

[54] REFLECTION-TYPE COUNTER

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[58] Field of Search **235/92 SB, 92 V**

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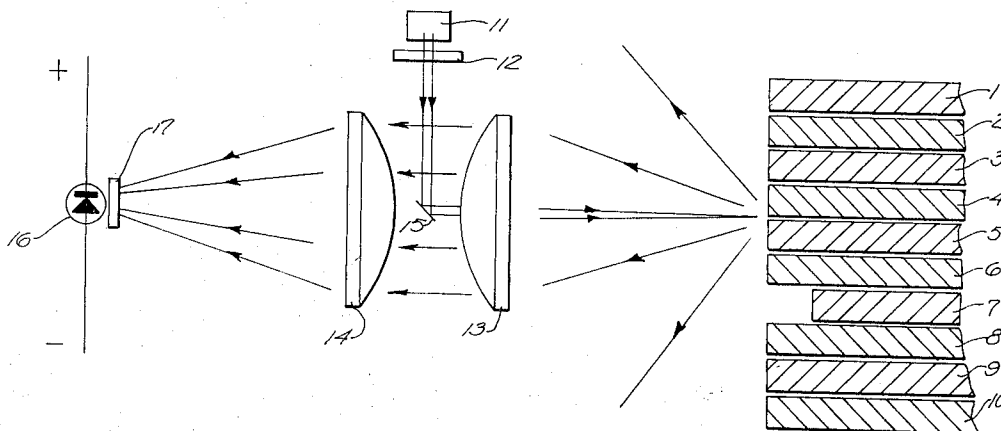
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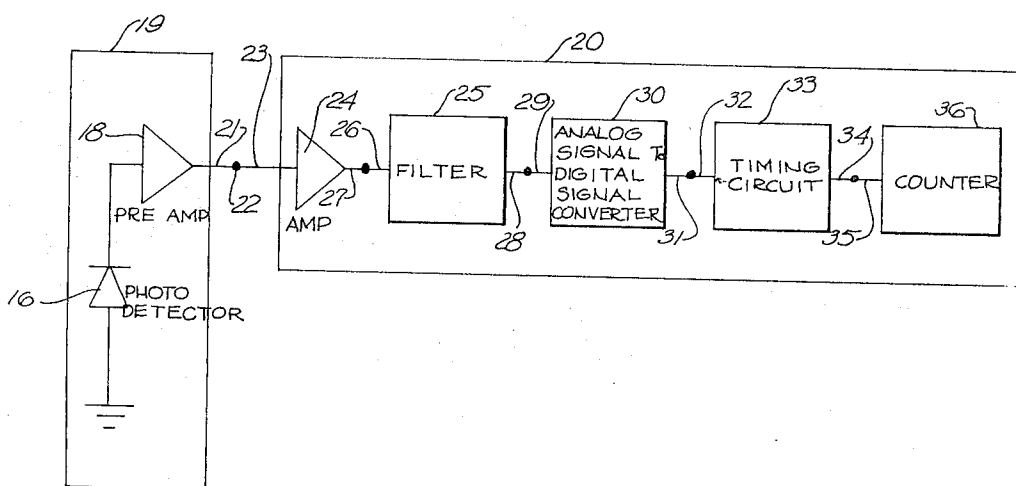
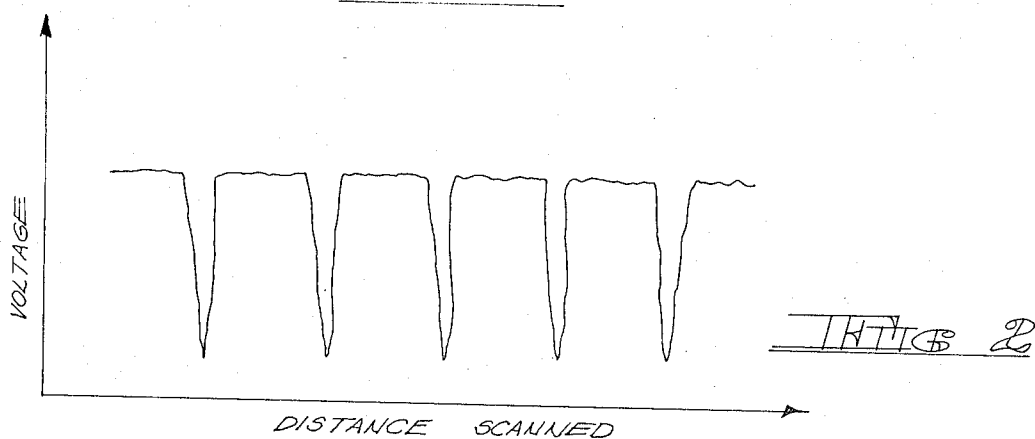
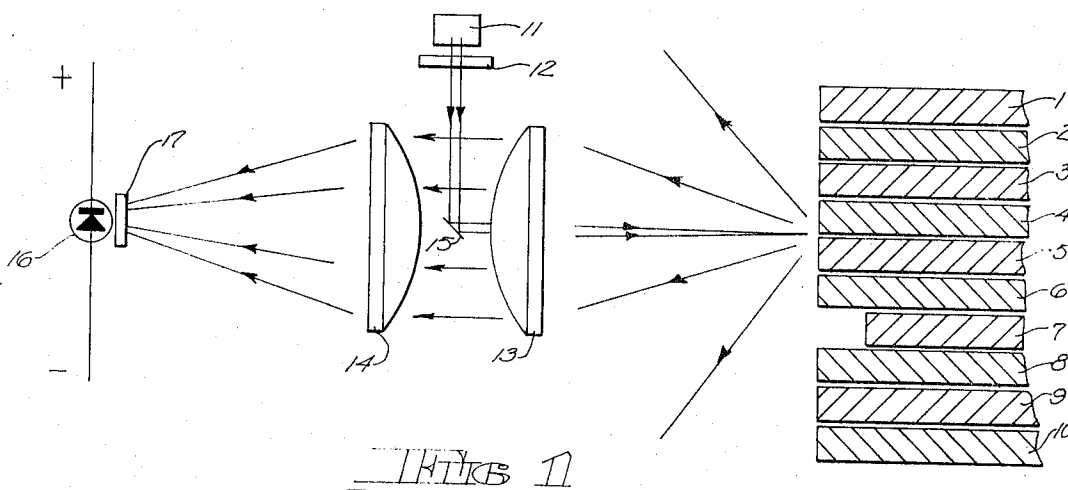
ABSTRACT

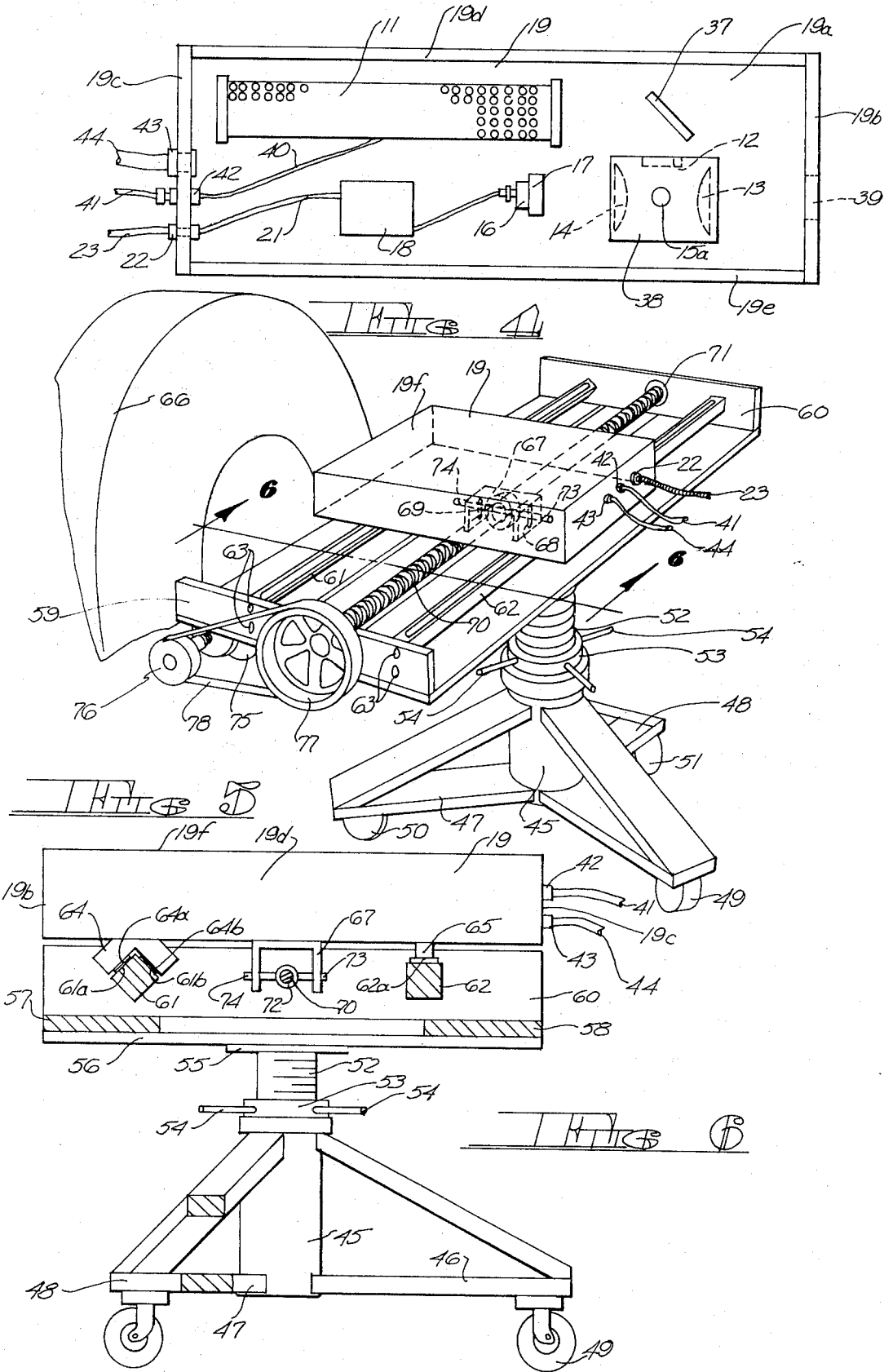
A reflection-type counter for counting a plurality of adjacent edges of reflective material as for example the number of convolutions in a coil of reflective material or the number of sheets in a stack of sheets of reflective material. The counter comprises a light source and means for focusing a beam of light of elliptical cross section from the source onto the edges being counted, the elliptical beam having a minor axis less than the width of the edges upon which it is focused. The beam is so oriented with respect to the edges being counted that both the angle of incidence and the angle of reflectance are substantially perpendicular to the edges being counted. The reflected beam is directed to a photo detector. The voltage output of the photodetector increases as the intensity of the light striking the detector increases. Thus the voltage output of the photodetector is greater when the light beam passes over an edge of the reflective material than when it passes over an interface between edges. Means are provided to process the voltage output of the photodetector into a digital signal. The number of times the signal drops below a predetermined level is counted and displayed. The electronics are such that the number displayed is equal to the number of interfaces passed by the beam plus one, thus giving the actual number of edges present.

18 Claims, 6 Drawing Figures



SHEET 1 OF 2





REFLECTION-TYPE COUNTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a counting means, and more particularly to a reflection-type counting means for counting a plurality of adjacent edges, or the like, of reflective material.

2. Description of the Prior Art

While the counter of the present invention may be used to count many different types of reflective articles and has a wide variety of applications, for purposes of an exemplary showing it will be described in its use as a means to count the number of convolutions in a coil of metal or the number of sheets in a stack of metallic sheet material.

In recent years it has become the practice in parts of the steel industry to sell steel by theoretical weight, rather than actual weight. This practice is intended to benefit the steel customer. It will be understood that under today's technology it is possible to maintain the gauge of the steel produced within very narrow tolerance limits. When a particular gauge is ordered by a customer, it is the general practice to assure that any variation in the gauge of the product delivered will not fall below the gauge ordered. Since any variation which may occur will be on the high side, if the steel is sold to the customer on the basis of actual weight, the customer may be required to pay for more than he ordered. If a theoretical weight, on the other hand, is used as the basis of the sale and is calculated in the light of the actual gauge designated by the customer, the customer will pay for not more than he ordered, even if gauge variation during processing results in a greater amount of steel than ordered.

The theoretical weight of steel coils or sheet material is calculated on the basis of the width, length and nominal thickness. Whether dealing with coils or stacked sheets, the width does not generally constitute a problem, nor does the nominal thickness which is simply taken to be the gauge ordered by the customer.

When dealing with coils, the problem lies in an accurate determination of the length of the steel strip. Prior art workers have devised a number of different length determining devices, some of which measure the steel prior to the coiling step, and others of which determine the length during the coiling step. These devices have a number of drawbacks, however. First of all, the results obtained from them are sometimes inconsistent. Secondly, they frequently require a permanent installation of a relatively complex mechanism. A number of prior art counting devices also require means actually contacting the metal being measured.

In the instance of stacked sheets, it is necessary to know not only the width, length and nominal thickness, but also the number of sheets in the stack. It is this last determination which presents the difficulty. Mechanical counting devices have not proved satisfactory and the counting of the stacked sheets by eye is both time consuming and frequently remarkably inaccurate.

Finally, prior art workers have developed reflection-type counting devices for various purposes. One such device, for example, is taught in U.S. Pat. No. 3,234,360. The prior art reflection-type counters have been characterized by the fact that they require the elements being counted to lie in a substantially planar ar-

ray. This renders them unsuitable for counting the convolutions of a steel coil or the sheets of a steel sheet stack because in such coils or stacks the edges of the various convolutions or sheets are not necessarily in planar array, some edges being located ahead or behind an ideal plane by as much as one-fourth inch or so. Under such conditions, the prior art reflection-type counters would give an inaccurate count.

The present invention is directed to a reflection-type counter capable of overcoming the above noted problems. In the instance of counting the sheets in a stack of steel sheets, the counter of the present invention demonstrates an average error of about 0.5 percent, ± 1 count. Once the number of sheets is known, the theoretical weight can be readily calculated, as is well known in the art.

With a coil, once the number of coil convolutions is known, the length of the coil can be calculated by the use of the formula $L = n \pi (r_1 + r_2)$, wherein L is the length of the coil, n is the number of convolutions, r_1 is the inside radius of the coil and r_2 is the outside radius of the coil. Through the use of the counter of the present invention, the number of coil convolutions can be determined with an average error of about 0.5 percent, ± 1 count. The length of a coil may be calculated with an average error of about 1 percent or less, taking into account errors in the measurement of r_1 and r_2 .

In addition, the counter of the present invention is simple in construction, easy to maintain and relatively inexpensive to manufacture. It does not depend upon contact with the metal and does not require a permanent installation. The counter may be portable and may be used at various points throughout the steel plant. It can also be used as a tool for checking coil length data obtained by other methods and can be used in the shipping department as a final check or means of determining the theoretical weight immediately prior to shipping.

SUMMARY OF THE INVENTION

The reflection-type counter of the present invention comprises an appropriate light source, a beam from which is passed through a cylindrical lens to render the beam of elliptical cross-section. A pair of additional lenses is provided, spaced from each other and optically aligned. A small mirror is located between the pair of lenses. The elliptical beam from the cylindrical lens enters between the pair of lenses and is directed by the small mirror through a first lens of the pair. This first lens focuses the light beam to a point of elliptical configuration in its focal plane. The edge of the coil or stack is located at or near the focal plane of the first lens. The long axis of the elliptical point of light is so oriented as to be parallel to the interfaces between the stacked sheets or coil convolutions. The minor axis of elliptical point of light is made as small as possible so as to be of a length less than the thickness of the sheets of the stack or the convolutions of the coil.

Light reflected by the edges of the stacked sheets or coil convolutions is collected and collimated by the first lens into the second lens of the pair. This second lens focuses the light onto a suitable photo detector through an appropriate filter means (if desired).

The voltage signal from the photo detector increases as the intensity of the light striking the detector increases. Thus, the voltage signal is stronger when the elliptical point of light passes over the edge of a sheet

or coil convolution and weaker when the elliptical point of light passes over an interface between sheets or convolutions.

Means are provided to amplify the signal from the photo detector. Gain control means are also provided. The amplified signal from the photo detector is an analog signal and additional means are present to convert this analogue signal to a pulse or digital signal. The pulse or digital signal, in turn, passes through a timing circuit and drives a digital counter by which the count is displayed. The timing circuit assures that the digital counter is not advanced by spurious signals.

Finally, appropriate mounting means are provided by which the counter can be moved along the edge of the coil or stack so that the individual convolutions or sheets can be scanned and counted. Means are also provided to move the counter at a fixed scan speed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation of the optical structure of the counter of the present invention.

FIG. 2 is an idealized graph of the output signal from the photo detector wherein the voltage is plotted against the distance across the edges of the sheet or coil convolutions.

FIG. 3 is block diagram of the electronic circuitry of the counter of the present invention.

FIG. 4 is a semi-diagrammatic plan view of the optical head of the counter of the present invention, illustrating an exemplary arrangement of the parts.

FIG. 5 is a perspective view illustrating the optical head and an exemplary portable mounting therefor positioned adjacent to a coil.

FIG. 6 is a cross sectional view taken along section line 6—6 of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The reflection-type counter of the present invention operates on the same principle as that which allows the human eye to count the number of convolutions of a coil or the number of sheets in a stack. That is, the operation of the device is based on the fact that less light is reflected from the interface between convolutions or sheets than from the edges of the convolutions or sheets themselves.

FIG. 1 is a diagrammatic representation of the optical structure of the counter of the present invention. To the right in FIG. 1 a plurality of layers of metal (1 through 10) are shown. For purposes of the present invention these metallic layers may be considered to be either some of the convolutions of a coil of steel or some of the sheets in a stack of steel sheets.

The basic elements of the optical structure of the counter comprise a light source 11, a cylindrical lens 12, an additional pair of lenses 13 and 14, a mirror 15 and a photo detector 16.

The light source 11 may be of any suitable type. Excellent results have been achieved, for example, with a neon-helium gas laser. The use of a laser as a light source has a number of advantages such as the proper light intensity and the fact that it provides a collimated beam of small diameter and easy to focus to a very tiny pinpoint of light.

The beam from light source 11 is first caused by pass through lens 12. Lens 12 is a cylindrical lens adapted to convert the beam of light from a circuit cross section

to an elliptical cross section. The purpose of this is that once the beam has been focused, it will appear on the edges of the convolutions or sheets being counted as a small, thin, ellipse or line of light, rather than a tiny spot of light. The lens 12 is so oriented that the ultimate ellipse or line of light will have its major axis parallel to the interfaces of the convolutions or sheets, while its minor axis will be less than the thickness of the convolutions or sheets. The use of an ellipse or line of light causes the light directed onto the photodetector to be substantially unaffected by burrs or other irregularities in the edges of the convolutions or sheets, because the light averages the edge contour. Thus, the chances of irregularities or burrs on the edges of the individual convolutions or sheets producing an erroneous count are greatly reduced.

While the lenses 13 and 14 may be of any suitable type, excellent results have been achieved with positive planoconvex lenses. The lenses 13 and 14 are optically aligned and supported by any suitable means (not shown). The mirror 15 must be quite small and is located between lenses 13 and 14. Again, suitable support means (not shown) may be provided for the mirror. The mirror is to angled that the beam from the light source, having passed through lens 12, is turned 90° and directed substantially perpendicular to the edges of the sheets or convolutions 1 through 10.

The function of lens 13 is two-fold. First of all, it is the lens which focuses the beam to form the above described ellipse or line of light at its focal plane. As will be evident from FIG. 1, since the lens 13 focuses the line of light substantially perpendicularly on the sheet or convolution edges, an accurate count will be achieved even if the edges do not all lie in a single plane. In FIG. 1 the sheet or convolution 7 is illustrated as being inset from the remainder. It will nevertheless be evident that the line of light, by virtue of the perpendicularity of the impinging rays with respect to the sheet or convolution edges, will properly traverse and record the convolution 9.

In the steel making process, when coils are wound or sheets are stacked, it is not uncommon for the edges of some of the sheets to lie ahead or behind a plane along the sheet edges by as much as one quarter inch or so. To accommodate for these discrepancies, the sheet stack or coil may be so located with respect to lens 13 that the focal point of lens 13 will lie substantially at the side of the sheet stack or coil, or about one quarter inch within the sheet stack or coil. It has been found that at a distance of about one inch on either side of the focal point, the ellipse or line of light will still be properly sized to provide an accurate count.

The second function of lens 13 is to collect and collimate a part of the light reflected from the edges of the convolutions or sheets 1 through 10 and the interfaces therebetween. The reflected light is collimated into lens 14 which serves to focus the reflected light onto the photo detector 16. The photo detector 16 may be of any suitable type such as a photodiode, phototransistor or the like.

The photodetector 16 generates a small voltage signal which increases as the intensity of the light striking the photodetector increases. Thus, the voltage signal from the photodetector will be greater when the line of light passes over one of the edges of convolutions or sheets 1 through 10 than when the line of light passes over an interface therebetween. FIG. 2 is a graph illus-

trating the analogue output from the photodetector 16. For purposes of an exemplary showing, the analogue signal of FIG. 2 is idealized. In this figure the voltage is plotted against the distance scanned by the line of light of the counter. The substantially horizontal portions of the plot represent the voltage signal of the photodetector as the point of light passes over the edges of the convolutions or sheets 1 through 10. The V-shaped depressions in the plot represent the voltage signal as the point of light passes over the interfaces between the convolutions or sheets.

Depending upon the type of light source used, it may be desirable to locate a filter means adjacent the photodetector. Since, in the exemplary embodiment described, a laser is used, an optical bandpass filter 17 is located adjacent the photo detector 16. The filter 17 passes the reflected laser light, but blocks out ambient light of other wavelengths, thereby reducing spurious or stray optical signals in the system. When such a filter is used, it should be selected to have a center bandpass wavelength and a bandpass appropriate for the particular light source used.

The structure thus far described comprises the optical structure of the counter of the present invention. In a non-limiting but exemplary embodiment of the device, which has been used with success, the light source 11 comprised a neon-helium gas laser having an output of 1 milliwatt. The cylindrical lens 12 was 20×40 mm with a focal length of 40 mm. The lenses 13 and 14 each had a 95 mm diameter and a 130 mm focal length. The mirror 15 was $\frac{3}{8} \times \frac{1}{4}$ inch front surface mirror supported by a $\frac{1}{4}$ inch diameter brass rod affixed to the supporting means for the lenses 12, 13 and 14. The photodetector was a silicon-type photodiode having a 0.035 cm^2 active area. Finally, the optical bandpass filter was selected to have a center bandpass wavelength of 6328 ± 15 angstroms and a bandpass of 100 ± 15 angstroms.

FIG. 3 is a block diagram of the electronic circuitry of the counter of the present invention. The voltage signal from photodetector 16 is fed into a pre-amplifier 18. As will be described hereinafter, the optical structure of the counter of the present invention together with the pre-amplifier will be located in an optical head used to scan the coil or sheet stock. The remainder of the electronic components will be located in a console remote from the optical head. In FIG. 3 the optical head is diagrammatically indicated at 19 and the console is diagrammatically indicated at 20. The pre-amplifier 18 may be of any suitable type well known in the art and readily available, appropriate commercial pre-amplifiers may be used. The purpose of the pre-amplifier is to boost the weak signal from the photodetector 16 to a higher level so that the signal can be fed to the remote electronic console 20 without loss or degradation. Thus, the pre-amplifier will enable the maintenance of signal quality with a desirable signal to noise ratio.

The output 21 of pre-amplifier 18 is connected by a suitable connector 22 to the input 23 of an amplifier 24 in the electronic console 20. In the embodiment described, amplifier 24 is used to provide a manual gain control. Under some circumstances of use, it may be desirable to control the gain in a non-manual fashion as, for example, through the use of a logarithmic amplifier or a combination of logarithmic amplifiers, under

which circumstances amplifier 24 would be eliminated.

The next electronic component in console 20 is a bandpass filter 25. The input 26 of the bandpass filter is connected to the output 27 of amplifier 24. The presence of filter 25 is desirable whether or not amplifier 24 is present. The filter is used to remove part of the signals representing side wall color variations and variations in how tightly a coil is wound. The center of frequency of bandpass filter 25 is determined by the scan speed and the edge thickness of the sheets or convolutions being counted. It will be understood that the output signal of filter 25 will still be an analogue signal. It is therefore necessary to convert this analogue signal to a pulse or digital signal to drive the digital counter to be described hereinafter. To this end, the output 28 of filter 25 is connected to the input 29 of an analogue signal to digital signal converter 30, the digital output 31 of the converter 30 is connected to the input 32 of a timing circuit 33, the purpose of which will be described hereinafter. Finally, the output 34 of timing circuit 33 is connected to the input 35 of a digital counter 36. The digital counter 36 will have suitable means in association therewith to display the count. It will be understood that appropriate power supply means (not shown) will be provided for the various elements thus far described.

As indicated above, the output of filter 25 is still an analogue signal. The converter 30 is provided to serve as an analogue-to-digital interface. That is, the converter 30 changes the analogue signal of filter 25 to a pulse signal or a digital signal suitable for driving the digital counter 36.

The converter 30 may take a number of well known forms. In the above mentioned successful exemplary embodiment of the invention, a commercially available Schmitt trigger was used. As is known in the art, a Schmitt trigger will remain in a low state (i.e., will have a logical zero output) until the input voltage increases above a first threshold voltage. At this time, the Schmitt trigger will switch to a high state (will have a logical one output) and will remain in the high state until the input signal decreases below the second threshold voltage of the Schmitt trigger, whereupon the Schmitt trigger will again switch to its low state. In this way, the analogue signal from filter 25 is converted to a digital signal at the output 31 of the Schmitt trigger or converter 30.

The output 31 of the Schmitt trigger or converter 30 could be connected directly to the input 35 of the digital counter 36. However, the accuracy and reliability of the reflection-type counter of the present invention can be greatly increased if a timing circuit is interposed between the converter 30 and digital counter 36. To this end, timing circuit 33 is shown in FIG. 3.

While the timing circuit 33 may take a number of well known forms, excellent results were achieved using a commercially available non-retriggerable monostable having a variable resistor and a capacitor connected across appropriate terminals thereof, as is known in the art.

The timing circuit 33 serves as a pulse width circuit such that as the signal at the output 31 of the Schmitt trigger or converter 30 goes from a low state to high state (i.e., from logic zero to logic one) the signal at output 34 of the timing circuit 33 will also go from a low state to a high state. However, the high state of tim-

ing circuit 33 will remain for a definite length of time which may be designated as t_0 . While in the high state, the timing circuit will ignore all input signal from the Schmitt trigger or converter 30. Only after it returns to the low state (after time t_0) will it respond to any input signal from the Schmitt trigger.

The time t_0 must be less than the time t required for the line of light to scan over one edge of one of the convolutions or sheets 1 through 10. This last mentioned time, t , is equivalent to d/v , where d is the material thickness and v is the scan velocity. In the above mentioned exemplary embodiment, excellent results have been achieved when t_0 was equal to about $0.7 t$. The capacitor works in conjunction with the variable resistor in the timing circuit to determine the time base for the timer. Thus, the variable resistor may be adjusted to achieve the desired value for t_0 .

The output 34 of timing circuit 33 is connected to the input 35 of counter 36. The precise nature of the digital counter 36 does not constitute a limitation on the present invention. Excellent results have been achieved using a commercially available conventional decimal counter provided with lamp means or the like to give a visual count reading.

FIG. 4 is a plan view illustrating an exemplary arrangement of the elements in the optical head. The optical head 19 may take the form of a substantially rectangular cabinet or the like having a bottom 19a, ends 19b and 19c, sides 19d and 19e, and a top 19f (see FIG. 5).

Since the light source 11 is illustrated in the form of a laser, and since a laser is generally of elongated configuration, for purposes of convenience, the laser is illustrated as being oriented parallel to the long axis of the optical head 19. In order to properly orient the laser beam so as to cause it to pass through the cylindrical lens 12, an additional mirror 37 is located in the optical head to direct the laser beam at the lens 12.

In FIG. 4 the lenses 12, 13 and 14 are shown mounted in an appropriate support means 38. Again, the nature of the support means 38 does not constitute a limitation on the present invention. Excellent results were achieved with a support means in the form of a clear plastic box-like structure, as shown. The mirror 15 was mounted as described above. The supporting dowel extended through the support 38 and was provided with a knob 15a whereby the position of the mirror could be adjusted.

The forwardmost end 19b of the optical head 19 has a perforation 39 therein through which the beam is directed upon the edges of the convolutions or sheets and through which the reflected light from the convolution or sheet edges passes. In FIG. 4 the filter 17 and photo-detector 16 are illustrated in position behind lens 14 and are shown connected to pre-amplifier 18. The output 21 of the pre-amplifier 18 is shown, as is connector 22 and the input 23 of the amplifier 24 in console 20. The electrical conduits 21 and 23 may be of the multiple conductor type and also include the power supply for the pre-amplifier 18. The laser 11 is shown as having an electrical conduit 40 connected to an electrical conduit 41 through an appropriate connector 42. The conduit 41 will be connected to an appropriate power supply for the laser 11.

Finally, where desired, an appropriate fitting 43 may be provided in the rearward end 19c of the optical head 19 permitting connection thereto of a conduit 44. The

conduit 44 is, in turn, connected to a source of filtered air. Thus, filtered air may enter the optical head through fitting 43 and exit the optical head through perforation 39 in its forward end 19b. The filtered air serves two purposes. First, it prevents dirt from collecting on the various surfaces. Second, it serves to cool the laser 11.

The mounting means for the optical head 19 may take many forms. For example, the optical head may be made a part of a permanent installation with the coil or stack to be scanned brought to it. On the other hand, the optical head may be mounted on a portable support means so that it may be used at various places in the steel making facility. Under such circumstances, the optical head and its support may be brought into position with respect to an already positioned coil or stack.

The most important elements to be kept in mind is that the optical head must be properly positioned to scan the coil convolutions or sheets and it must be moved at a constant and appropriate scan speed. The ellipse or line of light must be so oriented as to have its major axis parallel to the convolutions or sheets and the interfaces therebetween and its minor axis perpendicular thereto.

Depending upon the use to which it is put, the optical head may be moved horizontally or vertically. Irrespective of its direction of movement, it is preferred when scanning a coil that it scan along a diameter thereof, at which position the coil convolutions will best accommodate the line of light. When dealing with a stack of sheets, if the sheets are horizontally oriented, the optical head will best perform when moved vertically. The optical head may scan along a horizontal path, if the sheets in the stack are oriented vertically.

FIGS. 5 and 6 illustrate an exemplary portable mounting for the optical head 19, and the like parts are given like index numbers. The mounting comprises a vertically oriented, cylindrical, hollow body 45 supported by three appropriately braced legs 46, 47 and 48, evenly spaced thereabout. Each of the legs may be provided with caster means 49 through 51, respectively.

An externally threaded shaft 52 has an internally threaded sleeve 53 mounted thereon. The sleeve 53 is adapted to be supported by the upper end of the cylindrical body 45 and the shaft 52 is sized to telescope therein. The sleeve 53 may be provided with a plurality of radially extending handle means 54 by which it may be turned with respect to the shaft 52 to adjust the height of the shaft 52 and the structure it supports (to be described hereinafter).

The shaft 52 is surmounted by a horizontal plate 55 to which a beam 56 is affixed. The beam 56, in turn, supports at its ends a pair of transversely extending horizontal members 57 and 58 in parallel spaced relationship. The ends of the members 57 and 58 have vertically oriented end members 59 and 60 attached thereto. It will be evident from the description thus far given and FIGS. 5 and 6 that the members 56 through 60 form a horizontally oriented, elongated, substantially rectangular table-like structure. This table-like structure is vertically adjustable by means of threaded shaft 52 and the collar 53 thereon.

A pair of horizontally oriented beams 61 and 62 are affixed at their ends to the end members 59 and 60 by any suitable means such as machine screws, some of

which are shown at 63. The beams 61 and 62 are in parallel spaced relationship and are spaced upwardly from the table members 57 and 58.

As is most clearly seen in FIG. 6, the beam 61 is of square cross section and is so oriented that its diagonal is vertical. The uppermost sides of beam 61 are provided with a coating of or strips 61a and 61b of Teflon or other suitable friction-reducing material. The beam 62 is also of square cross section and is so oriented that its upper side and is horizontal. This upper side is again coated or provided with a strip 62a of Teflon or like material.

The optical head 19 is mounted upon and adapted to traverse along the beams 61 and 62. As a consequence, the bottom of the optical head near its forward end 19b has a pair of inverted V-shaped members. One such member is shown at 64 in FIG. 6. The inside surfaces of the legs of the member 64 are provided with a coating of or pieces 64a and 64b of Teflon or like material adapted to rest upon the Teflon strips 61a and 61b of beam 61. It will be evident from FIG. 6 that the inverted V-shaped elements 64 and the beam 61 will cooperate to maintain the optical head 19 in position on beams 61 and 62. The Teflon elements 61a, 61b, 64a and 64b will assure that the optical head will slide smoothly and easily on the beam 61.

The bottom of the optical head 19 near its rear end 19c has a centrally located foot 65. The foot 65 may be made of Teflon or is provided with a Teflon insert or a Teflon coating, and is adapted to lie on top of the Teflon strip 62a of beam 62. Therefore, the foot 65 will slide smoothly and easily along the beam 62.

In use, the structure thus far described is brought to a proper position with respect to a coil to be scanned. Such a coil is shown at 66 in FIG. 5. Through the use of collar 53, the table-like structure is vertically adjusted so that the optical head 19 will scan along the horizontal diameter of coil 66. Mechanical means are then provided to cause the optical head 19 to shift along beams 61 and 62, scanning the coil convolutions.

An exemplary mechanical means to shift the optical head 19 along the beams 61 and 62 is illustrated in FIGS. 5 and 6. An inverted U-shaped member 67 is mounted on the bottom of the optical head centrally thereof and between beams 61 and 62. The legs of the member 67 depend downwardly and are provided with longitudinal slots 68 and 69.

An elongated, threaded shaft 70 is mounted in bearings (one of which is shown at 71) in the end members 59 and 60 of the table-like structure. The threaded shaft 70 is in parallel spaced relationship with the beams 61 and 62. The shaft 70 carries an internally threaded collar 72 provided with diametrically opposed, radially extending arms 73 and 74. The arms 73 and 74 extend through the slots 68 and 69, respectively, of the inverted U-shaped member 67.

It will be evident from the above description that rotation of shaft 70 will cause movement of the optical head 19 along the beams 61 and 62 in a direction dependent upon the direction of rotation of the shaft. Movement of the optical head by rotation of shaft 70 is brought about by the interengagement of the arms 73 and 74 of collar 72 in the slots 68 and 69 in the member 67. This same interengagement will further assure that any slight departure from straightness of the shaft 70

will be accommodated by the slots 68 and 69 and will not impart vibration to the optical head 19.

To rotate shaft 70 a motor 75 is mounted on the underside of the table-like structure, at one end thereof.

The motor 75 is provided with a pulley 76. At the same end of the table-like structure the shaft 70 extends through the end member 59 and is provided with a pulley 77. The pulleys 76 and 77 are joined by a belt 78. To insure a constant scanning speed, the pulleys 76 and 77 and the belt 78 may be grooved. In the above noted successfully operated exemplary embodiment, the motor 75 was a one-fifth horsepower, 1,800 rpm synchronous motor and the combination of motor speed, pulleys 76 and 77 and threaded shaft 70 resulted in a scan speed of one inch per second. It will be understood that for scanning purposes the optical head may be moved in either direction and a direction control switch for motor 75 may be located on console 20.

The exemplary support means thus far described renders the optical head readily portable. The horizontal member 56 may be slidable with respect to the member 55 so that the final adjustment of the optical head toward and away from the coil may be made without moving the entire support structure. These various adjustments allow for ease and speed of set-up with respect to coils of different sizes.

Modifications may be made in the invention without departing from the spirit of it. For example, it would be within the scope of the invention to add an alarm circuit which would sound if the photodetector signal is less than a pre-selected peak-to-peak value. Such a warning device would come into play in an instance where the coil or sheet stack being scanned had edges which were too dark to properly reflect the scanning light.

It would also be within the scope of the invention to provide electronic means to determine r_1 and r_2 and to automatically calculate the length of the coil. The device is particularly adapted for such electronic means since it is preferred to scan the coil along a diameter thereof.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A reflection-type counter for counting a plurality of adjacent reflective elements with less reflective interfaces therebetween, said counter comprising an optical portion and an electronic portion, said optical portion comprising a light source, means to direct a beam of light from said source toward and substantially perpendicular to said reflective elements to be counted, means to focus said beam on said reflective elements so that said focused beam has a width less than the width of any one of said reflective elements, a photodetector providing a voltage signal which increases as the intensity of the light impinging upon it increases, means for collecting a part at least of the light reflecting from said reflective elements and the interfaces therebetween, means focusing said reflected light onto said photodetector whereby the voltage signal therefrom is an analogue signal of greater strength when said focused beam passes over said reflective elements and of lesser strength when said focused beam passes over the interfaces between said reflective elements, means to cause said focused beam to scan said reflective elements at a fixed scan speed, said means to focus said beam on said reflective elements and for collecting a part at least of

the light reflecting from said reflective elements and interfaces therebetween comprising a first lens, said reflective elements being located in front of said first lens and substantially in the focal plane thereof, said means for focusing said reflected light onto said photodetector comprising a second lens, said first and second lenses being optically aligned, said photodetector being located behind said second lens and on the axis of said first and second lenses, said light source being located to one side of said first and second lenses, said means to direct said beam of light comprising a mirror supported between said first and second lenses and being so oriented as to direct light from said source through said first lens and substantially perpendicularly onto said reflective elements, said electronic portion of said counter comprising means to convert said analogue voltage signal from said photodetector to a digital signal and a digital counter and display means driven by said digital signal and displaying the number of said reflective elements counted.

2. The structure claimed in claim 1 wherein said reflective elements to be counted comprise the edges of metallic sheets in a stack thereof.

3. The structure claimed in claim 1 wherein said reflective elements to be counted comprise the convolution edges of a coil of metal.

4. The structure claimed in claim 1 wherein said source of light comprises a laser.

5. The structure claimed in claim 1 including an optical filter ahead of said photodetector, said filter having a center bandpass wavelength and a bandpass so chosen as to pass said reflected light and block out ambient light.

6. The structure claimed in claim 1 including in said electronic portion means to amplify said voltage signal from said photodetector.

7. The structure claimed in claim 1 including in said electronic portion and bandpass filter ahead of said means to convert said analogue signal to a digital signal.

8. The structure claimed in claim 1 including a timing circuit between said means to convert said analogue signal to a digital signal and said digital counter, said timing circuit having a time base such as to prevent ad-

vancement of said digital counter by spurious signals from said converter means.

9. The structure claimed in claim 1 wherein said electronic portion is remotely located with respect to said optical portion.

10. The structure claimed in claim 1 wherein said means to convert said analogue signal to a digital signal comprises a Schmitt trigger.

11. The structure claimed in claim 1 including a third lens between said light source and said mirror to render said beam elliptical in cross section, said first lens focusing said beam to an ellipse of light having its major axis substantially parallel to said interfaces and its minor axis of a length less than the width of any one of said reflective elements.

12. The structure claimed in claim 11 wherein said source of light comprises a laser.

13. The structure claimed in claim 12 including an optical filter ahead of said photodetector, said filter having a center bandpass wavelength and a bandpass so chosen with respect to said laser light source as to pass said reflected light and block out ambient light.

14. The structure claimed in claim 13 wherein said electronic portion is located remotely of said optical portion, said optical portion including a pre-amplifier for said voltage signal from said photodetector.

15. The structure claimed in claim 14 wherein said optical portion is mounted in a cabinet a movable optical head.

16. The structure claimed in claim 15 including means to pass filtered air through said optical head to cool said laser and to prevent dirt from collecting in said head.

17. The structure claimed in claim 15 including support means for said optical head, said optical head being transversable on said support means in a direction appropriate to cause said focused beam to scan said reflective elements to be counted and motor means operatively connected to said head to traverse said head at a constant scan speed.

18. The structure claimed in claim 17 wherein said optical head and support means therefor are portable.

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