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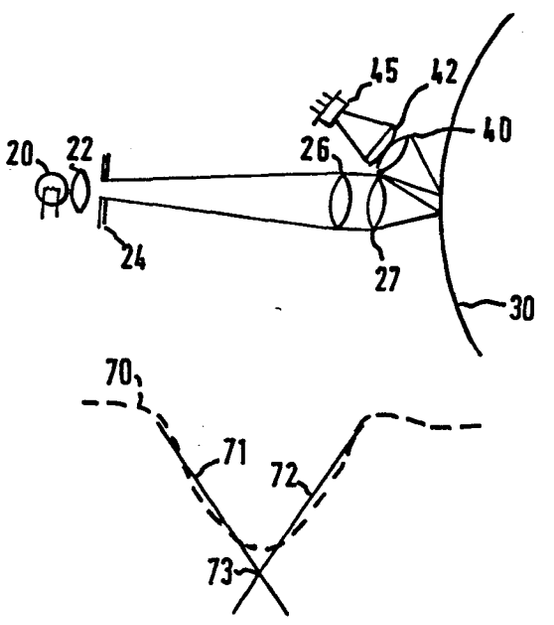
(54) Web registration measurement system.

(57) Web register measurement apparatus for use with a travelling web (30) carrying register marks (32, 34) of a predetermined shape and predetermined spacing along the direction of web travel includes an optical reader head (10) which has a lamp (20) for producing a light spot on the web (30) and a photodetector (45) for detecting light reflected from the spot on the web (30). The photodetector (45) in use produces an output signal 70 representative of the intensity of the reflected light. A pattern-recognizing unit 12, e.g. a computer or a microprocessor, is provided to analyse the output signal 70 to determine the exact centre of the signal 70, i.e. the moment of the minimum value 73 of the intensity of the reflected light by fitting the best slopes 71, 72 to the actual waveform of the signal 70. By determining the time intervals between the occurrences of such minimum values, lateral and/or longitudinal registration errors are deducible. A mask (24) is interposed either between the lamp (20) and the web (30) or between the web (30) and the photodetector (45), the mask (24) carrying a pattern which consists of at least one light-transmitting area (25, 125, 225, 325, 425) and non-transmitting area(s) and which is correlated with the register marks (32, 34) so as to produce a well-defined transition in the magnitude of the photodetector output (70, 71, 72).



EP 0 184 907 A1

WEB REGISTRATION MEASUREMENT SYSTEM

The present invention relates to a web registration measurement system for use, e.g. in printing presses printing in a plurality of colours on a continuously moving web, such as paper.

In such printing presses the colour of the finished printed matter is the result of a superimposition of several 'runs' of printing with different colours. It is clearly extremely important for a satisfactory product that the successive runs should be highly accurately controlled to ensure that substantially no relative displacement of the printed images to be superimposed should be perceivable.

To this end, webs have commonly been provided with register marks in the various colours of printing. The marks are first detected e.g. by an optical scanner and the separation between two marks is obtained. This separation is then compared with a desired value and a register error value is obtained. Then the error is sought to be corrected.

Register error may be longitudinal or lateral or a combination of these. Longitudinal error means that the separation of a given pair of marks along the direction of movement of the web is incorrect while lateral error means the transverse displacement of one colour, relative to another.

One known web registration measurement system described in GB-A-2 065 871, in which, in one form, the apparatus is capable of detecting both longitudinal and lateral error. The web is provided with a series of right-angled triangle-shaped marks. A single scanning head including a photodetector provides a signal for each mark passing under it while simultaneously the web speed is measured. Longitudinal error is obtained from

electronic processing circuitry which measures the time interval between the passage of the leading edges of a pair of marks and which multiplies the time value with the web speed value.

Lateral register error is obtained by measuring the interval between the leading and trailing edges of each mark passing the scanner and calculating the difference between the respective values of this interval for a pair of marks. This difference multiplied by web speed can be shown to be proportional to the lateral register error.

This known apparatus suffers from several drawbacks. The marks are relatively small and thus small spots of illumination are required. However, such small spots of light give rise to small photodetector output signals which may change only slightly with some colours (e.g. yellow) and are very sensitive to the physical and chemical structure of the web and to 'noise' in the circuitry. A further serious problem that this apparatus cannot solve satisfactorily occurs when the plane of the web deviates from its nominal plane: this means that the illuminating spot is no longer in focus at the target, so the amount of light reflected and available for detection is considerably reduced and the sharpness of the transition reduced. If the lateral excursion of the web takes the stop to one of the tips of the triangular mark, the distance between its leading and trailing edges becomes comparable to the spot size, causing resolution problems. Also, in that region the presence of dirt or a blemish on the web results in large inaccuracies of detection.

The present invention seeks to overcome the drawbacks of this and other known web registration measurement systems and to provide a system which is not appreciably sensitive to: noise, register mark colour, the state of focussing, lack of uniformity of illumination and the presence of dirt or blemishes.

According to a first aspect of the present invention, there is provided for use with web register measuring apparatus

that includes means for illuminating a spot on a travelling web and detecting means which are responsive to the reflected brightness of the spot which varies with the passage of register marks of a predetermined shape and spacing applied on the web and which are adapted to provide a corresponding electrical output:

a mask adapted to be interposed between either the illuminating means and the web or between the web and the detecting means and provided with a pattern of at least one light-transmitting area and at least one non-transmitting area, the said pattern being correlated with the said register marks so as to produce a well-defined transition in the magnitude of the said output respectively either when the image of said at least one light-transmitting area falls on a said register mark (or on a part thereof) or when the image of a said register mark (or on a part thereof) falls on said at least one light-transmitting area.

According to a second aspect of the invention, there is provided web register measurement apparatus for use with a travelling web carrying register marks of a predetermined shape and predetermined spacing along the direction of web travel, comprising illuminating means for illuminating a spot on the web, detecting means for detecting light reflected from the spot on the web and producing an output representative of the intensity of the reflected light, and analysing means for analysing the said output to determine the exact moment of minimum value of the intensity of the reflected light and for determining the time intervals between the occurrences of such minimum values.

According to a third aspect of the invention, there is provided web register measurement apparatus for use with a travelling web carrying register marks of a predetermined shape and predetermined spacing along the direction of web travel, comprising illuminating means for illuminating a spot on the web, detecting means for detecting light reflected from the spot on the web and producing an output representative of the intensity of the reflected light, and a mask interposed between either the illuminating means and the web or the web and said detecting means, the

said mask carrying a pattern consisting of at least one light-transmitting area and non-transmitting area(s), the said pattern being correlated with the said register marks so as to produce a well-defined transition in the magnitude of the said output respectively either when the image of said at least one light-transmitting area falls on a said register mark (or a part thereof) or when the image of a said register mark (or a part thereof) falls on said at least one light-transmitting area.

Preferably, the said pattern is generally of diamond shape and contains a plurality of diamond-shaped and/or rectangular light-transmitting areas, and wherein the correlated register marks are generally chevron-shaped; said areas and said register marks may extend at about 45° to the longitudinal direction of travel of the web, the detecting means being responsive to substantially complete extinction of reflected light.

In a preferred embodiment of said second aspect of this invention, a mask is interposed between either the illuminating means and the web or between the web and said detecting means, said mask being provided with a pattern of at least one light-transmitting area and non-transmitting area(s), the said pattern being correlated with the said register marks so as to produce a well-defined transition in the magnitude of the said output either when the image of said at least one light-transmitting area falls on a said register mark (or a part thereof), or when the image of a said register mark (or a part thereof) falls on said at least one light-transmitting area, respectively.

The said detecting means may be a photodetector effective to produce at least one electric output pulse for each passage of a register mark and said analysing means includes electronic means effective to find the exact centre of said pulse.

Advantageously, the electronic means is a microprocessor or a computer programmed to fit the best lines of the anticipated theoretical shape to the leading and trailing edges of the actual output pulse.

In one embodiment, the mask has a square or rhombic light-transmitting area and the web register marks are generally chevron or V-shaped. Expediently, the width of each limb of the register mark in the direction of travel of the web equals the apex to apex distance of the rhombus or square of the light-transmitting area. Advantageously, the included angle between adjacent sides of the square as well as the included angle between the limb of the chevron or V may be substantially 90° so that the sides of the square are inclined at 45° to the direction of travel of the web.

Preferably, the register marks include an extra mark shaped differently from the remaining register marks and serving both to locate the remaining register marks and to enable a calculation of web travel speed to be made; this extra mark may be a solid parallelogram or rhomboid, the shorter sides matching in length and angle one side of one limb of the chevron or V.

Other preferred embodiments include cases where a) the mask has a circular light-transmitting area and the web register marks are also circular; b) the mask has a circular light-transmitting area and the web register marks are shaped as triangles; or c) the mask has a circular light-transmitting area and the web register marks are also circular, the latter being grouped for each colour into a series of identical marks, identically coloured.

The invention is described, merely by way of example, with reference to the accompanying purely schematic drawings, wherein:

Figure 1 is a block diagram of apparatus according to the invention;

Figure 2 is a diagrammatic representation of the part of the apparatus comprised in the first block of the diagram of Figure 1;

Figure 3 is a diagrammatic representation of a mask for use with the apparatus according to Figures 1 and 2;

Figure 4 is a diagrammatic representation of register control marks on a web for use with the apparatus according to Figures 1 and 2 and the mask according to Figure 3;

Figure 5 is a diagrammatic voltage waveform obtained in use of the apparatus according to Figures 1 to 4;

Figure 6 is an enlarged detail of the waveform according to Figure 5, and

Figures 7 to 10 represent four additional and alternative embodiments of respective 'triplets' of mask shape, web register control mark shape and voltage waveforms.

Referring first to Figures 1 to 6, web register control apparatus comprises as sub-units a block 10 including an optical reading head and a detector; an amplifier unit 11; a pattern recognizing unit 12 and a display unit 13.

The block 10 is illustrated in Figure 2. It comprises a lamp 20, a lens 22 which collects light from the lamp 20 and passes it to a mask 24. The mask 24 has an aperture or a light-transmitting area 25 shaped as a square inclined at 45° to the horizontal (Figure 3).

The light from the mask 24 passes through lenses 26, 27 which image it as a tilted square spot on the surface of a web 30, e.g. paper travelling in long continuous lengths in a colour printing press (not shown) in which differently coloured images must be accurately superimposed or placed relative to each other to produce a desired final image. To assist in achieving this, the web 30 is provided with a plurality of web register control marks 32 of identical shape but (usually) of different colour spaced apart by predetermined equal distances. In addition, for a purpose described later, a further solid parallelogram-shaped control mark 34 is provided at the beginning (relative to the direction of web travel) of the series of the marks 32. These marks 32, 34 could be rhombic and rhomboidal, respectively.

In use, light reflected from the web 30 is collected by a lens 40 and passes through a colour filter 42 to a photodetector 45 effective to produce an electronic output signal which is an analogue of the intensity of the light reflected from the web 30 and reaching it. The filter 42 assists in equalising the magnitude of

the output signals for differently coloured webs and/or register marks.

The marks 32 are generally solid V-shaped or chevron-shaped. The two limbs of the V are at 90° to each other and 45° to the axis of travel. Each limb is of a predetermined thickness which corresponds to the length of each side of the square aperture or transmitting area 25 of the mask 24, or the optical system (to be described) is such that the square image has such length of sides. In this way the whole of the image can fall on a wholly solid part of the mark to produce a very sharp reduction (or extinction) of the amount of light reflected from the mark 32.

The mark 34 is a locator mark of parallelogram outline the shorter sides of which are equal in length to the sides of the chevrons (area 32).

Figures 5 and 6 show the waveforms of the output pulses. The upper horizontal line 50 represents 100% light transmission while the lower horizontal line 52 represents 0% light transmission. It will be seen that as the mark 34 passes under the mask the corresponding waveform 60 exhibits a generally trapezoidal dip in the signal, due to the passage of the leading and trailing edges of the mark, inclined at 45° (135°) to the direction of travel of the web. The pulse 60 serves to locate the other marks 32 on the web and from the separation of its flanks an approximation of the web velocity can be deducted.

The passage of each mark 32 under the mask 24 produces a double-peaked waveform 62, i.e. two essentially triangular pulses 63, 64 one of which is shown enlarged in Figure 6.

It will be evident that by comparing the separation of the peaks of a pair of pulses 63, 64 with the corresponding separation for a reference pair of masks (usually black), the lateral register error can be deduced, given knowledge of the web travel velocity. It will also be evident that

the averaged position of the centre of each pair of pulses can be used as the measure of longitudinal register error since the time (distance) between the same point on successive pulses is proportional to this error for constant web velocity. The web velocity can be determined accurately from a knowledge of the separation between the most widely separated of marks 32, these two being of the same colour (usually black).

In reality and as shown in dotted lines in Figure 6 the actual output signal 70, after amplification, will exhibit an irregular shape due to noise. Hence the unit 12 is employed to fit the best straight lines 71, 72 to the noisy points of the curve 70 and in this way the exact centre point 73 of the dip in the curve 70 is obtained. The unit 12 includes a microprocessor or a computer, using a programme containing information stored about mark colour, shapes, separation, sequence of colours etc., to obtain the best match. In this way the accuracy obtainable is 10-100 times better than the width of the dip in the signal 70. Moreover, reliable results can be obtained even if the mask aperture or the area 25 is not well focussed on the web and/or if the illumination is not uniform and/or if the image is rotated or partly obscured and/or if blemishes occur on the web.

Figures 7 to 10 show triplets of mask shape, register control marks and output signal waveforms. These triplets are alternatives to the embodiment described so far, and the same reference numbers will be used, apart from being augmented by 100, 200, 300 and 400, respectively.

Figure 7 shows a circular mask aperture or light-transmitting area 125 correlated with circular register marks 132. This combination gives rise to a generally sinusoidal waveform 162. Although this embodiment is feasible, finding the exact bottom of the curve is relatively difficult.

Figure 8 shows a smaller circular mask aperture or light-transmitting area 225 with a wedge-shaped or, more precisely, right-angled triangle-shaped register mark 232, known per se. The signal waveform 262 is well-defined when the

'spot' falls in the central area of the mark 232 but its amplitude falls away sharply when the 'spot' falls to the narrower apex area of the mark.

Figure 9 shows (on a scale greatly enlarged relative to Figures 7, 8 and 10) a mask with a rhombic outline filled with a complex pattern of rhombic and rhomboidal light-transmitting areas 325 of differing sizes correlated with generally chevron-shaped register marks 332. Each limb of the V is inclined at 45° to the direction of web travel and comprises a plurality of parallel, alternating white (light-reflecting) and black (light-absorbing) bands of different thicknesses. A superimposition of the two results in an extremely well-defined sharp peak in the waveform 362 or transition in the level of the intensity of reflected light. The advantage of the well-defined output signal is however somewhat offset by the difficulty of an optical arrangement that would operate satisfactorily in all anticipated operating circumstances.

Finally, Figure 10 shows a circular mask aperture or light-transmitting area 425 associated with a group of e.g. four circular register marks 432, all of the same colour, there being similar groups (not shown) for the other colours. The resulting waveform 462 is a relatively 'pure' sine wave when one circle crosses another in exact overlap, i.e. a total 'eclipse' occurs. The phase of the sine wave allows longitudinal errors to be deduced. As the image moves off the desired line the waveform 462 flattens out and by matching each dip to a part-sine wave the lateral error can be deduced.

Self-evidently other shape/configuration combinations of mask aperture and register marks are possible. Furthermore, the optical arrangement of Figure 2 could be reversed by exchanging the positions of the lamp and detector, i.e. so that the mask is over the detector.

CLAIMS

1. Web register measurement apparatus for use with a travelling web (30) carrying register marks (32, 34) of a predetermined shape and predetermined spacing along the direction of web travel, comprising illuminating means (20, 22, 26, 27) for illuminating a spot on the web, detecting means (45) for detecting light reflected from the spot on the web and producing an output (70, 71, 72) representative of the intensity of the reflected light, characterised in that analysing means (12) are provided for analysing the said output (70, 71, 72) to determine the exact moment of the minimum value (73) of the intensity of the reflected light and for determining the time intervals between the occurrences of such minimum values, lateral and/or longitudinal registration errors being deducible from said time intervals.

2. Web register measurement apparatus for use with a travelling web (30) carrying register marks (32, 34) of a predetermined shape and predetermined spacing along the direction of web travel, comprising illuminating means (20, 22, 26, 27) for illuminating a spot on the web (30) and detecting means (45) for detecting light reflected from the spot on the web (30) and producing an output (70, 71, 72) representative of the intensity of the reflected light, characterised in that a mask (24) is interposed either between the illuminating means (20, 22, 26, 27) and the web (30) or between said web (30) and said detecting means (45), the said mask (24) carrying a pattern consisting of at least one light-transmitting area (25, 125, 225, 325, 425) and non-transmitting area(s), the said pattern being correlated with the said register marks (32, 34) so as to produce a well-defined transition in the magnitude of the said output (70, 71, 72) either when the image of said at least one light-transmitting area (25, 125, 225, 325, 425) falls on a said register mark (32) (or a part thereof) or when the image of said register mark (32) (or a part thereof) falls on said at least one light-transmitting area (25, 125, 225, 325, 425), respectively.

3. For use with web register measuring apparatus that includes means (20, 22, 26, 27) for illuminating a spot on a travelling web (30) and detecting means (45) which are responsive to the reflected brightness of the spot which varies with the passage of register marks (32, 34) of a predetermined shape and spacing applied on the web (30) and which are adapted to provide a corresponding electrical output (70, 71, 72),

a mask (24) adapted to be interposed between either the illuminating means (20, 22, 26, 27) and the web (30) or between the web (30) and the detecting means (45), said mask (24) being provided with a pattern of at least one light-transmitting area (25, 125, 225, 325, 425) and at least one non-transmitting area, the said pattern being correlated with the said register marks (32, 34) so as to produce a well-defined transition in the magnitude of the said output (70, 71, 72) either when the image of said at least one light-transmitting area (25, 125, 225, 325, 425) falls on a said register mark (32, 34) (or on a part thereof) or when the image of a said register mark (32, 34) (or a part thereof) falls on said at least one light-transmitting area (25, 125, 225, 325, 425), respectively.

4. Apparatus according to claim 2, characterised in that (see Figure 9) the said pattern is generally of diamond shape and contains a plurality of diamond shaped and/or rectangular light-transmitting areas (325); that the correlated register marks (332) are generally chevron-shaped; and that preferably said areas (325) and said register marks (332) extend at substantially 45° to the longitudinal direction of travel of the web (30).

5. Apparatus according to claim 4, characterised in that the detecting means (45) is responsive to substantially complete extinction of reflected light.

6. Apparatus according to claim 1, characterised in that a mask (24) is interposed between either the illuminating means (20, 22, 26, 27) and the web (30) or between the web (30) and the detecting means (45), said mask (24) being provided with

a pattern of at least one light-transmitting area (25, 125, 225, 325, 425) and non-transmitting area(s), the said pattern being correlated with the said register marks (32, 34) so as to produce a well-defined transition in the magnitude of the said output (70, 71, 72) either when the image of said at least one light-transmitting area (25, 125, 225, 325, 425) falls on a said register mark (32) (or a part thereof) or when the image of a said register mark (32) (or a part thereof) falls on said at least one light-transmitting area (25, 125, 225, 325, 425), respectively.

7. Apparatus according to claim 1 or 6, characterised in that said detecting means is a photodetector (45) effective to produce at least one electric output pulse (70) for each passage of a register mark (32) and said analysing means includes electronic means (12) effective to find the exact centre (73) of said pulses.

8. Apparatus according to claim 7, characterised in that the electronic means is a microprocessor or a computer programmed to fit the actual waveforms producted to the corresponding theoretical shapes for the particular mask and registration mark shapes used.

9. Apparatus according to claim 6 or any claim appendant thereto, characterised in that the mask (24) has a square light-transmitting area (25) and the web register marks (32) are generally chevron or V-shaped, and further characterised in that the included angle between adjacent sides of the square as well as the included angle between the limb of the chevron or V is preferably substantially 90°.

10. Apparatus according to claim 9, characterised in that the width of each limb of the register mark (32) in the direction of travel of the web (30) equals the apex-to-apex distance of the square-shaped light-transmitting area (25); and in that, optionally, the width of each limb of the register mark (32), taken in the direction transverse to the direction of travel of the web (30), equals the apex-to-apex distance of the square-shaped light-transmitting area (25).

11. Apparatus according to any of claims 6 to 10, characterised in that the register marks include an extra mark (34) shaped differently from the remaining register marks (32) and serving both to locate the remaining register marks (32) and to enable a calculation of web travel speed to be made, and further characterised in that the said extra mark (34) is preferably a solid mark of rhomboidal or parallelogram shape.

12. Apparatus according to claim 6 or claim 7 or 8 when appendant to claim 6, characterised in that the mask (24) has a circular light-transmitting area (125, 225, 425), preferably in the form of an aperture in the mask (24) and the web register marks are also circular (132, 432) or are triangular (232).

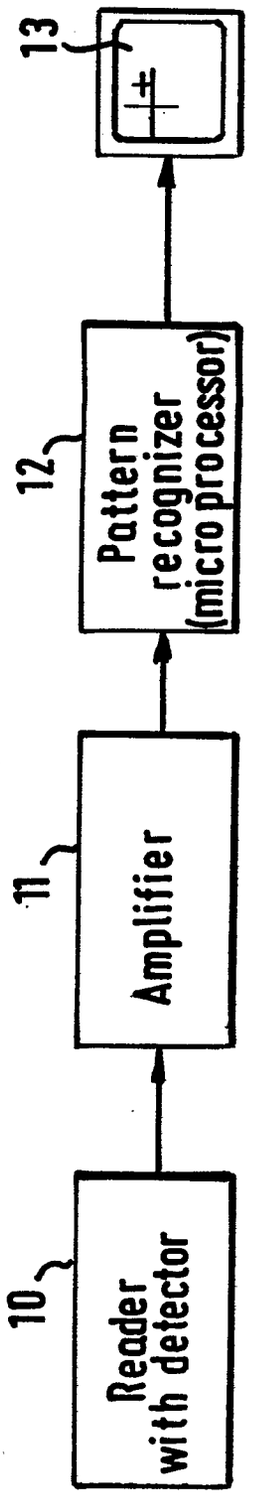


FIG.1

FIG.3

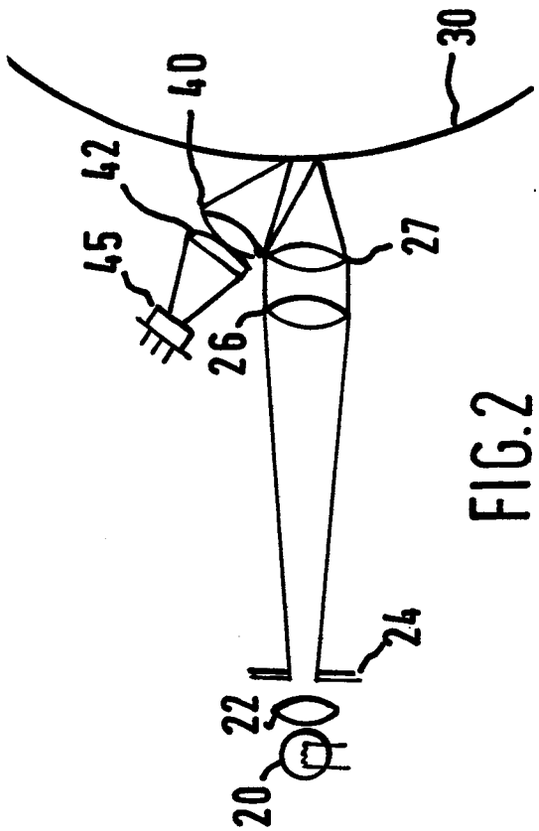


FIG.2

FIG.4

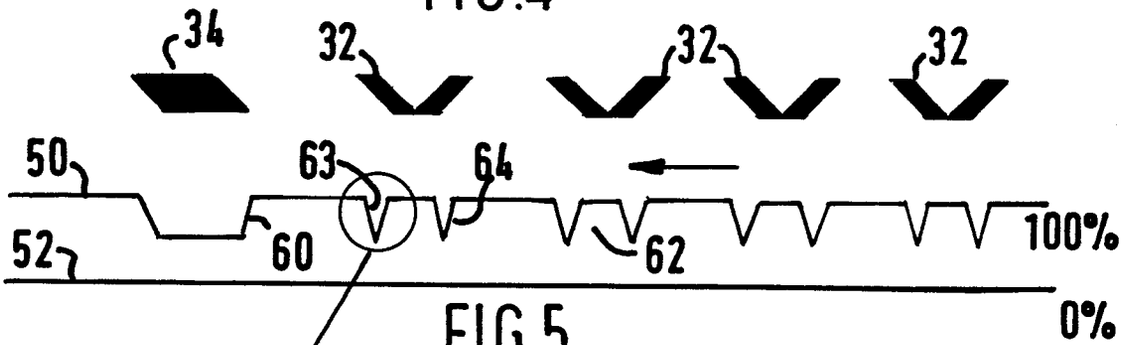


FIG.5

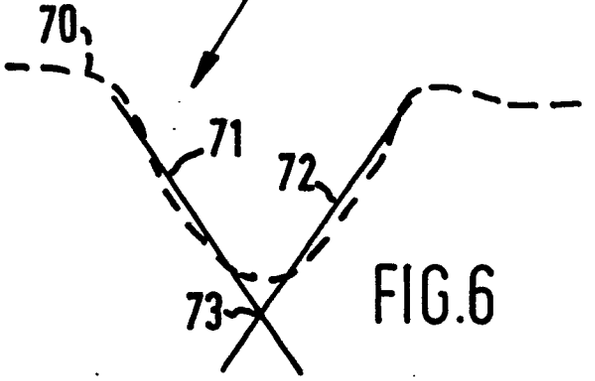


FIG.6

FIG.7

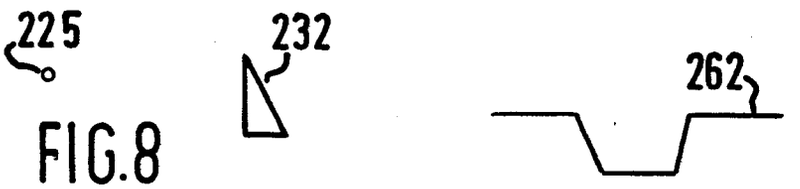


FIG.8

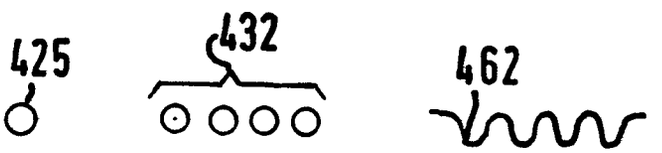


FIG.10

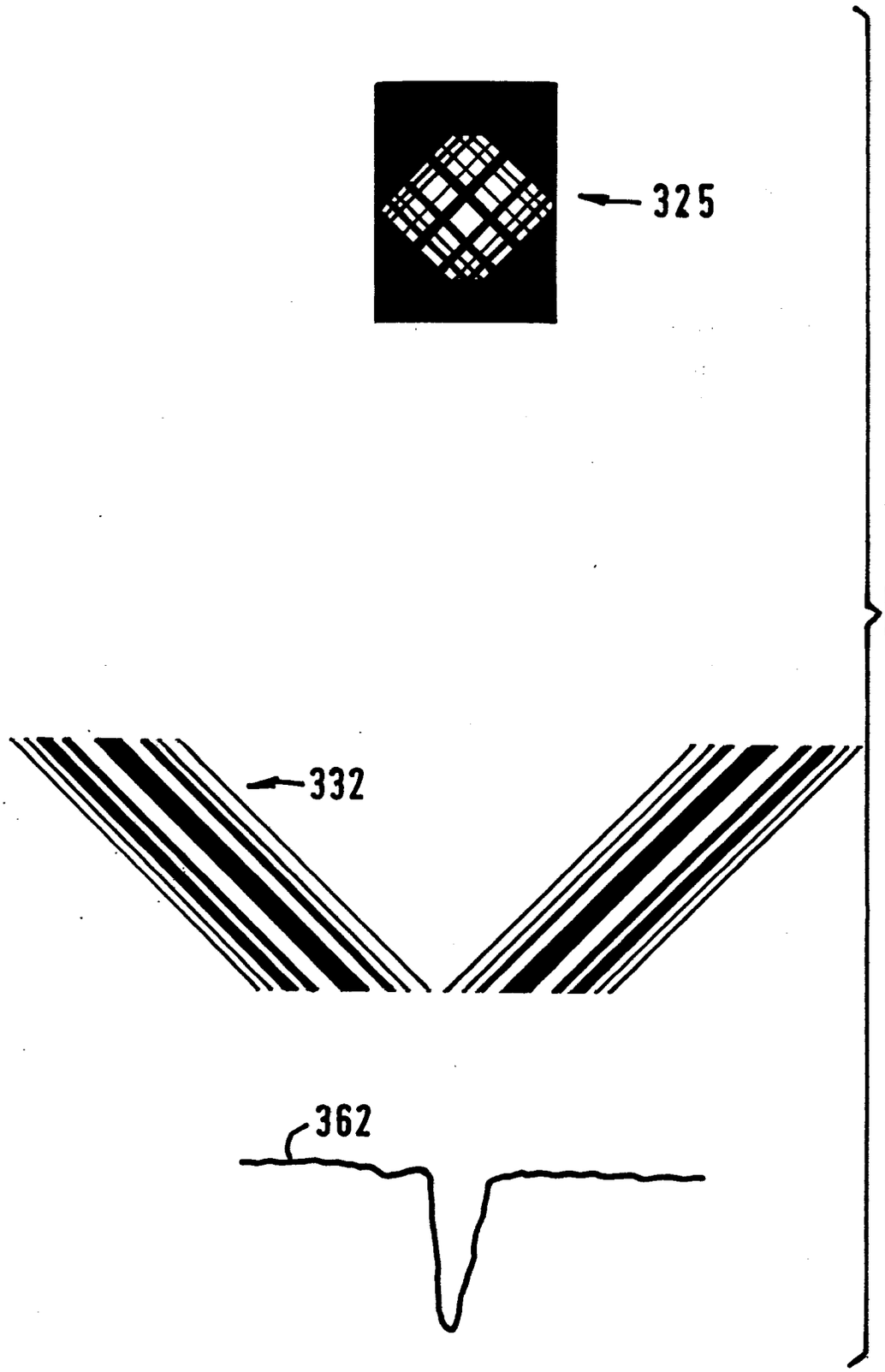


FIG.9

European Patent Office

EUROPEAN SEARCH REPORT

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 85308164.4

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
	DE - A1 - 2 731 914 (ERWIN SICK GMBH)		B 65 H 23/04 B 65 H 26/00 G 01 B 11/14
X Y	* Fig. 1-3; claims 1-8 *	1 1-3,6	
	--		
Y	DE - B2 - 2 630 209 (ERWIN SICK GMBH) * Fig. 1-5; claims 1,16,17 *	1-3,6	
	--		
D,X	GB - A - 2 065 871 (CROSFIELD ELECTRONICS)	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)
B 41 F B 65 H G 01 B

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
VIENNA	11-03-1986	SÜNDERMANN

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO Form 1503 03 82

European Patent Office

X CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid,

namely claims:

☒ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions,

namely:

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid,

namely claims:

☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims,

namely claims: