

PATENT SPECIFICATION

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(54) APPARATUS FOR THE DETECTION OF MARKS APPLIED TO STRIP MATERIAL

- (71) We, AGFA - GEVAERT AKTIEN-GESELLSCHAFT, a body corporate recognised under German Law, of Leverkusen, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—
- 10 This invention relates to an apparatus for the detection by photo-electric scanning of marks applied to strip material.
- Apparatus of this kind is used, for example, in apparatus for cutting film strips coming from photographic roll printing machines and developing machines. The marks which have to be detected are provided on the reverse side of the film and are spatially associated with the dividing bars separating the individual image fields. The cutting operation is controlled by the mark-detection apparatus. Marks of this type are commonly applied by means of rotating graphite wheels and previously proposed detection techniques have involved either photoelectric scanning or have made use of the lower electrical resistance of the graphite line. Difficulty arises, however, in that graphite marks of this type are frequently smudged to a varying degree during the course of processing of the strips after the printing operation, and also tend not to be very precisely positioned in relation to the side edge of the strip. In addition, other inscriptions such as stamped order numbers or correction values often extend into the vicinity of the marks, and this may lead with photoelectric scanning, for example, to detection errors and hence to cutting errors.
- The present invention provides apparatus for detecting scannable marks of predetermined width applied to strip material which comprises means for laterally guiding strip material, devices for scanning a plurality of areas situated adjacent to one another across a strip moving along the path defined by the guide means, each of which scanning devices includes means for illuminating a different one of the said areas and a photo-electric transducer arranged to receive light reflected from that area, and means for emitting a signal at a single common output when the response from any one of the transducers differs in a predetermined sense from a threshold value, the width of each of the said areas (measured across the strip path) not exceeding said predetermined mark width (measured across the strip).
- It will be appreciated that, if the apparatus is intended for use in detecting scannable marks of different widths, then the predetermined width taken in determining the size of the scanned areas should be that of the narrowest mark envisaged. For apparatus designed for detecting one size of mark only, the predetermined width will, of course, be that of the particular mark concerned.
- Advantageously, the width of each scanned area is less than the said predetermined mark width, and is preferably less than half said mark width. When this latter condition is satisfied, the marks to be detected will cover the whole width of at least one of the scanned areas, leading to a considerably higher signal-to-noise ratio and a correspondingly lower risk of detection errors.
- It will be appreciated that the apparatus of the invention will only detect marks having different reflection properties from the surrounding strip material and, furthermore, that whether or not a given mark will result in the emission of a mark signal will depend on the particular threshold value set.
- In some cases, the specular reflection from strip material, that is to say, the light

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reflected at an angle equal to the angle of incidence, is unsuitable for detecting the presence of a mark, and each transducer is preferably arranged to receive substantially no specular reflection.

Advantageously, the apparatus includes control means for maintaining the outputs from the transducers at the same predetermined level in the absence of a mark, and means for retarding operation of the control means to enable marks to be detected.

This ensures that equally bright scanned areas all lead to the same transducer output and has the advantage that the background areas of the strip give the same transducer output with strips of different reflective capacity.

Preferably, each illuminating means comprises a light source arranged to emit a beam in a plane parallel to the plane of a strip lying within the guide means, and means for deflecting the emitted beam onto the strip. An especially advantageous deflecting means comprises a substantially elliptical reflecting surface, the light source being at one focus of the ellipse and the area to be illuminated by that light source being at the other focus. Such a deflecting means enables the dimensions of the scanning device to be relatively small (as compared with the use of a prism).

Apparatus constructed in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows a portion of a web of material having various marks thereon;

Figs. 2 and 2a show the arrangement of the scanning elements, Fig. 2a being a plan view and Fig. 2 being a section along the line II-II;

Fig. 3 shows diagrammatically the values measured by the scanning elements in relation to the size of the marks and their position; and,

Fig. 4 shows a circuit diagram for the evaluation device.

Fig. 1 shows a portion of the reverse side of a film strip 1 having scannable marks 2 arranged in spatial association with the dividing bars on the upper surface of the strip. The mark 2, which may for example be produced by means of a graphite wheel which can be lowered with its periphery onto the plane of the paper strip, is substantially rectangular in shape. The width of the mark 2 normal to the direction of advance of the web is indicated by a , and the length in the direction of travel by b . Due to differences in the setting of the printing apparatuses in which the graphite marks are applied during or after the printing operation, the position of the mark in relation to the side edge of the paper strip 2 may fluctuate very greatly, by a

multiple of the width a of the mark. The position of a mark may vary laterally within the area designated 1a. The reverse side of the strip 1 also bears symbols 3, for example, the order number of the film in question or correction values, that is to say, data concerning the exposure values during the printing operation for the original in question. The thin lines constituting the symbols 3, which are fainter than the graphite mark 2, also extend into the area 1a (indicated in Fig. 1 by broken lines).

Within the guide means for the paper strip, a series of photoelectric scanning units is arranged along a line normal to the direction of movement of the film strip. Three such units are shown in plan view in Fig. 2a, and one of the units is shown in longitudinal section in Fig. 2.

Referring to Fig. 2, the scanning unit has a housing 5, which is located under the film strip 1 and a tubular lens lamp 6 of which the longitudinal axis extends in the direction of travel of the strip. The lamp consists of a thin tubular transparent body, of which the closure is in the form of a lens and within which there is a coil 6a. Lens lamps of this type can be obtained with diameters of up to just over 2 mm. The arrangement and focal length of the lens are such that the light issuing from the coil 6a is shaped into a sharp-pointed cone. Above the lamp 6, and ahead of it in the direction of travel of the film, is an aperture 5a, within which there is provided a glass window 10 to prevent dust entering the housing. The aperture may be formed, for example, by means of a milling disc.

In a direction normal to the direction of advance of the strip, a large number of similar tubular lamps are placed next to one another. As shown in Fig. 2a, intermediate diaphragms 107 ensure that the light from each lamp can only reach its corresponding aperture 5a.

Light from the lamp 6 is projected into the aperture by means of a concave elliptical mirror 7. The mirror 7 is so constructed and arranged that the coil of the lens lamp 6 is at one focal point of the ellipse, whilst the other focal point of the ellipse lies on the underside of the film strip 2. Immediately below the point at which the light beam meets the layer support, non-directional scattered light falls downwards in a normal direction through a tube 8 to a photo-receiver 9. In order to obtain high resolution of marks which are small and have sharp edges, the width of the tube 8 will be of the order of several tenths of a millimetre.

As a result of the impingement of the light beam on the strip 1 at an angle, specular reflection from the underside of

the strip does not reach the photo-receiver 9, or reaches it only after repeated diffusing reflections on the side walls of the tube 3. The output signal from the photo-receiver is therefore determined substantially by the intensity of the scattered light. This in turn leads to a considerably more favourable signal-to-noise ratio than would be obtained if the specular reflected beam were to be used. Thus, especially with a heavily glued material, plastic-coated paper, or with marks exposed onto the emulsion side of a film strip there is a high degree of reflection both in the darkened areas and in the undarkened areas so that, for example, if measurements were made using specularly reflected beams, a shining graphite mark would produce almost the same value as a matt, undarkened paper surface.

The reflecting mirror 7 need not be exactly elliptical. It is sufficient for the reflecting surface to lie on the great circle of curvature of an ellipse, and this simplifies the production of the mirror.

Referring now to Fig. 3, the substantially continuous straight line 11 shows the value at which the output currents of the individual photoelectric elements of the scanning units are kept by means of the lamp intensity with undarkened material. The region 11a represents the output current for a good graphite mark; it can be seen that the measured intensity and thus the current emitted sinks to approximately half the value for undarkened material. The width of the photo-electric element of each scanning unit is such that the region corresponding to the magnitude a in Fig. 1, extends over at least two scanning units, that is to say, the width of each scanning unit does not exceed $\frac{1}{2}a$. In this way, at least one scanning unit will detect over its whole photo-sensitive surface an area having differing absorption capacity. The curve for the measured values of the scanning elements which is indicated by 12 and shown by broken lines is that produced by a mark which extends over a substantial part of the width of the web 1 with a gradation which is less than that of the mark 2, for example, an order number 3. When the dimension of a mark passing over the scanners is less than the dimension b of the mark 2 in the direction of travel of the web, the intensity of illumination of the scanning elements may vary as represented by the curve 13. Although the curves 13 do in fact represent areas with a very high absorption capacity, a mark signal will not be emitted in such a case owing to the limited width of this disturbance, since in each of the scanning areas defined by the tubes 8 light from the undarkened areas will be mixed with the

limited scatter from the strongly absorbing areas 13.

A circuit for the evaluation of the photo-responsive elements in such a way that only the signal 11a leads to the delivery of a mark signal, is shown in Fig. 4. A photovoltaic cell 9 is connected, together with the photovoltaic cells of the other scanning elements, in parallel by way of a resistor 14 to a voltage source, and the cells 9 are also connected to chassis by way of two diodes 15, 16. The output of the photovoltaic cell 9 controls a Darlington transistor 17 acting as impedance transducer with negative feedback by a resistor 18. The output voltage of the transistor 17 is led to an amplifying device 22, and also to a so-called Or-circuit.

Referring first to the Or-circuit, the output signal of the transducer 17 is applied by way of a diode 19 to the base of a transistor 20 and also, by way of a resistor 21 in series with a further resistor 29, to the emitter of the same transistor 20. Between the resistors 21 and 29 there is a tapping for a high capacitance capacitor 30, which is connected, for example, to chassis. The collector of the transistor 20 is connected to chassis by way of an operating resistor 31 and is directly connected to one input of an operational amplifier 33 acting as comparator. Negative feedback is provided by means of a resistor 32. The second input of the amplifier 33 is connected to the slider of a potentiometer 34 which is connected as a voltage divider and is arranged to deliver the comparison voltage to the amplifier 33. The amplifying device 22 controls the intensity of the lamp 6 and is arranged to keep the output signal of the photovoltaic cell 9 at a constant value in the absence of a mark, a retarding device delaying changes in the lamp intensity in order that marks may be detected. By way of a Zener diode 23, a comparison voltage is delivered to the amplifier 22. This voltage is the same for all scanning elements and is applied to the emitter of a first amplifying transistor 24. The output of the transistor 17 is applied to the base of the amplifying transistor 24 by way of a resistor 25. Connected between the base and the collector of the transistor 24 there is a capacitor 26 which performs the retarding function; and connected to the collector of the transistor 24 is the base of a second amplifying transistor 27. The lamp 6 is connected into the emitter/collector section of the second amplifying transistor by way of a resistor 28.

A circuit comprising an impedance transducer 17, 18 and amplifying device 22 is provided for each of the photo-voltaic cells 9. Each such circuit is connected to the common voltage source for the photo-vol-

taic cells 9, and receives by way of the Zener diode 23 the comparison voltage for the first amplifying transistors 24, and the circuits are connected to the common evaluation device of the Or-circuit including the transistor 20. For this purpose, the resistors 21 are connected to a common point, as are the diodes 19.

The method of operation of the apparatus is as follows:

If a paper strip as shown in Fig. 1 is drawn with its uncoated reverse side over the scanning device shown in Figs. 2 and 2a, the photo-receivers 9 deliver voltages which are dependent on the intensity of the light which is incident on them. This incident intensity depends firstly on the intensity of the lamps 6 and, secondly, on the proportion of scattered light from the surface of the strip. By means of the common comparison voltage delivered by the Zener diode 23, the voltage for all the lamps 6 is so regulated that all the photovoltaic cells 9 behind their impedance transducer 17 deliver a voltage which lies on the straight line 11 in Fig. 3. The alteration of the voltage for the lamps 6 takes place with a certain delay, however, the duration of which is determined by the capacitance of the capacitor 26. After regulation of the lamp intensity, the diodes 19 have substantially equal voltage applied to them. The voltage is also applied to the base of the transistor 20. The voltage at the emitter of the transistor 20 is determined by the time-related average value of the signals at the resistors 21 averaged by means of the capacity 30. This time-related average corresponds to the means reflective capacity of the web of material. When the web of material is undarkened the transistor 20 remains blocked.

If a mark corresponding to the correction values 3 shown in Fig. 1 now moves over the scanning device, a current value corresponding approximately to the line 12 in Fig. 3 is delivered by the photovoltaic cells of a large number of scanning elements, until the lamp voltages are adjusted to compensate. The diode 19 to which the highest signal is applied remains conductive, while the other diodes are blocked. The collector of the transistor 20 therefore delivers a signal to the comparison device 33 which is in fact the greatest one measured. Owing to the setting of the resistor 34, however, this signal is not sufficient to cause a mark signal to be emitted at the output of the comparator 33.

When the mark 2 moves over the scanning device, one of the photovoltaic cells 9 will lie completely in the region of the gradation. Consequently, the current from that photovoltaic cell 9 sinks, with the re-

sult that the voltage at the output of the impedance transducer 17 also falls. The value of the comparison voltage derived from the potentiometer 34 is such that the reduced voltage delivered by 17 when a mark 2 is over the scanning device causes the comparison device 33 to respond. A mark signal is thus emitted at the single output of the device 33. The capacitor 26 is of such large dimensions, however, that it prevents adjustment of the lamp intensity in the short period during which the mark 2 influences the light flow onto the photovoltaic cell 9.

The amplifying device 22 enables the range of signal magnitudes within which a mark signal is to be emitted to be made considerably greater, without any fear that either ageing phenomena of the electrical components or a general alteration in the reflective capacity of the web 1, that is to say, its brightness, mark signals will be emitted when a disturbance corresponding approximately to the lines 12 or 13 in Fig. 3 passes the scanning device.

Instead of the Or-circuit shown in Fig. 4, other known direct-or alternating-current circuits can be provided for the formation of a function of this type.

An automatic cutting device which stops the web transport and sets a blade in motion is connected for example to the comparison device 33 in a known manner. The next transport step then takes place until the next mark is detected.

If the web is guided with any ordinary degree of accuracy during the application and scanning of the marks, three scanning units will generally suffice for adequately accurate detection of the applied marks.

WHAT WE CLAIM IS:

1. Apparatus for detecting scannable marks of predetermined width applied to strip material, which comprises means for laterally guiding strip material, devices for scanning a plurality of areas situated adjacent to one another across a strip moving along the path defined by the guide means, each of which scanning devices includes means for illuminating a different one of the said areas and a photo-electric transducer arranged to receive light reflected from that area, and means for emitting a signal at a single common output when the response from any one of the transducers differs in a predetermined sense from a threshold value, the width of each of the said areas (measured across the strip path) not exceeding said predetermined mark width (measured across the strip).

2. Apparatus as claimed in claim 1, wherein the width of each scanned area is less than said predetermined mark width.

3. Apparatus as claimed in claim 1 or claim 2, wherein the width of each of the

taic cells 9, and receives by way of the Zener diode 23 the comparison voltage for the first amplifying transistors 24, and the circuits are connected to the common evaluation device of the Or-circuit including the transistor 20. For this purpose, the resistors 21 are connected to a common point, as are the diodes 19.

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If a mark corresponding to the correction values 3 shown in Fig. 1 now moves over the scanning device, a current value corresponding approximately to the line 12 in Fig. 3 is delivered by the photovoltaic cells of a large number of scanning elements, until the lamp voltages are adjusted to compensate. The diode 19 to which the highest signal is applied remains conductive, while the other diodes are blocked. The collector of the transistor 20 therefore delivers a signal to the comparison device 33 which is in fact the greatest one measured. Owing to the setting of the resistor 34, however, this signal is not sufficient to cause a mark signal to be emitted at the output of the comparator 33.

When the mark 2 moves over the scanning device, one of the photovoltaic cells 9 will lie completely in the region of the gradation. Consequently, the current from that photovoltaic cell 9 sinks, with the re-

sult that the voltage at the output of the impedance transducer 17 also falls. The value of the comparison voltage derived from the potentiometer 34 is such that the reduced voltage delivered by 17 when a mark 2 is over the scanning device causes the comparison device 33 to respond. A mark signal is thus emitted at the single output of the device 33. The capacitor 26 is of such large dimensions, however, that it prevents adjustment of the lamp intensity in the short period during which the mark 2 influences the light flow onto the photovoltaic cell 9.

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Instead of the Or-circuit shown in Fig. 4, other known direct-or alternating-current circuits can be provided for the formation of a function of this type.

An automatic cutting device which stops the web transport and sets a blade in motion is connected for example to the comparison device 33 in a known manner. The next transport step then takes place until the next mark is detected.

If the web is guided with any ordinary degree of accuracy during the application and scanning of the marks, three scanning units will generally suffice for adequately accurate detection of the applied marks.

WHAT WE CLAIM IS:

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2. Apparatus as claimed in claim 1, wherein the width of each scanned area is less than said predetermined mark width.

3. Apparatus as claimed in claim 1 or claim 2, wherein the width of each of the



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said areas is less than half the said predetermined mark width.

4. Apparatus as claimed in any one of claims 1 to 3, wherein each transducer is arranged to receive substantially no specular reflection.

5. Apparatus as claimed in any one of claims 1 to 4, wherein each scanning device includes means for deflecting onto the strip the beam emitted by a light source.

6. Apparatus as claimed in claim 5, wherein each deflecting means comprises a substantially elliptical reflecting surface, the light source being at one focus of the ellipse and the area to be illuminated by that light source being at the other focus.

6. Apparatus as claimed in claim 5, wherein each reflecting surface lies on the great circle of the ellipse.

7. Apparatus as claimed in any one of claims 4 to 6, wherein each light source is arranged to emit a beam in a plane parallel to the plane of a strip within the guide means.

8. Apparatus as claimed in claim 7, wherein each light source comprises a lens lamp disposed in a plane parallel to the plane of a strip lying within the guide means.

9. Apparatus as claimed in any one of claims 1 to 8, wherein each transducer is arranged to receive light reflected in a direction normal to its associated area of the strip.

10. Apparatus as claimed in any one of claims 1 to 9, wherein the illuminating means includes a plurality of light sources arranged adjacent to one another, and there is provided a plurality of diaphragms arranged to prevent light from each source from being incident on more than one of the said areas.

11. Apparatus as claimed in any one of claims 1 to 10, which includes control means for maintaining the outputs from the transducers at the same predetermined level in the absence of a mark, and means for retarding operation of the control means to enable marks to be detected.

12. Apparatus as claimed in claim 11, wherein the control means includes means for controlling the intensity of the illuminating means.

13. Apparatus as claimed in claim 11 or claim 12, wherein the control means comprises a plurality of amplifying devices

connected one to each transducer.

14. Apparatus as claimed in claim 13, which includes means for supplying a common comparison signal to each amplifier, each amplifier being arranged to compare the output of its associated transducer with the comparison signal and to control the corresponding illuminating means accordingly.

15. Apparatus as claimed in claim 14, wherein the comparison signal supply means comprises a Zener diode, each amplifier includes two transistors, the first of which is connected at its base to the corresponding transducer, at its emitter to the Zener diode, and at its collector to the base of the second transistor, the emitter collector section of which lies in the supply circuit of the corresponding illuminating means, and the retarding means comprises a capacitor connected between the base and the collector of the first transistor.

16. Apparatus as claimed in any one of claims 1 to 15, wherein the signal-emitting means includes an OR-circuit arranged to deliver only the highest transducer output at any instant to a comparator for emitting the said signal.

17. Apparatus as claimed in claim 16, wherein there is provided a tapping from each transducer to the OR-circuit, and the OR-circuit includes a transistor to the base of which each tapping is connected by way of a diode and to the emitter of which each tapping is connected by way of a resistor, the collector of the transistor being arranged to deliver to the comparator the said highest output.

18. Apparatus for detecting marks applied to strip material, constructed substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

19. A scanning device constructed substantially as hereinbefore described with reference to, and as shown in, Figs. 2 and 2a of the accompanying drawings.

20. Apparatus as claimed in any one of claims 1 to 17, wherein the scanned areas do not extend across the whole width of the strip path.

ABEL & IMRAY,
Chartered Patent Agents,
Northumberland House,
303-306 High Holborn,
London, WC1V 7LH.

