Sept. 22, 1959 D. M. NEALE 2,905,755

ELECTRONIC TONE-MASKING SYSTEM FOR USE IN THE PRODUCTION OF COLOUR PRINTS

Filed Feb. 9, 1959 2 Sheets-Sheet 1

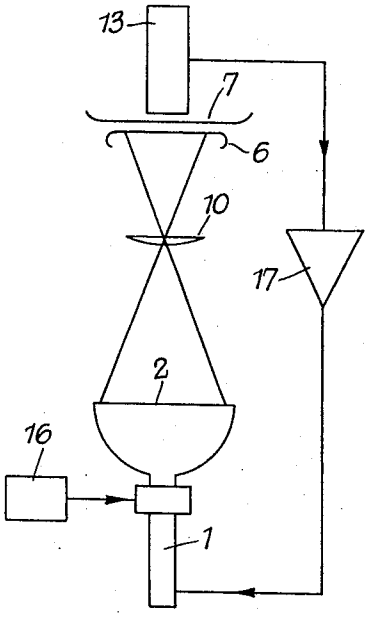


FIG.1

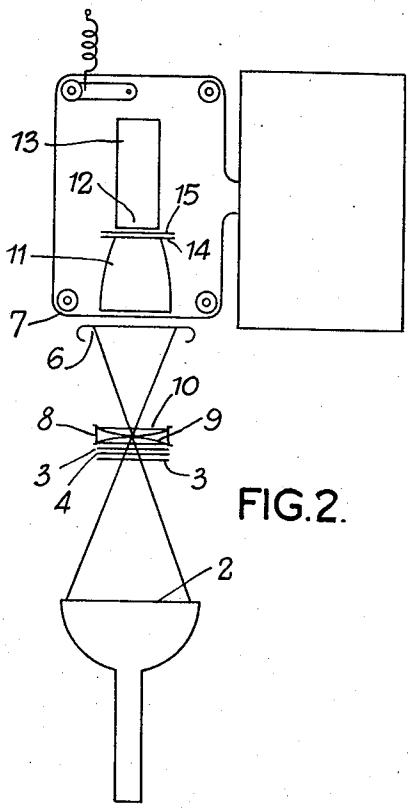


FIG.2.

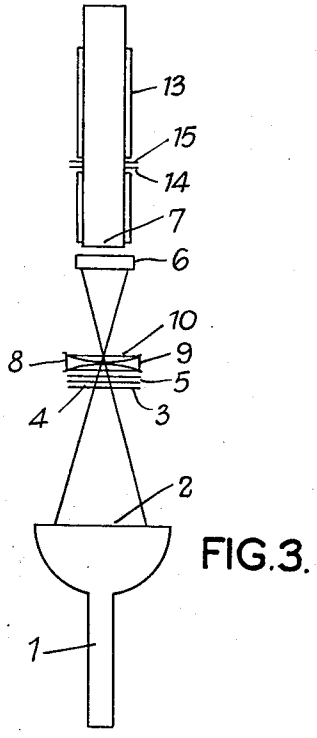


FIG.3.

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ELECTRONIC TONE-MASKING SYSTEM FOR USE IN THE PRODUCTION OF COLOUR PRINTS
Filed Feb. 9, 1959 2 Sheets-Sheet 2

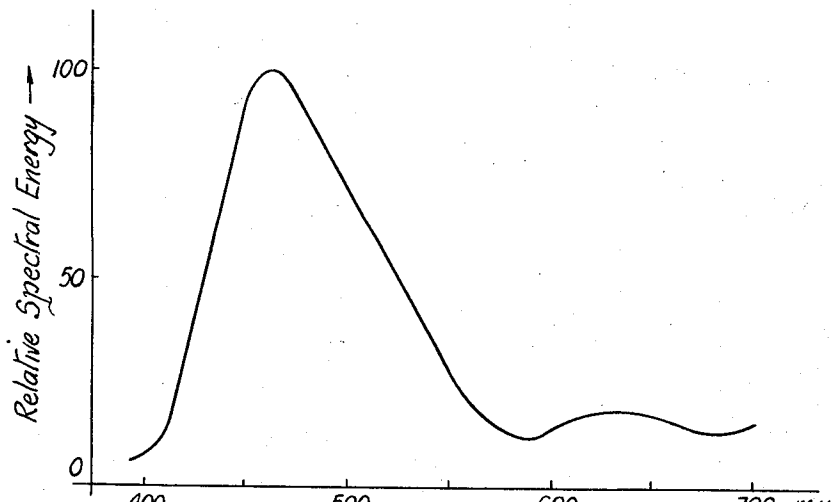


FIG.4

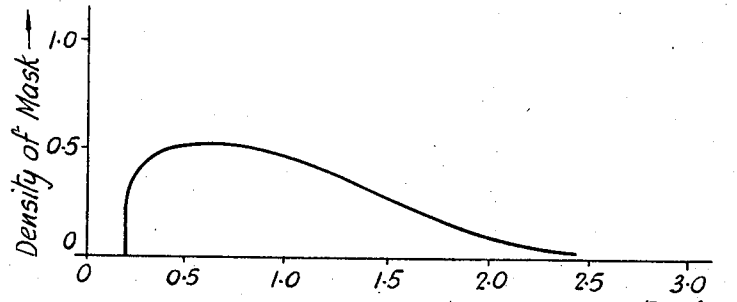


FIG.5

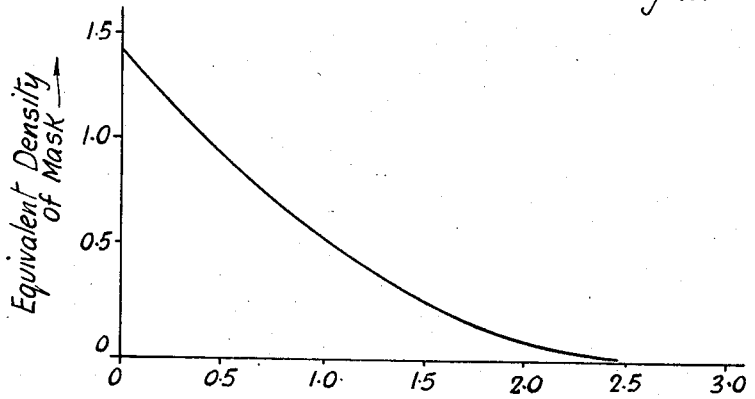


FIG.6

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ELECTRONIC TONE-MASKING SYSTEM FOR USE IN THE PRODUCTION OF COLOUR PRINTS

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Claims priority, application Great Britain February 19, 1958

6 Claims. (Cl. 178—5.4)

This invention relates to systems in which a cathode ray tube is used to modify the tone contrast of a colour reproduction being made by photographic means. Although the invention will be described with particular reference to the contact printing of positive colour transparencies on to reversal colour film, it will be appreciated that the principles described are equally applicable to negative-positive processes and to projection printing systems which may provide magnification, reduction, or unit-magnification printing from a colour record.

It is often desirable to print a colour record, hereinafter called the "original," on to colour film to produce after suitable processing copies of the original, which may be positive or negative, which will be referred to hereinafter simply as "copies." It is well known that in any such process the colouring of the copy tends to be a degraded representation of that of the original. This degradation of colouring is commonly reduced by adjusting the manufacture and processing of the colour film to provide a high contrast, i.e. a characteristic curve of steep gradient. Because a high contrast is used, a reproduction of a scale of grey tones necessarily shows an exaggerated difference between successive shades of grey. Thus if middle tones (corresponding to flesh tones, for example), are reproduced accurately, dark tones such as deep shadows become darker and light tones such as near-whites and pale skies become lighter. This effect can be disagreeable and in the production of copies from an original positive transparency, an appreciable departure from the desired gradation may occur either in the shadows or in the highlights or in both.

This objectionable feature can be reduced or eliminated by printing from the original in such a way as to reduce its apparent contrast without in any way modifying its colouring.

Known means for doing this include preparing from the original a grey negative record of the original on panchromatic film. After developing, fixing and drying, this grey negative record is placed in register with the original and light passing through the combination is used to expose the colour film on which the copies are to be printed. This method is expensive and cumbersome in practice and the copies may be marred by scratches and dirt on the grey negative record. These defects are, of course, reproduced in the copy with enhanced contrast.

The need for a separate grey negative record to provide contrast reduction or "masking" may be eliminated by using a known technique of electronic masking. This electronic system of contrast reduction involves the application of negative feedback to a flying spot scanner as described by R. Theile and H. McGhee, Journal of the British Institution of Radio Engineers, June 1952, pages 325–329. As applied to the printing of colour copies, the arrangement used is shown diagrammatically and in part by Figure 1 of the accompanying drawings. Here deflection circuits 16 cause the electron beam of a cathode ray tube 1 to trace on the phosphor screen 2 a rectangular television-type raster or any other convenient known type

of scanning pattern. An image of this scanning pattern is projected by a lens 10 on to the original 6 which is here shown in contact with the colour film 7 which is the copy material on to which the copy is to be printed. Behind the colour film is a photoelectric cell 13 which receives light transmitted by the original 6 and copy material 7 and provides an electrical current which is a measure of the transmittance of the original 6. This current is applied to an amplifier 17 the output of which is applied to the control grid or cathode of the cathode ray tube in a sense which reduces the brightness of the display at those points projected on to parts of the original having a high transmittance. As a result the display on the cathode ray tube screen takes the form of a negative image of the original, the contrast of this image being a function of the amplifier gain. The foregoing system is hereinafter referred to as "an electronic contrast-masking system of the type defined."

It will be appreciated that if, as will usually be the case, the original is being copied on to an integral tripack type of colour film, the light emitted by the cathode ray tube must contain substantial amounts of energy in the three bands corresponding to the wavelength bands to which the three emulsions of the colour film respond. Usually these three bands are in the red, green and blue parts of the spectrum. The relative energies required in the three bands must be balanced so that an original which represents a record of a neutral grey scale will produce a duplicate in which the steps of the scale are also grey. To obtain satisfactory spectral emission from the cathode ray tube it may be necessary to use a screen compounded of a mixture of two or three phosphors. Alternatively or additionally it may be necessary to interpose between the cathode ray tube and the colour film a colour modifying filter or filters. For example, it is well known that to minimise the colour degradations due to overlapping of dye absorption bands in the original and overlapping of emulsion response bands in the colour film, printing is best performed by a light source providing energy at only three discrete wavelengths, these wavelengths coinciding approximately with the peaks of the dye absorption curves. An approximation to such a spectrum may be produced by a cathode ray tube in which the screen comprises a mixture of red, green and blue phosphors each emitting over a relatively narrow band of wavelengths. In practice, however, a better result may be obtained by using a highly efficient phosphor in conjunction with selective filters. Despite the use of such combinations of phosphors and filters, the light used for exposing the colour film must still be balanced as described above, i.e. substantial proportions of its energy are contained in each of three bands of the spectrum designated red, green and blue. The term "balanced light" as hereinafter used will be understood to be defined in this way.

It is well known that in an integral tripack colour film the subtractive dyes used to form the colour image often approximate only indifferently to the ideal dyes which are required. In particular, the magenta and cyan dyes, which should transmit blue freely, often have substantial absorptions in the blue region. As a result of these deficiencies, subtractive colour films commonly reproduce saturated blues at an unduly low brightness. When a copy is made from the original a further loss in brightness of blues is apt to be experienced. Depending on the dyes used by the colour process in question, any particular colour or pair of colours (red, green or blue) may suffer loss of brightness in this way.

It is an object of the present invention to provide a method and apparatus for counteracting the loss of brightness in certain colours arising in the copying of subtractive colour films. According to the present invention, in the production of colour copies by means of an electronic

contrast masking system of the type defined, the printing of the duplicate is effected by substantially balanced light as hereinbefore defined and the photocell is selected, or its response modified by the interposition of colour filters, to produce a substantial response only to part of that portion of the spectrum of the printing light to which the emulsion or emulsions of the copy material respond. In a particular form of the invention the photocell is insensitive to, or made not to receive, the red emission of the printing light.

The invention may be further defined as a process for the production of colour copies which comprises causing the electron beam of a cathode ray tube to trace a scanning pattern on the phosphor screen of such tube, projecting an image of this scanning pattern on to a colour record, using this light to print on to a photographic copy material, collecting light from said copy material on a photo-electric cell, feeding the response of said cell to the control system of the cathode ray tube to reduce the brightness of the display on the screen at those parts corresponding to those parts of the colour record having a relatively low optical density whereby the display on the cathode ray tube takes the form of a negative image of the colour record, the light emitted by the screen containing substantial proportions of its energy in those parts of the spectrum required for printing, and providing that the light to which the photoelectric cell is caused to respond is in respect of part only of that portion of the spectrum of the light used for printing to which the photographic copy material is responsive.

The invention will be further explained with reference to the remaining figures of the accompanying drawings in which:

Figure 2 is a diagrammatic representation of the optical system seen in front elevation.

Figure 3 is a diagrammatic representation of the optical system seen in side elevation.

Figure 4 is a curve indicating the quality of light emitted by the cathode ray tube.

Figure 5 illustrates the characteristic of the type of contrast mask ideally required.

Figure 6 illustrates the type of contrast masking characteristics readily provided in practice.

In Figures 2 and 3 there is shown a cathode ray tube **1** the internal face of which carries a phosphor screen **2** comprising a mixture of a small proportion of zinc sulphide emitting green light under electron excitation and greater proportions of silver-activated zinc sulphide emitting desaturated blue-green light and cadmium phosphate emitting red light. On removal of electron excitation the light emission from either zinc sulphide phosphor falls in about 10 microseconds to $1/e$ of its emission under excitation. The corresponding "afterglow" time for the cadmium phosphate component is about 10 milliseconds. These three phosphor components combine to emit, when continuously excited, light of a quality indicated by the plot against wavelength of energy per unit wavelength band, as shown in Figure 4. The spectral energy distribution of this light is not satisfactory for the printing of copies and accordingly colour selective filters **3, 4, 5** are interposed in the optical path in a plane which is not imaged in the plane of the original **6**, or the colour film **7** on to which the original is to be printed. Preferably the filters **3, 4** and **5** are arranged, as shown, close to the lens mount **8** which houses the projection lens system **9. 10.** They serve to balance the spectral energy distribution of the light used for printing the copy.

Light passing through both the original **6** and the colour film **7** enters an integrating light-guide **11**, and is so conveyed to the photocathode **12**, of an end-window multiplier photocell **13.** Between the colour film **7** and the photocathode **12** is a further colour-selective filter or filters **14** and **15.** If the photocell **13** shows substantial response to the red light emission of the cadmium phosphate component in the phosphor of the cathode ray tube **1**, one of these filters should be of a red-absorbing nature. In this way it is provided that the photocell cannot respond to saturated reds in the original and these are accordingly printed in the same way as blacks, i.e. they receive maximum light from the cathode ray tube and are accordingly relatively brighter.

The second of these two filters may be a blue-absorbing filter which renders the photocell insensitive to saturated blues in the original. Thus, while both filters are used the contrast mask is derived entirely from the green transmission of the original. As a result, the brightness of saturated greens is restricted by the contrast mask, but that of saturated blues and reds is not.

These filters are equivalent to a green-transmitting filter, but it is convenient to keep the two components separate, so that the absorptions can be separately adjusted to give maximum transmission in the green.

The effective mask density, plotted against density of the original, should have a characteristic of the form shown in Figure 5. (The derivation of this curve is described in "The Reproduction of Colour," R. W. G. Hunt, pages 70–74, Fountain Press, 1957.) Using a linear feedback amplifier and assuming a cathode ray tube with linear modulation characteristic, the system of electronic masking described above provides an equivalent masking characteristic as shown in Figure 6. A better approximation to the required characteristic is obtained in the foregoing embodiment of the invention by using a diode to limit the amplitude of the feedback signal so that the brightness of the raster is the same at all points corresponding to parts of the original having green-light densities less than about 0.7 density unit.

It will be understood that the foregoing example of the invention, in which the photocell is made not to receive, or to receive a reduced amount of, the red and blue regions of the spectrum, is purely illustrative and essentially of value for the colour film materials which are currently available on the market. Changes in the absorption characteristics of the dyes in the colour film would necesistate variations in the selection of the response to be derived from the photocell.

What I claim is:

1. A process for the production of colour copies which comprises causing the electron beam of a cathode ray tube to trace a scanning pattern on the phosphor screen of such tube, projecting an image of this scanning pattern on to a colour record, using this light to print on to a photographic copy material, collecting light from said copy material on a photoelectric cell, feeding the response of said cell to the control system of the cathode ray tube to reduce the brightness of the display on the screen at those parts corresponding to those parts of the colour record having a relatively low optical density whereby the display on the cathode ray tube takes the form of a negative image of the colour record, the light emitted by the screen containing substantial proportions of its energy in those parts of the spectrum required for printing, and providing that the light to which the photoelectric cell is caused to respond is in respect of part only of that portion of the spectrum of the light used for printing to which the photographic copy material is responsive.

2. A process for the production of colour copies which comprises causing the electron beam of a cathode ray tube to trace a scanning pattern on the phosphor screen of such tube, projecting an image of this scanning pattern on to a colour record, using this light to print on to a photographic copy material, collecting light from said copy material on a photoelectric cell, feeding the response of said cell to the control system of the cathode ray tube to reduce the brightness of the display on the screen at those parts corresponding to those parts of the colour record having a relatively low optical density whereby the display on the cathode ray tube takes the form of a negative image of the colour record, the light emitted by the screen containing substantial proportions of its

energy in those parts of the spectrum required for printing, and providing that the photoelectric cell is responsive to part only of that portion of the spectrum of the light used for printing to which the photographic copy material is responsive.

3. A process for the production of colour copies which comprises causing the electron beam of a cathode ray tube to trace a scanning pattern on the phosphor screen of such tube, projecting an image of this scanning pattern on to a colour record, using this light to print on to a photographic copy material, collecting light from said copy material on a photoelectric cell, feeding the response of said cell to the control system of the cathode ray tube to reduce the brightness of the display on the scren at those parts corresponding to those parts of the colour record having a relatively low optical density whereby the display on the cathode ray tube takes the form of a negative image of the colour record, the light emitted by the screen containing substantial proportions of its energy in those parts of the spectrum required for printing, and providing that the light accepted by the photoelectric cell is received via a colour filter absorbing part of the portion of the spectrum of the light used for printing to which the photographic copy material is responsive.

4. A process for the production of colour copies which comprises causing the electron beam of a cathode ray tube to trace a scanning pattern on the phosphor screen of such tube, projecting an image of this scanning pattern on to a colour record, using this light to print on to a photographic copy material, collecting light from said copy materital on a photoelectric cell, feeding the response of said cell to the control system of the cathode ray tube to reduce the brightness of the display on the screen at those parts corresponding to those parts of the colour record having a relatively low optical density whereby the display on the cathode ray tube takes the form of a negative image of the colour record, the light emitted by the screen containing substantial proportions of its energy in those parts of the spectrum required for printing, and providing that the photoelectric cell is insensitive to red light, that being light to which the photographic copy material is sensitive.

5. A process for the production of colour copies which comprises causing the electron beam of a cathode ray tube to trace a scanning pattern on the phosphor screen of such tube, projecting an image of this scanning pattern on to a colour record, using this light to print on to a photographic copy material, collecting light from said copy material on a photoelectric cell, feeding the response of said cell to the control system of the cathode ray tube to reduce the brightness of the display on the screen at those parts corresponding to those parts of the colour record having a relatively low optical density whereby the display on the cathode ray tube takes the form of a negative image of the colour record, the light emitted by the screen containing substantial proportions of its energy in those parts of the spectrum required for printing, and providing that the light accepted by the photoelectric cell is received via a colour filter absorbing red light, that being light to which the photographic copy material is sensitive.

6. A process for the production of colour copies which comprises causing the electron beam of a cathode ray tube to trace a scanning pattern on the phosphor screen of such tube, projecting an image of this scanning pattern on to a colour record, using this light to print on to a photographic copy material, collecting light from said copy material on a photoelectric cell, feeding the response of said cell to the control system of the cathode ray tube to reduce the brightness of the display on the screen at those parts corresponding to those parts of the colour record having a relatively low optical density whereby the display on the cathode ray tube takes the form of a negative image of the colour record, the light emitted by the screen containing substantial proportions of its energy in those parts of the spectrum required for printing, and providing that the light accepted by the photoelectric cell is received via filters absorbing red and blue lights, these being lights to which the photographic copy material is sensitive.

No references cited.