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(54) PHOTOGRAPHIC COLOUR PRINTER

(71) We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America, of 343 State Street, Rochester, New York 14650, United States of America, 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:—

This invention relates to photographic colour printers, including a colour filter.

In subtractive colour printers, for example, it is common practice to illuminate a colour negative simultaneously with red, green and blue primary colour components from a white light source and to project an image of the illuminated negative in a printing beam on to a sheet of colour print material. Three subtractive primary filters f_c (cyan), f_m (magenta) and f_y (yellow) may be arranged to be movable selectively into and out of the printing beam of the projected image. The colour composition of the projected image may be monitored by three photosensitive devices which are selectively responsive to the red, green and blue colour components of the printing beam. Each of the photosensitive devices may be connected to a capacitive circuit which, under the influence of the output signal from the photosensitive device, charges to a predetermined voltage. As each capacitance charges to the predetermined voltage, a corresponding one of three subtractive primary filters is inserted in the printing beam. For example, after a time delay dependent upon the amount of red light striking the red sensitive photosensitive device, the cyan filter f_c is inserted into the printing beam to halt the red exposure of the sheet of colour print material. Similarly the blue exposure of the sheet of colour print material is halted

when the yellow filter f_y is inserted into the printing beam; and the green exposure is halted when the magenta filter f_m is inserted into the printing beam. When all three filters are moved into the printing beam, the exposure is stopped, since, theoretically, all light is cut off from the printing beam by the filters; however, as a safeguard, an opaque shutter is usually inserted thereafter into the printing beam. A colour printer of this type is disclosed in U.S. Patent 3,184,307.

The materials of the primary subtractive filters may be selected, as nearly as possible, to absorb only the light emitted by the white light source that has a selected band width roughly corresponding to the red, green and blue primary colour wave lengths. Filters of the complementary colours, cyan, magenta and yellow, absorb the red, green and blue colour components, respectively, of the white light source. The magenta and yellow filters may consist of gelatin filter films mounted in glass, and the composite structure is relatively durable. However, since cyan gelatin filter films are not economical, the cyan filter is usually constructed from an extremely thin, dichroic glass which is susceptible to fatigue and breakage. Furthermore, the gelatin filter films and the dichroic glass are subject to fading by the intense light of the printing beam over a period of time, and their respective absorbencies are subject to change.

Colour printers are relatively complex mechanically and, the subtractive primary filters are usually not disposed in direct view of the operator of the machine. Occasionally the relatively fragile cyan filter breaks and is not detected until the faulty prints are developed. At high speed printing rates a considerable amount of photographic paper and operator's time may be lost before the broken filter is detected.

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Also, it is necessary from time to time to check the colour filters for deterioration of their absorbcency characteristics due to fatigue and fading.

5 In accordance with the present invention there is provided a photographic colour printer in which a colour filter is movable between a first position remote from a printing beam of the colour printer and a second position in which the colour filter is disposed to intercept the printing beam to absorb a predetermined band width of the frequency spectrum of light in the printing beam, including means for monitoring the absorbcency characteristics of the colour filter when it is in the said first position and for producing a signal upon failure of the colour filter to absorb the said predetermined band width of light, and means responsive to the said signal for producing an indication of the failure of the colour filter.

Means may be provided for indicating the operative condition of the colour filter when it is in the first position.

25 In a preferred embodiment of the invention, a sensing device is responsive to the colour component of light that is normally absorbed by the filter in the first position for halting the operation of the colour printer and alerting the operator thereof when a broken or faded colour filter transmits the normally absorbed colour component. The term light, as it is employed in the context of the specification and claims, may be defined as an electromagnetic radiation in the wavelength range including infrared, visible, ultra-violet and X-rays radiation and not limited to radiation in the visible wavelength spectrum.

40 In one illustrative embodiment of this invention, the sensing device includes a light source for emitting light of a frequency bandwidth that is the complement of the colour component frequency bandwidth normally absorbed by the filter and a photo-responsive device responsive to the light emitted by the light source for producing an indication of an inoperative filter. The colour filter, when in the first position, substantially absorbs the frequency bandwidth of light emitted by the light source as long as it is in an operative condition. When the colour filter becomes inoperative due to breakage or fading, a portion of the light is transmitted by the filter upon the photo-responsive device which produces an indication of the inoperative condition. Switching means responsive to the movement of the colour filter to the first position is provided for connecting the output of the photo-responsive device to further means for producing the indication. When the colour filter is in the printed position, the switch is open and the output of the photoresponsive device is disconnected from the indicating means.

In the detailed description of the preferred embodiment of the invention presented below, by way of example, reference is made to the accompanying drawings, in which:

Fig. 1 is a schematic illustration in partial perspective of this embodiment of the sensing device; and

Fig. 2 is a schematic illustration in block form of an indication circuit employed in connection with the embodiment of Fig. 1.

Referring now to the drawings, and first to Fig. 1, a subtractive primary filter 10 is mounted in a filter holder 12 and is adapted to rotate about a suitable pivot 14 between a first or rest position depicted in solid lines at position 16 and a printing position depicted in dotted lines at 18. In the printing position 18, a printing light beam from a white light source (not shown), as indicated by arrow 20, passes through the filter 10 onto a sheet of colour printing material (not shown) in the manner disclosed, for example, in the aforementioned U.S. Patent 3,184,307.

The filter holder 12 may be pivoted between the rest position 16 and the printing position 18 by the energization of solenoids 22 and 24 which are selectively energized by a single pole, double throw switch 26 connected in an electric circuit with a voltage source V_s and the solenoids 22 and 24. The contacts of the switch 26 are normally in the position depicted in Fig. 1 and the energization of the solenoid 22 thereby is effective to retain the filter holder in the rest position. The contacts of switch 26 may be actuated by a solenoid 28 in response to the charging of a capacitance time delay circuit 29 to a predetermined voltage in response to the detection by a photosensitive device (not shown) of a predetermined amount of a primary colour in the printing beam as described hereinbefore.

In accordance with the present invention, the operative condition of the colour filter 10 is detected when the colour filter 10 is moved from the printing position 18 to the rest position 16. The broken or faded filter is automatically detected in the rest position, and an audible or visible signal is generated to alert the operator of the breakage or fading of the filter.

This condition is detected by a sensing means which in accordance with the embodiment of the invention shown in Fig. 1 includes a lamp 30 energized at terminals 32 by the power supply V_s . Lamp 30 emits light that is reflected by a parabolic reflector 34 in the direction of the arrow 36 through a light source filter 38 which absorbs all wave lengths of light emitted by the light source 30 except that band width of light that is normally absorbed by the primary subtractive filter 10. Therefore, the absorption spectrum of the colour filter 38 is complementary to the absorption spectrum of the

subtractive primary filter 10. A neon bulb 40 is connected between the power supply terminal 32 and the lamp 30 and may be mounted on the control panel of the colour printer to alert the operator if the light source 30 fails.

The filtered light indicated by the arrow 36 is normally absorbed by the primary subtractive filter 10 as long as the filter is intact and not faded. If the filter is faded or broken in any part, at least a portion of the light 36 will pass through the primary subtractive filter 10 and a directional filter 42 and strike the surface of the photoresponsive device 44. The directional filter 42 passes only light which is substantially perpendicular to its planar surface. The filter 42 is desirable because the primary subtractive filter 10 consists of a dichroic glass that absorbs only near perpendicular incident light in accordance with its absorption spectrum. The filter 42 prevents oblique rays of light passing through the primary subtractive filter from striking the surface of the photoresponsive device 44. The photoresponsive device 44 may comprise a photovoltaic cell that generates a current at its output terminals 46, 47 proportional to the light striking the surface of the photocell.

As stated hereinbefore, the dichroic filter employed in colour printers is normally the cyan filter that absorbs light in the red colour wave lengths. Therefore, the light source filter 38 should be a red filter that absorbs all wave lengths of light emitted by the light source 30 except the red colour wave lengths, and, if the cyan filter 10 is intact and not faded, and in its rest position 16, the photovoltaic cell 44 will generate little current. To prevent the photovoltaic cell 44 from generating any current when the filter holder 12 is in the printing position 18, a switch 48 having spring contacts 50 and 52 and terminals 54 and 56 is provided to be engaged by a projection 58 on the filter holder 12. As shown in Fig. 1, the switch contacts are closed by the depression of spring contact 50 by the projection 58 when the filter 10 is in the rest position 16. However, when the filter 10 is rotated to the printing position 18, the switch contacts 50 and 52 are reopened. The switch 48 is connected between the output terminals 46, 47 of the photovoltaic cell and the indicating circuitry as shown and described in detail in Fig. 2.

Referring to Fig. 2, there is shown a circuit which may be employed in connection with the apparatus shown in Fig. 1 to produce an alarm and halt the operation of the colour printing machine in response to the detection of a broken or faded colour filter. The output terminals 46, 47 of photovoltaic cell 44 are connected to a point of common potential such as ground and an

input terminal of an operational amplifier 60, respectively. A variable reference potential determined by the setting of the movable contact arm 61 of rheostat 62 is applied across the output terminals 46 of the photovoltaic cell 44. The rheostat 62 is adjusted to vary the sensitivity of the photovoltaic cell 44 as explained hereafter.

In the absence of any light striking the photovoltaic cell 44, the potential at contact arm 61 is applied to the input terminals of the operational amplifier 60 which may be arranged to operate without feedback at maximum gain. The operational amplifier 60 inverts the polarity of the applied potential to develop at its output terminal 64 a negative polarity signal. The negative polarity signal is applied through the contacts 50 and 52 (which are closed by action of the projection 58 of Fig. 1) of the switch 48 to the base electrode of switching transistor 66. The switching transistor 66 is reverse biased by the negative polarity voltage applied at its base terminal and is rendered nonconductive thereby.

When, however, light strikes the surface of the photovoltaic cell 44, the cell generates a current proportional to the light falling upon it and develops a potential that is opposite in polarity to the reference potential of the contact arm 61. When the developed potential exceeds the reference potential, the output signal appearing at terminal 64 of the operational amplifier 60 changes from a negative polarity signal to a positive polarity signal. If a broken, faded filter 10 is in the rest position, the switch contacts 50 and 52 of switch 48 are closed by the action of the projection 58 on the filter holder 12 of Fig. 1. The positive polarity signal developed by the operational amplifier 60 is therefore applied by the switch contacts 50 and 52 of the switch 48 to the base electrode (input terminal) of the switching transistor 66.

The positive polarity applied at the base electrode of the switching transistor 66 is effective to render the transistor 66 fully conductive and to thereby allow current to flow from the voltage source V through the relay coil 68 to ground. In the absence of any current flowing through the relay coil 68, the movable contact of a relay switch 70 engages a fixed contact 72, as depicted in Fig. 2, thereby connecting voltage source V to the colour printer supply. However, when current passes through the relay coil 68, the movable contact of relay switch 70 engages a fixed contact 74, and the voltage source V is connected to the terminals of an indicator which, as depicted, may take the form of an alarm bell 76. Thereafter, the voltage supply is disconnected from the colour printer, and the operation of the colour printer is halted. The alarm bell 76 is energized to alert the operator of the fact that

the filter has broken or become faded. The alarm bell 76 continues to ring until it is manually reset and the filter 10 is changed. Since the colour printer supply voltage has been interrupted, the filter holder 12 cannot be rotated out of the rest position until the supply voltage is restored.

From the description of the preferred embodiment set forth above, it is apparent that the invention can be practiced in many alternative ways. It is apparent that the invention may be practiced in substantially the same manner as disclosed in the preferred embodiment in Fig. 1 of any light source filter 38 that has a wave length absorption in the visible or invisible frequency spectrum that is complementary to that of the filter 10. Therefore, the invention may be practiced with respect to any colour filter 10, whether it is subtractive or additive in nature or absorbs only ultra-violet or infrared light.

Also, it is apparent that the alarm triggered by the detection of the broken filter may be audio or visual or any combination of the two, and the colour printer supply may or may not be interrupted in the manner shown.

WHAT WE CLAIM IS:—

1. A photographic colour printer in which a colour filter is movable between a first position remote from a printing beam of the colour printer and a second position in which the colour filter is disposed to intercept the printing beam to absorb a predetermined band width of the frequency spectrum of light in the printing beam, including means for monitoring the absorbency characteristics of the colour filter when it is in the said first position and for producing a signal upon failure of the colour filter to absorb the said predetermined band width of light, and means responsive to the said signal for producing an indication of the failure of the colour filter.

2. A printer as claimed in Claim 1, wherein the monitoring means comprises:— means for providing a beam of light having a frequency spectrum of the said predetermined band width and for directing this beam of light in a predetermined path intercepted by one surface of the colour filter

when the colour filter is disposed in the said first position; and photoresponsive means located in the said predetermined path adjacent to the opposite surface of the colour filter for detecting the transmission of the beam of light through the filter if the filter has failed to absorb the said predetermined band width of light and for providing the said signal indicative of the degree of transmission of the said predetermined band width of light by the colour filter.

3. A printer as claimed in Claim 2, wherein the monitoring means is operative to detect the transmission of the said predetermined band width of light through the filter if the filter is broken.

4. A printer as claimed in Claim 2, wherein the monitoring means is operative to detect the transmission of the said predetermined band width of light through the filter if the filter has faded.

5. A printer as claimed in Claim 1 or Claim 2, comprising means, including an input terminal adapted to receive the said signal, for producing an indication of the failure of the colour filter, and a switch responsive to the movement of the colour filter to the said first position for applying the said signal to the input terminal and responsive to the movement of the colour filter from the said first position for disconnecting the said signal from the input terminal.

6. A printer as claimed in any preceding claim, further comprising means responsive to the production of the said signal by the monitoring means when the colour filter is disposed in the said first position for disabling the further operation of the colour printer.

7. A printer as claimed in Claim 1, including means responsive to movement of the colour filter from the said first position for preventing the response to the said signal of the said means for producing an indication.

8. A photographic colour printer substantially as hereinbefore described with reference to Figure 1 or to Figures 1 and 2 of the accompanying drawings.

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