Referring now to Figure 2 there is shown an idealized voltage vs. core displacement graph for a linearly variable differential transformer of the type preferred for use in the present system. By virtue of the differential nature of the transformer there is a unique position of the core that produces a null output from the transformer. This position of the core will be referred to as the null position of the core. The graph in Figure 2 shows the alternating output voltage in the secondary winding 36 as a function of the displacement of the core 32 from the null position. Displacement of the core to the right from the null position produces an alternating output voltage of one phase, arbitrarily designated positive phase on the graph. Displacement of the core to the left from the null position produces an alternating output voltage of the opposite or negative phase. Due to the linear feature of the transformer the alternating output voltge is substantially linearly proportional to the core displacement. The system is initially adjusted so that with web 12 displaying zero curvature, the magnetic core 32 is positioned by lever 26 in the null position. Because of the direction in which the core 32 is displaced from the null position is determined by the direction in which the web deviates from a straightline path between shoes 19 and 21, the resulting phase position of the output of transformer 34 with respect to the alternating wave from oscillator 42 reflects the direction of curvature of web 12. The amplitude of the output voltage is substantially linearly proportional to the amount or degree of curvature of the web.

The amplitude of the output of transformer 34 is used to provide an indication or alarm when the curvature increases beyond a predetermined tolerance. The transformer output voltage is amplified as may be required, as in amplifier 44, and is then impressed upon the amplitude selector 46. The latter device operates in exactly the same manner as the amplitude selector disclosed in the copending application Serial No. 729,148, filed April 17, 1958, and assigned to the same assignee as the present application. The amplitude selector 46 is described in detail and claimed in said copending application and a detailed description thereof here is considered unnecessary. However, it should be noted that amplitude selector 46 comprises a voltage comparator network, an integrator network and a switch connected in that sequence. The alternating output from amplifier 44 is fed to the comparator where it is compared to a steady reference voltage supplied by rectifier and filter 50 from oscillator 42. The comparator network feeds the integrator network with a pulse each time the alternating wave exceeds the steady reference voltage. The duration of these pulses varies with the amount by which the alternating waves in each cycle exceed the reference voltage. A succession of such pulses are integrated in the integrator network. When the integrated result reaches a predetermined voltage level the switch is operated to produce a signal which is fed to an indicator, an alarm or other utilization device.

In the present instance the value of the reference voltage fed from rectifier and filter 50 is selected such that it represents the maximum tolerable curvature of web 12. Consequently, an indication or signal is given whenever the curvature of web 12 exceeds the tolerable value.

To effect the curvature correction of the web, the output voltage from the transformer secondary, amplified as may be required, is impressed upon the phase detector 48 together with a reference or switching voltage from the oscillator 42. Any curvature of the web will result in a transformer output voltage either in phase or 180° out of phase with the reference voltage and having an amplitude which is a function of the amount of curvature of the web. The phase position of the transformer output with respect to the alternating reference voltage is detected in the phase detector and as a result a differential voltage output is obtained from the phase detector. This output is amplified in the amplifier 52 and delivered to the servomotor 56 through the saturable transformer 54. The motor 56 is driven in one direction or the other depending upon the phase position of the transformer output voltage and for a duration corresponding to the amplitude of this voltage. The motor in turn drives the worm gear 58 in the proper direction to turn the bars 60, 62 in the direction to bring the knife edges 61, 63 into engagement with the corresponding surface of the web thereby reducing the curvature of the web. When the curvature is such that the web is bowed toward the observer as the web is viewed in Figure 1, the correction is made by motor 56 rotating the bars clockwise so that bar 60 is pressed downwardly upon the web. When the curvature is in the opposite direction the correction is made by motor 56 rotating the bars counterclockwise so that bar 62 is pressed upwardly upon the web. In either case the result is a reduction in the curvature of the portion of the web approaching the lever 26.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. In an apparatus for handling a continuous web of material, means including guide means defining a feed path for said web and for feeding said web therealong while maintaining the same taut under tension, said guide means defining a straight-line portion of said path and being positioned for maintaining said web taut with straight web in said straight-line portion of said path while leaving curved web free to depart therefrom, curvature sensing means juxtaposed to said straight-line portion of said feed path and responsive to longitudinal curva-

ture of the taut web out of said straight-line path portion, web straightening means juxtaposed to said feed path in advance of said curvature sensing means, and means coupled to and responsive to said curvature sensing means for actuating said web straightening means thereby to reduce curvature of said web.

2. In an apparatus for handling a continuous web of material, means defining a feed path for said web and for feeding said web along said path at least approximately in conformity therewith while maintaining the web taut under predetermined tension, said path-defining and feed means including guide elements disposed to direct the tensioned web toward conformity with said feed path at a given portion of its travel, web curvature sensing means juxtaposed to said feed path at said directed portion of the web travel for detecting deviation of the tensioned web from said feed path due to residual curving of the web despite said tensioning and guiding thereof, web straightening means juxtaposed to said feed path in advance of said curvature sensing means, and means coupled to and responsive to said curvature sensing means for actuating said web straightening means thereby to reduce the residual curvature of the web.

3. In an apparatus for handling a continuous web, means including guide means defining a feed path for said web and for feeding said web therealong while maintaining the same taut under tension, said guide means defining a straight-line portion of said path and being positioned for maintaining said web taut with straight web in said straight-line portion of said path while leaving curved web free to depart therefrom, curvature sensing means juxtaposed to said straight-line path portion and mounted for displacement from a predetermined position, corresponding to the passage of straight web thereby, in a direction and to an extent corresponding to the curvature of said web, web straightening means juxtaposed to said feed path in advance of said curvature sensing means, means coupled to said curvature sensing means and for providing a signal determined by the amount and direction of curvature of said web, and means responsive to said signal for correspondingly actuating said web straightening means in a direction to reduce curvature of said web as it advances thereby.

4. In an apparatus for handling a continuous web, means including guide means defining a feed path for said web and for feeding said web therealong while maintaining the same taut under tension, said guide means defining a straight-line portion of said path and being positioned for maintaining said web taut with straight web in said straight-line portion of said path while leaving curved web free to depart therefrom, curvature sensing means juxtaposed to said straight-line path portion and mounted for displacement from a predetermined portion, corresponding to the passage of straight web thereby, in a direction and to an extent corresponding to the curvature of said web, web straightening means juxtaposed to said feed path in advance of said curvature sensing means, means coupled to said curvature sensing means and for

providing a signal having an amplitude and a polarity corresponding respectively to the amount and direction of curvature of said web, means responsive to said signal for corresponding actuating said web to straightening means in a direction to reduce curvature of said web as its advances thereby, and means responsive to the amplitude of said signal for providing an indication when the curvature of said web exceeds a predetermined value.

5. In an apparatus for handling a continuous web, means defining a feed path for said web and including a pair of spaced rolls and a pair of spaced guide elements intermediate said rolls forming a straight-line path therebetween, said guide elements each being positioned to bear against a surface of said web as it passes thereby with one of said guide elements bearing against one surface of said web and the other of said guide elements bearing against the opposite surface of said web, a bifurcated lever pivotally mounted adjacent to said path intermediate said guide elements with the arms thereof extending on opposite sides of said feed path and adapted to contact opposite surfaces of the web extending between said guide elements, web straightening means juxtaposed to said feed path in advance of said guide elements, and means coupled to and responsive to said lever for actuating said web straightening means thereby to reduce curvature of said web.

6. In an apparatus for handling a continuous web, means defining a feed path for said web and including a pair of spaced rolls and a pair of spaced guide elements intermediate said rolls forming a straight-line path therebetween, said guide elements each being positioned to bear against a surface of said web as it passes thereby with one of said guide elements bearing against one surface of said web and the other of said guide elements bearing against the opposite surface of said web, a bifurcated lever pivotally mounted adjacent to said path intermediate said guide elements with the arms thereof extending on opposite sides of said feed path and adapted to contact opposite surfaces of the web extending between said guide elements, a web straightening means juxtaposed to said feed path in advance of said guide elements, means including a linearly variable differential transformer having a movable magnetic core connected to said bifurcated lever and for providing a signal having an amplitude and a polarity corresponding respectively to the amount and direction of curvature of said web, means responsive to said signal for correspondingly actuating said web straightening means in a direction to reduce curvature of said web as it passes thereby, and means responsive to the amplitude of said signal for providing an indication when the curvature of said web passing said bifurcated lever exceeds a predetermined value.

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