

June 11, 1940.

D. C. STOCKBARGER

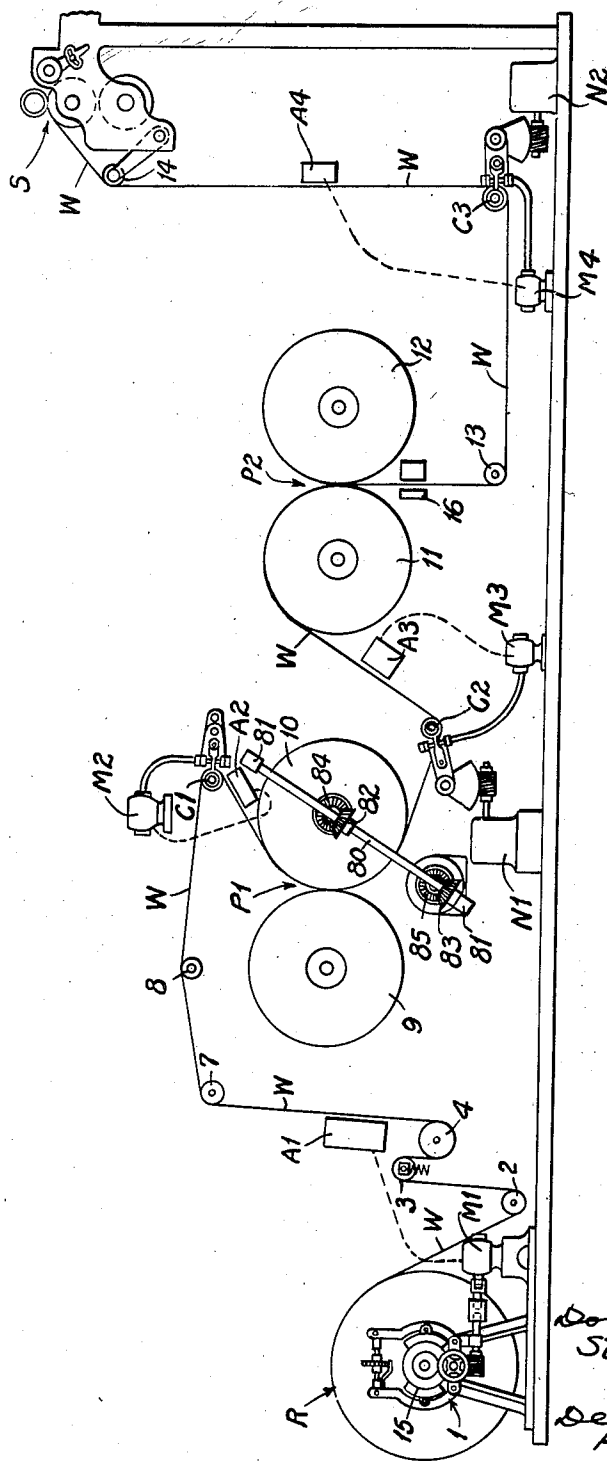
2,203,706

METHOD OF AND APPARATUS FOR MAINTAINING WEB ALIGNMENT

Filed May 5, 1937

6 Sheets-Sheet 1

FIG. 1.



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FIG. 2.

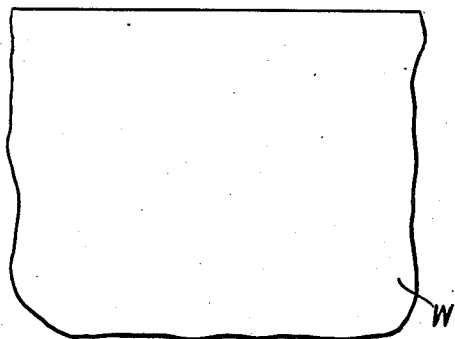


FIG. 3.

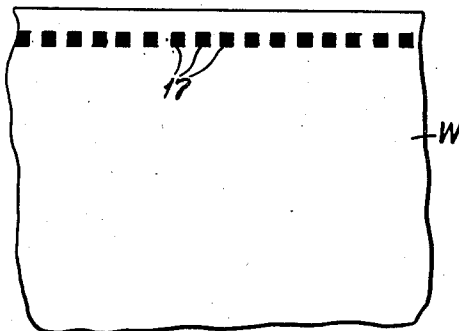


FIG. 4.

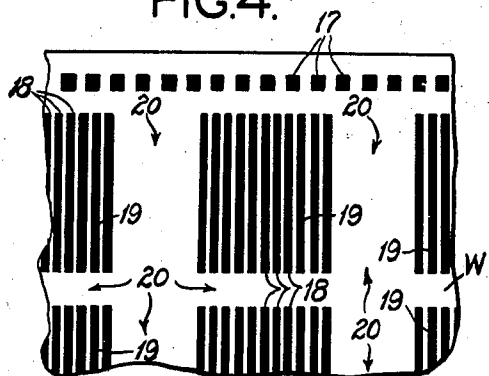


FIG. 5.

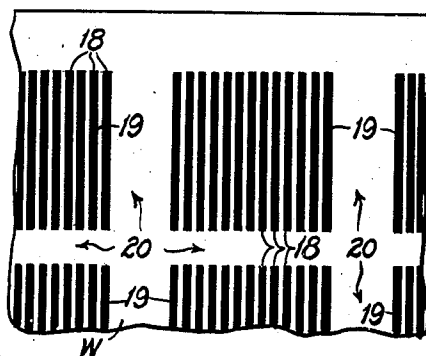


FIG. 6.

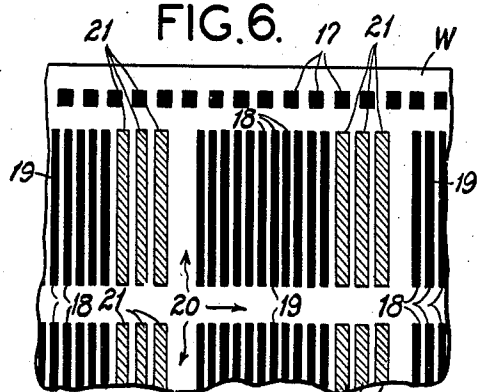


FIG. 7.

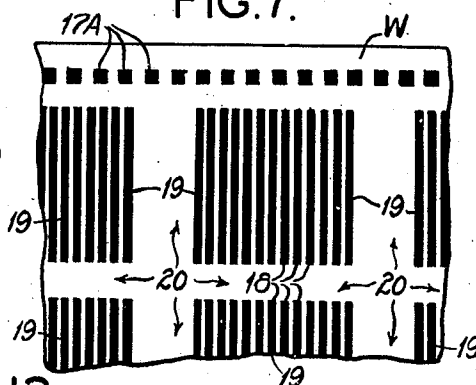


FIG. 9.

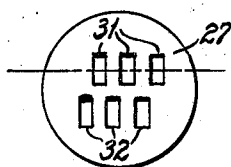
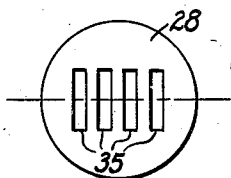


FIG. 13.



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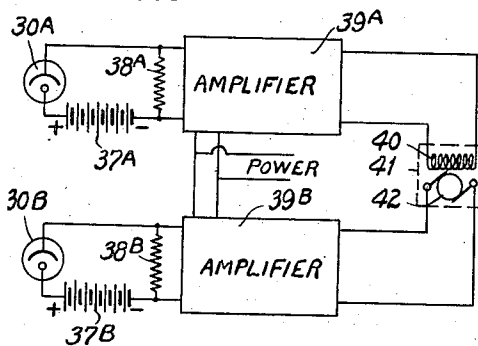
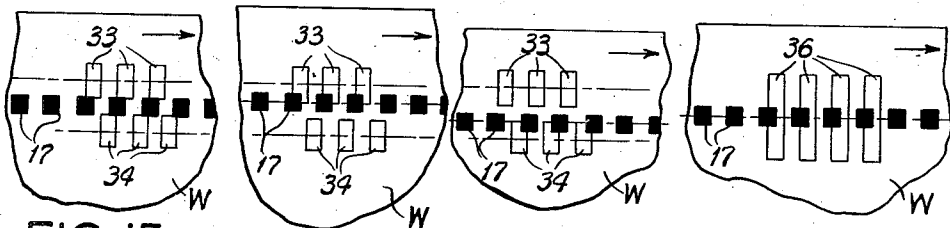
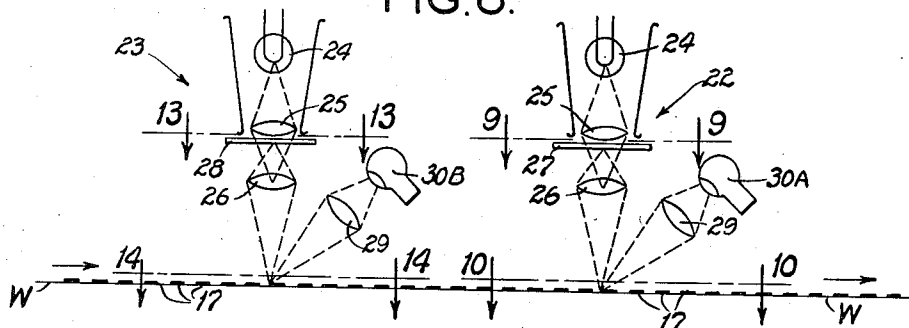
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FIG. 8.



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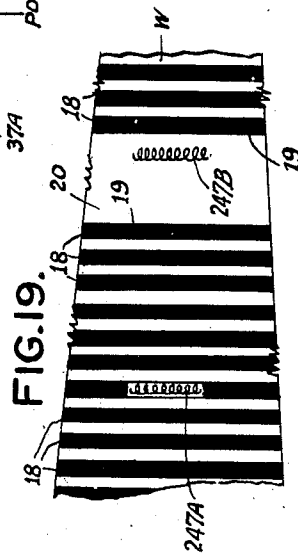
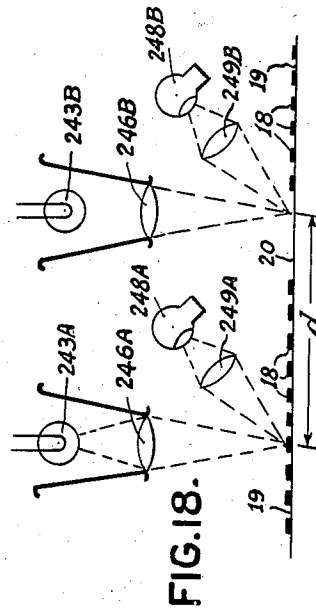
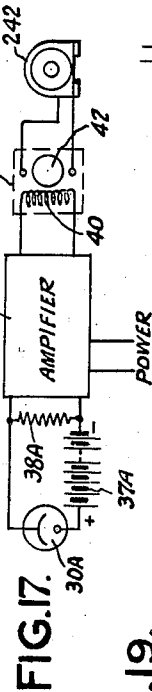
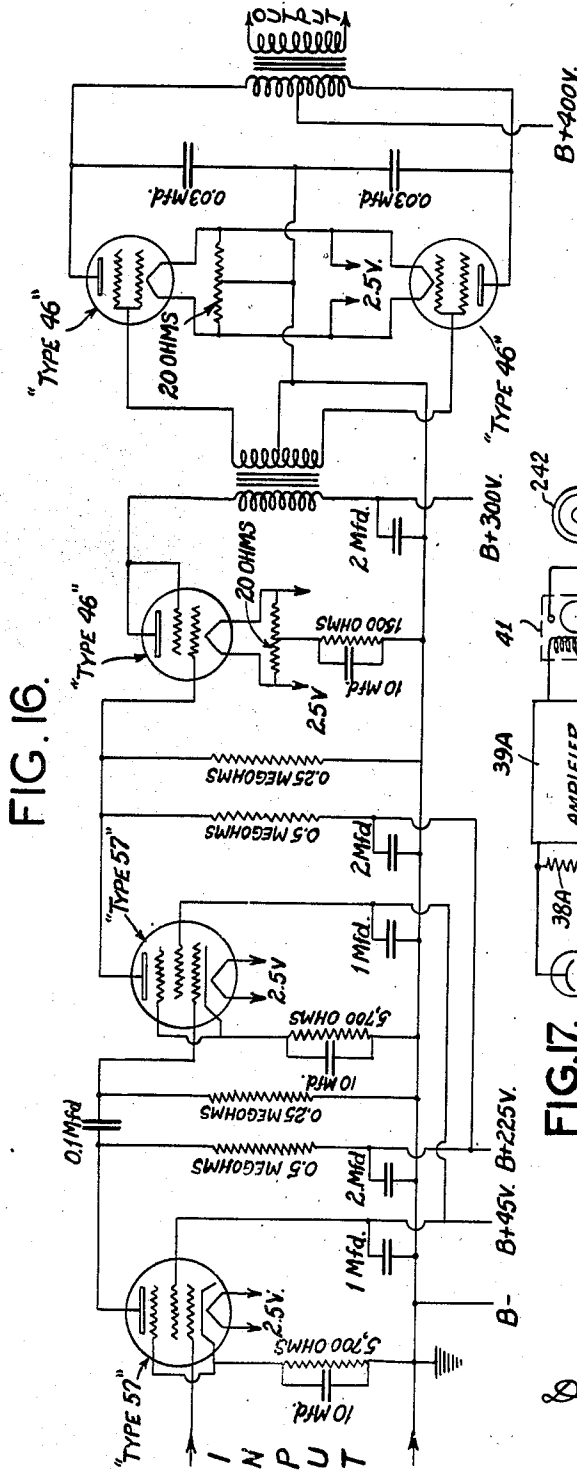
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FIG. 20.

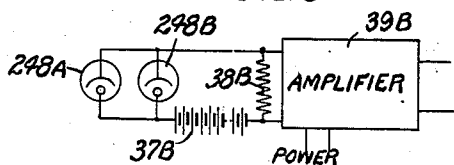


FIG. 21.

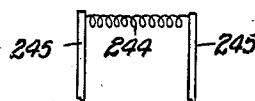


FIG. 22.

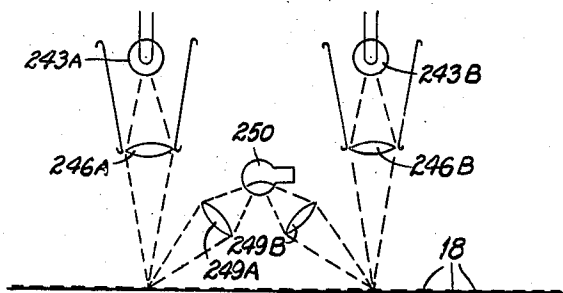


FIG. 23.

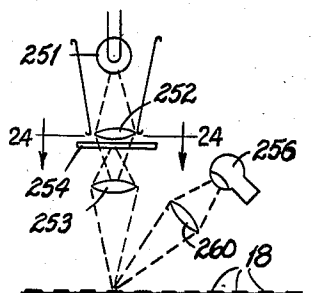


FIG. 24.

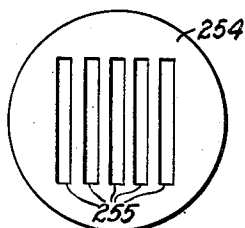


FIG. 25.

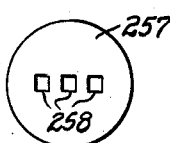


FIG. 26.

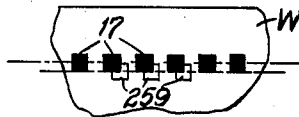


FIG. 27.

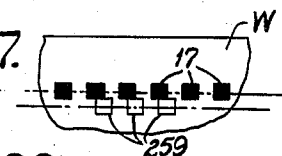


FIG. 29.

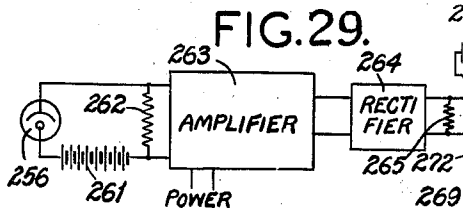


FIG. 28.

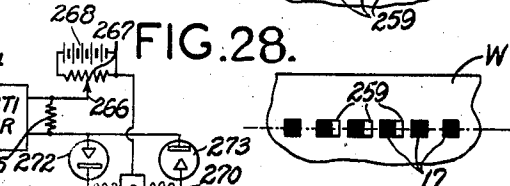


FIG. 31.

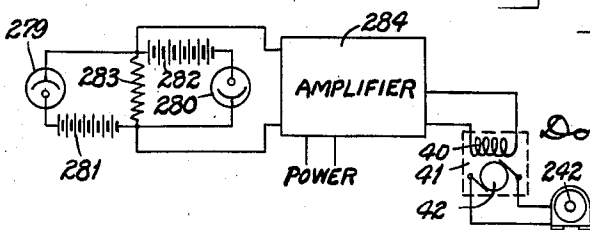
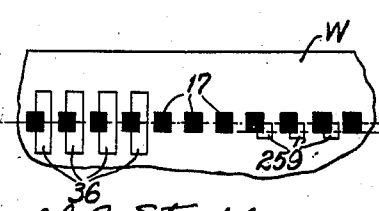


FIG. 30.



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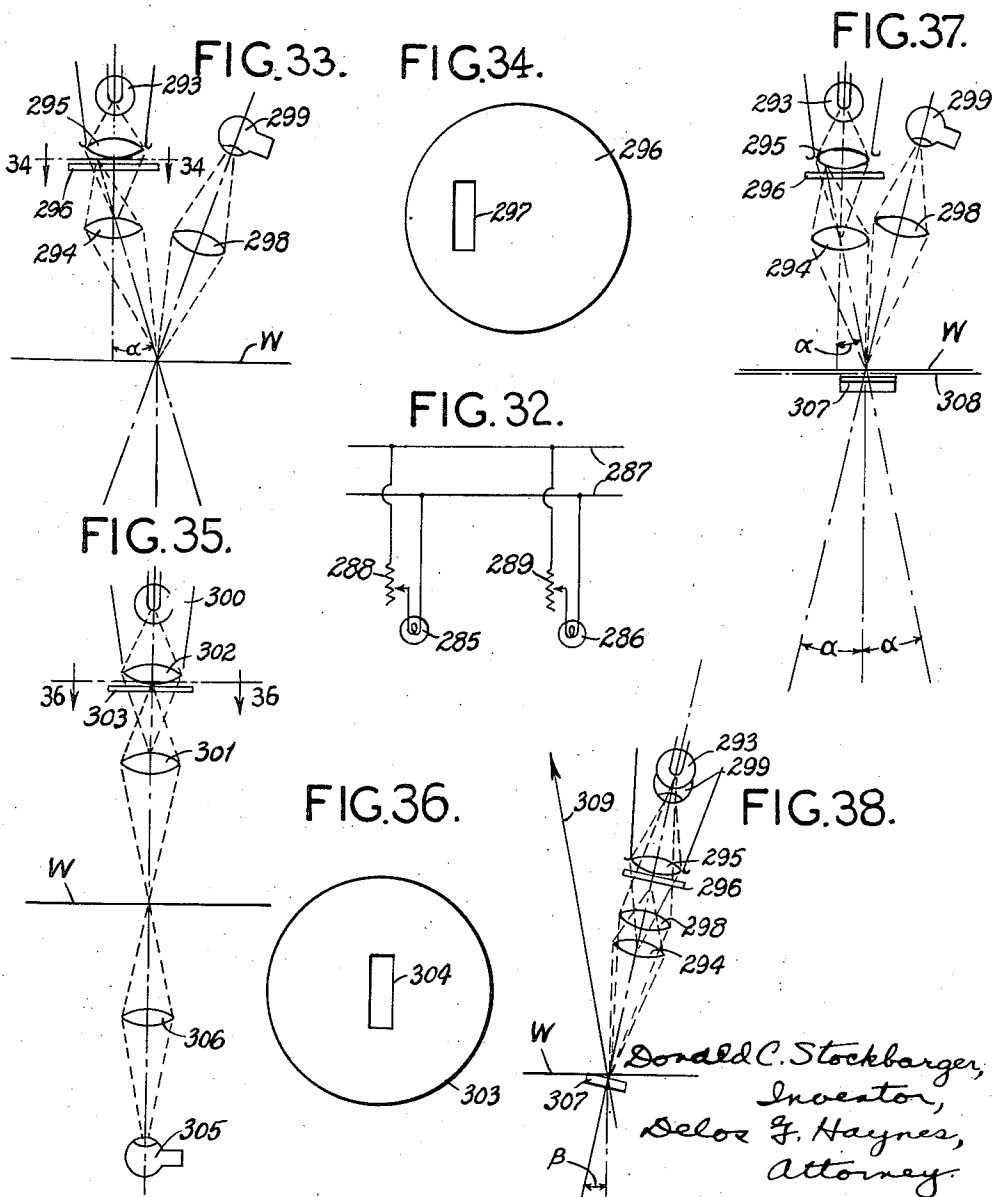
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UNITED STATES PATENT OFFICE

2,203,706

METHOD OF AND APPARATUS FOR MAINTAINING WEB ALIGNMENT

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Application May 5, 1937, Serial No. 140,997

19 Claims. (Cl. 271—2.6)

This invention relates to methods of and apparatus for maintaining web alignment, and with regard to certain more specific features, to methods of and apparatus for determining or detecting the alignment or misalignment of webs made of materials such as paper and the like, as they pass through a machine performing an operation on such webs, such as a printing press.

Objects of the invention

Among the several objects of the invention may be noted:

The provision of methods of an apparatus for maintaining web alignment which interpose no mechanical obstruction to the movement of the web;

The provision of methods of and apparatus for maintaining web alignment which are capable of accurate operation at web speeds up to and exceeding six hundred feet per minute, as encountered in modern high-speed rotary presses;

The provision of methods of and apparatus for maintaining web alignment which are substantially free of inertial forces, whereby misalignment may be more speedily corrected;

The provision of methods of and apparatus for maintaining web alignment which operate upon actuation by predetermined index positions, or abnormalities therefrom, of periodically repeating patterns upon the web, which patterns may comprise either printed regions normally contained on the web, or specially provided patterns, or both;

The provision of methods of and apparatus for maintaining web alignment which include a detection of an abnormality in the position of the web, a determination of the direction of such abnormality, and the application of a correcting influence properly suited to the said direction of the abnormality;

The provision of web alignment detectors operating upon optical principles, wherein detection is made of the normality or abnormality in position of a periodically repeating pattern upon the web;

The provision of web alignment detectors including photoelectric observing means included in circuits supplying corrective means for abnormalities in alignment of the web;

The provision of lateral web alignment detectors which are so disposed as to generate alternating current power upon the establishment of an abnormal alignment, said current being in phase or out of phase with another source of

alternating current power depending upon the direction of lateral misalignment of the web;

The provision of lateral web alignment detectors as in the next preceding paragraph, in which the other source of alternating current power is a photoelectric system optically actuated by periodically repeating patterns on the moving web;

The provision of lateral web alignment detectors as in the second preceding paragraph, in which the other source of alternating current is controlled as to frequency by the speed of the moving web;

The provision of methods and apparatus of the class described which are relatively simple and economical in construction and in operation.

Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, steps and sequence of steps, and features of construction and operation and arrangements of parts, which will be exemplified in the structures and methods hereinafter described, and the scope of the application of which will be indicated in the following claims.

The drawings

Referring now more particularly to the accompanying drawings, in which are illustrated several of the various possible embodiments of the invention,

Fig. 1 is a diagrammatic side elevation of a printing press showing alignment controls in accordance with the present invention;

Figures 2 through 7 are fragmentary plan views of typical webs of paper in various conditions hereinafter to be described;

Fig. 8 is a diagram of an optical arrangement for a preferred lateral alignment control;

Fig. 9 is a cross section taken substantially along line 9—9 of Fig. 8, showing a mask;

Fig. 10 is a cross section taken substantially along line 10—10 of Fig. 8, and illustrates the image of the mask of Fig. 9, as projected onto a web, the said web being properly aligned;

Fig. 11 is a view similar to Fig. 10, but illustrating the same elements when the web is laterally misaligned in one direction;

Fig. 12 is a view similar to Fig. 10, but illustrating the elements when the web is laterally misaligned in the other direction;

Fig. 13 is a cross section taken substantially along the line 13—13 of Fig. 8, showing another mask;

Fig. 14 is a cross section taken substantially

along line 14—14 of Fig. 8 showing the image of the mask of Fig. 13 as projected on a web;

Fig. 15 is an electrical circuit diagram for the lateral alignment control of Fig. 8;

Fig. 16 is an exemplary electrical amplifier circuit;

Fig. 17 is an electrical circuit of an alternative form of lateral alignment control;

Fig. 18 is a diagram of an optical system which may be used as an alternative to a portion of the optical system illustrated in Fig. 8;

Fig. 19 is a fragmentary plan view of the web as used in connection with the optical system of Fig. 18;

Fig. 20 is an electrical circuit for use in connection with the embodiment shown in Fig. 18;

Fig. 21 is a diagrammatic side elevation of a lamp filament and support;

Fig. 22 is an optical diagram showing an alternative to the Fig. 19 embodiment;

Fig. 23 is an optical diagram showing still another alternative to the Fig. 19 embodiment;

Fig. 24 is a cross section taken substantially along line 24—24 of Fig. 23, showing a mask;

Fig. 25 is a plan view of another mask useful in connection with the Fig. 23 optical system;

Fig. 26 is a plan view of the image of the mask of Fig. 25 as projected on a web, the web being properly aligned laterally;

Fig. 27 is a view similar to Fig. 26, except that the web is laterally misaligned in one direction;

Fig. 28 is a view similar to Figures 26 and 27, except that the web is laterally misaligned in the other direction;

Fig. 29 is a diagram of an electrical circuit for the lateral alignment control using the mask of Fig. 23;

Fig. 30 is a fragmentary plan view of a web, with certain images projected thereon, in connection with still another alternative lateral alignment control;

Fig. 31 is an electrical circuit for the embodiment illustrated by Fig. 30;

Fig. 32 is an electrical circuit showing a manner of controlling the brilliance of lamps;

Fig. 33 is a diagram of an optical system adapted particularly for use with webs of a specularly reflecting type;

Fig. 34 is a cross section taken substantially along line 34—34 of Fig. 33, showing a mask;

Fig. 35 is a diagram of an optical system adapted particularly for use with transparent webs;

Fig. 36 is a cross section taken substantially along line 36—36 of Fig. 35, showing a mask; and,

Figures 37 and 38 are two views of an optical system which is useful alternatively to the system shown in Fig. 35, with transparent webs.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

General description of press and preferred control system

With modern high-speed rotary printing presses, the problem of direction control of the moving paper or other web upon which the printing is being done is a difficult one. By direction control of the web is meant the directing and guiding of the web in such manner that each portion of the web reaches the proper location on the plate which is doing the printing at the proper time, so that the printed matter will appear on the web at the proper position with respect to subsequent further printing, cutting, trimming, binding, and like operations. In order to control the

placement of the web, it must be guided against lateral displacement from a desired course.

Attempts have heretofore been made to control the position and location of the moving web through a printing press by means of mechanical feelers and like elements which engage the moving web itself. However, the easy tearing and breaking character of paper, which is the material of which the web is usually composed, makes such control methods in general unsatisfactory, since the feelers or like mechanism all too easily tear the web. This is particularly true when the web travels at the high speeds encountered in modern rotary presses, such as six hundred feet per minute. Further, the inertia of such mechanical web control means makes it substantially impossible for them to respond with sufficient speed to abnormalities in position of the web, and corrective movements, if they are applied at all, are applied only after such a delay that considerable wastage of web material is brought about in the meanwhile.

Optical methods of web control are in general more satisfactory, since they depend upon light phenomena, which have no inertia, and are thus responsive with greater speed to an abnormality in the web position. Further, the light rays used for detection of abnormalities in position of the web offer no mechanical or other obstruction to the movement of the web, and cannot tear or otherwise disfigure the web, as is the case with mechanical feelers and the like.

However, up to the present time, no optical web control mechanisms have been provided which are capable of controlling the moving web with desired accuracy, particularly at relatively high press speeds. The present invention is, so far as I know, the first provision of such optical control systems.

The present invention, in its broader aspects, is applicable not only to the alignment of webs passing through printing presses, but to webs passing through machinery which performs operations on the web in accordance with certain dimensional characteristics thereof, such as cutters, trimmers, folders, and the like, as will be pointed out in greater detail hereinafter. However, in order to simplify the explanation of the present invention, it will be described principally in its application to printing presses.

There is accordingly shown in Fig. 1, in highly diagrammatic form, a multiple-press, rotary printing press, which is equipped with the alignment control features of the present invention. Referring more particularly to Fig. 1, index character R indicates a paper or web supply roll, that is supported in a cradle device indicated generally at numeral 1. Proceeding from the roll R is a web W of paper, on which the printing is to be accomplished. From the roll R the web W passes around an idler roll 2, a tensioning roll 3, and idler rolls 4, 7 and 8, to a compensating roll C1 hereinafter more fully to be described. From the compensating roll C1 the web W passes between the two cylinders 9 and 10 of the first press P1, receiving therein a desired impression. From the press P1, the web W passes around a second compensating roll C2, and thence between the cylinders 11 and 12 of a second press P2. From the second press P2 the web W passes around an idler roll 13, a third compensating roll C3, an idler roll 14, and into a slitter mechanism indicated generally by letter S. For present purposes, the operations on the web will be considered to have terminated when the web is de-

livered to the slitter S, although the slitter S is itself provided with alignment controls in accordance with the present invention.

Index character A1 indicates, in Fig. 1, a grammatic lateral alignment detection device, which, operating through a motor M1, drives a roll-shifting device indicated generally by numeral 15 (to be described in greater particular hereinafter) in the cradle 1 supporting the roll R. Lateral alignment detector A1, together with its motor M1 and device 15, serves to perform a first, relative lateral guiding operation on the web W, in order to provide that the web W, as it passes to the idler rolls 7 and 8, is substantially laterally aligned for the press P1. However, in order that the web W may be accurately aligned, laterally, before it passes into the press P1, a second lateral web alignment detector A2 is provided. This detector A2, operating through a motor M2, controls the compensating roll C1, in a manner hereinafter to be described, so that if the web W is at all displaced from its desired lateral course as it passes the detector A2, a correction is substantially immediately applied by the compensating roll C1 in order to correct the travel of the web W. The web W is thus delivered to the press P1 in perfect lateral alignment.

When the web W passes from the press P1, however, it contains thereon a certain amount of printed matter, and it is necessary that the second press P2 deliver its impression on the web W in a precise lateral arrangement with respect to the matter printed on the web by press P1. Lateral control of the web W as it enters the press P2 is therefore advisable. For this purpose, a lateral alignment detector A3 is provided in juxtaposition to the web W between the presses P1 and P2. The lateral alignment detector A3 controls a motor M3, which in turn operates on the compensating roll C2.

The properly aligned web W now passes through the second press P2, and receives, for the present example, its final printing impression. Numeral 16 indicates a break detector that is provisioned in juxtaposition to the web W just beyond the press P2. The function of the break detector 16 is to shut down, through the action of a relay, all of the power applied to the press, in case the web W should break, for any reason. From the press P2, the now completely printed web W passes to the slitting mechanism indicated by letter S. It will readily be seen that it is necessary that the slitting mechanism be precisely positioned laterally with respect to the printed matter on the web. Hence a lateral alignment detector A4 is provided, and this detector, acting through a motor M4, controls the operation of compensating roll C3 in such a manner that the web W reaches the slitter mechanism S in proper lateral position.

The foregoing cursory description of Fig. 1 indicates the various controls employed in the preferred embodiments of the present invention, and the general manner in which they operate to assure the proper guiding of the web through the multiple presses. The scheme of operation, it will be seen, is to detect an abnormality in the position of the web at any desired location, and then automatically to apply a correcting influence such that the abnormality is corrected in the minimum possible time. In other words, while an abnormally positioned region of the web may record itself on an alignment detector as such, and while that particular abnormally

positioned region will then go on and pass through the press in abnormal position, such abnormality in the meanwhile will have set the correcting mechanism to work, so that before many feet of web have passed the detector the abnormality has been corrected.

Alignment detection

Basically, the system or method provided by the present invention for the purpose of detecting the lateral alignment of a moving web comprises optically detecting whether or not a predetermined part of a periodically repeating pattern on the web is in a predetermined index position at a predetermined time relative to the beginning of the cycle in which the detection takes place, determining whether any displacement of the predetermined part of the web pattern from the predetermined index position is positive or negative such as to the right or to the left, for example, producing an electrical signal or controlling the flow of electric current in the circuit of a correcting means in accordance with the algebraic sign of the displacement if there is a displacement at the time of the detection, correcting the alignment of the web in accordance with the signal developed by the detector and repeating the above-described detection during each successive cycle or during a majority of cycles at predetermined equal relative times after the beginnings of the respective cycles in which detection occurs, and applying a web alignment correction each time detection occurs if correction is needed.

The periodically repeating pattern on the web may be an art design or printed words, for example, and the predetermined part of the pattern at which detection occurs may be an edge of an art figure or the top of a line of printed words, for example. The periodically repeating pattern may be a special pattern printed on the web for the sole purpose of alignment detection such as a dot or a row of dots located outside any other printed areas which may be on the web; and such special patterns may if desired be located to coincide with parts of the web which are subsequently to be removed by trimming or otherwise rendered unobjectionable.

Alternatively, the periodically repeating pattern need not be a printed pattern, but may comprise, for example, a series of perforations of periodically repeating character in the material of the web, or a series of regions on the web treated so as to make them transparent or translucent if the rest of the web is relatively opaque web, or opaque if the rest of the web is relatively translucent or transparent. The pattern need only be of such a character that it presents a different light reflectivity or light transmissibility from the body of the web itself.

Figures 2 through 7 aid in visualizing what is meant by the terms "periodically repeating pattern" as used in the preceding few paragraphs. Figure 2, for example, shows a fragment of a paper web W as it ordinarily comes from the roll R, and represents either the obverse or the reverse of the web. It is seen that the web W has no printed matter or other type of "periodically repeating pattern" thereon. Fig. 3 shows the obverse of the web W after it has been provided with a simple form of printed periodically repeating pattern, comprising a row of spots 17. The spots 17 may be printed on the web W by a special small mechanism provided especially for this purpose, or they may be printed on the

web W by the first press P1 through which the web passes, or they may be provided preprinted on the web W as it comes in the form of roll R. The spots 17 may be located on the web in a region that is to become the binding margin of a book page, for example, or on an edge of the web that is later to be trimmed off, or the spots 17 may be printed in a disappearing ink that remains visible only long enough for alignment detection purposes.

For maximum convenience, the row of spots 17 is not printed on the web prior to its passage through the first press P1, the web then being laterally controlled before it enters the press P1 by alignment detectors inspecting the edge of the web, instead of a periodically repeating pattern. Such an alignment detector, for example, is shown and described in the copending application of John L. Jones, Serial No. 140,998, filed May 5, 1937. In other words, referring to Fig. 1, lateral alignment detectors A1 and A2 are of a suitable edge-inspecting type, but since the press P1 provides a periodically repeating pattern on the web W in the form of a row of spots 17, for example, lateral alignment detectors A3 and A4 may be and preferably are types that inspect the periodically repeating pattern. If the aforesaid special printing mechanism is used to put the pattern on the web W, however, instead of the press P1, or if the web in the roll R is pre-printed with the pattern, then one or both of the lateral alignment detectors A1 and A2 may be of the pattern-inspecting type, depending (in the former instance) upon the location of the said special printing mechanism.

Fig. 4 shows the obverse side of the web W after it has passed through the first press P1. The press P1 has imprinted upon the web W a number of lines 18 of characters such as letters. For simplification, the lines are shown in Fig. 4 and in subsequent figures, as solid black lines. The lines 18 are arranged into groups or regions 19, which are separated by unprinted spaces 20. Each of the groups 19, considered as a group, represents a pattern on the web W, and by the very nature of the press cylinders 9 and 10, and the manner in which they imprint the regions 19 on the web W, said regions 19 recur at periodic intervals (at least as often as once for each complete rotation of the cylinders 9 and 10) on the web W. Hence the regions 19 are classed as "periodically repeating patterns" as above defined.

The reverse side of the web W is not ordinarily printed in the first press P1. Printing on the reverse side of the web W is ordinarily done in the second press P2, after which it has the appearance, for example, as shown in Fig. 5. Like the obverse shown in Fig. 4, the web W has been imprinted with a number of lines 18 arranged in periodically repeating groups 19 separated by unprinted region 20. Thus, in the example shown, both obverse and reverse sides of the web W are provided with periodically repeating patterns.

If two colors are wanted in the finished printing, and but one side of the web W is to be printed, then the second press P2 may be used to print the second color, with suitable interchange of the printing and backing cylinders. For example, the obverse side of the web W as it proceeds from the second press P2, set up as a color press, is indicated, for example, in Fig. 6. Here it will be seen that in addition to the matter appearing in Fig. 4, portions of the unprinted spaces 20 have

been filled with additional printed matter 21, which may, for example, be in a color other than that of the printed region 18. In Fig. 6, the periodically repeating pattern may now be considered to consist of the combination of a group of lines 18 and their associated regions 21, or of the groups of lines 18 or the groups of lines 21 taken separately, providing the detection system is of differential color sensitivity, if lines 18 and 21 differ in color.

If two or more colors are wanted in the finished printing, and both sides of the web W are to be printed (even if one side has but one color), then additional presses over the two presses P1 and P2 shown in Fig. 1 are ordinarily needed, and alignment controls are preferably provided for each of these additional presses. Alignment controls, for example, are of particular utility in securing accurate registry of overlapping color impressions in multi-color (such as three- or four-color) picture printing, where multiple presses are involved.

Ordinarily, the special periodically repeating pattern provided for alignment detection purposes, such as the spots 17, need appear only on one side of the web W. However, in some instances it is advantageous to have this pattern on both sides of the web. In this case such a pattern on the reverse side of the web may be provided (1) in the web W initially, as it comes in the form of roll R, (2) by the same special printing mechanism hereinbefore referred to, or a duplicate of it, or (3) by the press P2 as the reverse of the web W receives its first printing impression. Fig. 7 shows such a special pattern in the form of a row of spots 17A, similar to the row of spots 17 in Figures 3, 4, and 6. It is important, when a special pattern such as the spots 17A is provided on the reverse of the web W, that it align accurately with the special pattern (such as the spots 17) on the obverse of the web W, so that one lateral alignment detector inspecting the obverse of the web will not buck against another lateral alignment detector inspecting the reverse of the web.

For lateral web alignment the detection is applied in such a way as to determine whether or not a web edge or a pattern edge or both edges have wandered from their true or desired course, due to non-uniform web tensions for example, and the correction is applied in such a way as to remove effectively the cause of the wandering of the edge of the web or of the sequence of patterns with respect to the edge of the web or both. It is not necessary to detect and correct web alignment and pattern alignment simultaneously nor with the same apparatus, nor is it necessary to detect and correct either alignment once each successive cycle. Detection and correction may occur several times at predetermined intervals during each cycle of any predetermined or random fraction of the total number of cycles which fraction may be unity, or they may occur only once during each of said cycles if desired. It is clear that the required relative frequency of detection and correction will depend in any case on the magnitude of the tendency to wander, on the degree to which the correction is to be applied and on other things.

Another example will aid in visualizing the need for and the application of the hereinbefore described method of web alignment detection and control in the printing industry. A web of paper

seventeen inches wide is traveling through a small rotary press for the purpose of printing manifold forms each seventeen by twenty-two inches in size and each designed to have an average margin of one inch all around the printed matter. All forms are alike and are normally spaced equidistantly along the web. After printing, the web passes through a cutter which operates once for each twenty-two inches of travel of the web at normal relative speed and thus the web is intended to be cut into sheets seventeen by twenty-two inches in size. It is assumed that the cutter is spaced at such a distance from the cylinder that the top and bottom margins are normally one inch in width. If the web does not unwind evenly from roll it may not feed into the press along a straight line, but may wander with the result that the margins on either side of the web are not constant and of one inch width. An alignment detector placed between the roll and the press may be used in connection with a corrector to suppress the wandering of the web so that the lateral margins are as nearly one inch as desired. Thus a great improvement in the appearance of the forms is obtained and it becomes possible to reduce the over-all size of the forms if desired, and thus to reduce the cost of stock because no allowance need be made for varying widths of margins to insure that no margin will be less in width than some required amount.

The preferred system for lateral alignment detection in connection with the present invention is illustrated in Figures 8 through 15. A system of the type indicated in Figures 8 through 15 may be used, for example, in locations A3 and A4 in the diagrammatic illustration, Fig. 1, and in locations A1 and A2 (or one of them) if the pattern is on web W prior to its passage through the first press P1, as hereinbefore described.

The preferred lateral alignment system illustrated in Figures 8 through 15 makes use of the row of spots 17 on the web W, as shown in Figures 3, 4, 6, and 7. For this preferred system, the spots 17 are each of square shape and the same size, and are spaced apart, on a common center line running parallel to the edge of the web W, distances equal to their own widths. The spots 17 are preferably printed on with ink or pigment (such as black) which reflects discernibly less light than the surrounding, unprinted regions of the web W. In Fig. 8, which is an edgewise view of the web W, the spots 17 are given a considerable elevation, so that their function with respect to the remainder of the apparatus may be understood; in practice, it will be understood, the spots 17 are only of the thickness of printing ink.

As appears from Fig. 8, there are mounted above the web W a pair of optical systems indicated generally by numerals 22 and 23. The optical system 22 is the lateral web alignment detector proper, while the optical system 23 is for the purpose of generating an alternating current used with the lateral alignment correcting means, as will be explained hereinafter. The two optical systems 22 and 23 are identical, except for the apertures in certain masks. Each system comprises a light source 24, which may suitably be an incandescent filament bulb in which the filament is concentrated into a small area. In each system 22 and 23, a lens 25 focuses an image of the filament of light source 24 on a second

lens 26. Positioned just in front of each lens 25 is a mask, indicated by numeral 27 in system 22 and by numeral 28 in system 23. The front lenses 26 focus images of certain apertures in the masks 27 and 28 on the web W. In each system 22 and 23, the respective light sources 24, and lenses 25 and 26, are arranged on an optical axis which is preferably, although not necessarily, perpendicular to the plane of the web W, and the masks 27 and 28 are perpendicular to these optical axes (or parallel to the web W, in any event).

Arranged on optical axes which intersect the points of intersection of the axes of the systems just described and the web W, for each system 22 and 23, are photoelectric detection systems comprising collecting lenses 29 and suitable photoelectric cells 30A and 30B. The lenses 29 project rays emanating from the images on the web, of the apertures in masks 27 and 28, on the respective cathodes of the photoelectric cells 30A and 30B, respectively.

The mask 27 for the optical system 22 is shown in plan view in Fig. 9. The mask 27 has two parallel rows of uniformly spaced rectangular openings or apertures. The apertures in one row are indicated by index characters 31, while the apertures in the other row are indicated by index characters 32. It will be understood, however, that the apertures 31 and 32 are individually all preferably of the same size. The openings 31 and 32, in their respective rows, are displaced from each other in the direction of the row center-lines by an amount equal to the short dimension of a single aperture, and the two rows are displaced in the direction at right angles to said center-line direction by an amount which causes the projected images of the apertures 31 and 32 on the web W, in the optical system 22 of Fig. 8, to be separated by a distance preferably just equal to the width of the spots 17 on the web W. This arrangement is indicated in Fig. 10, in which rectangles 33 are the images of apertures 31, as projected by the lens 26, and rectangles 34 are the images of the apertures 32. The widths of the individual apertures 31 and 32 are such that the widths of their projected images 33 and 34, along their respective row center lines, are preferably just equal to the widths of the individual spots 17. It will be noted that the two rows 31 and 32 are arranged in a staggered relation, each aperture (except the end apertures) being disposed along its respective center line in such manner that its sides are effectively continuations of the opposite sides of two adjacent apertures in the opposite row. In the embodiment shown, three apertures 31 form one row while three apertures 32, form the other row, but the number three is not critical and may be increased or decreased depending, for example, upon the sensitivity of the photoelectric detecting system employed. The lengths of the individual apertures 31 and 32, in a direction at right angles to the center lines of the rows, are all equal, and are determined by the amount of lateral displacement it is expected to encounter in the moving web. In the embodiment as shown, the apertures 31 and 32 are approximately twice as long as they are wide and this arrangement will provide full correction for a web which does not deviate laterally through a distance more than a maximum of six or so times the width of the row of spots 17.

The mask 28 for the optical system 23 of Fig. 8 is shown in plan view in Fig. 13. It contains a single row of parallel rectangular apertures

35 centrally positioned along a common center line. The width of each of the apertures 35, along the common center line, may be equal to the width of the apertures 31 and 32 of mask 27, along their respective center lines; in any case, the width of each aperture 35, along the common center line, is such that the width of its image 36 on the web W (Fig. 14) is equal to the width of each of the spots 17. The apertures 35 are preferably all of the same length, and the length is such that the projected images 36 of said apertures 35 are of the order of twice the length of an image 33 or 34 plus the width, cross-wise of the center line, of the spots 17.

The masks 27 and 28 are mounted in their respective optical systems 22 and 23 in such manner that center lines of their projected aperture images on the web W are parallel to the center line of the row of spots 17 on the web W. Further, the optical systems 22 and 23 are so positioned that, when the web W is in lateral alignment, the center line of the row of spots 17 lies mid-way between the center lines of the rows of images 33 and 34, for the optical system 22, and coincides with the center line of the images 36, for the optical system 23. These arrangements are indicated in Figures 10 and 14, respectively. Furthermore, the optical axes of the two systems 22 and 23 are displaced from each other, in a direction along the direction of motion of the web W, in such a manner that when one of the spots 17 exactly coincides with one of the images 36 (i. e., the leading and trailing edges of said spots 17 are coextensive with the forward and rear edges of the image 36), then, at exactly the same time, the leading and trailing edges of another one of the spots 17 are in exact register with the forward and rearward edges, respectively, of either one of the images 33 or one of the images 34. For present purposes, it makes no difference whether the images 33 or the images 34 are chosen for this last condition. By such an arrangement, spots 17 cross the images 36 in the same phase relationship that said spots 17 cross the selected row of images 33 or 34, and in an out-of-phase relationship with the other row of images 34 or 33. In Figures 10 and 14, the in-phase relationship is maintained between images 36 and images 33, while images 36 and images 34 are in out-of-phase relationship. The purpose of this arrangement will be described hereinafter.

The electrical circuit in which the photoelectric cells 30A and 30B of the optical systems 22 and 23, respectively, are connected, is indicated in Fig. 15. Cell 30A is connected in series with a battery 37A across a resistance 38A, the terminals of which lead to a suitable alternating current amplifier 39A. The design and characteristics of the amplifier 39A are within the abilities of one skilled in the art of photoelectric cell amplifiers, and are not set forth in great detail herein for that reason. By way of example, however, a suitable amplifier circuit is shown, together with its exemplary constants, in Fig. 16. The Fig. 16 circuit is that of a resistance-coupled amplifier having a two stage voltage amplifier using the so-called "type 57" tubes, and a two stage power amplifier using the so-called "type 46" tubes, the last stage of the power amplifier being a push-pull circuit. With the constants shown in Fig. 16, it has proved to be satisfactory to use, as the photoelectric cell 30A, a "Visitron type AV" cell, with the resistance 38A having a value of 100,000 ohms and the battery 37A having a potential of 22 volts.

The photoelectric cell 30B of optical system 23 is similarly connected, in series with a battery 37B, across a resistance 38B, the terminals of which are in turn connected to a suitable amplifier 39B, which may also be of the type shown in Fig. 16, for example.

The output leads of an amplifier 39A are connected to the field 40 of a motor 41, which may be, for example, of common "universal" design for operation on either direction alternating current. The output leads of amplifier 39B are connected to the armature 42 of the motor 41. Motor 41 is the motor M1, M2, M3, or M4 of Fig. 1, depending upon which lateral alignment system is being considered. As indicated in Fig. 1, motors M1, M2, M3, and M4 are associated with the respective compensating rolls which correct lateral misalignment; the nature of this connection, and of the operation of the compensating roll, will be more fully developed hereinafter.

The operation of the lateral alignment detector as thus described is as follows:

Referring first to the operation of the optical system 22, or lateral alignment detector proper: So long as the web W is in proper lateral alignment, the row of spots 17 continuously passes between the two rows of images 33 and 34 heretofore described. The individual spots 17 do not cross any of the images 33 and 34, and hence do not vary the light reflected therefrom to the photoelectric cell 30A. The light reflected from the images 33 and 34 to the photoelectric cell 30A, it is to be noted, depends in quantity upon the reflection characteristics of the web W. In general the web W reflects more or less diffusely. The spots 17 are printed in an ink, or other substance, which reflects less light than does the web W itself. Or, in the alternative, the spots 17 may be printed with an ink or other substance that reflects more light than does the web W itself. The primary intention is that there shall be a differential reflectivity between the spots 17 and the surrounding area of web W. In all cases in which the differences in said reflection characteristics are unusually small, steps must be taken to increase the differential or else the over-all sensitivity of the apparatus as may be required. Furthermore, in general, cases will arise in which the detection can be made more positive through the introduction of selectively absorbing light filters so that the web is effectively illuminated by light of certain spectral characteristics such as red light, for example. The use of selectively absorbing light filters may be particularly advantageous in web alignment detection when the web W is printed with one or more colored substances.

If the web W becomes misaligned, or wanders, to the left, then the condition pictured in Fig. 11 will be observed. The row of spots 17 now, instead of passing between the rows of images 33 and 34 without affecting either one of them, now passes in such a manner that successive spots intersect or pass across the images 33. Because of the differential reflectivity of the spots 17, with respect to the web W, this passage of the spots 17 across the images 33 will result in the variation or modulation of the amount of light reaching the photoelectric cell 30A, and because of the intermittent character of both the spots 17 and the images 33, this modulation will be of a periodically varying character setting up an alternating current in the photoelectric cell 30A. The frequency of the alternating current is dependent upon the speed of travel of the web

W, one complete alternation being produced each time a spot 17, and its succeeding blank space, traverses one of the images 33. The several images 33, it will be seen, act in parallel in this respect, and thus so serve to increase the amount of modulated light falling on the photoelectric cell 30A without in any way affecting the frequency of the modulation.

The periodic variation in the amount of light reaching the photoelectric cell 30A, which is connected in series with the battery 37A and the resistor 38A, causes a periodic variation in the amount of current flowing through the resistor 38A. Since the input terminals of the alternating current amplifier 39A are connected to opposite ends of the resistor 38A the alternating current component in the voltage drop across the resistor 38A produced by the variation in the current flowing through the resistor 38A causes the amplifier 39A to deliver alternating current power, of suitable magnitude, to the field 40 of the motor 41. The fundamental frequency of the alternating current power so produced is the same as the fundamental frequency of the periodic variation in the amount of light reaching the photoelectric cell 30A.

The fact that the photoelectric cell 30A may be receiving unmodulated light (such as is reflected from the momentarily unaffected images 34, for example) at the same time that it is receiving modulated light from the images 33, is of no consequence, since the response of said photoelectric cell 30A is then a direct current response and this introduces no alternating current component in the voltage drop across the resistor 38A.

Motors such as the one indicated at 41 in Fig. 15 are ordinarily designed to be operated on sinusoidal alternating current, but unless suitable steps are taken current from the amplifier 39A will not be sinusoidal. If the amplifier 39A amplifies without distortion of the wave form, the output current may be expected to have the wave form of the alternating current component of the voltage drop across the resistor 38A, and said voltage drop can be made to have substantially the wave form of the light modulation produced by the motion of the spots 17 across images 33 as hereinbefore described. The shape of the spots 17 and of the images 33 (and 34) can be calculated in such manner that the wave form of the modulation can be controlled, as in the reproduction of sound in talking motion pictures, but this is usually impracticable for several reasons, and hence, therefore if the motor 41 does not function satisfactorily on non-sinusoidal current, all undesirable harmonics should be removed by means of a filter network having a high transmission for alternating current of the fundamental frequency, such as a band-pass filter, for example. It is recognized that alternating current amplifiers may have filter networks possessing the aforementioned characteristics, and, therefore, it is assumed that the amplifier 39A is so designed.

If the web W wanders or deviates or becomes misaligned laterally to the right, the condition pictured in Fig. 12 will be observed, instead of the condition pictured in Fig. 11. The only difference between Fig. 11 and Fig. 12 is that in Fig. 12, the modulation of light reaching the photoelectric cell 30A is produced by the passage of spots 17 across the images 34, rather than the images 33. Electrically, the effect is the same as that described which relates to Fig. 11.

However, since the images 34 are spaced at a different relative location than the images 33, the peaks of alternating current produced across the resistance 38A will occur at different times. This time relationship will be developed more fully hereinafter.

The operation of the optical system 23, hereinbefore designated as an alternating current generator, will now be described. In general, it is similar to the operation of the optical system 22, with the exception that light modulation is now produced by passage of the spots 17 across the images 36 (see Fig. 14) regardless of the deviation or wandering of the web W, within limits determined by the lengths of the images 36. This passage of the spots 17 across the images 36 means that modulated light, of the same wave form as that produced in the optical system 22, will be delivered at all times to the photoelectric cell 30B, and this will in turn cause the imposition of a relatively constant form of alternating current component in the voltage drop across the resistor 38B. This alternating current component in the voltage drop across the resistor 38B is amplified by the amplifier 39B, which is in many respects similar to the amplifier 39A, and the amplifier 39B thus delivers alternating current power to the armature 42 of motor 41. As in the case of amplifier 39A, amplifier 39B may desirably have a filter network for affecting the wave form of the output alternating current, to make it suitable for running the motor 41.

Because the same spots 17 actuate the photoelectric cells 30B and 30A, and because the widths of the images 33, 34, and 36 are all the same, the fundamental frequencies of the alternating current power produced by the amplifiers 39A and 39B will be the same. Because of the longitudinal spacing requirements for the optical systems 22 and 23, as hereinbefore mentioned, the outputs of amplifiers 39A and 39B will be in phase if it is modulation of the light from the images 33 that is affecting the photoelectric cell 30A (or, in other words, if the web is misaligned to the left). Or, on the other hand, if the modulation of light reaching the photoelectric cell 30A is produced by passage of spots across the images 34 (in the case of lateral deviation of the web to the right), the alternating current power delivered by the amplifier 39A to the motor 41 will be 180° out of phase with respect to the power delivered by the amplifier 39B. The motor 41 is of such characteristics that when its field and armature are respectively excited by the in-phase currents, it rotates in one direction, while when its field and armature are respectively excited by the out-of-phase currents, it rotates in the other direction.

In the foregoing discussion it is assumed for simplicity that the phase displacements between input signals and respective output currents in the amplifiers 39A and 39B are identical. The principal is unaffected by this assumption. In any case the distance between the optical systems 22 and 23 is adjusted to establish the desired phase relationship between the output currents of the amplifiers 39A and 39B so that the operation of the equipment is substantially as recited.

It is now seen that, with the system described, lateral deviation of the web W in one direction results in the rotation of motor 41 in one direction, while lateral deviation of the web W in the other direction causes the motor 41 to run in the other direction. If the web W is running true, as shown in Fig. 10, then, since the photoelectric cell 30A receives no modulated light, the

amplifier 39A delivers no alternating current power to the motor field 40, and hence the armature of the motor 41 does not move at all.

As has heretofore been intimated, the motor 41 controls a suitable compensating roll mechanism in such manner that when it rotates in one direction or the other, it tends to correct the misalignment of the web, laterally, in the proper direction. A suitable compensating roll mechanism, for example, is shown in the copending application of myself and John L. Jones, Serial No. 140,996, filed May 5, 1937.

In Fig. 1, numerals N1 and N2 indicate suitable motors that operate on the same compensating rollers C2 and C3 as do motors M3 and M4, respectively, for purposes of correcting longitudinal misalignment of the web.

It will be seen that the amount (not frequency) of modulation of the light reaching the photoelectric cell 30A depends upon the relative areas of the individual spots 17 that pass through the images 33 or 34, and that this relative area in turn depends upon the extent of lateral displacement. For example, if the lateral displacement is but slight, then, as indicated in Figures 11 and 12, only part of the area of each spot 17 passes across the respective images 33 or 34. If the lateral deviation is great, then the entire area of each spot 17 will cross either image 33 or 34. The amount of photoelectric current modulation as thus produced, affects the amplifier 39A in such manner that a related amount of alternating current power is delivered to the field 40 of the motor 41. In other words, the greater the lateral deviation, the stronger the alternating current signal delivered to the amplifier 39A, and the greater the alternating current power delivered to the motor 41. Since the speed of rotation of the motor 41 depends upon the amount of power delivered to it, greater lateral deviation of the web W will cause faster rotation of the motor 41, and consequently more rapid correction of the lateral deviation. This factor is important in the operation of the press as a whole, because it means that greater lateral deviations, which are more wasteful of web material, will be reduced more rapidly than small deviations, which are not so serious from the standpoint of waste.

The amplifiers 39A and 39B are constructed so that their power output, at all operating speeds of the press, when delivered to the field 40 and armature 42 of motor 41, is sufficient to insure the performance described. This is accomplished by suitable design and apportionment of the amplifier circuit characteristics, which is well within the skill of amplifier technicians. It should be noted that in general the armature 42 of the motor 41 requires several times as much power as the field 40, and therefore the amplifier 39B must be designated with this purpose in mind.

While the lateral alignment detection system thus described is preferred for use with presses of the type herein principally concerned, it may be widely modified and take several highly varying forms, of which several will be described in greater detail hereinafter.

Alternative embodiments

The description of the preferred embodiments of the invention, and the parts thereof, all as indicated in Fig. 1, has now been completed. It is obvious, however, that many changes may be made in the individual items, such as the alignment detectors, and the like, within the field of

the present invention. It is not the intention of the present application to describe all of such alternative embodiments, but as some of them embody principles somewhat different than the principal embodiments described, they will be set forth hereinafter. The alternative embodiments will, in general, be described along the same lines as the preferred embodiments.

It will be understood, in connection with the alternative embodiments hereinafter described, that they may individually be used, or may jointly be used together with part or all of the preferred embodiments heretofore described.

Fig. 17 indicates an alternative lateral alignment detector circuit which is in some respects a simplification of the circuit shown in Fig. 15. It will be recalled, by reference to Fig. 8, that the optical system 23 and photoelectric cell 30B, together with its connected amplifier 39B, all were described as an alternating current generating system. In Fig. 17, this photoelectric alternating current generating system is eliminated, and replaced by a simple, ordinary form of alternating current generator indicated by numeral 242. This alternating current generator 242 is mechanically driven from some rotating part of the press, such as one of the press cylinders, so that the generator 242 produces current at a fundamental frequency corresponding to the fundamental frequency of the current produced by the photoelectric system 22 (Fig. 8) and applied to the field 40 of the motor 41. The generator 242 is connected direct to the armature 42 of the motor 41. The circuit feeding the field 40 is the same as in Fig. 15.

The operation of this alternative embodiment of Fig. 17 is substantially identical to the operation of the preferred lateral alignment detector, except that the armature current is supplied with mechanically generated alternating current, from the generator 242, instead of photoelectrically generated alternating current, from the optical system 23, photoelectric cell 30B, etc. This embodiment may accordingly be designated as one in which the armature current is mechanically generated, instead of photoelectrically generated. This embodiment should be used only when a careful control of the longitudinal alignment of the web is maintained, since longitudinal misalignment, if great enough, might result in an unwanted phase displacement, between the field and armature voltages of the motor 41.

Alternating currents can be generated, with certain favorable setups of type, by using the printed matter itself in an optical-photoelectric system such as that shown in Figures 18 through 21, inclusive. Use is now made of the alternating light and dark areas constituting the lines of printed matter themselves upon the web W. These lines or printed matter are indicated with their usual numeral 18 in Figures 18 and 19. Referring more particularly to Fig. 18, numerals 243A and 243B indicate a pair of incandescent filament lamps, the filaments of each of which preferably comprises a long coil, indicated in Figure 21 by numeral 244, supported on supports 254 at its ends. Lenses 246A and 246B project images of the filaments 244 of lamps 243A and 243B on the surface of the moving web W, as indicated in Fig. 18, in such manner that the projected images 247A and 247B lie parallel to the lines 18 of printed matter. The optical axes of the two systems are so arranged with respect to the printed matter on the web W, that

one of the images 247A and 247B is at all times within a printed region; in other words, the distance d (Fig. 18) is such that at no time is it possible for both image 247A and image 247B to lie in an unprinted area. A photoelectric cell 248A looks at the image 247A through a collecting lens 249A, while a similar photoelectric cell 248B looks at the image 247B through a collecting lens 249B.

Fig. 20 shows the electrical circuit in which the photoelectric cells 248A and 248B are connected. Referring to Fig. 20, it will be seen that the two photoelectric cells 248A and 248B are connected in parallel, and function in the circuit as a single cell. It is merely as if the photoelectric cells 248A and 248B, together connected in parallel, are substituted for the single photoelectric cell 30B in the alternating current generator side of the circuit of Fig. 15. The usual battery 37B and resistance 38B and amplifier 39B are provided, and the output of the amplifier 39B can be used in any desired manner, for example, in connection with an alignment detection and correction system.

If necessary, more than two complete optical systems as indicated in Fig. 18 may be provided, in order that at least one filament image is at all times focused on a region including printed lines 18. In this detection system, in which synchronism is an important feature, it is important that the printed lines 18 be equi-distantly spaced and that unprinted areas have lengths, measured along the length of the web W, such that were they filled with lines 18, all lines on the web W would be equi-distantly spaced. The distance d (Fig. 18) between spots is therefore a whole multiple of the spacing of the lines 18.

The operation of this alternating current generator is as follows: When the web moves longitudinally, the passage of lines 18 through or across the images 247A and 247B, produces a flicker or modulation in the reflected light reaching the photoelectric cell 248A or the cell 248B, or both, and therefore the current flowing through the resistor 38B contains an alternating current component and the voltage drop across the resistor 38B contains an alternating current component. From this point on, the operation of this alternating current generator is precisely the same as that of the preferred embodiment, as indicated in Fig. 15. The fact that one photoelectric cell 248A or 248B may be receiving unmodulated light during a part of the time is of no consequence since the response of said cell is then a direct current response and no alternating current component in the voltage drop across the resistor 38B results. As in the case of the preferred embodiment, it is desirable that the amplifier 39B of Fig. 20 be provided with a filter network or other suitable means for regulating the wave form of the output alternating current.

Fig. 22 indicates an alternative construction that may be substituted for the optical system shown in Fig. 18. The only change, in this instance, is that a single photoelectric cell 250 is provided, which cell 250 receives a light from both images 247A and 247B. This is accomplished by suitably positioning the lenses 249A and 249B. The single photoelectric cell 250 now receives the modulated light from both images, and is preferably connected in a circuit identical to that of Fig. 20 except that only one photoelectric cell is used. In other words, the circuit connections now become identical to those shown in Fig. 15,

with the single photoelectric cell 250 replacing the photoelectric cell 30B.

In the embodiments of Figures 18 and 22, it is not necessary that the image on the web W be that of a coil filament 244 as shown. For example, Fig. 23 shows a single optical system (which is used in duplicate in either the Fig. 18 or Fig. 22 embodiments), in which a lamp 251 of the concentrated filament type is provided. A lens 252 focuses an image of the filament of lamp 251 on a lens 253, in such manner as to fill the lens 253 with light. Numeral 254 indicates a mask which is positioned between the lenses 252 and 253, as close to the lens 252 as possible. The lens 253 focuses images of apertures in the mask 254 on the web W.

The mask 254 is indicated in plan view in Fig. 24. It will be seen that it is provided with a plurality of apertures 255, which constitute parallel long narrow rectangles. The size and disposition of the rectangular apertures 255 is such that these apertures, projected by the lens 253, will form images on the web W, which images exactly overlie the printed lines 18 on the web W. In other words, images of the apertures 255 are now substituted for the filament images 247A and 247B of Fig. 19. The aperture images operate in exactly the same manner in generating alternating current as do the images of the coil filaments 247A and 247B. In Fig. 23, a single photoelectric cell 256 is shown; this photoelectric cell will be either the cell 248A, the cell 248B, or the cell 250, depending upon which embodiment is used with the mask type of light projector shown in Fig. 23.

All the alternative embodiments heretofore described are concerned with alternate methods of generating alternating current power for the armature 42 of the motor 41, the lateral alignment detector proper of the preferred embodiment having been left unchanged. Fig. 23, together with Figures 25 through 29, serves on the other hand to illustrate an alternative form of lateral alignment detector proper. For this alternative embodiment, the mask 254 of the Fig. 23 optical system is replaced by a mask 257 as shown in Fig. 25. The mask 257 is provided with three substantially square apertures 258, and these apertures are of such size and shape that their images on web W are of size and shape identical to any three consecutive selected spots 17 of the row of spots 17 heretofore described. The row of spots 17 is again used for lateral alignment detection, as in the preferred lateral alignment detector. The identity in size, shape, and disposition, of the images of apertures 258 in mask 257 with the spots 17, is shown in Fig. 26, where the said images are indicated by numeral 259.

Fig. 26 shows the preferred normal condition to be obtained when the web W is in proper lateral alignment. It will be seen that in this normal arrangement, the center line of the row of spots 17 is displaced from the center line of the row of images 259 by an amount equal to half the width of the spots (or the images); in other words, as the web W moves, the maximum area overlapped is one-half the total area of the images. The center lines of the images 259 and of the spots 17, are, however, parallel.

The photoelectric cell 256 (Fig. 23) is arranged to look at the images 259 through a collecting lens 260. Under normal conditions of proper lateral web alignment, the cell 256 will receive uniform unmodulated light from one-half of each

of the images 259, and modulated light from the other half of said images 259, as successive spots 17 pass thereacross. If lateral misalignment should occur, in such manner that the web W is misaligned to the left, however, the condition shown in Fig. 27 will be brought about. In Fig. 27, it will be noted that the center lines of the spots 17 and images 259 are now displaced by such an amount that the spots 17 no longer cross over any part of the images 259 at all, but merely pass tangent thereto. This means that the photoelectric cell 256 will now receive nothing but uniform unmodulated light, since the lack of any intersection of the spots 17 with the images 259 means that no modulation will be brought about. Just prior to the achievement of this maximum condition, however, it will be seen that the relative portion of the area of the images 259 traversed by the spots 17 reaches a minimum value; hence the amount of modulated light reaching the cell 256 will be a minimum.

If lateral misalignment to the right takes place, looking in the direction of travel of the web, the condition observed in Fig. 28 may be observed. Here a maximum condition is pictured, such that the center lines of spots 17 and the center line of the images 259 now exactly coincide. With the condition of Fig. 28, it will be seen that a maximum amount of modulated light will reach the photoelectric cell 256, because now the spots 17 are passing across the entire areas of the images 259, and effectively greatly modulating the light reflected therefrom to the photoelectric cell 256.

Referring to Figures 26, 27, and 28 together, it will be seen that the system is such that if normal lateral alignment is maintained, a modulated current of normal magnitude is produced by the photoelectric cell 256; if lateral misalignment to the left takes place, the amount of modulated current is reduced, while if lateral misalignment to the right takes place, the amount of modulated current is increased.

Fig. 29 shows the circuit by which this varying amount of modulated light reaching the photoelectric cell 256 is translated into an effective control. Referring to Fig. 29, it will be seen that the photoelectric cell 256 is connected in series with a battery 261 and the series combination is connected across the ends of a resistor 262. The resistor 262 is in turn connected to an amplifier 263, such as is used in previous embodiments. The output of the amplifier 263 is fed into a suitable rectifier 264, which is capable of changing the alternating current component of the output current of the amplifier 263 to a direct current. Numeral 265 indicates a resistor that is connected across the output of the rectifier 264. One of the output wires then goes to the sliding contact 266 of a potentiometer 267, across the ends of which is connected a battery 268.

Numerals 269 and 270 indicate the oppositely facing magnets or coils of a relay 271 to be described in greater detail hereinafter. The coils 269 and 270 are connected in series, and the midpoint thereof is connected to one end of the potentiometer 267, as illustrated. The other end of the coil 269 is connected to the anode of a half-wave rectifier 272, while the other end of coil 270 is connected to the cathode of a half-wave rectifier 273. The cathode of rectifier 272 and the anode of rectifier 273 are in turn connected together and to the opposite output wire of the rectifier 264.

Numeral 274 indicates the armature of the

relay 271, and this armature 274 is normally held in position (as by a spring) mid-way between the coils 269 and 270. The armature 274 carries a pair of central movable contacts 275, which individually cooperate with two pairs 276 and 277 of relatively fixed contacts. The arrangement of the movable contacts 275 and fixed contacts 276 and 277 is that of the customary double-pole, double-throw switch, and connections are so made that when power is supplied in a cross-over manner to the contacts 276 and 277, then while the contacts 275 are connected to a reversible motor 278 as indicated in Fig. 29, the position of the armature 274 determines the relative polarity of the power fed to the armature of the motor 278, and hence by movement of the armature 274 under the influence of either coil 269 or coil 270, the direction of rotation of the motor 278 may be controlled.

With the armature 274 in its central or neutral position, however, the movable contacts 275 make connection with neither the fixed contacts 276 nor the fixed contacts 277, and hence the motor 278 does not operate.

The operation of the circuit of Fig. 29 is as follows: The sliding contact 266 of resistor or potentiometer 267 is set at such a position that no current flows through either of the coils 269 or 270 when the web alignment is correct, and, therefore, under this condition the armature 274 is in a neutral position and the movable contacts 275 do not connect with either of the fixed contacts 276 or the fixed contacts 277. This is true because the voltage drop across the resistor 265 is opposed by an equal voltage drop applied by the potentiometer 267 and battery 268 in combination. If, now, the web W wanders to the left, looking in the direction of travel of the web, and the condition of Fig. 27 is observed, then the voltage drop across the resistor 265 becomes less than the voltage supplied by the potentiometer 267 and current flows through the rectifier 273 and coil 270 and consequently the armature 274 is drawn over so that the movable contacts 275 connect with the fixed contacts 277, and the armature of the motor 278 thus receives power and rotates in one direction.

If, on the other hand, the web W wanders to the right, and the condition observed in Fig. 28 is observed, then the voltage drop across the resistor 265 is greater than the voltage supplied by the potentiometer 267 and current flows through the rectifier 272 and coil 269 and consequently the armature 274 is drawn over so that the movable contacts 275 connect with the fixed contacts 276 and power is supplied to the motor armature to enable it to rotate in a reverse direction. The magnitude of the voltage drop across the resistor 265 is determined by the magnitude of the alternating current voltage drop appearing across the resistor 262 as a result of the reception of modulated light by the photoelectric cell 256 and; therefore, the position of the armature 274 is determined by the magnitude of the light modulation and hence by the distance apart of the center-lines of the spots 17 and of the images 259 of the apertures 258 in mask 257. It is seen, therefore, that when the web W is correctly aligned, the armature 274 of relay 271 is in a neutral position, but should the web W wander laterally in one direction or the other the armature 274 moves in one or another of two directions and supplies power to the armature of the motor 278 to make it rotate in one or the other direction.

In this embodiment of the invention of Fig. 29 it is important that the voltage drop across the resistor 265 be independent of the speed of travel of the web W and this fact should be taken into consideration in the design of the amplifier 263. Also, it is apparent that the lateral wandering is limited by the width of the row of images 259 and, therefore, this embodiment is intended primarily for application to cases in which great wandering does not occur.

Figures 30 and 31 illustrate still another alternative lateral alignment detector. The optical system for this embodiment is not shown separately, it being substantially identical to the optical system of Fig. 8, with the single exception that the mask 27 of the right-hand system 22 is replaced by the mask 257 of Fig. 25. The combined system as thus constructed brings about a condition such as that pictured in Fig. 30 on the moving web. In Fig. 30, the customary row of spots 17 is provided. Numerals 259 indicate the images projected by the apertures 258 of mask 257 in the right-hand optical system 22, and all conjoint actions of the spots 17 and images 259 are along the same lines as those indicated for the embodiment of Figures 26, 27, 28, and 29. Numeral 36 indicates the images projected by the apertures 35 of mask 28 in the left-hand optical system 23 of Fig. 8. As indicated in Fig. 30, the center line of the row of images 36 and the center line of the row of images 259 are both parallel to the center line of the row of spots 17, and the first-mentioned center line may coincide with the third-mentioned center line whereas the second-mentioned center line may be displaced from the third-mentioned center line by a distance equal to one-half the width of the row of spots 17 when the lateral web alignment is correct. As in prior embodiments, the width of the row of images 259 may be equal to the width of the row of spots 17, but the width of the row of images 36 is purposely sufficiently wide that the lateral wanderings of the web W do not cause the row of spots 17 to move laterally outside the row of images 36.

The longitudinal motion of the spots 17 across the images 36 produces a modulation of the light reflected from the web W, and a photoelectric cell 279 (Fig. 31) is provided in position to respond to this modulation in light. This modulation in light is unaffected by lateral wandering of the web W, and, therefore, the alternating current response of the photoelectric cell 279 is independent of the lateral displacement of the web W and is relatively constant. The longitudinal motion of the spots 17 across the images 259 produces a modulation of the light reflected from the web W, and a photoelectric cell 280 (Fig. 31) is provided in position to detect these modulations. The magnitude of said modulations, and, therefore, the magnitude of the alternating current response of the photoelectric cell 280 is a function of the lateral displacement of the web W such that the alternating current response of the cell 280 increases when said displacement is in one direction and decreases when said displacement is in the opposite direction, all as described in connection with the embodiment of Figures 26 through 29.

Referring to Fig. 31, the photoelectric cells 279 and 280 are connected in series-aiding in a balanced circuit together with series-aiding batteries 281 and 282, respectively. Numeral 283 indicates a resistor connected across the balanced circuit. The polarities of the photoelectric cells 279 and 280 and of the batteries 281 and 282

are such that no alternating current voltage drop appears across the resistor 283 when the alternating current responses of the two cells 279 and 280 are equal, but an alternating current voltage drop does appear across the resistor 283 when the alternating current responses of the cells 279 and 280 are unequal, it being understood that alternating current voltage drops and alternating current responses of fundamental frequency are being considered and that the phase relationship of the said alternating current responses is correct. As in all cases in which alternating currents are produced through the longitudinal motion of spots such as 17 across well-defined light spots or images projected on the web W, the wave form of the alternating current is determined by the relative shape and sizes of said light spots and, therefore, can be adjusted through design of the mask, for example, if desired, although such adjustment is not always necessary as has been pointed out hereinbefore.

The phase relationship of the alternating current responses of fundamental frequency of the cells 279 and 280 is readily adjusted by regulating the distance apart of the images of the masks 28 and 257, for example, and one satisfactory adjustment is such that the phase displacement of the alternating current response of the cell 279 relative to the alternating current response of the cell 280 is zero considering the fundamental frequency. In the circuit shown in Fig. 31 the relative phase displacement of the fundamental alternating current voltage drop across the resistor 283 with respect to some standard alternating current voltage, such as from a generator 242, depends on which cell 279 or 280 has the greater fundamental alternating current response, it being remembered that no fundamental alternating current voltage drop appears across the resistor 283 when the fundamental alternating current responses of the cells 279 and 280 are equal and the phase displacement relationship between said responses is correct. The balanced photoelectric cell circuit shown in Fig. 31 may be used in connection with any other suitable circuit, as indicated in Fig. 31, for example, and the appearance or nonappearance of an alternating current voltage drop of fundamental frequency across the resistor 283 together with the relative phase displacement of the fundamental alternating current voltage drop across the resistor 283 when one or the other of the cells 279 and 280 receives a predetermined relative amount of modulated light of fundamental frequency constitute a valuable and useful selective detection of lateral web alignment. In this case, the generator 242 supplies the standard, alternating current voltage, and should be driven by the press. Longitudinal wandering of the web W should not be allowed to take place with this embodiment.

In Fig. 31 the balanced photoelectric cell circuit is shown together with a circuit similar to the circuit shown in Fig. 17. In Fig. 31, numeral 284 indicates a suitable amplifier and all other parts are similar to and bear the same numbers as parts hereinbefore described in connection with Fig. 17. As hereinbefore described, numeral 242 indicates a suitable source of alternating current power, said power having a fundamental frequency which is proportional to the linear speed of travel of the web W and the current flowing through the armature 42 of the motor 41 is at all times in phase of 180° out of phase with any alternating current of fundamental frequency flowing through the field wind-

ing 40 of the motor 41, adjustments having been made to insure this condition. When the cells 279 and 280 each receive modulated light of such character and amount that the fundamental alternating current responses cancel one another, as when the lateral web alignment is correct, no fundamental alternating current voltage drop appears across the resistor 283 and, therefore, no fundamental signal is delivered to the amplifier 284 and the field winding 40 receives no power so that the armature 42 is stationary. When the web W is displaced in one direction by an amount which is within the limits set by the dimensions of the images 259, for example, one cell 279 or 280 responds excessively so that a fundamental alternating current voltage drop appears across the resistor 283 and said voltage drop is of a magnitude dependent on the displacement of the web W. Therefore, the amplifier 284 delivers power to the field winding 40 so that the armature 42 rotates slowly when the lateral displacement of the web W is small and the armature 42 rotates at successively higher speeds when the displacement of the web W is successively greater, and the direction of rotation of the armature 42 is determined by which cell 279 or 280 gives the greater fundamental alternating current response. The motor 41 can be used to operate corrective means such as hereinbefore described and may be expected only to supply power for corrective purposes when correction of alignment is required and to selectively correct the alignment through said means in accordance with the direction of the correction required and at a rate dependent on the degree of the correction required.

In this embodiment it is important that the fundamental alternating current responses of the cells 279 and 280 be equal when the web alignment is correct laterally if the circuit shown in Fig. 31 is used, but the said responses are not necessarily equal even when the cells 279 and 280 receive equal amounts of the modulated component of the light reflected by the web W unless suitable steps are taken to make them equal, for among other things the response of a cell 279 may depend on the voltage of the battery 281, for example, and not all cells have the same dynamic response characteristics even though they have the same static response characteristics. Numerous factors enter to make it advisable to adjust the fundamental alternating current responses of the cells 279 and 280 to the end that no power is delivered to the field winding 40, for example, when the lateral web alignment is correct and this adjustment may sometimes be made most conveniently through control of the illumination of the web W by the two lamps in the optical systems employed. If the lamps are incandescent electric lamps the above mentioned adjustment may be made by regulating the amount of power delivered to the individual lamps, for example, as illustrated in Fig. 32 or/and said adjustment may be made by regulating the effective aperture of the individual lenses employed by means of an adjustable stop or diaphragm of the type frequently used in connection with a camera lens, for example.

In Fig. 32, which is a diagram of an electrical circuit, lamps 285 and 286 are shown connected to the same source of power (wires 287) and in series with the lamp 285 is an adjustable rheostat 288 while in series with the lamp 286 is an adjustable rheostat 289. The Fig. 32 arrangement

permits individual adjustment of the light outputs of the lamps 285 and 286 for the purpose hereinbefore set forth.

In optical systems in which an image of a mask is projected on the web W, such as the systems shown in Figures 8 and 23, some consideration should be given to the choice of the light source and of the lenses. Taking Fig. 8 as an example, the light sources 24 should be of high brightness and should emit radiation to which the photo-electric cells 30A and 30B are highly sensitive. The sources 24 should have such construction and dimensions that their images on the lenses 26 produced by the lenses 25 fill the lenses 26 substantially uniformly, so that the illumination of the web W may be great. The diameter of the lenses 25 should be great enough to insure that light passes through all parts of all apertures in the respective masks used. The lenses 26 should be sufficiently well corrected to produce well-defined undistorted images of the apertures in the respective masks on the web W. The lenses 29, and their analogous lenses, are used as collecting lenses primarily for the purpose of permitting the respective photoelectric cells to be placed at a convenient distance from the web W, as indicated in the several drawings.

In all optical systems where images of apertures in masks are projected onto the web W, it is important that the plane of the mask be parallel to the plane of the web W, and that the lenses be mounted properly in order that the proper spacings and shaping of the images on the web W will be obtained. The optical systems shown in the different illustrations are intended merely as examples of ways in which suitable light spots or images can be projected on the surface of a web, there being other ways in which the desired illumination can be obtained.

Thus far the consideration of web alignment detection and correction has been inferentially limited to relatively opaque diffusely reflecting web materials and consequently only those systems have been described which make use of differences in diffuse reflectivity of the web surface under various conditions such as the condition in which a part of the surface is covered or coated with printer's ink, for example. There are cases in which better detection can be had by utilizing the difference between diffuse and specular reflection characteristics of the web surface and there arise in practice many cases in which it is either desirable or else necessary to make use of the transmission characteristics of the web in place of reflection characteristics. Examples of these will now be presented.

If the web surface is naturally a good diffuse reflector but a poor specular reflector, whereas a pattern printed or otherwise laid thereon specularly reflects a relatively high percentage of the incident light, the illuminating system and photoelectric cell detecting system are set up in such a way that their effective optical axes intersect the web at the same point, make equal angles with a line normal to the web surface at said point and lie in a plane which includes said normal line. Under these conditions light reflected from any specularly reflecting spot illuminated by the illuminating system is received by the photoelectric cell and maximum response is thereby assured. Under these same conditions light from any spot which reflects less in the direction predetermined by the setting of the aforementioned optical axes produces a photo-

electric cell response which is less than the maximum response resulting from specularly reflected light. The difference between the two responses is utilized in any of the manners hereinbefore described in application of the principles to alignment detection of predominantly diffusely reflecting webs. With the optical apparatus arranged as just described, web alignment detection is similarly accomplished in cases in which the web surface is naturally a good specular reflector whereas a pattern laid thereon specularly reflects a relatively small percentage of the incident light.

It will at once be recognized that there may be marked advantages to be gained by utilizing the difference between the amounts of specularly and diffusely reflected light inasmuch as this difference may be greater than the difference between the amounts of light diffusely reflected from printed and unprinted web surface.

In addition to relatively opaque webs, such as webs of heavy bond paper, there are also encountered in commercial practice webs which are either highly transparent or else translucent, such as "Cellophane." When the alignment of a transparent or translucent web is to be detected, advantage may be taken of the difference in the amount of light transmitted by printed and unprinted areas. This difference is often much greater than any difference between amounts of light reflected by printed and unprinted surface areas of the same web. When convenient, the illuminating system may be set up to direct rays towards the web in a direction normal to the web surface and the photo-electric cell may be placed on the opposite side of the web in position to receive those rays which are transmitted by the web. A mirror may be mounted at such an angle as to reflect the transmitted rays in any desired direction such as back through the web to a photoelectric cell placed on the same side of the web as the illuminating system. In any case the principles of detection are the same as when reflection characteristics of a web surface are utilized. Printed patterns intercept a part or all of the beam of light which is projected on the web and the reduced response of the photoelectric cell, relative to the response when interception is absent, is made to produce or control an effect in one or more of the manners hereinbefore described.

Fig. 33 is a diagram of an optical system, in which index character W represents a web having, for example, a naturally diffusely reflecting surface and a pattern which specularly reflects a relatively large fraction of the incident light, such as a pattern printed in a high-gloss or metallic ink. An image of a source of light 293 is focused on a lens 294 by a lens 295. Between said lenses, near the lens 295 and with its plane perpendicular to the axis of the lens 295 is mounted a mask 296 having an aperture 297 (see also Fig. 34). The aperture 297 is located off the axis of the lenses 294 and 295, said axis being perpendicular to the plane of the web W. An image of the aperture 297 is focused on the web W by the lens 294. A line drawn from the center of the aperture 297 to the center of the image of said aperture, for convenience called herein the effective optical axis of the illuminating system, makes an angle α with the axis of the lens 294 and hence with a line normal to the surface of the web W at the point of intersection of the effective optical axis with the surface of web W. Light falling on a diffusely reflecting area of the web W is reflected back in all directions within an imaginary hemisphere

laid on the web W with the plane surface of said hemisphere lying in the plane of the web W. Light from the source 293 falling on a specularly reflecting area of web W, however, is reflected back from the web W in a particular direction such that the angle of emergence is equal to the angle of incidence. Therefore, the photoelectric detecting system, comprising a lens 298 and a photoelectric cell 299 is advantageously disposed with its axis intersecting the plane of the web W at the center of the image of the aperture 297 and with said axis lying in the plane defined by the effective optical axis of the illuminating system and the axis of the lens 294 and with said detecting system axis making the hereinbefore described angle α with a line normal to the surface of the web W at the center of the image of the aperture 297. As the web W travels the photoelectric cell 299 receives light alternately from diffusely and specularly reflecting areas but the amount of light specularly reflected to the cell 299 is relatively much greater than the amount of light diffusely reflected to the cell 299 and therefore the light received by the cell 299 is modulated and the electrical response of the cell 299 contains an alternating current component which may be amplified and utilized in any desired manner as hereinbefore described, for example. Thus, if the pattern on the web W is a row of spots analogous to the row of spots 17 shown on the web W in Fig. 2 and each spot is a relatively good specular reflector, an alternating current can be developed which has a fundamental frequency determined by the speed of travel of the dots across the image of the aperture 297.

It is at once apparent that the same result is achieved if the unprinted web W specularly reflects more of the incident light than does the pattern. It is also apparent that two or more correctly spaced identical apertures 297 in the mask 296 may be used if desired provided they are properly located off the axis of the lens 295.

Fig. 35 is a diagram of an optical system in which web W is assumed to be material which transmits a relatively high percentage of light incident on one side, such as "Cellophane," for example. An image of a light source 300 is projected on a lens 301 by a lens 302 and preferably, as in all such systems, the lens 301 is filled with the image of the source 300. A mask 303 is mounted close to the lens 302, for example. The plane of the mask 303 is parallel to the web W and is perpendicular to the axes of the lenses 301 and 302 and an aperture 304 of the mask 303 (see also Fig. 36) is located with its center on the said axes. Under these conditions the effective optical axis of the illuminating system, as defined hereinbefore, coincides with the axes of the lenses 301 and 302. The photoelectric detecting system comprising a photoelectric cell 305 and a lens 306 is placed on the opposite side of the web W with the axis of the detecting system coincident with the effective optical axis of the illuminating system. It is clear that with the present arrangement of essential apparatus a relatively large amount of light may reach the photoelectric cell 305 from the source 300 when the web W is not printed nor otherwise covered or rendered opaque over the region on which the image of the aperture 304 falls, and that the periodic interception of the incident light by a relatively opaque film of ink, for example, causes a periodic decrease in the amount of light reaching the cell 305 from the source 300. The web

W may again have printed on it a row of spots analogous to the row of spots 17 shown on the web W in Fig. 2, for example, and the illuminating system may be located to project an image of the aperture 304 across the row of dots in such a way that the motion of dots across the image of the aperture 304 produces a maximum modulation of the light reaching the cell 305 for some predetermined lateral alignment of the web W, for example. Under these conditions, as the web W travels the electrical response of the cell 305 contains an alternating current component produced by the variation in the amount of light reaching the cell 305, and the alternating current component may be amplified and utilized to control web alignment correction means, for example, in any of the manners hereinbefore described. It is apparent that the same result is had if the unaltered web W transmits less of the incident light than does the pattern region. Two or more correctly spaced identical apertures 304 in the mask 303 may be used if desired.

Figures 37 and 38 are two diagrammatic views in elevation of an optical system. Corresponding parts bear the same numerals as and may be similar to parts of the Fig. 33 system, but in addition there is shown in Fig. 37 a plane mirror 307 (in place of the web W shown in Fig. 35) and an axis 308 which coincides with the line of intersection of the reflecting surface of the mirror 307 with the plane defined by the effective optical axis of the illuminating system and the axis of the detecting system, all three axes intersecting at a point in the surface of the mirror 307. The web W, which is now relatively transparent or which contains a relatively transparent pattern, moves in a plane close to and above the mirror 307 and the entire optical system may be rotated about the axis 308 so that intersecting lines which are normal to the surfaces of the mirror 307 and of the web W subtend a small angle beta (shown diagrammatically in Fig. 38). With the apparatus set up in the manner described, light from the source 293 can reach the photoelectric cell 299 by passing through a relatively transparent region in the web W, striking the mirror 307 and being reflected back through the web W, but less light from the source 293 can reach the photoelectric cell 299 when the image of the aperture 297 of the mask 296 falls on a relatively opaque region of the web W than when said image falls on a relatively transparent region of the web W. Due to the rotation of the entire optical system about the axis 308 through the small angle beta, light specularly reflected from the surface of the web W does not reach the photoelectric cell 299, but travels in a direction indicated diagrammatically by the arrow 309. The passage of regions of the web W having different transmission characteristics across the image of the aperture 297 produces a modulation of the light reaching the cell 299 and hence produces an alternating current component in the electrical response of the cell 299, and said alternating current component can be amplified and utilized in any desired manner, as hereinbefore described, for example.

Definitions

The word "web" as used herein, is meant to be inclusive of sheet-like material of any and all compositions. For example, the web may comprise paper, cloth, "Cellophane," metallic foils, rubber sheets, and the like.

The term "photoelectric cell," as used herein,

is meant to be inclusive of any and all photosensitive or other radiation detecting devices, such as the so-called soft or gas-filled tubes, the so-called "electron multiplier" tubes, bolometers, photolytic cells, selenium cells, and like devices.

It may here be pointed out that photosensitive devices are essentially detectors of radiation. Thus, the radiations usable in the present invention are not confined to visible light rays, but may include infra-red rays and ultra-violet rays, providing these radiations are not harmful to the material of the web, and provided suitable radiation detectors are used. All of such radiations are comprehended to be within the scope of the term "light" as herein used.

The term "image" as used herein signifies the trace of a beam of light with a plane lying substantially in the plane of the web surface. For example, a spot of light on the web produced by interposing an apertured mask in a beam of light directed at the web is considered an image. Also, in the case of a relatively transparent web or portion of web, the light passing through the web in a bounded region is also considered an image.

Some of the apparatus and methods herein disclosed are separately claimed in the copending application of the present applicant Stockbarger and John L. Jones, Serial No. 140,996, filed May 5, 1937, and in the copending application of John L. Jones, Serial No. 140,998, filed May 5, 1937.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in carrying out the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. Means for detecting the lateral alignment of a moving web, said web having thereon a row of periodically repeating patterns extending in the direction of motion of said web, said patterns being of different light transmitting and/or reflecting characteristics than the remainder of said web, comprising means for producing at least a pair of light images on said web, said images being positioned, when the web is in correct lateral alignment, on opposite sides of said row of patterns on said web, and photoelectric means positioned to observe said light images, whereby, when said web wanders laterally, said row of patterns traverse one or another of said images, depending upon the direction of lateral misalignment, and thereby modulate the light reaching said photoelectric means, the individual images on the opposite sides of said row of patterns having a staggered arrangement with respect to the row arrangement, whereby the phase displacement of the modulation of light reaching said photoelectric device is different for the two possible directions of lateral misalignment.

2. Means for detecting the lateral movement of a moving web, said web having thereon a row of periodically repeating patterns extending in the direction of motion of said web, said patterns being of different light transmitting and/or reflecting characteristics than the remainder of said web, comprising means for producing at least a pair of light images on said web, said images being positioned, when the web is in correct lateral alignment, on opposite sides of said row

of patterns on said web, photoelectric means positioned to observe said light images, whereby, when said web wanders laterally, said row of patterns traverses one or another of said images, depending upon the direction of lateral misalignment, and thereby modulate the light reaching said photoelectric means, a resistor connected in a circuit with said photoelectric means, the modulations of light reaching said photoelectric means setting up a periodically varying voltage drop across said resistor, an amplifier whose output is controlled by said voltage drop, and control means operated by the power output of said amplifier.

3. Means for detecting the lateral alignment of a moving web, said web having thereon a row of periodically repeating patterns extending in the direction of motion of said web, said patterns being of different light transmitting and/or reflecting characteristics than the remainder of said web, comprising means for projecting at least a pair of spaced light images on said web, said images being positioned, when the web is in correct lateral alignment, on opposite sides of said row of patterns on said web, photoelectric means positioned to observe said light images, whereby, when said web wanders laterally, said row of patterns traverses one or another of said images, depending upon the direction of lateral misalignment, and thereby modulate the light reaching said photoelectric means, the individual images on the opposite sides of said row of patterns having a staggered arrangement with respect to the row arrangement, whereby the phase displacement of the modulation of light reaching said photoelectric device is different for the two possible directions of lateral misalignment, a resistor connected in a circuit with said photoelectric means, the modulations of light reaching said photoelectric means setting up a periodically varying voltage drop across said resistor, an amplifier whose output is controlled by said voltage drop, and control means operated by the power output of said amplifier.

4. Means as set forth in claim 3, in which the last-named means comprises a motor having separate field and armature connections, the power output terminals of said amplifier being connected to the field of said motor, and a separate source of alternating current power of the same fundamental frequency as the alternating current power obtained from said amplifier connected to the armature of said motor.

5. Means as set forth in claim 3, in which the last-named means comprises a motor having separate field and armature connections, the power output terminals of said amplifier being connected to the field of said motor, and a separate source of alternating current power of the same fundamental frequency as the alternating current power obtained from said amplifier connected to the armature of said motor, the said last-named source of alternating current power supplying alternating current in phase with the alternating current from said amplifier when said patterns traverse one of said images, and out of phase with the alternating current from said amplifier when said patterns traverse another of said images, whereby said motor rotates in opposite directions depending upon the direction of lateral misalignment of said web.

6. Means as set forth in claim 3, in which the last-named means comprises a motor having separate field and armature connections, the power output terminals of said amplifier being connect-

ed to the field of said motor, and a separate source of alternating current power of the same fundamental frequency as the alternating current power obtained from said amplifier connected to the armature of said motor, the said last-named source of alternating current power supplying alternating current in phase with the alternating current from said amplifier when said patterns traverse one of said images, and out of phase with the alternating current from said amplifier when said patterns traverse another of said images, whereby said motor rotates in opposite directions depending upon the direction of lateral misalignment of said web, said last-named source of alternating current power comprising means for projecting at least one light image on the moving web across the path of said periodically repeating patterns, photoelectric means positioned to observe said last-named light image, whereby the light reaching said last-named photoelectric means is modulated as the said patterns traverse the said last-named light image, a resistor connected in a circuit with the last-named photoelectric means, the modulations of light reaching said last-named photoelectric means sets up a periodically varying voltage drop across said last-named resistor, and an amplifier whose output is controlled by said last-named voltage drop.

7. Means as set forth in claim 3, in which the last-named means comprises a motor having separate field and armature connections, the power output terminals of said amplifier being connected to the field of said motor, and a separate source of alternating current power of the same fundamental frequency as the alternating current power obtained from said amplifier connected to the armature of said motor, the said last-named source of alternating current power supplying alternating current in phase with the alternating current from said amplifier when said patterns traverse one of said images, and out of phase with the alternating current from said amplifier when said patterns traverse another of said images, whereby said motor rotates in opposite directions depending upon the direction of lateral misalignment of said web, the said last-named source of alternating current power comprising an alternating current generator mechanically coupled for its drive with the moving web itself.

8. Means as set forth in claim 3, in which the last-named means comprises a motor having separate field and armature connections, the power output terminals of said amplifier being connected to the field of said motor, and a separate source of alternating current power of the same fundamental frequency as the alternating current power obtained from said amplifier connected to the armature of said motor, the said last-named source of alternating current power supplying alternating current in phase with the alternating current from said amplifier when said patterns traverse one of said images, and out of phase with the alternating current from said amplifier when said patterns traverse another of said images, whereby said motor rotates in opposite directions depending upon the direction of lateral misalignment of said web, said last-named source of alternating current power including a photoelectric cell positioned near said moving web, in such manner that the said last-named photoelectric cell receives modulated light from the web in accordance with the passage of patterns on said web before said photoelectric cell.

9. The method of detecting the lateral align-

ment of a moving web, which web contains a row of uniformly spaced patterns thereon, which patterns are of a different light reflective and/or transmissive character than the remaining regions of said web, which comprises producing at least a pair of light images on said web, one of said light images being normally positioned on one side of said row of patterns, while another light image is normally positioned on the other side of said row of patterns, and photoelectrically observing the said light images on the moving web, whereby, when said web becomes laterally misaligned, said row of patterns, instead of passing between said light images, intersects one or another of said light images and thereby produces a modulation in the photoelectrically observed light, and disposing the individual images at different locations along the line of movement of said web, so that the said modulations of light are in different phase displacement for different directions of misalignment of said web.

10. A lateral alignment detector for a moving web containing a row of uniformly spaced, uniformly shaped patterns thereon extending in the direction of travel of said web, which patterns are of a different light reflective and/or transmissive character than the remainder of said web, comprising means producing a light image on said web, said light image being located in such a position on said web that, when said web is properly aligned longitudinally, said patterns successively pass over a part of said image, and a photoelectric cell positioned to observe the said light image on said web, the said patterns, as they successively pass over part of said image, modulating the light reaching said photoelectric cell, the said image being fixed in position relative to the web, whereby, when said web wanders laterally in one direction, the said patterns traverse a smaller proportion of the area of said image and thereby set up a lesser quantity of modulated light at said photoelectric cell, and when said web wanders laterally in the other direction, the said patterns traverse a greater proportion of the area of said image thereby setting up greater quantities of modulated light at said photoelectric cell, a resistor connected in a circuit with said photoelectric cell, the modulated light reaching said photoelectric cell setting up an alternating current voltage drop in said resistor, said voltage drop varying in magnitude in accordance with the amount of modulated light falling on said photoelectric cell, an amplifier whose output is controlled by said voltage drop, and means connected to said amplifier establishing a selective control operating differentially upon the impression thereon of amplified alternating current power exceeding or falling short of a normal amount of alternating current power characteristic of correct lateral alignment of said web.

11. A lateral alignment detector for a moving web containing a row of uniformly spaced, uniformly shaped patterns thereon extending in the direction of travel of said web, which patterns are of a different light reflective and/or transmissive character than the remainder of said web, comprising means producing a light image on said web, said light image being located in such a position on said web that, when said web is properly aligned longitudinally, said patterns successively pass over a part of said image, and a photoelectric cell positioned to observe the said light image on said web, the said patterns, as they successively pass over part of said image, modulating the light reaching said

photoelectric cell, the said image being fixed in position relative to the web, whereby, when said web wanders laterally in one direction, the said patterns traverse a smaller proportion of the area of said image and thereby set up a lesser quantity of modulated light at said photoelectric cell, and when said web wanders laterally in the other direction, the said patterns traverse a greater proportion of the area of said image thereby setting up greater quantities of modulated light at said photoelectric cell, a resistor connected in a circuit with said photoelectric cell, the modulated light reaching said photoelectric cell setting up an alternating current voltage drop in said resistor said voltage drop varying in magnitude in accordance with the amounts of modulated light falling on said photoelectric cell, an amplifier whose output is controlled by said voltage drop, and means connected to said amplifier establishing a selective control operating differentially upon the impression thereon of amplified alternating current power exceeding or falling short of a normal amount of alternating current power characteristic of correct lateral alignment of said web, the said last-named means comprising a rectifier transforming the alternating current output of said amplifier into a direct current, the potential of which varies in accordance with the magnitude of said alternating current power, an outside potential bucked against said direct current potential so produced, a double acting relay having two electro-magnetic coils, and connections between said direct current potential, said outside potential, and said two coils, in such manner that when said direct current potential exceeds said outside potential, one of said coils is empowered, while when said direct current potential falls below said outside potential, the other of said coils is empowered.

12. A lateral alignment detector for use in connection with a moving web having a row of periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding regions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said pattern and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photoelectric cell positioned to observe its respective light image on the web.

13. A lateral alignment detector for use in connection with a moving web having a row of periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding regions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the

row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said pattern and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photo-electric cell positioned to observe its respective light image on the web, and a balanced circuit including both of said photoelectric cells.

14. A lateral alignment detector for use in connection with a moving web having a row of periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding regions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said pattern and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photoelectric cell positioned to observe its respective light image on the web, and a balanced circuit including both of said photoelectric cells, said two images being disposed apart in the direction of movement of said web at such a distance that individual patterns in said row of patterns traverse said two images in the same phase relationship.

15. A lateral alignment detector for use in connection with a moving web having a row of periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding regions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said pattern and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photoelectric cell positioned to observe its respective light image on the web, and a balanced circuit including both of said photoelectric cells, the traversal of said light images by said patterns resulting in the modulation of the light reaching said photoelectric cells, which modulation in light results in the formation of periodically varying currents within said photoelectric cells.

16. A lateral alignment detector for use in connection with a moving web having a row of periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding re-

gions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said pattern and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photoelectric cell positioned to observe its respective light image on the web, and a balanced circuit including both of said photoelectric cells, the traversal of said light images by said patterns resulting in the modulation of the light reaching said photoelectric cells, which modulation in light results in the formation of periodically varying currents within said photoelectric cells, the balanced circuit being so arranged that so long as said web is in proper lateral alignment, both cells produce substantially the same amount of modulated current, whereby they cancel each other, but when said web is out of lateral alignment, the cell associated with said first-named optical system receives modulated light of greater or less intensity, depending upon the direction of lateral misalignment of the web, thereby setting up a condition of unbalance within the said balanced circuit.

17. A lateral alignment detector for use in connection with a moving web having a row of periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding regions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said pattern and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photoelectric cell positioned to observe its respective light image on the web, and a balanced circuit including both of said photoelectric cells, the traversal of said light images by said patterns resulting in the modulation of the light reaching said photoelectric cells, which modulation in light results in the formation of periodically varying currents within said photoelectric cells, the balanced circuit being so arranged that so long as said web is in proper lateral alignment, both cells produce substantially the same amount of modulated current, whereby they cancel each other, but when said web is out of lateral alignment, the cell associated with said first-named optical system receives modulated light of greater or less intensity, depending upon the direction of lateral misalignment of the web, thereby setting up a condition of unbalance within the said balanced circuit, and a web corrective device the operation of which is controlled by the said condition of unbalance in said circuit.

18. A lateral alignment detector for use in connection with a moving web having a row of

periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding regions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said pattern and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photoelectric cell positioned to observe its respective light image on the web, and a balanced circuit including both of said photoelectric cells, the traversal of said light images by said patterns resulting in the modulation of the light reaching said photoelectric cells, which modulation in light results in the formation of periodically varying currents within said photoelectric cells, the balanced circuit being so arranged that so long as said web is in proper lateral alignment, both cells produce substantially the same amount of modulated current, whereby they cancel each other, but when said web is out of lateral alignment, the cell associated with said first-named optical system receives modulated light of greater or less intensity, depending upon the direction of lateral misalignment of the web, thereby setting up a condition of unbalance within the said balanced circuit, amplifying means connected to the said balanced circuit to amplify the alternating current response produced therein, and a web corrective device under the control of the output alternating current power from said am-

plifying means, said last-named means comprising a motor, the amplified alternating current power being connected to the field of said motor, and an outside source of alternating current power of the same fundamental frequency as the alternating current from said amplifying means, supplying power to the armature of said motor.

19. A lateral alignment detector for use in connection with a moving web having a row of periodically repeating patterns of uniform shape and spacing thereon, which row extends in the direction of motion of the web, and which patterns have a different light reflective and/or transmissive character than the surrounding regions of said web, which comprises a pair of optical systems, one of said systems producing a light image on the said web, which image is of substantially the same size and shape as said patterns, the center line of said image being normally displaced from the center line of the row of patterns, as long as said web is in proper lateral alignment, and the second optical system producing a light image on said web, which second light image extends across the path of movement of said patterns and is of sufficient width to provide for lateral misalignments of said webs, each of said optical systems including a photoelectric cell positioned to observe its respective light image on the web, and a balanced circuit including both of said photoelectric cells, the traversal of said light images by said patterns resulting in the modulation of the light reaching said photoelectric cells, which modulation in light results in the formation of periodically varying currents within said photoelectric cells, said balanced circuit comprising the two photoelectric cells, and two batteries all arranged in series-aiding relationship, and a resistor connected across the circuit between analogous elements of the two photoelectric cells.

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