

Feb. 19, 1963

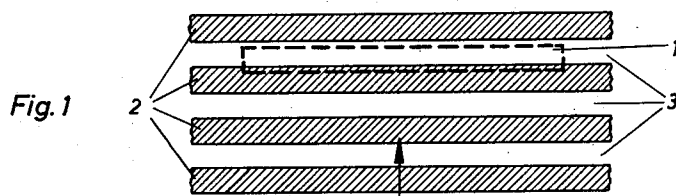
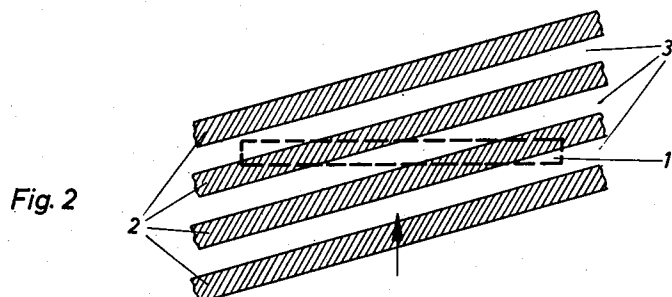
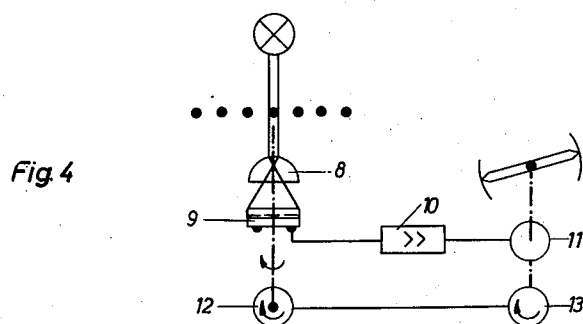
H. MAHLO

3,077,656

PHOTOELECTRIC DEVICES FOR INDICATING THE LAY OF WEFT
THREADS AND FOR CONTROLLING WEFT STRAIGHTENERS

Filed April 24, 1959

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Fig. 5

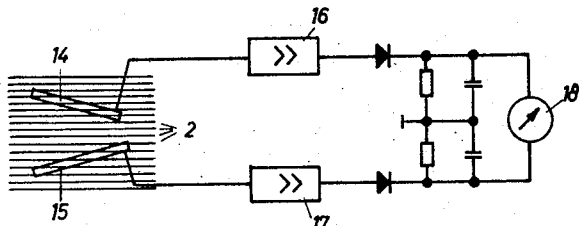


Fig. 6

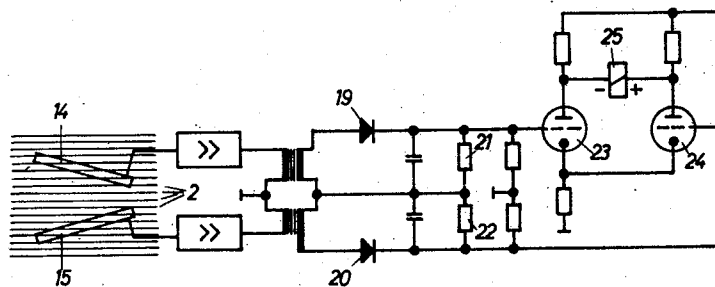


Fig. 7

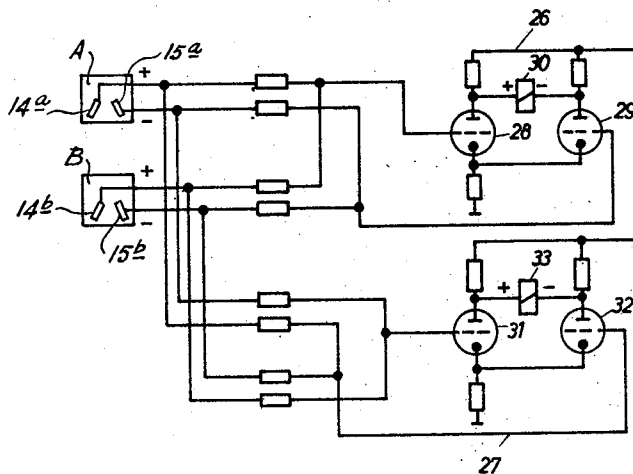
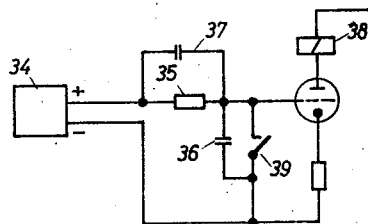


Fig. 8



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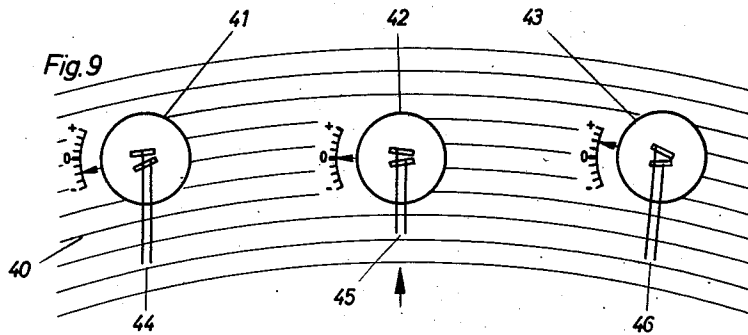
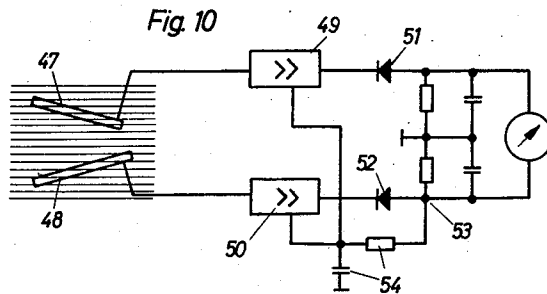
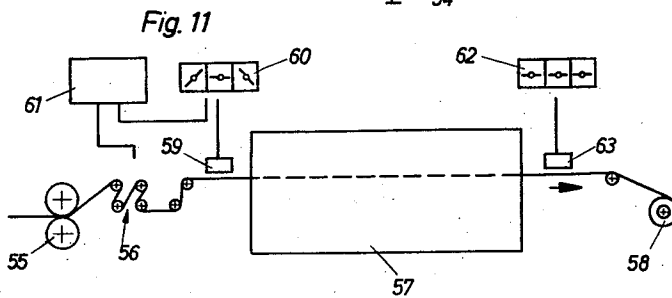
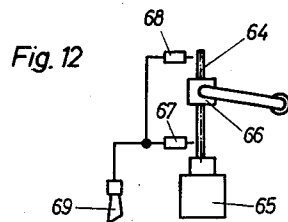
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3,077,656

PHOTOELECTRIC DEVICES FOR INDICATING THE LAY OF WEFT THREADS AND FOR CONTROLLING WEFT STRAIGHTENERS

Heinz Mahlo, Saal (Danube), Bavaria, Germany

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9 Claims. (Cl. 26—51.5)

This invention relates to an arrangement for optically ascertaining and indicating the lay or direction of weft threads in webs of travelling woven cloth or fabric and for controlling weft straightening apparatus.

In the drying of woven textile materials it is important that the fabric is without distortion when it leaves the drying apparatus, that is, has its weft threads lying exactly at right angles to the warp threads. The operator can visually inspect the fabric during drying in slowly running drying apparatus and, when distortion of the material occurs, he takes the appropriate steps to correct it by hand. Fast running fabric cannot, however, be inspected with sufficient speed by the naked eye. Thus, in the case of modern drying machines, which may have an evaporative capacity of 500–1000 kilograms of water per hour and may run at speeds of up to 200 yards of fabric per minute, the maximum operating speed is not determined by the drying capacity of the machine but by the operator's ability to inspect the fabric. A great number of devices has already been proposed in which photo-electric cells are used for automatic control of the lay of the weft threads. None of these devices has proved to be satisfactory in practice.

The present invention differs basically from the devices already known, by utilizing the following principle. If a photoelectric cell having an elongated light aperture, the effective width of which corresponds substantially to the thickness of a weft thread, or to the gap between two adjacent weft threads, is placed with the longitudinal axis of the aperture parallel to the weft threads and is illuminated through the travelling fabric, the cell is alternately strongly illuminated and substantially darkened. If the longitudinal axis of the cell aperture is inclined with respect to the direction of the weft threads, the cell is partly illuminated and partly darkened at any moment. When the longitudinal axis of the aperture lies parallel to the direction of the weft threads the cell generates an alternating voltage having a maximum amplitude. The amplitude becomes smaller as the angle between the longitudinal axis of the cell aperture and the weft threads becomes more obtuse. The frequency of the alternating voltage corresponds approximately to the rate of passage of the weft threads, which for the purpose of the present invention is of no importance.

The object of the invention is to provide means for controlling the lay or direction of the weft threads of a travelling web of woven cloth in which a source of light is arranged at one side of the fabric and one or more photoelectric cells are arranged at the other side of the fabric in such a manner that the alternating voltages generated by the photoelectric cells upon movement of the fabric have a maximum amplitude when the weft threads and the longitudinal axes of the apertures of the photoelectric cells lie parallel to one another so that the alternating voltages can be used to control the operation of a weft straightening apparatus. The photocell exposed to the light source through the woven cloth or fabric may be rotated about an axis perpendicular to the plane of the fabric. In this case only one photocell is required for each sensing point. When the fabric is running, this photocell supplies a maximum alternating voltage at each angular position in which it lies parallel to the wefts. Alternatively, rather than rotating the photocell continuously,

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it may be oscillated parallel to the surface of the fabric, the oscillating movement extending in each direction beyond the sector defined by the maximum angular error in the lay of the weft threads which may occur in practice.

However, in preferred embodiments of the invention, an arrangement for optically sensing the lay of weft threads in moving woven fabric comprises a pair of photoelectric cells for each light source, and the elongated or slot-shaped openings or apertures admitting light from the sources to the related cells are oppositely slanted with respect to a line at right angles to the direction of movement of the fabric so that the amplitudes of the voltages generated by the photoelectric cells of each pair vary in opposite directions in response to the deviation of the weft threads from parallels to that line at right angles to the direction of movement. The opposite variations of the amplitudes of the voltages generated by the pair of cells are a function of the deviation, and may actuate means by which such deviation is corrected.

In practice, it is found that a web of woven cloth shrinks during drying in a tentering frame, and frequently leaves the frame with the weft threads lying in a backward concave bow even when it enters the frame with straight weft threads at right angles to the warp threads. To avoid this it is useful, in certain cases, to arrange for the fabric to enter the frame with the weft threads lying in a convex bow, thereby ensuring that the fabric leaves the frame with straight weft threads. In tentering frames in which the two clamping chains have stretched unequally in the course of time, the fabric leaves the frame with the weft threads skewed in one direction, even though the fabric has entered the frame with the weft threads laid correctly. In order to deal with the above conditions, control devices embodying the invention are preferably arranged in such a manner that either skewing or bowing of the weft threads up to a predetermined maximum amount, or a combination of both faults, are provided for. This can be carried into practice in two different ways. The sensing devices consisting of one or more photocells can be mounted in such a manner that the cells may be slewed. When the fabric weft enters the frame with a predetermined bow, the two outer sensing devices are slewed in opposite directions so that they lie at similar angles to the line of fabric movement. In the case of a predetermined skewing of the weft threads, all the sensing devices are correspondingly slewed in the same direction at the same angle to the direction of fabric movement. The same results can be achieved without slewed the sensing devices themselves, by arranging the control devices in such a manner that separate compensation or biasing is provided for each of the sensing devices.

The invention will now be described in more detail by ways of example with reference to the accompanying drawings in which:—

FIGURE 1 shows a photocell lying parallel to the weft threads;

FIGURE 2 shows a photocell lying inclined to the weft threads;

FIGURE 3 shows a sensing arrangement with a magnifying lens in the path of the light beam;

FIGURE 4 shows an indicating arrangement in which a photocell turns about an axis perpendicular to the plane of the fabric;

FIGURE 5 shows a stationary arrangement which in accordance with a preferred embodiment of the invention, is provided with two photocells;

FIGURE 6 shows a sensing arrangement with a circuit for transmitting signals to a weft straightening ap-

paratus so as to cause it to eliminate distortion of the woven fabric;

FIGURE 7 shows an arrangement for correcting skew distortion as well as bow distortion of the weft threads of the woven fabric;

FIGURE 8 shows a distortion correcting arrangement with a resistance-capacitance unit connected in series;

FIGURE 9 shows three sensing heads spaced across a moving web of woven fabric and each provided with two photocells which can be slewed in their supports;

FIGURE 10 shows a circuit containing two amplifiers having automatic gain control;

FIGURE 11 schematically shows an arrangement with sensing heads at the entrance and exit ends of a tenting frame; and

FIGURE 12 schematically shows a device for sounding warning signals when the extreme positions of the weft thread correcting device are reached.

Referring to FIGURE 1, it will be seen that the photocell 1 has an elongated or slot-shaped light aperture the effective width of which corresponds substantially to the thickness of one weft thread 2 or of the gap 3 between adjacent threads. The longitudinal axis of the aperture is shown extending parallel to the weft threads. In FIGURE 2, the weft threads are shown inclined with respect to the slot-shaped aperture or opening of the photocell. In FIGURE 3, a light source 4 is shown projecting a beam of light on to or past weft threads 5, through a cylindrical lens 6 and on to a photocell 7. The lens 6 produces an enlarged image of the weft threads 5 on the photocell 7. When the cylindrical lens and the photocell rotate about an axis perpendicular to the axis of the lens and in a plane parallel to the surface of the woven fabric, the photoelectric cell produces a maximum alternating voltage at each instant when the direction of the axis of the lens is parallel to the lay of the weft of the woven fabric. If the transmitter of a synchronous electric transmission system is driven synchronously with the rotating lens and photocell, and the rotor of the receiver of the transmission system is damped either by oil or by eddy currents and has a pointer attached to it, this pointer moves to the point at which the maxima of the alternating voltage repeatedly occur if the receiver is also fed with the alternating voltage generated by the photocell after being amplified and rectified. Such an arrangement is shown in FIGURE 4 in which 8 is the lens, 9 the photocell, 10 the amplifier and 11 the rotor of the receiver of the synchronous transmission system. The synchronous electric transmission system consists of the transmitter 12 and the receiver 13. It is possible to arrange several indicator systems side by side along the path of the fabric. All the systems are driven by means of a common synchronous electric transmission.

The basic idea of the invention is preferably embodied in arrangements which do not require rotating or moving parts. An indicating device having such an arrangement is shown in FIG. 5. At one side of the fabric two cells 14 and 15 are disposed at any desired, but preferably equal and opposite, angles to the normal weft direction, and are illuminated through the fabric. The alternating voltages produced by the cells 14 and 15 are individually amplified in the amplifiers 16, 17 and then rectified. When the weft threads are in truly rectangular relationship to the length of the fabric, alternating voltages of equal amplitude are generated in the two cells. The magnitudes of the direct voltages produced by the two rectifiers respectively connected to the amplifiers are consequently equal and the instrument or meter 18 indicates zero. When the fabric is distorted and the lay of the wefts approaches the longitudinal axis of the slot-shaped opening or aperture of the cell 14, the amplitude of the alternating voltage produced by this cell increases whereas the amplitude of the alternating voltage produced by the cell 15 diminishes. The instrument or meter 18 now indicates a value differing from zero, which is a function

of the extent to which the weft threads are skewed. When the lay of the wefts approaches the longitudinal axis of the slot-shaped opening of the photocell 15, the instrument 18 indicates a value differing from zero in the opposite direction. It is again possible to distribute any number of these sensing arrangements across the width of the fabric and to connect them with suitable indicating, alarm or recording mechanisms. Furthermore, it is possible to connect the sensing arrangements to control mechanisms for conventional weft straightening apparatus correcting distortion appearing in the fabric. The circuit shown in FIGURE 6 has proved useful for this purpose. The rectifiers 19, 20 produce direct voltages across the resistances 21, 22, the respective magnitudes of which correspond to the alternating voltages generated by the two cells. The voltages on the respective grids of the tubes 23, 24 are consequently equal when the alternating voltages generated by the two cells are of equal amplitude. A polarized relay 25 is connected between the anodes of the tubes 23, 24, so that it is in its neutral position when the voltages on the grids of both tubes are equal. When the alternating voltage generated by one cell increases and that of the other cell diminishes the relay 25 moves to one or to the other of its contact positions for closing a corresponding electric circuit (not shown) by which a conventional weft straightening apparatus (not shown) is actuated. The closing of the contacts of the relay 25 can be periodically interrupted in known manner so that the control signal to the straightening apparatus consists of a series of impulses.

In order to correct skewing as well as bowing of the weft threads of the fabric, the arrangement shown in FIGURE 7 may be employed. In this arrangement, sensing heads A and B are disposed adjacent the opposite selvages of the moving fabric. The head A includes two photocells 14a and 15a having slot-shaped light-admitting openings enclosing an acute angle, and the head B similarly includes two photocells 14b and 15b with their slot-shaped openings enclosing an acute angle. The angles enclosed by the photocells 14a and 15a and by the photocells 14b and 15b are both bisected by a line at right angles to the direction of movement of the fabric.

The circuit indicated generally at 26 is intended to provide signals for correcting skew distortion, while the circuit indicated generally at 27 is intended to provide signals for correcting bow distortions of the fabric.

The circuit 26 includes tubes 28 and 29 and a polarized relay 30 connected between the anodes of tubes 28 and 29 so that relay 30 is in its neutral position, when the voltages or potential of the grids of tubes 28 and 29 are equal, and any deviation between such voltages causes movement of relay 30 to one or the other of its contact positions for providing the desired skew correction signal.

As shown in FIG. 7, the photocells 14a and 14b of both heads A and B are connected, in parallel, to the grid of tube 28, while the photocells 15a and 15b are connected, in parallel, to the grid of tube 29. When the weft threads are at right angles to the direction of movement, the voltages generated by the photocells 14a and 14b are equal to the voltages generated by the photocells 15a and 15b so that the grids of tubes 28 and 29 are at the same potential and relay 30 maintains its neutral position. When the weft threads are skewed, in one direction or the other, the voltages generated by photocells 14a and 14b both either increase by the same amount or decrease by the same amount, while the voltages generated by photocells 15a and 15b both either decrease equally or increase equally. Thus, the voltages, impressed on the grids of tubes 28 and 29 are made to differ from each other and the relay 30 is displaced to one or the other of its contact engaging positions for providing a correction signal to a conventional skew correcting apparatus (not shown).

When a bow distortion of the weft threads occurs, the voltages generated by the photocells 14a and 14b vary

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in opposite directions, that is, either increase or decrease, respectively, while the voltages generated by the photocells 15a and 15b similarly vary in opposite directions. Thus, the voltage changes of photocells 14a and 14b cancel each other and the voltage changes of photocells 15a and 15b cancel each other, so that the potentials of the grids of tubes 28 and 29 remain equal and the circuit 26 does not transmit a correction signal in response to a bow distortion.

Further, as shown in FIG. 7, the circuit 27 for bow distortions includes tubes 31 and 32 and a polarized relay 33 connected between the anodes of tubes 31 and 32 to move to one or the other of its contact engaging positions only when the grids of tubes 31 and 32 are at different potentials. The photocells 14a and 15b are connected in parallel to the grid of tube 32, while the photocells 14b and 15a are connected in parallel to the grid of tube 31.

When the weft threads are at right angles to the direction of travel of the fabric, in which case the voltages generated by all of the photocells are equal, or when the weft threads are skewed, so that, the increase or decrease in the voltage generated by the cell 14a is equal to, and thus cancels, the decrease or increase, respectively, in the voltage generated by the cell 15b, and the changes in the voltages generated by cells 14b and 15a similarly cancel each other, then the potentials of the grids of tubes 31 and 32 are equal and relay 33 remains in its neutral position. However, when there is a bow distortion of the weft threads, the voltages generated by the cells 14a and 15b both either increase by the same amount or decrease by the same amount, while the voltages generated by the cells 14b and 15a both either decrease equally or increase equally, whereby the potentials of the grids of tubes 31 and 32 deviate from each other to move relay 33 to one or the other of its contact engaging positions for transmitting a correction signal to the associated conventional bow correction apparatus (not shown).

Of course, if both a skew distortion and a bow distortion of the weft threads occur simultaneously, then both circuits 26 and 27 will operate at the same time to transmit skew and bow correction signals.

The arrangements described with reference to FIGS. 6 and 7 may be improved by connecting a resistance-capacitance combination in the input circuit of the tube and providing the relay with an additional contact which periodically short-circuits the voltage at the capacitor, as is indicated in FIGURE 8. The control voltage from a photocell of the sensing device 34 is fed over the resistor 35 to the capacitor 36. When this capacitor is charged up to a predetermined level, the relay 38 attracts and simultaneously closes the contact 39. Thus the capacitor 36 is discharged and the relay 38 is released. The capacitor 36 is now recharged over the resistor 35. This cycle occurs with increasing rapidity with rising control voltage. The sequence of impulses is therefore rapid with a high control voltage, that is, in response to a large deviation of the weft threads from their correct lay, and slow when the deviation is small. By connecting a further capacitor 37 in parallel with the resistor 35 the differential quotient of the control voltage with respect to time is added. This has the effect of adding anticipation to the control.

Distortion of the fabric during drying in a tentering frame, or caused by distortion of the frame itself, is taken into account as follows:

FIGURE 9 shows three sensing heads 41, 42, 43 spaced apart across the web of fabric 40, and mounted for rotational adjustment about axes perpendicular to the plane of the fabric. The heads 41, 42 and 43 have pairs of photocells 44, 45 and 46, respectively, and are arranged with the elongated light admitting apertures of each pair of photocells enclosing an equal acute angle. Further, the several sensing heads are rotationally adjusted so that

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the line bisecting the angle between the photocells 45 of the central head 42 is at right angles to the direction of movement of the fabric. The head 41 is adjusted so that the line bisecting the angle between its photocells 44 is inclined in one direction from the perpendicular to direction of movement so as to be tangential to the curve of the weft threads on the left-hand side of the figure and the head 43 is adjusted so that the line bisecting the angle between its photocells 46 is tangential to the curve of the weft threads at the right-hand side of web of fabric.

The photocells of each of the heads 41, 42 and 43 may be connected to an indicating circuit of the kind shown on FIG. 5 so that the indicator or meter of each circuit will show a zero indication so long as the weft threads of the fabric entering the tentering frame have the initial bow distortion necessary to counteract the opposite bow distortion resulting from drying in the frame. If the meters associated with one or more of the adjusted heads departs from its normal indication, then the usual apparatus provided for controlling the lay of the weft threads may be suitably adjusted. Further, if the lay of the weft threads which is to be maintained is other than the bowed configuration of FIG. 9, the heads 41, 42 and 43 are adjusted so that correct lay of the weft threads occurs when the lines bisecting the angles between the pairs of photocells are tangential to the weft threads at the portions of the latter scanned by the respective heads.

It has been shown in practice that the amplitude of the alternating voltage delivered by the photocells depends to a certain extent upon the kind of fabric being operated upon. If the fabric is thick, the amplitude is greater than it is with thin fabric and, in the case of colored fabric, the amplitude is greater than it is with non-colored fabric. In general, the contrasts in colored fabric are stronger as between bright and dark. The amplifiers amplifying the voltages generated by the photocells of the sensing heads are preferably provided with automatic gain controls so that the differences in voltage due to differences in the fabric are compensated for. For this purpose circuits well known in the electronic art may be used.

FIGURE 10 shows such an arrangement. The alternating voltages occurring at the two photocells 47, 48 are amplified in the amplifiers 49, 50 and rectified by rectifiers 51, 52. A direct voltage produced at point 53 and having a magnitude proportional to the rectified output of the amplifiers 49, 50 is fed, as an automatic gain control voltage, to the amplifiers 49, 50 over a resistance-capacitance network 54.

As previously mentioned, the fabric may leave the tentering frame with weft distortion although it had entered the frame with correctly laid weft threads. This can be checked by using two of the previously described sensing devices, the heads of the first device being at the input end and those of the second device being at the exit end of the tentering frame. The control of the weft straightening apparatus is preferably carried out by the device at the input end, so that there is no time lag. If the sensing device at the exit end of the frame were used for delivering the control voltage there would always be a lag in the control equal to the time taken for the fabric to pass through the frame so that lengths of fabric might leave the frame with distorted wefts.

When two sensing devices are used in this manner the heads of the sensing devices as shown in FIGURE 9 can be adjusted, for example, to a predetermined bow of the weft threads and the weft straightening apparatus is thus regulated to cause the fabric to enter the machine with this predetermined bow. The indicating instruments or meters of the sensing device at the exit end of the frame then indicate whether the fabric which entered with the predetermined bow is leaving the frame with straight weft threads, as intended. FIGURE 11 shows

an arrangement suitable for the above purpose. The fabric passes a mangle 55, then the weft straightening apparatus 56, and finally through the tentering frame 57, before being wound up on the roller 58. The sensing heads of device 59 scan the lay of the weft threads and the indicating instruments 60 depict it. This device 59 also operates the regulator 61 which controls the straightening apparatus. The indicating instruments 62 indicate the lay of the weft threads at the exit of the tentering frame which is scanned by the heads of sensing device 63. The indications of the device arranged at the exit of the machine may also be used to correct automatically the settings of the heads of the device 59 for predetermined bow and skew distortions at the input end of the tentering frame.

It has been found in practice that fabrics entering the frame are sometimes so distorted that the distortion cannot be corrected even with the weft straightening apparatus in its extreme position. When that condition occurs, the fabric leaves the machine with distorted weft threads although the straightening apparatus and the control device work faultlessly. To overcome this disadvantage, it is useful to include limit switches in the weft straightening apparatus which produce either a visual or acoustic warning signal when the weft straightening apparatus reaches one of its extreme positions. This warning signal indicates that the operator must adjust the operation by hand. FIGURE 12 shows a device for providing the desired warning signal. A threaded regulating spindle 64 is rotated by a reversible motor 65. The weft straightening apparatus is displaced by movement of a nut member 66 on spindle 64. Limit switches 67, 68 are selectively closed when one or the other of them is contacted by the nut member 66. The horn 69 is operated by the closing of either one of the switches 67 and 68 which are connected in parallel in the energizing circuit of the warning horn.

What I claim is:

1. In an arrangement for optically sensing the lay of weft threads in moving woven fabric; the combination of at least one light source disposed at one side of the moving fabric, a pair of photoelectric cells for each light source disposed at the opposite side of the moving fabric, said photoelectric cells of said pair each having a slot-shaped opening admitting light from said source to the respective cells following passage of the light between the weft threads of the moving fabric so that each cell is intermittently energized to generate voltages having a maximum amplitude when the weft threads of the moving fabric extend parallel to the slot-shaped opening of the respective cell, the slot-shaped openings of said pair of photoelectric cells being oppositely slanted with respect to a line at right angles to the direction of movement of the fabric so that the amplitudes of the voltages generated by said photoelectric cells of said pair vary in opposite directions in response to the deviation of the weft threads from parallels to said line, and means actuated by the opposite variations of said amplitudes as a function of said deviation.

2. The combination as in claim 1; wherein said slot-shaped openings of said pair of photoelectric cells are at an acute angle with respect to each other, with said acute angle being bisected by said line at right angles to the direction of movement of the fabric so that the amplitudes of the voltages from said pair of cells are equal when the lay of the weft threads of the fabric is at right angles to said direction of movement of the fabric.

3. The combination as in claim 2; wherein a pair of said photoelectric cells is disposed adjacent each of the opposite selvages of the moving fabric; and wherein said means actuated by the opposite variations of the amplitudes includes first and second control means for weft straightening apparatus effective to correct for skewing and bowing, respectively, of the weft threads, first circuit means connecting the similarly slanted cells of both pairs of cells in parallel to said first control means for actuat-

ing the latter when the weft threads adjacent the opposite selvages deviate in the same direction from right angles to said direction of movement of the fabric, and second circuit means connecting the oppositely slanted cells of both pairs in parallel to said second control means for actuating the latter when the weft threads adjacent the opposite selvages deviate in opposite directions from right angles to said direction of movement of the fabric.

4. The combination as in claim 2, wherein said means actuated by the opposite variations of the amplitudes includes means amplifying and rectifying the voltages from said pair of photoelectric cells, and indicating means receiving the amplified and rectified voltages from both cells to indicate any disparity between the amplitudes of the respective voltages.

5. The combination as in claim 2, wherein said means actuated by the opposite variations of the amplitudes includes control means for actuating a weft straightening apparatus and having a neutral position and opposed operating positions, and electrical circuit means for said control means effective to dispose the latter in said neutral position when the voltages from said pair of cells are equal and to dispose said control means in said opposed operating positions when the voltage from one of said cells is greater than the voltage from the other cell of said pair.

6. The combination as in claim 2, wherein a pair of said photoelectric cells is disposed adjacent each of the opposite selvages of the moving fabric, and wherein said means actuated by the opposite variations of the amplitudes includes first and second control means for weft straightening apparatus effective to correct for skewing and bowing, respectively, of the weft threads, circuit means feeding the voltages from the cells of both pairs which are similarly slanted with respect to said line to said first control means for actuating the latter, and circuit means feeding the voltages from the cells of both pairs which are oppositely slanted to said second control means for actuating the latter.

7. The combination as in claim 1, wherein a plurality of light sources is provided and a pair of photoelectric cells is associated with each light source, the cells of each pair having their slot-shaped openings arranged at an acute angle to each other, and each pair of cells being mounted for rotation, as a unit, to vary the angle between a line bisecting the angle between the related slot-shaped openings and the direction of movement of the fabric; and wherein each of said pairs of cells is connected with said means actuated by opposite variations of the amplitudes.

8. The combination as in claim 1, wherein the slot-shaped openings of said pair of cells are arranged at an acute angle to each other so that the voltages from said cells have equal amplitudes when the weft threads are parallel to a line bisecting said acute angle, and said means actuated by opposite variations of said amplitudes includes amplifying means receiving the voltages from said pair of cells, control means actuated by differences between the amplified voltages, and means responsive to changes in the average of the voltages from both cells to vary the amplitude of the difference between the voltages for actuating said control means.

9. The combination as in claim 8, wherein said means responsive to changes in the average of the voltages from both cells includes automatic gain control means for said amplifying means, thereby to compensate for voltage differences resulting from the character of the moving fabric.

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