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## (54) SCANNING HEADS FOR TRANSPARENCIES


(71) We, CROSFIELD ELECTRONICS LIMITED, a British company of 766 Holloway Road, London N19 3JG, 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:—


A peculiar property of some transparency materials is their susceptibility to temporary bleaching under intense illumination. This bleaching occurs in a period of 1—2 seconds and results in a reduction of density of the order of 0·2 or 0·3 density units. The phenomenon is reversible, that is to say when the illumination is removed, the original density is restored. Of course if the illumination is too intense, or is maintained for too long a period, permanent damage is produced.

This temporary bleaching phenomenon can cause a good deal of trouble when setting up a scanner to scan a transparency, since the setting adjustments are usually made with the transparency stationary in the illuminating spot. The adjustments are thus made on the bleached state of the transparency, whereas when scanning commences, the transparency is moving rapidly through the illuminating spot and there is therefore no time for the temporary bleaching to occur. The problem does not arise with all transparency materials, but it is particularly likely to occur with materials which have been poorly processed. It is therefore difficult to detect when the phenomenon has occurred and there is therefore a clear requirement for a scanner in which the setting up adjustments will be unaffected by occurrence of this phenomenon.

A scanning image analyser according to the present invention comprises: a support for a transparency; focus-control means having a first condition in which it focuses light from a light source on to a spot on a transparency on the support and a second condition in which an area of the transparency, for viewing by an operator, is illuminated with unfocused light; photo-electric means receiving light from the source which has passed through the transparency; means for relatively moving the transparency support and the photoelectric means continuously for scanning the transparency to obtain an image-representing signal from the photoelectric means or under the control of an operator to select a spot on the transparency for density measurement; and further comprising, for measuring the density of a spot on the transparency selected by the operator, operator-controlled switching means for actuating the focus-control means to its first condition, a sample-and-hold circuit for sampling the output of the photoelectric means, and control means operating the sample-and-hold circuit within a predetermined period after initiation of illumination of the selected spot on the transparency with focused light following operation of the said switching means, whereby the value of the density-representing signal retained by the sample-and-hold circuit is independent of changes in the output of the photoelectric means occurring after the sampling period.

The predetermined period is suitably chosen, in relation to the bleaching characteristic of the transparency, to be insufficient for the focused light spot to have caused bleaching of the transparency, before the sample is taken. In the preferred form of apparatus embodying the invention a viewing screen receives the defocused image of the area of the transparency which is illuminated when the focus control means is in its second condition. This enables the operator to select the spot the density of which is required to be measured. Thus, in such an apparatus prior to a scanning operation the defocusing means is effective and the operator views an image of an illuminated area. For measuring the density of a selected spot, the light spot is focused, the selected spot is temporarily illuminated and the sample and hold circuit derives its signal from the photoelectric means; and for subsequent scanning the beam is focused and is effective through-

out the scanning operation to cause the photo-electric means to generate a signal which is continuous or substantially continuous and represents the image densities of the successively scanned points of the image.

In this way, the density of the selected spot is measured without the spot having been bleached before the measuring takes place.

In one embodiment of the invention, an auxiliary lens is inserted in the light beam to defocus the light spot for normal viewing of the transparency before taking a density measurement, and the movement of the auxiliary lens out of the light beam is timed to occur just before the sample-and-hold circuit is triggered, the sample-and-hold circuit being arranged to sample the value of the signal from a photo-multiplier which receives the light transmitted through the transparency. The sample-and-hold circuit may comprise, for example, an analogue-to-digital converter responsive to the output from the photomultiplier, a conversion cycle of the converter being triggered each time a sample-and-hold is desired. The digital output is then maintained indefinitely for subsequent processing and display of the numerical value.

In one alternative embodiment of the invention, the transparency is only momentarily illuminated with the focused light spot and the measurement of the amount of light transmitted through the transparency is synchronised to take place at the same time as the transparency is illuminated. In this case a number of measurements are normally made at the same spot on the transparency and the measurements are averaged.

In order that the invention may be better understood, two forms of apparatus embodying the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a schematic sectional view of an analysing scanner and the associated measuring circuits;

Figure 2 is a schematic view of the analysing scanner in the direction of the arrow A shown in Figure 1;

Figure 3 is a block diagram of the circuit, including sequence control, for the apparatus shown in Figures 1 and 2;

Figure 4 is a timing diagram for the circuit of Figure 3; and

Figure 5 illustrates diagrammatically a second form of analysing scanner embodying the invention.

In Figures 1 and 2, a transparency 10 is mounted on the periphery of a transparency drum 11. The diagram shows only the essential optical parts of the scanner which are located in a tube 12 positioned within the drum 11. Light from a xenon lamp 13 enters the tube at one end and is directed by a lens L1 on to a prism 14 which deflects the light downwards through a lens L2 in the wall of the tube 12 and thence through the transparency drum 11 and the transparency 10.

The light emerging from the transparency drum is received by an objective lens L3 (Figure 2) and is then redirected by a prism 15 either on to a sliding mirror 16 (when the mirror is in the position shown in Figure 2) or into the scanning head 17 (when the mirror is moved to the position shown in dashed outline in Figure 2). The scanning head is of a conventional type and will normally include apertures, colour filters and photomultipliers for recording the strength of the signal received from the transparency. In practice, sharp and unsharp apertures, beam-splitters, dichroic filters and four photomultipliers might be included within the head.

When the sliding mirror 16 is in the position shown in Figure 2, the light beam is directed on to a translucent viewing screen 18 so that the illuminated portion of the transparency can be viewed before taking any measurement. When viewing the transparency in this manner, the illuminating light spot is defocused, and this is achieved by inserting into the light beam auxiliary lens L4 (Fibure 1). This normally rests in the light path but during scanning of the transparency or during the taking of a setting-up measurement, a solenoid 19 is energised to pull the lens L4 out of the light beam. A focused light spot then falls upon the transparency. The intensity of the defocused light spot is much less than that of the focused light spot and it is therefore only when the focused light spot is incident on the transparency that the temporary bleaching phenomenon may occur.

The sliding mirror 16 shown in Figure 2 is moved between the two positions shown in response to the energisation and de-energisation of a solenoid 20. This solenoid may be, for example, a rotary solenoid and may act on the mirror through a rack and pinion.

The operating sequence of the scanner shown in Figures 1 and 2 will now be described with reference to these Figures and to Figure 3, which shows a block circuit diagram illustrating the sequence control, and Figure 4 which is a timing diagram for parts shown in Figure 3.

In the normal rest state of the scanner, the auxiliary lens L4 is in the light path and the sliding mirror 16 is in the position shown in full lines in Figure 2 where it reflects an image of a selected area of the transparency on to the viewing screen 18. The transparency drum 11 can then be moved as required to select a desired area of the transparency for observation on the viewing screen 18 by an operator. The transparency is not susceptible to bleaching at this stage because the light spot illuminating the selected area is defocused.

When the operator wishes to make a measurement of the light transmitted through a selected spot on the transparency to permit him to make preliminary adjustments to the settings of the analyser prior to the scanning operation, he aligns the selected spot with the known position of the light beam when focused. He then operates a switch 21 which acts through a pulse forming circuit 22 to initiate the operation of the solenoid timing monostable circuit 23. The circuit 23 energises the coil 24 of a solenoid relay, the contact 25 of which completes a circuit for the auxiliary lens solenoid 19 and the mirror solenoid 20. The energisation of these two solenoids results in movement of the auxiliary lens L4 and the mirror 16 out of the light path, so that a focused light beam now passes through the selected spot of the transparency to a photomultiplier or photomultipliers in the scanning head 17.

Simultaneously with the application of the pulse from the circuit 22 to the solenoid timing monostable circuit 23, a pulse is applied to a delay monostable 26. As is evident from the waveforms *b* and *c* shown in Figure 4, the delay monostable 26 generates a negative-going pulse, the purpose of which is to ensure that application of pulses from a clock oscillator 27 (waveform *a*) to a pulse counter is delayed until the solenoids 19 and 20 have completed the operations of moving the auxiliary lens L4 and mirror 16. The manner in which the pulses reach the counter will now be described. The trailing positive-going edge of the pulse from the delay monostable 26 sets a counter 30 to zero and is also applied to the "clock" input of a first D-type flip-flop 31, which will be referred to as the enabling flip-flop. As the D input of this flip-flop is permanently wired to a high voltage level, the pulse from the circuit 26 results in a high level at the Q output of flip-flop 31 and therefore at one input of an AND gate 32. As a consequence, the next pulse from the clock oscillator 27 passes through the AND gate 32 to the preset terminal of a second D-type flip-flop 33, which will be known as the clock sync flip-flop. The D input of the flip-flop 33 is permanently wired to a low voltage level. The inverted output of the AND gate 32 results in a signal from the flip-flop 33 which enables a further AND gate 34 to pass inverted clock pulses from the oscillator 27 to the counter 30. Waveform e in Figure 4 shows the output of the clock sync flip-flop and waveform f is the output of gate 34. When the fourth clock pulse reaches the counter, the counter generates a "carry" pulse at its output (waveform g, Figure 4) and this is applied to the clock input of the flip-flop 33 and the preset terminal of the flip-flop 31. The leading negative-going edge of this "carry" pulse reverses the output of the flip-flop 31 and the trailing positive-going edge of the carry pulse reverses the output of the flip-flop 33. This blocks the gate 34 so that it passes no further clock pulses.

The four pulses which are passed by the gate 34 are also applied through an inverter amplifier 35 to a sample-and-hold circuit 41 which at each clock pulse samples the output of the photomultiplier and pre-amplifier circuit 17*a* and holds this value while an analogue digital converter 42, also triggered by the clock pulse from amplifier 35, converts the held value to digital form and applies its digital output to a data processing circuit 43. The circuit 43 includes an averaging means to take the average of the 4 digital outputs from the converter 32, corresponding to the 4 samples taken in response to the clock pulse circuits. The averaging means may for example comprise an accumulator the output of which is effectively displaced two places to the right to effect the division by 4. The digital output of the circuit 43, representing the average of the 4 readings, is applied to a digital display device 44.

The pulse from the timing monostable 23 is long enough to ensure that the four readings have been taken. At the end of this pulse the solenoids 19 and 20 release and the apparatus returns to its viewing condition.

The solenoids 19 and 20 are also energised by the relay 24 when a switch 45 is actuated to start a scanning operation. This closes a circuit to the general scanner control circuits 46 which energise the relay 24 and a relay 42 controlling the energisation of the motor for producing relative movement of the drum and scanning head.

Figure 5 shows the arrangement of the beam generating means and transparency drum in an alternative form of the invention in which a rotating chopper disc 50 is formed with a small hole 51 and interrupts the passage of light from the source 13 to the tube 12 for about 99% of the time required for the disc to complete a revolution. An additional lens L5 focuses light from the source at the disc 50. The disc 50 is rotated by a small motor 52 and the assembly of motor and disc is mounted on a rocking or rotating frame operated by a solenoid 53 so that the disc can be completely withdrawn from the light path when not required. In an alternative form, an electromagnet is energised to attract a small armature attached to the disc so that the disc is held stationary in a position in which light passes through the hole 51 during viewing or scanning operations.

A photocell 54 receives light reflected from the incident side of the disc 50 and generates a trigger signal whenever the passage of the hole 51 through the light beam interrupts the reflected light received by the

photocell 54. The output of the photocell 54 triggers the sample and hold circuit. As before, the auxiliary lens L4 is out of the light path during measurements and during scanning. Thus, when measurements are taken focused light reaches the transparency for only 1% of the time and its average intensity is insufficient to cause temporary bleaching.

WHAT WE CLAIM IS:—

1. A scanning image analyser comprising: a support for a transparency; focus control means having a first condition in which it focuses light from a light source on to a spot on a transparency on the support and a second condition in which an area of the transparency, for viewing by an operator, is illuminated with unfocused light; photoelectric means receiving light from the source which has passed through the transparency; means for relatively moving the transparency support and the photoelectric means continuously for scanning the transparency to obtain an image representing signal from the photoelectric means or under the control of an operator to select a spot on the transparency for density measurement; and further comprising, for measuring the density of a spot on the transparency selected by the operator, operator-controlled switching means for actuating the focus control means to its first condition, a sample-and-hold circuit for sampling the output of the photoelectric means, and control means operating the sample-and-hold circuit within a predetermined period after initiation of illumination of the selected spot on the transparency with focused light following operation of the said switching means, whereby the value of the density-representing signal retained by the sample-and-hold circuit is independent of changes in the output of the photoelectric means occurring after the sampling period.

2. A scanning image analyser in accordance with claim 1, in which the focus-control means includes a lens for focusing light from the source and a further lens, movable in and out of the path of a beam from the source, for defocusing the light, the further lens being moved out of the beam path in response to operation of the said switching means.

3. Apparatus in accordance with claim 1 or 2, further comprising a viewing screen and means operable to provide at the viewing screen an image of the illuminated area when the focus control means is in its second condition.

4. Apparatus in accordance with claim 3, in which the means operable to provide an image at the viewing screen comprises a mirror mounted for movement into and out of the beam path and arranged, when in the beam path, to deflect light from the said area to the viewing screen.

5. A scanning image analyser in accordance with any one of claims 1 to 4, in which the control means operates the sample-and-hold circuit a number of times within the said predetermined period to provide a corresponding number of samples of the output of the photoelectric means, the image analyser further comprising an averaging circuit for generating an output representing the average of the samples.

6. A scanning image analyser in accordance with claim 1, comprising a rotating disc and means responsive to the operator-controlled switching means for moving the rotating disc into the path of light from the light source during a measurement, the rotating disc blocking light from the transparency for the major part of its cycle of rotation and having an aperture permitting the passage of light for a small portion of the cycle of rotation to reduce the average illumination of the transparency during measurement.

7. A scanning image analyser in accordance with claim 6, further comprising means responsive to the position of the said aperture during rotation of the disc for operating the sample-and-hold circuit.

8. A scanning image analyser, substantially as herein described with reference to figures 1 and 2, or figures 1 to 4, or figure 5 of the accompanying drawings.

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1583145 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
**Sheet 1**

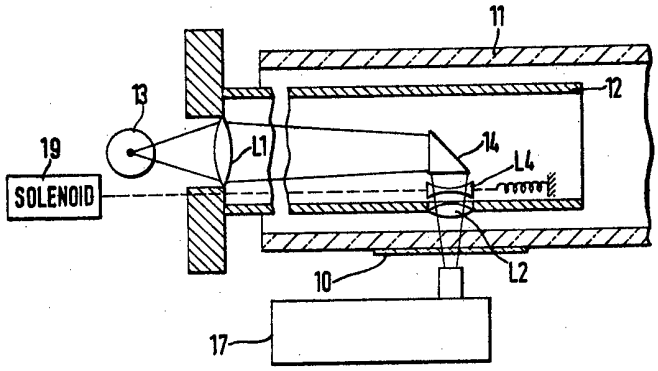



FIG. 1

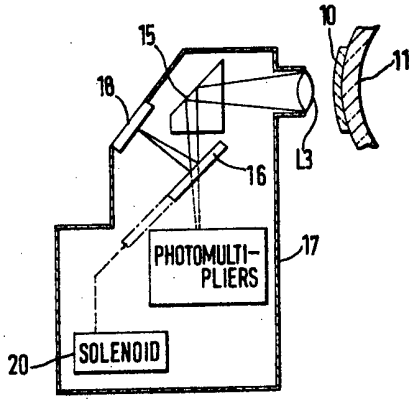



FIG. 2

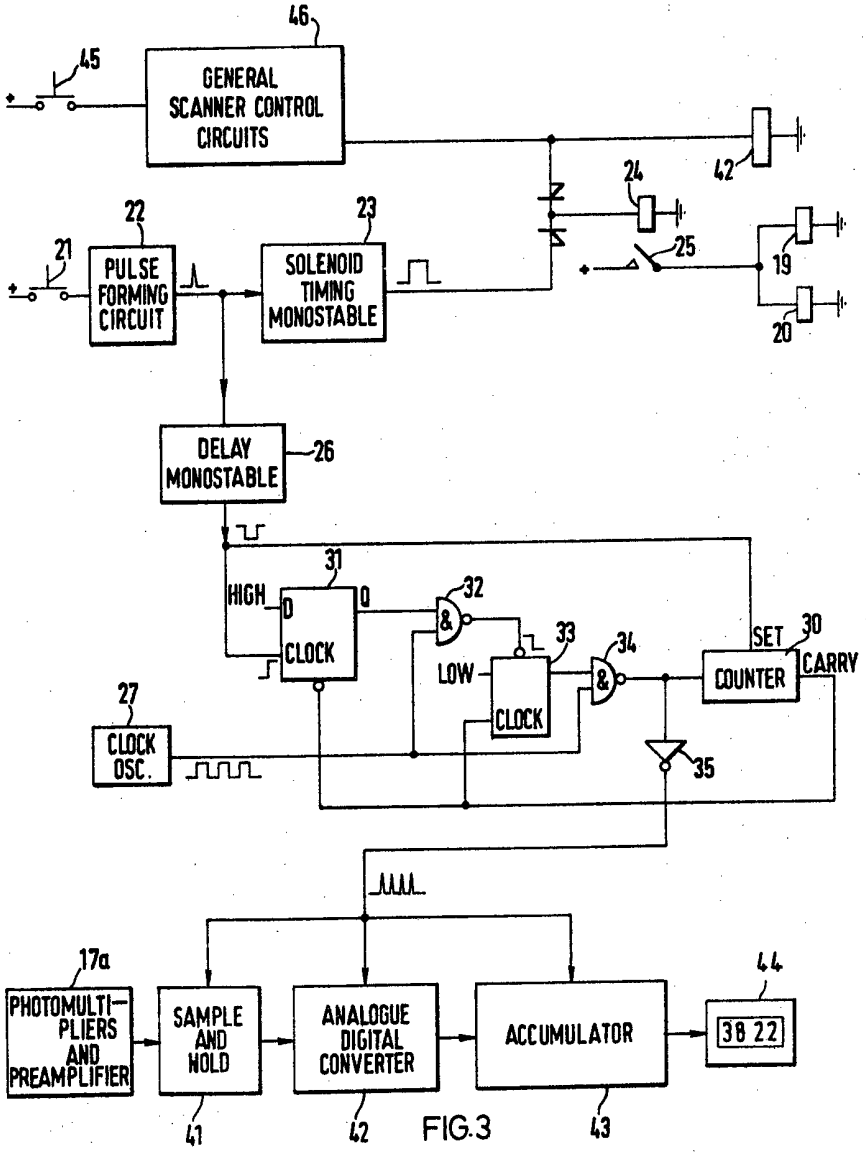

46
45
GENERAL SCANNER CONTROL CIRCUITS
42
24
22
23
21
PULSE FORMING CIRCUIT
SOLENOID TIMING MONOSTABLE
25
19
20
DELAY MONOSTABLE
26
31
HIGH
D
Q
CLOCK
32
33
34
LOW
CLOCK
SET
30
COUNTER
CARRY
27
CLOCK OSC.
35
17a
PHOTOMULTI-PLIERS AND PREAMPLIFIER
SAMPLE AND HOLD
ANALOGUE DIGITAL CONVERTER
ACCUMULATOR
44
38 22
41
42
43

FIG.3

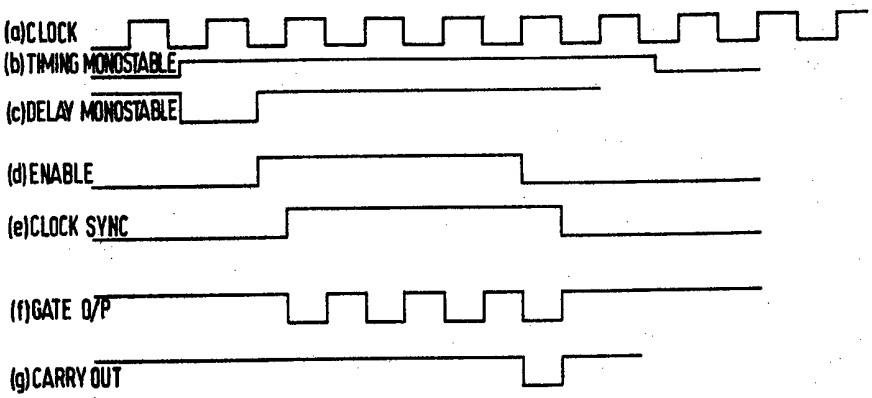

(a)CLOCK
(b)TIMING MONOSTABLE
(c)DELAY MONOSTABLE
(d)ENABLE
(e)CLOCK SYNC
(f)GATE O/P
(g)CARRY OUT

FIG.4

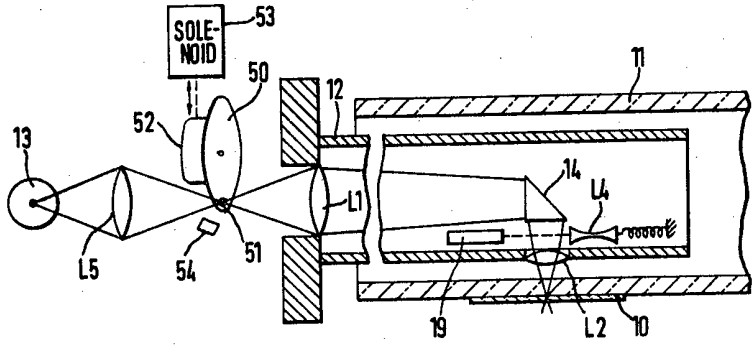

SOLE-NOID
53
50
52
12
11
13
14
L4
L1
L5
54
51
19
L2
10

FIG.5