

Jan. 18, 1966

D. M. NEALE ETAL

3,229,574

METHOD OF PHOTOGRAPHIC PRINTING OF COLOR RECORDS

Filed March 31, 1965

4 Sheets-Sheet 2

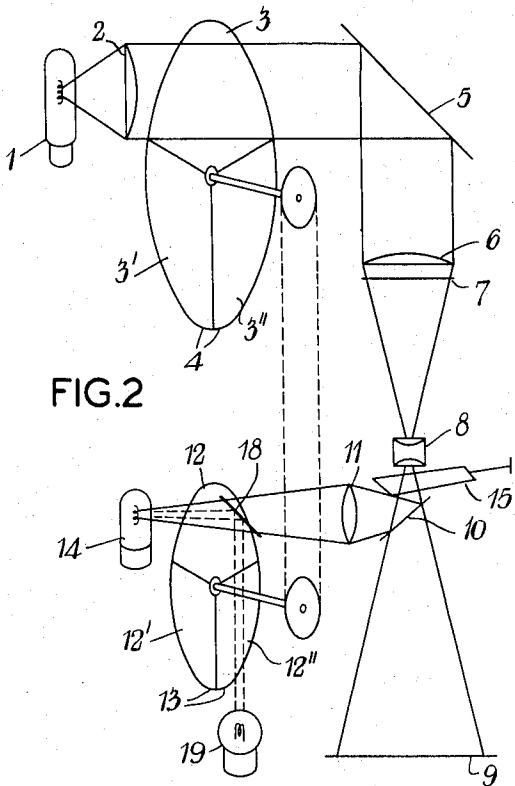


FIG. 2

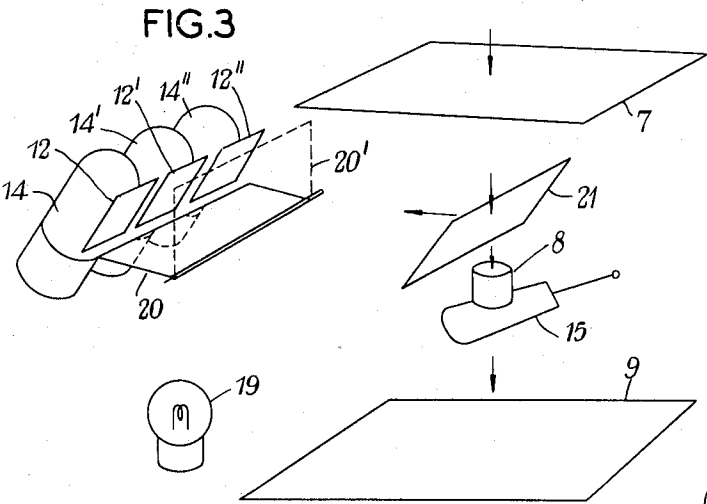


FIG. 3

Inventors
Denis Manktelow Neale
Albert Henry Gregory Ninnim
By Cushman, Warky & Cushman
Attorneys

Jan. 18, 1966

D. M. NEALE ET AL

3,229,574

METHOD OF PHOTOGRAPHIC PRINTING OF COLOR RECORDS

Filed March 31, 1965

4 Sheets-Sheet 3

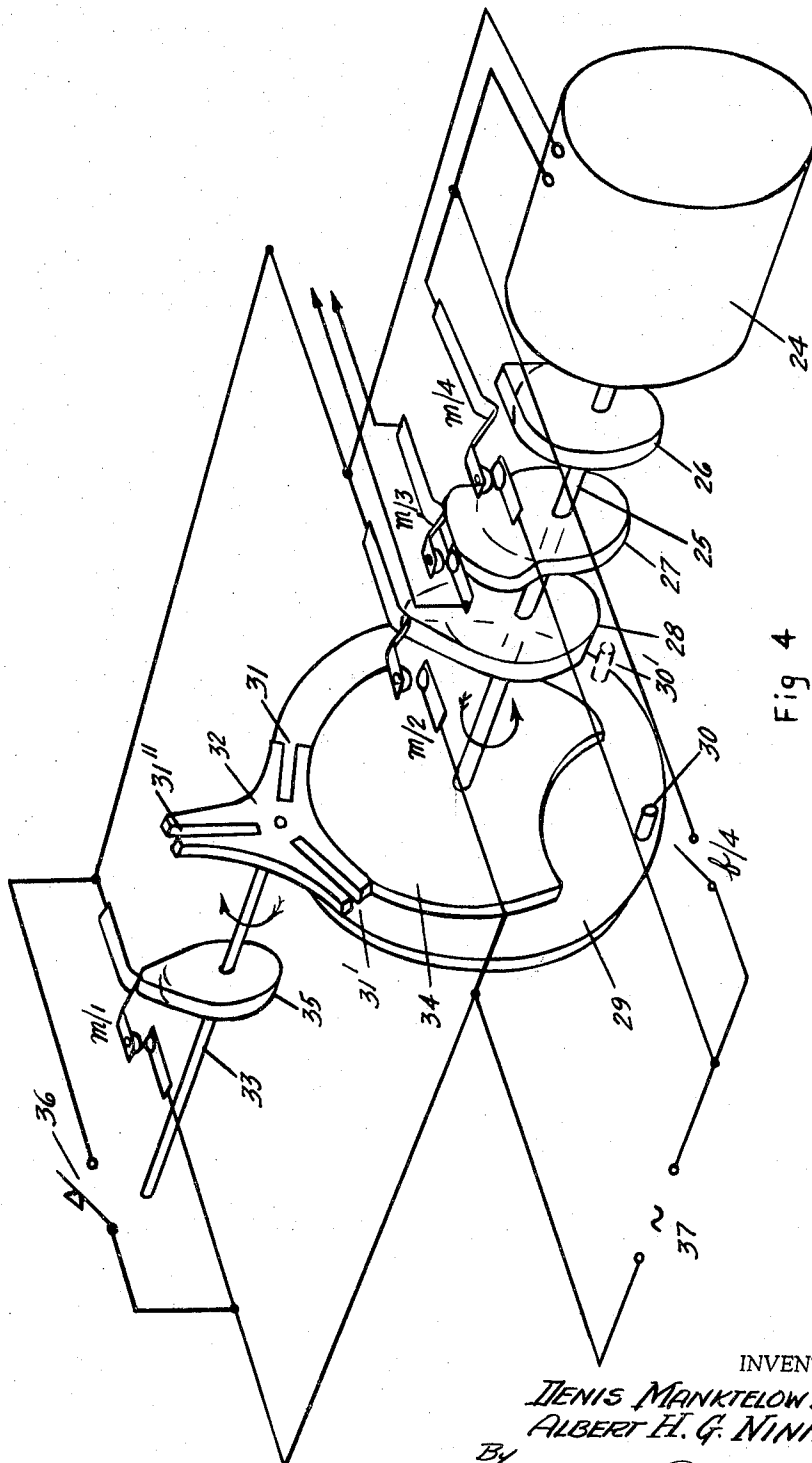


Fig 4

INVENTORS

DENIS MANKTELOW NEALE
ALBERT H. G. NINNIM

BY

Cushman, Fading & Cushman
ATTORNEYS

Jan. 18, 1966

D. M. NEALE ETAL

3,229,574

METHOD OF PHOTOGRAPHIC PRINTING OF COLOR RECORDS

Filed March 31, 1965

4 Sheets-Sheet 4

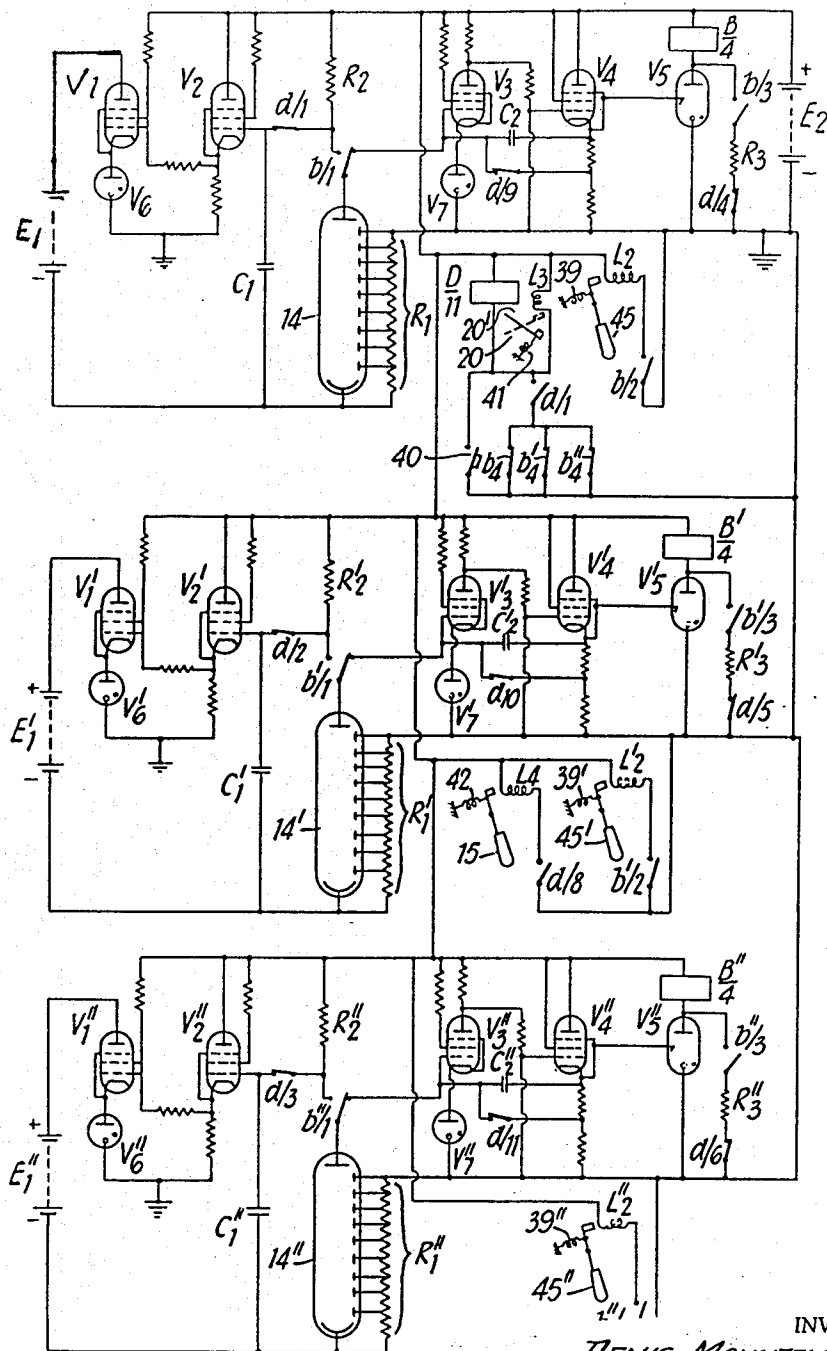


FIG. 5

INVENTORS

DENIS MANKTELOW NEALE

ALBERT H. G. NINNIM

By

Cushman, Delaney & Cushman
ATTORNEYS

1

3,229,574

**METHOD OF PHOTOGRAPHIC PRINTING OF
COLOR RECORDS**

Denis M. Neale and Albert H. Ninnim, both of Ilford,
Essex, England, assignors to Ilford Limited, Ilford, Eng-
land, a British company

Filed Mar. 31, 1965, Ser. No. 453,860

Claims priority, application Great Britain, Apr. 6, 1961,
12,467/61

5 Claims. (Cl. 88—24)

This is a continuation-in-part of application Serial No. 181,615, filed on March 22, 1962, now abandoned.

The invention relates to a method and apparatus used in photographic printing of colour records. In particular, it relates to photo-electric apparatus used to measure the light fluxes in three spectral bands as transmitted by a multicolour photographic record. The word "measure" is here used to indicate that the light fluxes are assessed by comparison with a fixed light flux. The apparatus is thus clearly distinguishable from that class of apparatus in which a light flux is assessed by measuring the current delivered by a photo-electric cell, it being assumed that the efficiency of conversion of light to electrical current remains constant over a time amounting to minutes or even hours.

In the printing of photographic multicolour transparencies and color negatives in particular, it is known practice to divert a proportion of the printing light transmitted by the negative and to cause it to fall on combinations of color-selective filters and photoelectric cells such that three electric currents are obtained proportional respectively to the light fluxes transmitted by the negative in the red, green and blue bands of the spectrum of the printing light. The combinations of filter and photocell may all be operative simultaneously. In an alternative known type of apparatus, a single photocell is used in front of which red, green and blue filters are moved in turn and in synchronism with the insertion of red, green and blue filters in the path of printing light reaching the photosensitive print material. In many known forms of apparatus, the electrical current obtained from each of the three combinations of filter and photocell is applied to apparatus for terminating exposure of the print material to light of the corresponding colour, red, green or blue, as the integral of electrical current against time reaches a selected value.

Known apparatus is prone to inconsistencies due to a variety of causes. One of the more elusive causes of inconsistency has now been identified with variations of spectral sensitivity response of the photocell or photocells with variation of temperature. The sensitivity, and in particular the spectral sensitivity characteristic of a photo-emissive cell, is dependent on very thin surface layers on the photocathode. Typically these surface layers contain caesium and this has a vapour pressure at room temperatures which is sufficiently high for distillation to occur in the vacuum cell. As a result there is a tendency for caesium to migrate from one part of the cell to another, the movement being always towards the coldest part of the photocell. Such migration will occur relatively rapidly if the cell is warmed rapidly, but to some extent it must be expected whenever the temperature of the cell changes at all since it is not practicable to arrange that all parts of the cell heat and cool at identical rates. When migration of caesium occurs in this way, the sensitivity and spectral response of the photocell cathode are changed. The changes in spectral response lead to errors in assessment of the relative red, green and blue light fluxes transmitted by the colour negative. Known types of automatic printers use photocells in temperature controlled enclosures in an attempt to eliminate this source of instability. The method is not entirely satisfactory, however, and other remedies have been sought.

2

One alternative approach has been described by Gundelfinger, Taylor and Yancey (Journal of Photographic Science, vol. 8, No. 5 pp. 161-170). This comprises using each photocell-filter combination only as a null detector. Light transmitted through the negative is continuously compared with light from a stable reference source and the intensity of printing light is adjusted until the photocell indicates equality. In this way small variations in colour sensitivity of the photocell are made unimportant. The method described by Gundelfinger et al. involves adjusting the light transmitted by the negative to a substantially constant intensity and quality so that all prints are made with equal exposure times. In such a system, it follows that the printing exposure time is determined by the amount of light transmitted by a negative of maximum optical density when all the available printing light is used. Even negatives of low optical density will require the same printing time. In consequence the average exposure time is much longer than could be obtained with a similar light source in the more commonly used type of printer which uses all the available printing light for printing each negative and therefore prints each negative as quickly as possible.

The photoelectrical assessment method described by Gundelfinger et al. is not readily applicable to the more conventional types of printer just referred to because when a variable light flux is transmitted by the colour negative it is not readily compared with the reference lamp continuously in a null manner. If such comparison is attempted, it is difficult to preserve the advantages offered by a photoelectric integrating exposure time control, viz. that there is no need to stabilise the printing light source against the effects of supply voltage variations.

It is an object of the present invention to provide, as a step in the production of colour prints from photographic multicolour transparencies, an improved method of assessing the intensity of light in a spectral band.

According to the present invention there is provided a method for the production, from a colour transparency, of a multicoloured photographic print on print material having components selectively sensitive to three spectral bands, by means of printing light containing light in each of said three spectral bands, which method comprises applying in respect of each spectral band separately the procedure of allowing light from a stable reference source to fall on light sensitive means, such as a photocell, after passing through a colour-selective filter chosen so that the combination of colour filter and photocell produces a response confined to the band of spectral sensitivity of only one component of the photographic print material, adjusting the sensitivity of a circuit associated with the photocell so that the electrical output from said circuit assumes a preselected value, maintaining the said adjusted sensitivity constant while light from said reference source is removed or obstructed, directing printing light on to said photocell through a colour selective filter selecting substantially the same spectral band, and assessing the exposure of the print material to printing light in said spectral band in accordance with the resultant output of said electrical circuit.

According to a preferred form of the present invention, the photocell includes a secondary emission electron multiplier, the current amplification factor of said electron multiplier being controlled by adjustment of voltage applied to said electron multiplier, said adjustment being provided by an electrical power amplifier responsive to changes in said electrical output so long as the said photocell receives light from said stable reference source.

Since photographic colour printing machines have already been used for several years in which some of the elements of the present invention also appear, it will now

be shown in what fundamental manner the present invention differs from such earlier practice.

To this end reference is made to the accompanying drawings in which:

FIG. 1 illustrates an electronic circuit used in a first embodiment of the present invention.

FIG. 2 illustrates a printing machine of known type which may be used in conjunction with the circuit of FIG. 1.

FIG. 3 illustrates a printing machine according to a preferred embodiment of the invention.

FIG. 4 illustrates a motor and switch assembly used in said first embodiment.

FIG. 5 illustrates an electronic circuit used in said preferred embodiment.

Referring to these drawings, FIG. 2 represents diagrammatically the principal optical components of a colour printing machine according to said earlier practice. In FIG. 2 light from a lamp 1 passes through a condenser lens 2 and a colour selective filter sector 3 of a tricolour sector disc 4 to strike a mirror 5 whence it is reflected to strike a field lens 6 and the multicolour negative 7. The lens 8 receives some of the light transmitted by the negative and forms an image of the negative in the plane of the print material 9. A partially reflecting plate 10 diverts parts of the light passing the lens 8 to pass a further lens 11 and a colour selective filter sector 12 of a tricolour sector disc 13 and so fall on a multiplier photocell 14. The filter sectors 3 and 12 of the discs 4 and 13 are of like colour. Moreover the discs are coupled so that they may be rotated to bring into operation other filter sectors 3', 12' and 3'' and 12''. The three sectors on each disc transmit red, green and blue light respectively and the sectors in operative position on the two discs are always of like colour.

When a print is not being exposed, a shutter 15 obstructs light passing the lens 8 and a reflector 18 moves to direct on to the multiplier photocell 14 light from a stable reference lamp 19. The sensitivity of a multiplier photocell depends critically on the voltage applied to the electron multiplier. Commonly the individual secondary emission electrodes, known as "dynodes," are connected to tappings on a resistance chain connected across a voltage supply hereinafter referred to as the dynode supply. It will be understood by those skilled in the art that it is readily arranged that the dynode supply voltage shall be adjusted automatically so that, irrespective of substantial changes in photocathode sensitivity or secondary emission efficiency of the dynodes, the output current from the multiplier photocell collector shall be held closely to a preselected value.

When a print is to be exposed, the dynode supply voltage is initially at the automatically determined value. The automatic control is then disabled so that the dynode supply voltage remains constant at the automatically determined value and is held at this value irrespective of changes in photocell collector current occurring during the print cycle. The reflector 18 then moves so that light from the reference lamp 19 no longer strikes the photocell 14. Next, shutter 15 moves to allow light passing the negative 7 to fall on print material 9 and photocell 14 as hereinbefore described. Printing now commences, the print material 9 being exposed to light of the colour transmitted by the filter sector 3. The filter sector 12 is intended to modify the spectral response of the photocell 14 to match closely the spectral response of that emulsion layer of the print material 9 which is sensitive to light of the colour transmitted by the filter sector 3. The collector current drawn by the photocell 14 in this condition is proportional to the integrated light flux transmitted by both the filter sector 3 and negative 7. The said collector current is used, according to means familiar to those skilled in the art, to terminate the printing exposure by causing shutter 15 to move into the closed position when a preselected integral of collector current against time

has been drawn by the photocell 14. When this happens, filter sector discs 4 and 13 each rotate to bring coloured sectors 3' and 12' into operative position. The shutter 15 then reopens and again closes when a second preselected integral of collector current against time has been drawn by the photocell. The discs 4 and 13 then rotate to bring sectors 3'' and 12'' into operative position and a final exposure is given to the print material. It will be understood that the three exposures in a complete print cycle comprise exposure to the red, green and blue bands of the spectrum separately. The component colour exposures may usually be administered in any convenient order provided discs 4 and 13 move in step with each other and in correct relation to the circuits determining the preselected value of each collector current integral. At the completion of the print cycle, shutter 15 obstructs light passing lens 8, reflector 18 moves to direct light from lamp 19 on to photocell 14 and the automatic control of dynode supply voltage becomes operative once more.

Photographic colour printing machines of the type just described suffer from the aforementioned effects of temperature changes on the spectral sensitivity of the photocathode of the photocell 14. Consequently, the exposure integrals of the red, green and blue components do not remain in the required proportion although, by virtue of the automatic sensitivity adjustment, the total exposure administered to the print material remains substantially constant. After processing, prints are therefore apt to show irregularity of colouring, although their mean density is usually well controlled. Some improvement in colour stability is obtained by enclosing the photocell 14 in a temperature controlled housing. In practice, however, this is found to be only a partial solution.

In the known practice described above, light from the stable reference lamp 19 reaches photocell 14 only through filter 12. If, for example, filter 12 is a green filter, the automatic control of dynode supply voltage will correct for any variations in sensitivity of photocell 14 to green light. Accordingly, when the print cycle is initiated, the correct exposure of print material to green light is administered. If, however, the sensitivity to red light or to blue light has not changed in proportion to the sensitivity to green light, the exposure of print material to red light and to blue light will be incorrect and the print will show a colour cast after processing to colour.

In the present invention, this limitation is overcome by arranging that, immediately before the multiplier photocell is used to assess the intensity of printing light of any of the three colours, red, green and blue, the photocell is exposed to light from a stable reference lamp which light has passed through a filter corresponding to the colour of light to be assessed in the immediately following operation and the dynode supply voltage is adjusted to provide a predetermined output from the multiplier photocell while so exposed to the stable reference lamp.

To facilitate comparison with the known practice described above, an embodiment of the invention will now be described with reference to the printing machine of known type shown in FIG. 2. All the parts shown in FIG. 2 are still used, but the cycle of operations is different.

In the embodiment shown in FIG. 2, the standby condition corresponds to shutter 15 closed and light from reference lamp 19 reflected by reflector 18 to pass through filter sector 12 and fall on photocell 14. The automatic control of dynode supply voltage thus operates to set the sensitivity of photocell 14 so that the emission of light from lamp 19 in the band passed by filter 12 produces a preselected collector current from the multiplier photocell. At the start of the print cycle, the sensitivity of the photocell 14 is thus already set to control accurately exposure of the print material to light transmitted by filter sector 3 and negative 7. On initiation of the print cycle, therefore, the photocell dynode supply voltage is

5

disabled, reflector 18 moved to remove reference lamp illumination of the photocell and shutter 15 opens. At the attainment of a preselected integral of collector current against time, the shutter 15 closes and discs 4 and 13 rotate to bring sectors 3' and 12' into operative position.

At this stage in the print cycle, the method of the present invention is clearly seen to differ from that of the known practice described above. After sectors 3' and 12' have moved into operative position, the reflector 18 once more moves into position to reflect light from lamp 19 on to photocell 14. The automatic control of dynode voltage is again made operative so that a preselected collector current is obtained from the photocell when illuminated by that spectral band of the emission of lamp 19 transmitted by filter sector 12'. When sufficient time has been allowed for the automatic control of dynode supply voltage to become fully effective with filter 12' operative, the dynode supply voltage is again disabled, the reflector 18 again removed and shutter 15 opens to initiate printing with light transmitted by filter sector 3' and negative 7. The photocell collector current is again integrated until a preselected integral of current against time is reached, whereupon shutter 15 closes and discs 4 and 13 rotate to bring sectors 3'' and 12'' into operative position. Reflector 18 again moves to reflect light from lamp 19 through sector 12'' on to the photocell 14. The automatic control of dynode voltage is again made operative so that a preselected collector current is obtained from the photocell when illuminated by that spectral band of the emission of lamp 19 which is transmitted by filter sector 12''. When sufficient time has again been allowed for the automatic control of dynode supply voltage to become fully effective with filter 12'' operative, the dynode supply voltage is again disabled, the reflector 18 again removed and shutter 15 opens to initiate printing with light transmitted by sector 3'' and negative 7. The collector current is again integrated and when a preselected integral of current against time has been reached, shutter 15 closes to terminate the entire print cycle. Discs 4 and 13 now advance to bring sectors 3 and 12 once more into operative position, reflector 18 moves into operative position and the automatic control of dynode supply voltage becomes operative so that the apparatus is prepared for the initiation of another print cycle.

It will be understood that, whereas the known earlier practice cited involved a single standardisation of photocell sensitivity against a reference illumination containing only one of the three spectral bands which were to be separately assessed photoelectrically, the present invention proposes the standardisation of photocell sensitivity against reference illumination confined to the spectral band, typically red, green or blue, which is to be assessed by that photocell in the immediately following operation. Thus, whereas the earlier known practice employed only a single standardisation operation before the photocell assessed three different spectral bands, the present invention utilizes a separate standardisation of photocell sensitivity with respect to each separate spectral band to be assessed.

Reference will now be made to FIGS. 1 and 4 which represent electrical circuits and a motor arrangement used to permit the present invention to be applied to the printer shown in FIG. 2.

In FIG. 1, the photocell 14 is shown as containing a nine-stage electron multiplier, the dynodes of which are connected to tapplings on the resistance chain R1. All contacts of relays A/4 and B/4 have been drawn in positions corresponding to the de-energized condition of relays A/4 and B/4. When the printer is in a stand-by condition, i.e. when it is not printing, relay A/4 is de-energized, relay B/4 is energized. Accordingly, during stand-by, the collector 22 of photocell 14 is connected by contacts b/1 to a load resistor R2.

6

Light from the reference source 19 falls on the photocathode 23 of photocell 14 and gives rise to a current which is drawn by collector 22 through R2 from supply E2. Cathode follower V2 applies to the control grid of series valve V1 a potential about two volts in excess of the collector potential of photocell 14. If the collector current is greater than is required, the voltage drop across R2 will be abnormally large and the grid of V1 will accordingly be held less positive than normal. The cathode of V1 is, however, held at a positive potential by the glow stabilizer V6. Consequently an excessive collector current from photocell 14 leads to an increased grid bias on V1. As a result, V1 passes a reduced current through V6 and R1 back to the floating voltage supply, E1. The reduced current through R1 produces a reduced dynode supply voltage across R1 and as a result the amplification factor of the electron multiplier is reduced. This in turn causes the collector current of photocell 14 to diminish. A state of equilibrium is reached when the dynode supply voltage leads to a collector current providing the bias on V1 required to maintain said dynode supply voltage. The operating voltage of the glow stabiliser tube V6 is chosen to be greater than the bias voltage which must be applied between grid and cathode of V1 substantially to cut off anode current in V1. The voltage of supply E2 is made several times the operating voltage of V6. It follows therefore that although the sensitivity of photocathode 23 may vary considerably, the dynode supply voltage will be adjusted automatically to reduce the variations in collector current to a much smaller percentage.

In FIG. 4 a motor 24 is shown coupled to a shaft 25 to which are fixed cams 26, 27, 28 and the driving disc 29 of a three-station Geneva motion. For each complete rotation or shaft 25, pin 30 engages one of the slots 31, 31', 31'', in the star wheel 32, turning shaft 33 through 120° of rotation. Thereafter pin 30 disengages said slot and shaft 33 is locked against further rotation because locking plate 34, attached to disc 29, prevents star wheel 32 from turning. Shaft 33 is coupled to disc 13 (FIG. 2) so that for each revolution of shaft 25, one of the filters 12, 12', 12'' is removed from operative position and the next filter is brought into such position.

In FIG. 4, the cams and Geneva motion are in the stand-by condition, i.e. with the machine not printing. Contacts b/4 are shown in the position corresponding to relay B/4 being de-energized. As shown in FIG. 4, motor 24 is de-energized because cams 35 and 28 hold contacts m/1 and m/2 open. Cam 27 holds contact m/3 open and so relay A/4 (FIG. 1) is de-energized, leaving mirror 18 in position to direct light from source 19 through filter sector 12 to photocell 14. Relay B/4 is energized by current flowing through hold-on contacts b/3 and a/4, relay B/4 having been energized during a preceding cycle of printing. Contacts b/2 are therefore closed, holding solenoid L2 energized and thus holding shutter 15 in position to obstruct the path of light passing lens 8. Contacts b/1 are in position to connect collector 22 to load resistor R2 so that the dynode supply voltage is adjusted automatically, as described above, to produce a pre-determined collector current when light from source 19 passes filter 12 and falls on photocathode 23.

To initiate a printing cycle, key switch 36 is closed momentarily. Current then flows from mains supply 37, through key switch 36 to the motor and returns through contacts m/4 to supply 37. As shaft 25 turns, contacts m/2 close so that even when key switch 36 is opened, motor 24 continues to drive shaft 25. Cam 27 now allows contacts m/3 to close, energizing relay A/4, opening contacts a/1 and disabling the automatic control of dynode supply voltage. Capacitor C1 now communicates to the control grid of V2 any change in dynode supply voltage due, for example, to variation of supply voltage E1. Any such change is conveyed to the control grid of V1 by the cathode follower V2 and the resultant change in conductance of V1 serves to oppose the change in dynode supply

voltage. Once contacts *a/1* open, therefore the dynode supply voltage is maintained at the value established immediately prior to opening of contacts *a/1*.

Energization of relay *A/4* closes contacts *a/2* energizing solenoid *L1* which withdraws mirror *18* from operative position. Contacts *a/4* open, so allowing relay *B/4* to deenergize. Contacts *b/1* therefore return to the position shown in FIG. 1 and contacts *a/3* open so that current drawn by collector *22* charges capacitor *C2*.

V3 and *V4* comprise an operational amplifier of known type. The feedback capacitor *C2* serves as a current integrator. Current drawn by collector *22* produces only a small depression of the voltage at the grid of *V3* but a much larger rise in potential of the cathode of *V4*.

De-energization of relay *B/4* causes contacts *b/2* to open, de-energizing solenoid *L2* and allowing shutter *15* to be withdrawn by a return spring *39* from the path of printing light. De-energization of relay *B/4* also causes contacts *b/4* to open so that motor *24* is de-energized when cam *26* opens contacts *m/4*. When this happens, disc *29* stops with pin *30* in the position shown dotted at *30'*.

Printing of the negative *7* now proceeds with light passing filter *3*. Part reflector *10* directs a proportion of printing light through filter *12* to photocell *14*. Collector current from photocell *14* is integrated by capacitor *C2*, causing the cathode potential of *V4* to rise until trigger tube *V5* conducts energizing relay *B/4*.

Energization of *B/4* closes contacts *b/2* energizing solenoid *L2* and causing shutter *15* to obstruct the path of printing light. Contacts *b/1* re-connect collector *22* to load *R2*. Contacts *b/4* close to energize motor *24*, so causing pin *30* to turn the star wheel *32* and filter discs *13* and *4* through *120°* of rotation. Cam *27* opens contacts *m/3* so that relay *A/4* is de-energized. Contacts *a/3* discharge capacitor *C2*, contacts *a/2* open to cause *L1* to allow the mirror *18* to move into operative position under the action of a control spring *38*. Contacts *a/4* close, completing a hold-on circuit for relay *B/4* through contacts *b/3* and *R3*. By making the resistance of *R3* small, the voltage across *R3* is arranged to be less than the voltage required to maintain a discharge from anode to cathode of *V5*. Consequently the discharge in *V5* is extinguished.

Contacts *a/1* close when relay *A/4* is de-energized. Consequently, the automatic adjustment of dynode supply voltage becomes operative once more and adjusts the dynode supply voltage to a value giving a pre-determined collector current in respect of light reaching photocell *14* through filter *12'* from reference source *19*.

Motor *24* continues to drive shaft *25* until pin *30* once more reaches position *30'*. The sequence already described is then repeated except that printing occurs with light passing filter *3'* and assessment of printing light is made by photocell *14* through filter *12'* while the dynode supply voltage is maintained at a value established while light from source *19* fell on photocell *14* through filter *12'*.

When the integrated collector current has again charged capacitor *C2* sufficiently to cause trigger tube *V5* to conduct, relay *B/4* is again energized and motor *24* turns shaft *25* through another complete revolution, as already described, filter *3'* and *12'* thereby being removed from operative position and filters *3''* and *12''* being brought into operative position. Before motor *24* comes to rest, cam *27* opens and closes contacts *m/3* so temporarily de-energizing relay *A/4* and causing the dynode supply voltage to be adjusted as previously described to a value producing the predetermined current at collector *22* when photocell *14* receives light from source *19* through filter *12''*. When cam *27* allows contacts *m/3* to close again, another part-exposure of the print material *9* occurs, this time to light passing filter *3''*. Printing light is assessed by photocell *14* through filter *12''* while the dynode supply voltage is maintained at the value established while photocell *14* received light from reference source *19* through filter *12''*.

When the integrated collector current has again charged capacitor *C2* sufficiently to cause trigger tube *V5* to conduct, relay *B/4* is again energized and motor *24* turns shaft *25* to rotate star wheel *32*, filter disc *4* and filter disc *13* through a further *120°* of rotation. This causes cam *35* to open contacts *m/1* so that when cam *28* opens contacts *m/2* the motor is de-energized. The apparatus is thus left in the stand-by condition, viz. with pin *30* in the position shown, with filters *3* and *12* in operative position, with relay *A/4* de-energized and relay *B/4* energized, with shutter *15* obstructing light passing lens *8* and with mirror *18* directing light from reference source *19* through filter *12* onto photocell *14*.

It will be understood that the embodiment of the invention as described with reference to FIG. 2 leads to a method of automatic photographic printing which is slower and more complex than the known practice described above on account of the two additional standardization operations which are required between the separately administered exposures of the print material to light of colours transmitted by filter sectors *3*, *3'* and *3''*. Accordingly, a preferred embodiment of the invention will be described with reference to FIG. 3 and FIG. 5.

In FIG. 3 the negative is initially illuminated by light containing all three spectral bands, red, green and blue, required for printing the negative *7* by projection through lens *8* onto the print material *9*. Any convenient known type of lamphouse may be used, but shutters *45*, *45'* and *45''* in FIG. 5 are required to terminate exposure to the red, green and blue components of printing light separately.

Part of the light transmitted by the negative *7* strikes the reflecting surface *21* and falls on three multiplier photocells *14*, *14'*, *14''* after passing through colour selective filters *12*, *12'*, *12''*, respectively. An opaque movable flap, shown at *20* in FIG. 3, can be swung to position *20'* wherein it obstructs light from the negative and surface *21* but allows light from reference lamp *19* to reach photocells *14*, *14'* and *14''* after passing filters *12*, *12'*, *12''*, respectively.

FIG. 5 represents an electronic circuit which may be used in conjunction with the embodiment of the invention shown in FIG. 3. FIG. 5 will be seen to comprise three similar sub-circuits. The sub-circuit associated with photocell *14* is closely similar to the circuit of FIG. 1, like parts being indicated by like reference letters and numbers. Sub-circuits associated with photocells *14'* and *14''* are identical with that associated with photocell *14*, corresponding parts being indicated by like reference letters and numbers, parts relating to photocell *14'* being identified by a single strike and parts relating to photocell *14''* being identified by a double strike.

Before commencement of the print cycle, the movable flap is in position *20'* and each photocell is thus illuminated by a different spectral band of the light emitted by reference lamp *19*, said spectral bands being selected by colour selective filters *12*, *12'*, *12''*. Each multiplier photocell is connected to a separate circuit providing automatic control of its dynode voltage supply so that the collector current of each photocell assumes a preselected value when illuminated as described by the lamp *19* through its associated filter *12*, *12'* or *12''*.

When key switch *40* is briefly closed to initiate a printing cycle, relay *D/11* is energized, contacts *d/4*, *d5'*, *d/6* open and relays *B/4*, *B'/4*, *B''/4* are deenergized. A hold-on circuit for relay *D/11* is thus formed through contacts *d/7* and any of the contacts *b/4*, *b'/4*, *b''/4*. When key switch *40* is opened, therefore, relay *D/11* remains energized.

Energization of relay *D/11* opens contacts *d/1*, *d/2*, *d/3*, thereby disabling the automatic control of dynode supply voltage to each of the photocells *14*, *14'*, *14''*. For each photocell the preadjusted sensitivity to the spectral band passed by its respective filter thereafter remains constant.

Solenoid L3, connected in parallel with relay coil D/11 is also energized to cause the movable flap to assume the position shown at 20 in FIGS. 3 and 5. When in position 20, the flap obstructs light from lamp 19, but allows light from the negative 7 and reflector 21 to pass filters 12, 12', 12'' to strike photocells 14, 14', 14''. Integration of each photocell collector current now begins separately. Energization of relay D/11 causes contacts d/8 to close so that solenoid L4 is energized and shutter 15 opens to allow light passing lens 8 to form an image of the negative 7 on print material 9. As each photocell collector current produces a preselected integral of current against time, the corresponding trigger tube V₅, V₅' or V₅'' conducts to energize the corresponding relay B/4, B'/4 or B''/4. Contacts b/2, b'/2 or b''/2 on said relay close to energize solenoid L2, L'2, or L''2, so bringing into operative position the shutter 45, 45', or 45'' terminating exposure of the print material to the spectral band corresponding to the spectral transmission of filter 12, 12' or 12'' associated with the photocell producing the said preselected integral of current against time.

When all three relays B/4, B'/4, B''/4 have been energized, all contacts b/4, b'/4, b''/4 are open, relay D/11 becomes de-energized, contacts d/8 open and solenoid L4 becomes de-energized also, allowing spring 42 to move shutter 15 into position to obstruct the path of light passing lens 8. Solenoid L3 is de-energized also and spring 41 causes the movable flap to return to the position shown at 20'. Relay contacts b/1, b'/1, b''/1 return to that state which is the reverse of that shown in FIG. 5 and relay contacts d/1, d'/1, d''/1 close so that the automatic control of dynode supply voltage to each photocell becomes operative once more.

It will be appreciated that the printing method described with reference to FIG. 3 is considerably faster than that described with reference to FIG. 2. Moreover, the simplification of switching processes required during a complete print cycle largely off-sets the complication involved in providing three separate multiplier photocells with three independent circuits for controlling automatically the dynode supply voltages.

The above-described embodiments are illustrative of the invention but are not intended to limit the possibilities of insuring that the intensity of light in a spectral band is accurately assessed. The apparatus disclosed herein are examples of arrangements in which the inventive features of this disclosure may be utilized, and it will become apparent to one skilled in the art that certain modifications may be made within the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A method for the production, from a colour transparency, of a multicoloured photographic print on print material having components selectively sensitive to three spectral bands utilizing printing light containing each of said three spectral bands, comprising for each spectral band separately the steps of: directing light containing the three-spectral bands from a stable reference lamp to a first colour-selective filter designed to pass light in the separate band onto light sensitive means to generate a first electrical signal for said band having a value corresponding to the light in the separate spectral band; adjusting said electrical signal from the light sensitive means in order to bring said electrical signal to a preselected value, thereafter maintaining the said adjusted sensitivity constant; interrupting the light directed from said stable reference lamp; passing printing light through the colour transparency onto said printing material to expose same and passing printing light also through a filter transmitting light in substantially the same spectral band as said colour-selective filter onto said light sensitive means to generate a second electrical signal; and interrupting the passage to the printing material and to the light sensitive means of printing light in said separate band in response to the value of said second signal as modified by a said adjusted sensitivity.

2. A method according to claim 1, wherein the printing light which is directed to the said light sensitive means is such light after it has passed through said colour transparency.

3. A method for producing a multicoloured photographic print as set forth in claim 1 wherein the procedure recited is consecutively performed for each of the three separate spectral bands.

4. A method for producing a multicoloured photographic print as set forth in claim 1 wherein the procedure recited is simultaneously performed for each of the three separate spectral bands.

5. A method for producing a multicoloured photographic print as set forth in claim 1 wherein said second electrical signal is integrated against time, the printing light being interrupted when the integrated signal reaches a prescribed value.

References Cited by the Examiner

UNITED STATES PATENTS

3,090,289 5/1963 Gundelfinger ----- 82—24 X

50 NORTON ANSHER, *Primary Examiner*.

EVON C. BLUNK, *Examiner*.

R. A. WINTERCORN, *Assistant Examiner*.