Feb. 28, 1961 R. J. SAUL ET AL 2,972,794

WEFT STRAIGHTENER

Filed May 23, 1958 3 Sheets-Sheet 1

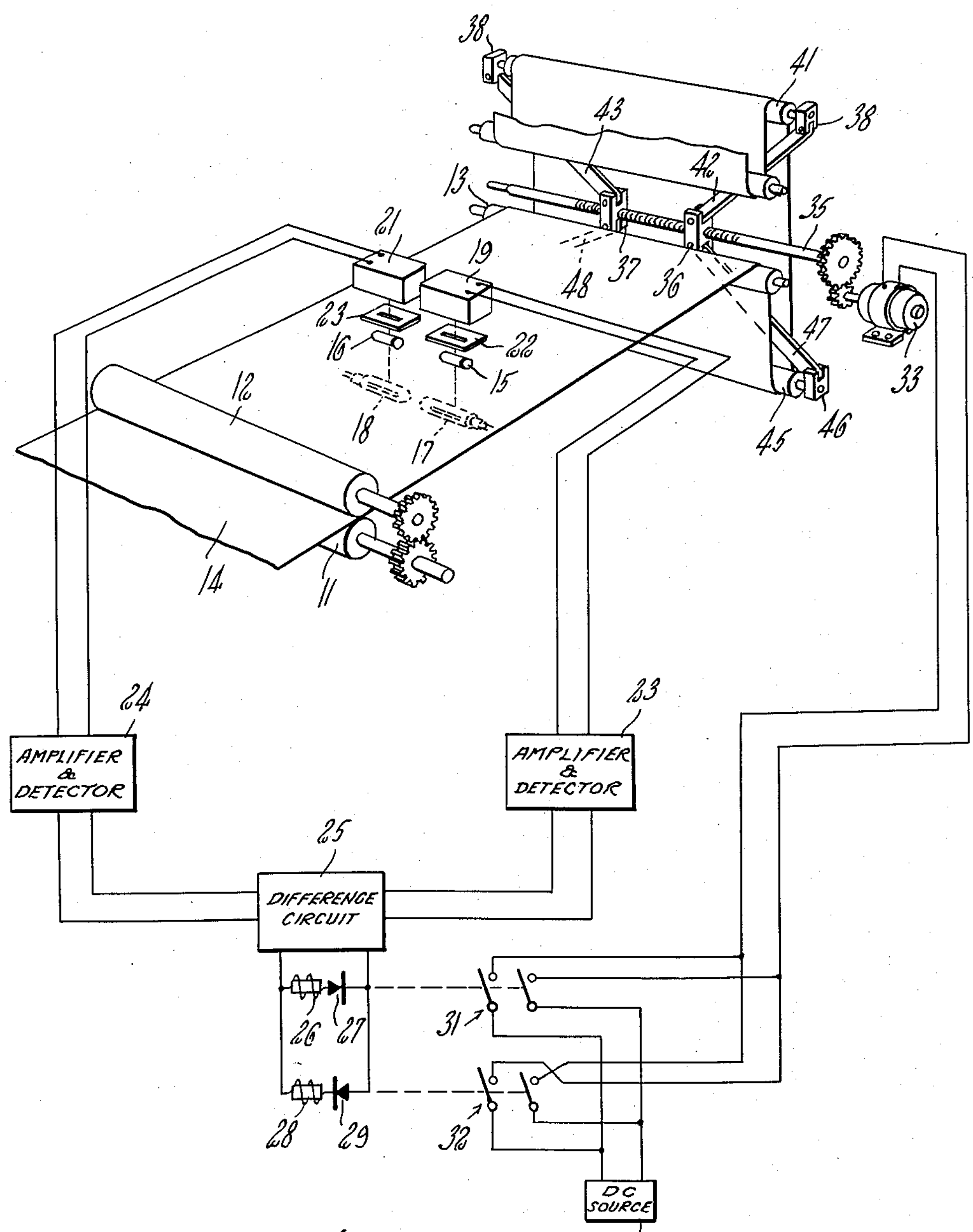

Fig. 1.

WEFT STRAIGHTENER

Filed May 23, 1958 3 Sheets-Sheet 2

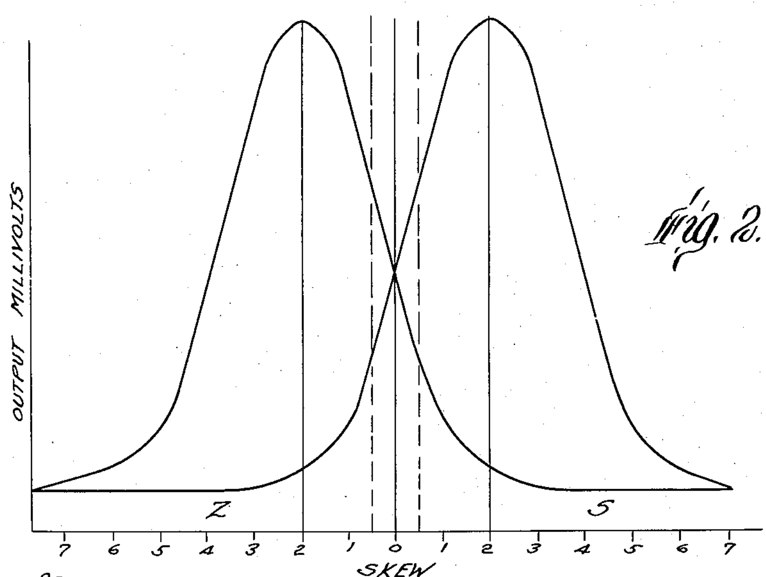

Fig. 2.

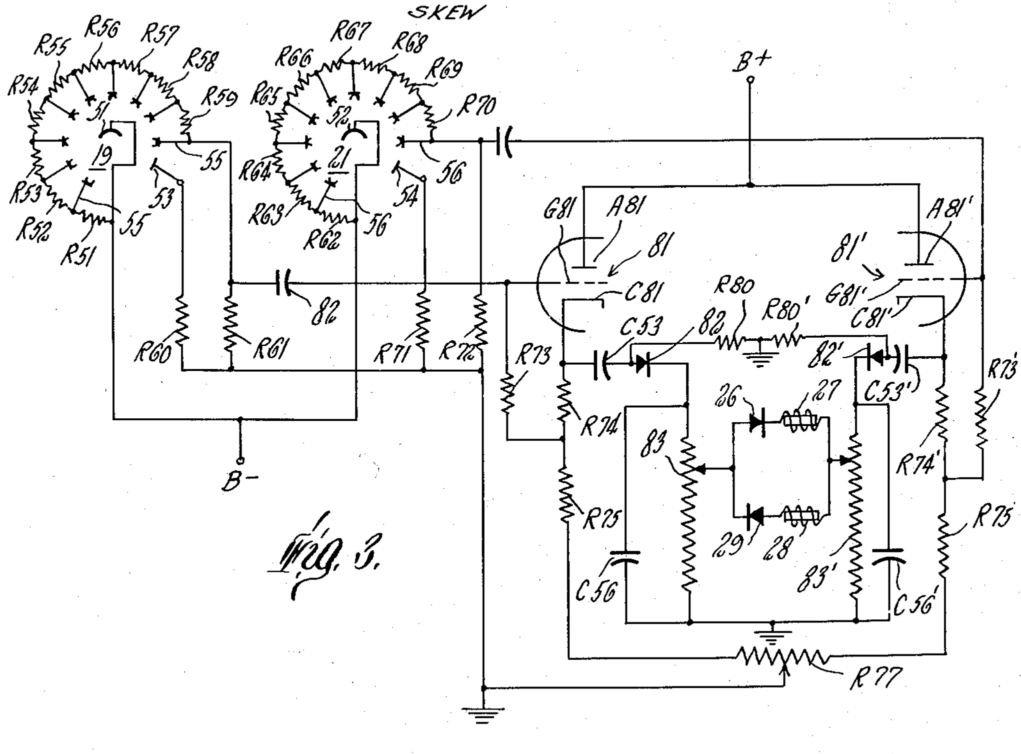

Fig. 3.

WEFT STRAIGHTENER

Filed May 23, 1958

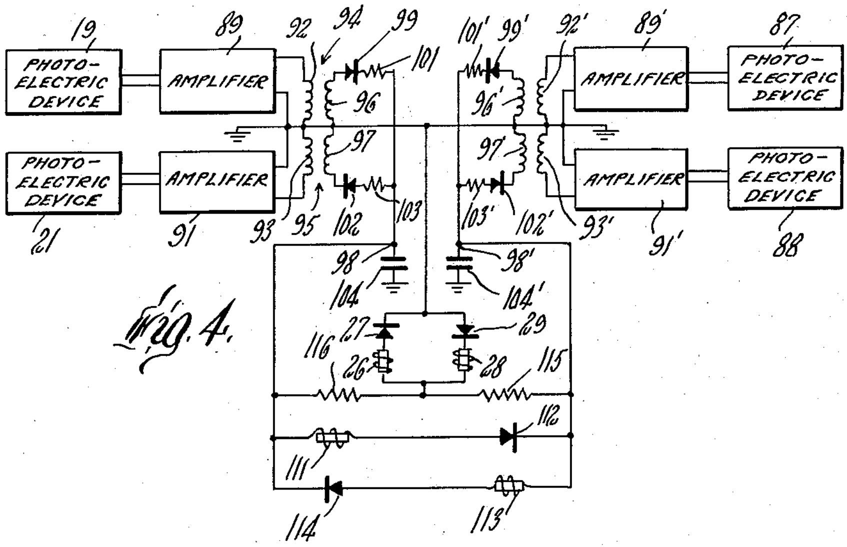

Fig. 4.

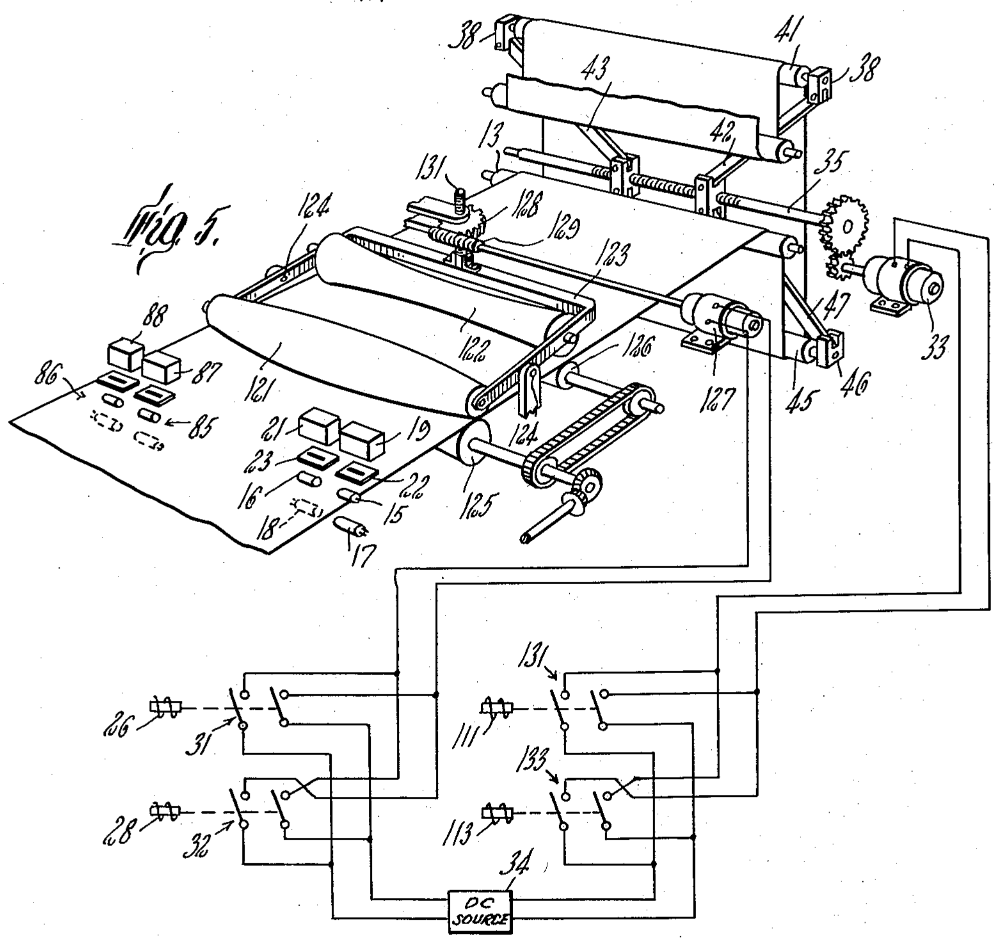

Fig. 5.

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WEFT STRAIGHTENER

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10 Claims. (Cl. 26—51.5)

This invention relates to the processing of woven fabrics and more particularly it is concerned with the straightening of the weft elements in fabrics of this kind.

In the manufacture of woven fabrics it is usually necessary to straighten the weft elements, that is to orient them at right angles to the warp elements at various points in the manufacturing process. This is because the weft elements tend to become disoriented as a result of printing, dyeing, and other operations, which is objectionable especially from an appearance standpoint. Accordingly, a standard practice in the textile art has been to station an operator, or operators, in a position to observe the line of the weft elements and take such corrective action with regard to their straightness as may be necessary. Weft straightening devices are well known and it is a relatively simple matter to change the orientation of the weft elements once their existing line is known. For example, a conventional tenter frame can be used for this purpose, or, alternatively, canted or cone-shaped rolls.

Due to the fact that the fabric is subject to continuous travel at relatively high speed and due to the continual variations in the straightness of the weft, it has proven impossible to achieve by manual control the degree of straightness desired, however. In fact to do any kind of a job at all the operator must be experienced and capable of making the necessary straightness corrections rapidly before an appreciable quantity of the fabric has passed beyond his control. Even with an experienced operator, manual control leaves much to be desired because of the practical difficulty of presenting the weft elements to the view of an operator in a form whereby they may be readily observed. Consequently, it has been proposed to automate this straightening process through the use of photoelectric detection apparatus, and a corrective system based on signals derived from the photoelectric apparatus. For the most part, apparatus of this kind has depended upon counts of the weft elements, taken at transversely displaced points thereof, and the derivation of a phase relation between the counts. The problem with this kind of scheme is that the cloth is not regular as to thread diameter or spacing which adversely affects the accuracy of the control.

It is an object of the present invention, therefore, to provide an improved system for detecting and correcting for the lack of straightness in woven fabrics which, in principle, is independent of phase relations.

It is a further object of the invention to provide a system of the above mentioned character which is capable of detecting the amount of skew of elemental sections of the weft elements at selected locations in the transverse direction of the fabric.

According to the present invention an optical projection system is employed to provide a real enlarged image of each weft element as it passes a longitudinally fixed station. In essence, this projection system comprises a cylindrical lens disposed adjacent to the fabric approximately at right angles to its direction of travel. It is a

property of a cylindrical lens that no magnification takes place in the direction of its axis, with the result that the warp elements whose thickness dimension is approximately parallel to the lens axis are not magnified. As regards the weft elements, the amount they are magnified depends upon their angular displacement. That is to say, if the lens is of circular section, or in other words a rod, which is preferred for its simplicity, a circular lens section will be presented to each elemental length of weft when it is aligned with the rod axis. When the weft is skewed with respect to the rod, however, the lens action will be produced through an oblique meridian of the rod which defines an elliptical section, and the shape of the ellipse will be dependent upon the amount of skew present. Since the focal length of an elliptically shaped lens section is different from that of a circular section and varies according to the dimensions of the ellipse, it follows that the sharpness of the image formed by the lens at a selected image plane will vary according to the amount of skew present.

To make use of this effect, there is mounted on the opposite side of the fabric from the lens a suitable light source whereby real images of the weft elements are clearly defined, and there is mounted beyond the lens a suitable light sensing system sensitive essentially to but one weft element at a time, such as a slit in the image plane followed by a photomultiplier tube. Preferably the height dimension of the slit is approximately equal to the diameter of the image size of the weft elements. As the fabric is fed longitudinally past the lens, the amount of light transmitted to the photoelectric device is caused to modulate with the alternate passage of the weft elements and their interstices, the modulation amplitude depending upon the contrast ratio between the relatively dark area presented by the elements, and the light area by their interstices. In turn, this contrast ratio is caused to vary depending upon the focus of the image with respect to the position of the slit, for as the image moves out of focus and becomes progressively more blurred, it will appear less dark. Also the amount of variation in light intensity at the photoelectric device depends upon the angular relation between the image and the slit, for the more perfect is their alignment, the more of the slit area will be occupied by the weft images and alternately their interstices. The net result, therefore, is that the modulation amplitude of the signal produced by the photoelectric device provides a direct measure of the skew of the weft elements with respect to the warp elements.

Preferably, there are employed according to the invention a pair of such optical projection systems and their associated photoelectric light sensing devices which are transversely spaced from one another. In this way, there is afforded a means for determining the sense of the angular displacement of the weft elements with respect to the warp elements. Thus, masks with slit-shaped apertures are interposed between each lens and its associated photoelectric sensing device, the apertures being aligned with the lenses and the lenses being oriented so as to have small, equal and opposite angular displacements with respect to the transverse line of the fabric. Since the light contrast ratio is a function of the degree of alignment between the weft elements and the lens axes and between the images and the slits, it follows that for any given skew angle one of the photo cells will provide a modulating signal of greater amplitude than the other, and that the sense of the amplitude difference will correspond to the sense of the skew. Accordingly, the modulation amplitude difference of the signals will provide information as to both the amount and sense of the skew on the basis of which an appropriate corrective action can be automatically initiated. As aforementioned, means for correcting skew are well known and can be variously adapted to be controlled automatically.

The novel features of the invention together with further objects and advantages thereof will become more readily apparent from the following detailed description of the preferred embodiment illustrated in the accompanying drawings.

Fig. 1 is a diagrammatic view of the system according to the present invention;

Fig. 2 is a graph representing the voltage output of the photoelectric devices employed in the system as a function of the skew of the weft elements;

Fig. 3 is a schematic diagram of the electrical circuit employed in the system;

Fig. 4 is a schematic diagram of the electrical circuit employed in a modification of the system according to the present invention; and

Fig. 5 is a diagrammatic view of the straightening mechanism employed in the modified system.

With reference now to the drawing, it will be observed that the system includes a pair of feed rolls **11**, **12** and a guide roll **13** to transport a strip of material **14**, which is to be straightened, along a fixed longitudinal path. Disposed at a fixed station adjacent to the line of travel of the material are a pair of transversely spaced cylindrical lenses **15** and **16** in the form of rods, and on the opposite side of the material from the rods are light sources **17** and **18**. Light transmitted through the material and through the lenses is intercepted by a pair of photoelectric devices **19** and **21** provided with apertured masks **22** and **23**, respectively. The masks **22** and **23** have slit-shaped apertures which are aligned with the respective rods and in combination therewith extend at relatively small, equal and opposite angles to the transverse line of the material. Because the angular displacements of the rods are equal, the images produced thereby lie in a common focal plane whenever the weft elements extend along the desired transverse line. The masks **22** and **23** are preferably disposed in a common plane corresponding to the focal plane of the images of the weft elements produced by either one of the rods when the weft is in alignment therewith. By way of example, a contra-rotation of the rods in the neighborhood of two degrees relative to the transverse line of the material has been used effectively, which calls for the masks to be located in the focal plane of the weft element images that are produced when the weft elements are skewed two degrees with respect to the desired transverse line.

As will be described more in detail hereinafter, what is presented to the photoelectric devices is light of modulating intensity resulting from the alternate passage of the weft elements and their interstices. Consequently, corresponding modulations are manifested in the output signals from the photoelectric devices which are applied to respective amplifier and detector networks **23** and **24**. Networks **23** and **24** are coupled to a difference circuit **25** whose output is applied to a first relay circuit including relay coil **26** and diode **27**, and a second relay circuit including relay coil **28** and diode **29**. As shown, the diodes **27** and **29** are oppositely connected so that a selected one of the coils will be energized depending on the sense or polarity of the output voltage from the difference circuit. Associated with the relay coils **26** and **28** are switch contacts **31** and **32**, respectively, which serve to energize a reversible direct current (D.C.) motor **33** from a suitable D.C. source **34**. The contacts are connected so that the polarity of the voltage as applied to the motor **33** is made to depend upon which relay coil is energized, thereby to control the direction of rotation of the motor.

Geared to the motor **33** is a screw shaft **35** onto which are threaded a pair of nuts **36** and **37**. Bearing blocks **38** for an idler roll **41** are pivotally connected to the nuts by links **42** and **43** such that the nuts are constrained to move axially on the screw shaft. Opposite the roll **41** is another idler roll **45**. Bearing blocks **46** for roll **45** are pivotally connected to links **47** and **48** which at their other ends are also pivotally connected to the nuts **36** and **37**. The nuts are threaded in the same direction so that they move together with rotation of the shaft **35** by the motor **33**, thereby to cant the rolls **41** and **45** with respect to one another.

In operation, the factors that affect the modulation amplitude of the signals generated by the photoelectric devices are two. On the one hand the focal distance of the weft element images from the lenses varies as a function to the skew of the weft and as a consequence, a corresponding variation in the light contrast ratio between the weft elements and their interstices is produced. The formula given below theoretically defines the modulation signal amplitude on the basis of this effect for relatively small angles of skew up to 10°.

$$Ei = E_{\max}\left(\frac{2S}{S+Ti}\right)$$

where

$$S+Ti=\left[\frac{M+H}{M+\frac{M}{(MD\cos^2 b)-1}}\right]\left(\frac{O}{M}\right)\left[\frac{M}{(MD\cos^2 b)-1}\right]$$

and

D is the dioptric power of the lens at any skew angle b measured relative to the lens axis

M is the distance from cloth to lens

N is the distance from lens to image with the cloth straight

O is the thread interstice height

S is one-half the slit height A

Ei is the modulation signal amplitude at any skew angle a measured relative to the slit axis

$E_{\max}$ is the modulation signal amplitude when $a=0$.

The other factor that affects the modulation amplitude is the degree of registry, that is, the angular relation, between the slit-shaped apertures and the weft images. It can be shown that for small angles of skew, the following theoretical formula applies.

$$Ei = E_{\max}\left[\frac{AB-(B/2)^2\tan\left(\frac{b}{\cos^2 b}\right)}{AB}\right]$$

where B is the slit length.

A plot of modulation signal amplitude as a function of skew angle is shown in Fig. 2. From Fig. 2 it will be observed that the maximum modulation signal amplitude produced by the respective photoelectric devices occurs at equal and opposite skew angles of approximately two degrees. This is because weft images will be aligned with the slit in one of the masks in each of these cases, and the focal plane of these images will coincide with the plane of the mask. The four degree displacement of the amplitude maxima in Fig. 2 is due to the action of the masks and lenses which function as a means for providing discrimination according to the sense of the skew angle. That is to say, after the signals from the photoelectric devices have been amplified and detected, they are combined in the difference circuit **25** whereby a composite D.C. signal is produced having an amplitude corresponding to the amount of skew present, and a polarity representative of the sense of skew angle. When the D.C. signal from the difference circuit reaches a predetermined threshold amplitude, one of the relays is actuated and the motor is started in a selected direction. As is apparent, the motor then functions to cant the rolls **41** and **45** in the proper direction to correct for the skew of the weft elements, and this will have the effect of reducing the modulation amplitude difference of the signals until the relay switch contacts open, and the motor is de-energized. By way of example, the system has been found to work well when one of the relays is actuated upon the occurrence of plus or minus one-half degree of skew. This is shown by the dotted lines in the diagram of Fig. 2 which define the skew range within which the modulation amplitude difference voltage is insufficient to actuate the relay contacts.

In Fig. 3 there is shown a complete circuit to perform the amplifying detecting and differencing functions described in connection with Fig. 1. The photomultiplier tubes 19 and 21 are shown toward the left of this figure with their cathodes 51 and 52 connected to a suitable source of B minus and their collectors 53 and 54 connected to ground through respective resistors R60 and R71. As shown, each tube has a plurality of dynodes, numbered 55 in the case of tube 19, and 56 in the case of tube 21, which, through the medium of secondary emission, are adapted to amplify the current flowing between the cathode and a first of the dynodes, and to provide an output current between the last dynode and a collector. The collector for tube 19 is numbered 53 and the collector for tube 21 is numbered 54. To this end, the dynodes are placed at increasingly higher potentials through the use of a conventional voltage divider arrangement including resistors R51 through R59 for tube 19 and resistors R62 through R70 for tube 20. Specifically, resistor R51 is connected between B minus and the first dynode 55, resistor R52 is connected between the first dynode and the second dynode, and so forth around to the last dynode where the circuit is completed to ground through a resistor R61. Similarly, resistor R62 is connected between B minus and the first dynode 56, resistor R63 is connected between the first and second dynode, etc., the circuit being completed through a resistor R72 from the last dynode to ground.

The signal produced by photomultiplier tube 19 is applied to the grid G81 of a triode 81 by way of a coupling capacitor 82. Triode 81 has its anode A81 connected to a suitable source of B plus, and its cathode C81 connected to ground through a cathode circuit including a resistor R74, a resistor R75 and one portion of a balancing potentiometer R77. Grid bias is obtained through resistor R74 whose end remote from the cathode C81 is coupled to the grid G81 through a resistor R73.

Disposed in parallel with the aforementioned cathode circuit is a detector circuit from which an output signal is derived. This circuit is seen to include a coupling capacitor C53 to pass the output signal, a diode 82 to rectify the signal, and a load resistor in the form of a potentiometer 83, at one end connected to the diode 82, and at the other end connected to ground. There is also a resistor R80 between capacitor C53 and ground to provide a D.C. return path and a capacitor C56 disposed in parallel with the potentiometer for control of the transient respone of the detector circuit.

Photomultiplier 21 is connected to a circuit of like character wherein corresponding elements have been designated by the same reference numerals with a prime attached. Thus the triode associated with photomultiplier 21 is designated 81′ and its detector circuit is seen to include a diode 82′, a potentiometer 83′ and a capacitor C56′ coupled across the potentiometer. The cathode circuit includes in addition to resistors R74′ and R75′, the other portion of potentiometer R77. Potentiometer R77 is adjusted so that when the output signals from the photomultiplier tubes are equal, like signals will be produced in the detector circuits.

Coupled between the movable arms of the potentiometers 83 and 83′ are the relay coils 26 and 28 of Fig. 1, with their associated diodes 27 and 29. The arrangement is such that the difference of the output voltages derived by the detector circuits is applied across the relay circuits, and according to the sense of this difference voltage, current is caused to flow through a given one of the relay coils. Potentiometers 83 and 83′ are adjusted so that the difference voltage is at a minimum when the weft elements extend in a transverse line, that is at right angles to the warp elements. In this way, compensation may be provided for errors in the alignment of the optical systems, or differences in the characteristics of the photomultiplier tubes and triodes. The potentiometers may be ganged so that their movable arms move in opposite directions whereby an adjustment can be readily made to obtain a selected amount of skew.

Although thus far the invention has been described in connection with skew correction only, it may also be employed to correct bow as well by the addition of a second pair of optical systems and associated photoelectric devices. In Fig. 4 there is shown transversely spaced from the optical systems, including lenses 15 and 16, optical systems of like character designated generally by the numerals 85 and 86, acting on a pair of photocells 87 and 88, respectively. One pair of optical systems and their associated photocells are preferably located near one edge of the material and the other pair of optical systems at the other edge.

As shown in Fig. 4, photoelectric devices 19 and 21 are coupled to suitable amplifiers 89 and 91 and the output signals from the amplifiers are individually coupled to the primaries 92 and 93 of a pair of output transformers designated generally by the numerals 94 and 95. The secondary windings 96 and 97 of the transformers each has a common terminal which is connected to ground as is one end of each primary winding. The other ends of the secondary windings are coupled to a point 98 through individual rectifying circuits including a diode 99 and a resistor 101 on the one hand, and a diode 102 and a resistor 103 on the other. The sense of the transformer winding connections is such that the output signals from the amplifiers will add in a series-aiding manner across the series combination of the secondary windings. Diodes 99 and 102 are oppositely connected; however, thereby to produce a direct output voltage across the resistors 101 and 103 which is balanced to ground when the input signals to the primaries are balanced. There is also a capacitor 104 between point 98 and ground for like purpose as in Fig. 3.

As is apparent, photoelectric devices 87 and 88 have their signals applied to an identical circuit wherein corresponding elements have been designated by the same reference numerals with a prime attached. Thus, the signal derived between point 98′ and ground is equivalent to that derived between 98 and ground. Connected between points 98 and 98′ is a first relay circuit including a relay coil 111 and a diode 112, and a second relay circuit including a relay coil 113 and a diode 114. There is also connected between points 98, 98′ a pair of serially disposed resistors 115 and 116. The skew correction relay circuit described in connection with Figs. 1–3 is connected between the junction of resistors 115, 116 and ground. Specifically, relay 26 and diode 27 form a first series circuit between this junction point and ground, and relay coil 28 and diode 29 a second.

In operation, if it be assumed that the weft elements are bowed rather than skewed, the output voltages between points 98, 98′ and ground will be equal and opposite with the result that neither of the relay coils 26 and 28 becomes energized. Across the relay circuits including relay coils 113 and 144, however, the output voltages add algebraically, and depending upon their magnitude and sense, as determined by the amount and direction of the bow in the material, one of the relay coils will be energized. Conversely, when the material is skewed rather than bowed, there will be no voltage across relay coils 113 and 144, and instead, the voltages between points 98, 98′ and ground will aid in causing one of the relay coils 26 and 28 to become energized.

A mechanism suitable for removing bow of the weft elements is shown in Fig. 5 in association with the skew correction mechanism described in connection with Fig. 1. The former is seen to include a convex idler roll

121 and a longitudinally spaced concave idler roll 122 journalled in a yoke 123. Mounted beneath the respective idler rolls with the material in between are bed rolls 125 and 126 which are driven, as for example from the drive rolls 11, 12 of Fig. 1. Yoke 123 is mounted for pivotal movement about points 124 intermediate the idler rolls, so that as one of these rolls is brought to bear on the material the other roll is caused to move away therefrom. Movement of the idler rolls in opposite directions toward and away from the material is produced by a motor 127 which drives an axially fixed gear wheel 128 through a worm 129. The gear wheel, in turn, is threaded onto a vertically disposed screw 131 which has a pivotal connection to the cross arm of the yoke.

As in the case of motor 33, motor 127 is of a reversible D.C. type, and is coupled to a D.C. source 34 through switch contacts 131 and 133 which are actuated by the relay coils 111 and 113, respectively. By virtue of the arrangement of the switches, the motor will be energized by a supply voltage of one polarity when switch contacts 131 are closed, thereby to start the motor in one direction, whereas when the relay contacts 133 are closed, the motor will be started in the reverse direction. The result is that rolls 121 and 122 are adapted to be raised and lowered as required to correct for the bow that is present, the correction being reflected in a reduced output voltage across the operative one of the relay coils 111 and 113. As soon as the bow has been brought to within tolerance, the voltage across this relay coil will be insufficient to maintain its associated switch contacts closed, and the motor will be de-energized.

Although the invention has been described as being applicable to the correction of skew alone or, alternatively, skew and bow, those skilled in the art will appreciate that various combinations of signals can be produced in accordance with the principles of the invention to correct for such disoriented conditions of the weft known to those skilled in the art as dog-legs, sinusoids and others. Likewise, error signals derived in accordance with the invention may be utilized in entirely different ways from those shown herein. For example, there may be provided a dual lens system which is adapted to correct for bow instead of skew. Various alternatives of this nature that are within the spirit and scope of the invention will, no doubt, occur to those skilled in the art so that the invention should not be deemed to be limited to the details of what has been shown herein by way of illustration, but should be deemed to be limited only by the scope of the appended claims.

What is claimed is:

1. Apparatus of the character described comprising in combination feed means to produce longitudinal travel of a strip of woven material past a fixed station, said woven material being made up of spaced warp and weft elements defining interstices, cylindrical lens means to produce real enlarged images of the weft elements as they pass said fixed station, and light sensitive means disposed beyond said lens means on the same side of the material thereas to produce a modulating electrical signal in response to the images of said weft elements and their interstices and means to detect the modulation amplitude of said signal.

2. In a skew correction system for a strip of woven material subject to longitudinal travel past a fixed station, said woven material being made up of spaced warp and weft elements defining interstices, the combination including cylindrical lens means to produce real enlarged images of the weft elements as they pass said fixed station, said images being focused in a plane whose location is determined by the skew of said weft elements with respect to the lens means axis, light sensitive means disposed beyond said lens means on the same side of the material thereas to produce a modulating electrical signal in response to the images of said weft elements and their interstices, and means to detect the modulation amplitude of said signal.

3. In a skew correction system for a strip of woven material subject to longitudinal travel past a fixed station, said woven material being made up of spaced warp and weft elements defining interstices, the combination including cylindrical lens means to produce real enlarged images of the weft elements as they pass said fixed station, said images being focused in a plane whose location is determined by the skew of said weft elements with respect to the lens means axis, light sensitive means disposed beyond said lens means on the same side of the material thereas to produce a modulating electrical signal in response to the images of said weft elements and their interstices, masking means to provide a slit-shaped aperture in a plane parallel to said focal plane between said light sensitive means and said lens means, and means to detect the modulation amplitude of said signal as determined by the location of said focal plane and the angular displacement of said images with respect to the slit-shaped aperture.

4. In a skew correction system for a strip of woven material made up of spaced warp and weft elements defining interstices, the combination including feed means to produce longitudinal travel of the strip past a fixed station, cylindrical lens means to provide real enlarged images of sections of the weft elements as they pass said fixed station, said images being focused in a plane whose location is determined by the skew of said weft element sections with respect to the lens means, light sensitive means disposed beyond said lens means on the same side of the material thereas to produce first and second modulating electrical signals in response to the images of the weft element sections and their interstices, masking means to provide first and second slit-shaped apertures between said light sensitive means and said lens means, said apertures having equal and opposite angular displacements with respect to the transverse line of the material, and means to detect the modulation amplitude difference of said signals as determined by the location of said focal plane and the angular displacements of said images with respect to the slit-shaped apertures.

5. A skew correction system for a strip of woven material made up of spaced warp and weft elements defining interstices, said system comprising feed means to produce longitudinal travel of the strip past a fixed station, cylindrical lens means to provide real enlarged images of the weft elements as they pass said fixed station, said images being focused in a plane whose location is determined by the skew of said weft elements with respect to the lens means axis, light sensitive means disposed beyond said lens means on the same side of the material thereas to produce a modulating electrical signal in response to the images of said weft elements and their interstices, and means to vary the orientation of the weft elements with respect to the warp elements as a function of the modulation amplitude of said signal.

6. A skew correction system for a strip of woven material made up of spaced warp and weft elements defining interstices, said system comprising feed means to produce longitudinal travel of the strip past a fixed station, cylindrical lens means to provide real enlarged images of sections of the weft elements as they pass said fixed station, said images being focused in a plane whose location is determined by the skew of said weft elements with respect to the lens means, light sensitive means disposed beyond said lens means on the same side of the material thereas to produce first and second modulating electrical signals in response to the images of the weft element sections and their interstices, masking means to provide first and second slit-shaped apertures between said light sensitive means and said lens means, said apertures having equal and opposite angular displacements with respect to the transverse line of the material, and means to vary the orientation of the weft

elements with respect to the warp elements as a function of the magnitude and sense of the modulation amplitude difference of said signals.

7. A skew correction system for a strip of woven material made up of spaced warp and weft elements defining interstices, said system comprising feed means to produce longitudinal travel of the strip past a fixed station, cylindrical lens means to provide real enlarged images of sections of the weft elements as they pass said fixed station, said images being focused in a plane whose location is determined by the skew of said weft elements with respect to the lens means, light sensitive means disposed beyond said lens means on the same side of the material thereas to produce first and second modulating electrical signals in response to the images of the weft element sections and their interstices, masking means to provide first and second slit-shaped apertures between said light sensitive means and said lens means, said apertures having equal and opposite angular displacements with respect to the transverse line of the material, means to vary the angular orientation of the weft elements in opposite senses with respect to the warp elements, and means to condition said last-named means to vary the orientation of the weft elements when the modulation amplitude difference of said signals reaches a predetermined threshold value.

8. A skew correction system for a strip of woven material made up of spaced warp and weft elements defining interstices, said system comprising a feed mechanism to produce longitudinal travel of the strip past a fixed station, a pair of transversely displaced rod-shaped lenses disposed adjacent to the surface of the strip at said station, said lenses being oriented with their axes parallel to the surface of the strip and at relatively small equal and opposite angles with respect to the transverse line of the material, a source of light disposed on the opposite side of the material from the lenses to produce in combination therewith real enlarged images of sections of the weft elements as they pass sajd fixed station, said images being focused in a plane whose location is determined by the skew of the weft elements with respect to the axes of the lenses, a pair of photoelectric devices disposed beyond said lenses on the same side of the material thereas to produce first and second modulating electrical signals in response to the images of the weft element sections and their interstices, a pair of masks interposed between the lenses and the photoelectric devices, respectively, said masks having slit-shaped apertures aligned with the respective lenses, circuit means to provide a direct current voltage representing in amplitude and polarity the amplitude and sense of the difference of said modulating electrical signals, and means to vary the angular orientation of the weft elements as a function of said voltage.

9. A skew correction system for a strip of woven material made up of spaced warp and weft elements defining interstices, said system comprising feed means to produce longitudinal travel of the strip past a fixed station, a pair of cylindrical lenses adapted to provide real enlarged images of sections of the weft elements as they pass said fixed station, said sections having an appreciable spacing in a direction transverse to the line of travel of the material, and said images being focused in a plane whose location is determined by the skew of the weft elements with respect to the lenses, light sensitive means disposed beyond said lenses on the same side of the material thereas to produce first and second modulating signals in response to the images of the weft element sections and their interstices, and means to vary the angular orientation of the weft elements with respect to the warp elements as a function of said signals.

10. A skew correction system for a strip of woven material made up of spaced warp and weft elements defining interstices, said system comprising feed means to produce longitudinal travel of the strip past a fixed station, first cylindrical lens means disposed adjacent one edge of the material to provide real enlarged images of a pair of edge sections of the weft elements as they pass said fixed station, second cylindrical lens means disposed adjacent to the other edge of the material to provide real enlarged images of another pair of edge sections of the weft elements as they pass said fixed station, a first pair of photoelectric devices disposed beyond said first lens means on the same side of the material thereas to produce a first pair of modulating electrical signals in response to the images of one pair of edge sections of the weft elements and their interstices, a second pair of photoelectric devices disposed beyond said second lens means on the same side of the material thereas to produce a second pair of modulating electrical signals in response to the images of the other pair of edge sections of the weft elements and their interstices, a first pair of masks having slit-shaped apertures interposed between said first lens means and said first pair of photoelectric devices, respectively, said apertures having equal and opposite angular displacements with respect to the transverse line of the material, a second pair of masks having slit-shaped apertures interposed between said second lens means and said second pair of photoelectric devices, respectively, said last-named apertures having the same displacement with respect to the transverse line of the material as said first-named apertures, and means to vary the angular orientation of the weft elements as a function of said signals.

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UNITED STATES PATENT OFFICE
CERTIFICATION OF CORRECTION

Patent No. 2,972,794 February 28, 1961

Robert J. Saul et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, lines 24 and 25, for that portion of the formula reading

$$\frac{M + H}{M} \quad \text{read} \quad \frac{M + N}{M}$$

Signed and sealed this 11th day of July 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents