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PHOTOGRAPHIC COLOR PRINTING APPARATUS

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Fig. 1

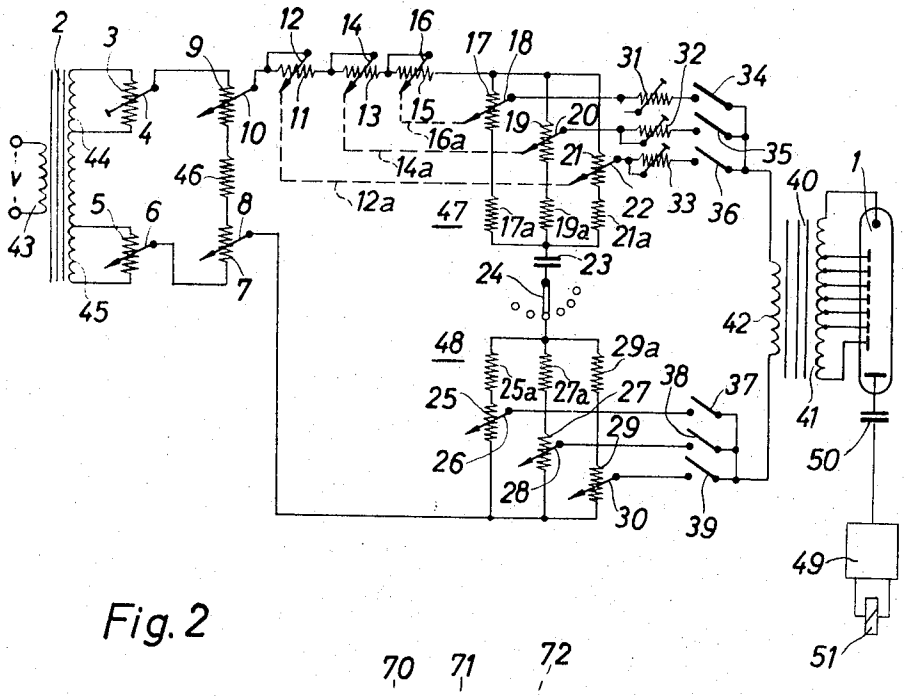
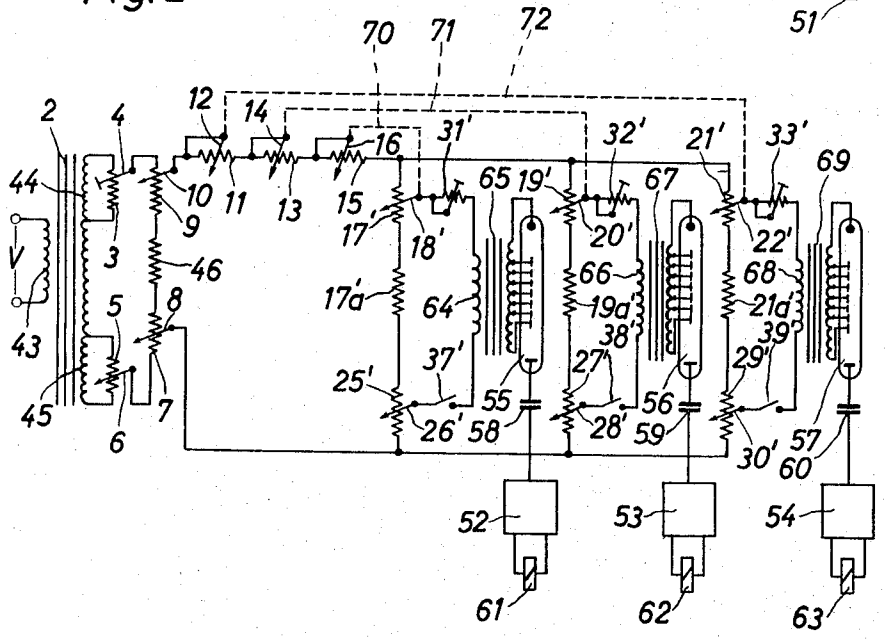


Fig. 2



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PHOTOGRAPHIC COLOR PRINTING APPARATUS

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Continuation of application Ser. No. 842,290, Sept. 25, 1959. This application Aug. 1, 1966, Ser. No. 569,534
Claims priority, application Germany, Sept. 26, 1958, A 30,403
17 Claims. (Cl. 88—24)

ABSTRACT OF THE DISCLOSURE

A color correction network having three parallel branches, each of said branches having an adjustable impedance corresponding to a particular color, is series connected to a copy density compensation network consisting of three adjustable series impedances. The moving arm of each of these impedances is connected to the moving arm of the corresponding color correction impedance in such a manner that a positive change in one of the color correction impedances results in a negative change of a magnitude equal to one divided by the number of impedances in each of the compensation impedances.

Cross-references to related applications

This is a continuation of my application Ser. No. 842,290, filed Sept. 25, 1959, and entitled, "Photographic Color Printing Apparatus".

In the U.S. Patent No. 3,002,425, which is assigned to the assignee of the present application, there is described a photographic color printing appartus that is sensitized by three partial illuminations in the primary colors blue, green and red, which are provided in time sequence. In corresponding sequential manner respective color filters are introduced into the light beam. For proper operation of this and other apparatus of the same general class, it is essential under conditions of change in the concentration of one of the color components, also to alter the remaining color contributions to such a degree as to maintain constant the total density of the copy. In the prior art the maintenance of such constancy has posed appreciable problems and has required extreme care in the operation of the printing apparatus.

Accordingly it is a general object of the invention to provide control apparatus for photographic printing which avoids the disadvantages of the appartus of the prior art.

A further, and more specific object of the invention is the provision of control apparatus of the aforementioned character that admits of ready adjustment by the operator to provide the partial illuminations in the desired contributions and yet maintains the total density of the copy constant automatically without further attention.

Another object of the invention is to provide control apparatus of the character described that is relatively simple, inexpensive and easy to operate.

These and other objects are attained in accordance with the invention and in the preferred manner, by provision of denstiy correction devices which are coupled to the illumination control means for the respective partial colors in such manner as to maintain constant the total density of the copy.

The invention will be better understood upon consideration of the following more detailed remainder of the specification, of which the appended claims form a part, together with the accompanying drawings, in which:

FIG. 1 is a schematic illustration of control apparatus in accordance with a preferred embodiment of the invention; and

FIG. 2 is a schematic illustration of another embodiment of the invention.

Referring to FIG. 1 of the drawings, reference numeral **1** deisgnates a photocell of the secondary electron multiplier type, which as such forms part of the color printing apparatus proper. The latter is not illustrated in detail, since it forms no part of the present invention, and moreover is fully disclosed in the aforementioned U.S. Patent No. 3,002,425. Alternatively other known types of printing apparatus may be coupled to the control apparatus presently described. For present purposes, it is sufficient to state that the apparatus further includes electronic means, indicated in block form as at **49**, for controlling the three partial illuminations, which is coupled to the anode of photocell **1** between said anode and one plate of a capacitor **50**. The other plate of the capacitor **50** is grounded. The illumination control arrangement **49** is described in the aforementioned U.S. Patent No. 3,002,425. Photocell **1** is disposed in the path of light transmitted or reflected by the copy material. Its photocurrent is controlled by energizing potentials supplied to its control electrodes in the manner presently described, and in turn controls the potential of capacitor **50**. A relay **51** is coupled to the control means **49** and is effective to extinguish the copy light and to change the color filter when the changing potential of capacitor **50** attains a predetermined magnitude. This is described in the aforementioned U.S. Patent No. 3,002,425.

Energizing potential is applied between the cathode and a plurality of control electrodes of the photocell **1** from the secondary **41** of a high voltage transformer **40**, the control electrodes being connected to respective tap points of said secondary. The voltage input to the primary **42** of the transformer is derived ultimately from the primary **43** of an input transformer **2**, which is energized by the line alternating voltage V. The secondary of transformer **2** is provided with a pair of balanced windings **44** and **45** across which are connected a density adjustment potentiometer **3** and a potentiometer **5** respectively, which together with a further potentiometer **7** serve to take into account the instant arrangement of the masks or filters of the copying frame.

A fourth density adjustment potentiometer **9** is connected at one end to the slider **4** of potentiometer **3**, and at its other end via a resistor **46** to one end of potentiometer **7**, the other end of the latter being connected to slider **6** of potentiometer **5**. Across the sliders **10** and **8** there are connected in series the following elements in order; rheostat-connected potentiometers **11**, **13** and **15**, which are provided for density compensation; a network **47** that is provided for the purpose of color correction; a capacitor **23**; a selector switch **24**; and a network **48**, which is provided for calibration purposes.

The color-correction network **47** includes three parallel branches, each including a potentiometer that is in series with a fixed resistor, designated as **17** and **17***a*, **19** and **19***a*, and **21** and **21***a* respectively. The sliders of the potentiometers, designated as **18**, **20** and **22** respectively, are ganged mechanically to sliders **12**, **14** and **16** of the mentioned rheostats **11**, **13** and **15** respectively for movement of respective slider pairs in unison. The mechanical connections are designated as **12***a*, **14***a* and **16***a* respectively. The sliders **12**, **14** and **16** are short-circuited to the respective left ends of the associated rheostats.

The network **48** includes three parallel branches, each including a fixed resistor in series with a potentiometer, designated as **25***a* and **25**, **27***a* and **27**, and **29***a* and **29**. The network **48** is exemplary of several similar calibration networks, not illustrated, which may be selected by means of the switch **24**.

The sliders **18**, **20** and **22** of the color-correction potentiometers **17**, **19** and **21** are connected respectively to color-adjustment rheostats **31**, **32** and **33**, which are in turn connectable to the upper end of transformer primary **42** through respective switches **34**, **35** and **36**. The sliders **26**, **28** and **30** of the calibration potentiometers **25**, **27** and **29** are directly connectable to the lower end of transformer primary **42** through respective switches **37**, **38** and **39**.

During the time interval of blue illumination, the switches **34** and **37** are closed, whereas the remaining parallel switches are open. For green illumination, switches **35** and **38** are closed, while for red illumination switches **36** and **39** are closed, the remaining parallel switches in each instance being open.

Due to the electrical network comprising the parallel-connected branches **17**, **17***a*, **19**, **19***a* and **21**, **21***a* and the series-connected branch **11**, **13**, **15** connected in series therewith and the predetermined cooperative adjustment of the resistors **11** and **21**, **13** and **19**, and **15** and **17** due to the mechanical coupling of the slider pairs **12** and **22**, **14** and **20**, and **16** and **18**, there results automatic electrical density correction. Should one of the three partial illuminations be increased by a factor k corresponding to a variation of the settings of one of the sliders **18**, **20** and **22**, each of the three partial illuminations is automatically decreased by the factor $\frac{1}{3}k$ in view of the coupling of the sliders **18**, **20** and **22** to the sliders **12**, **14** and **16** and due to the resistances of the cooperatively varied resistors **11** and **21**, **13** and **19**, and **15** and **17**, as well as of the fixed resistors **17***a*, **19***a* and **21***a*, of the electrical network. Thus it is seen that, in accordance with the invention, the total density of the copy remains constant, although the color components of the copy may be changed relative to one another. It is also readily seen that this desired result is achieved by simple and inexpensive means, whose operation requires relatively little care on the part of the operator, and therefore chances for errors are greatly minimized.

The invention is also useful when the partial illuminations of the printing material during a complete exposure process take place simultaneously, and, therefore, three photoelectric cells are provided, each for automatically regulating one of said three partial illuminations.

An embodiment suitable for individual photocells is illustrated in FIG. 2, to which reference is now made. Here photocells **55**, **56** and **57** concurrently receive partial illuminations in the primary colors red, green and blue, respectively. They correspond to photocell **1** of FIG. 1. Accordingly, they are provided with respective control means **52**, **53** and **54**, which correspond to unit **49** of FIG. 1; respective capacitors **58**, **59** and **60**, which correspond to capacitor **50** of FIG. 1; respective relays **61**, **62** and **63**, which correspond to relay **51** of FIG. 1; and respective transformers **65**, **67** and **69**, which correspond to transformer **40** of FIG. 1.

The primary windings **64**, **66**, **68** of the transformers **65**, **67**, **69** are connected to individual color correction networks, which correspond to those illustrated in FIG. 1 as indicated by like reference numerals followed by a prime. The description of the "blue" color correction network may be taken as implicitly describing the remaining "green" and "red" networks, which are connected in shunt therewith. Winding **64** is connected at its upper end through the color adjustment rheostat **31'** to the slider **18'** of color correction potentiometer **17'**, whose upper terminal is connected to density compensation rheostat **16** as in the embodiment of FIG. 1. Potentiometer **17'** connects at its lower end through fixed resistor **17'***a* and calibration potentiometer **25'** to slider **8**. Slider **26'** of potentiometer **25'** connects to the lower end of winding **64** through calibration switch **37'**. The circuitry to the left of the color correction network is identical to that of FIG. 1. The mechanical interconnections between slider pairs **16** and **17'**, **14** and **20'**, and **12** and **22'** are designated by **70**, **71** and **72**, respectively.

In operation, the relays **61**, **62** and **63** are arranged, in cooperation with respective control networks **52**, **53** and **54**, to switch off respective blue, green and red copy light sources (not shown). Alternatively these relays may be arranged to switch on respective color filters into the copy light path thereby likewise to interrupt the associated partial illumination. The contacts **37'**, **38'** and **39'** are associated with relays **61**, **62** and **63**, and are closed in response to the respective control networks **52**, **53**, **54**, during the time intervals of respective partial illuminations.

By virtue of the intercoupling of the potentiometer slider pairs **12** and **22'**, **14** and **20'**, and **16** and **18'**, there is also obtained the result that with a change in the settings of one of the sliders **18'**, **20'** or **22'** tending to vary the partial illumination by a factor of k, the associated slider **12**, **14** or **16** is positioned so as to vary the partial illumination by a factor of $\frac{1}{3}k$ and the total copy density remains constant.

The invention admits of many modifications. For example, the potentiometers **5**, **6** and **7**, **8** may be omitted for the case of use of a single size or form copy where adjustable masks are not required; also for the case where the photocell receives illumination from a partially transmissive mirror disposed intermediate the positive and negative planes. As a further alternative, these potentiometers may be replaced by switch selected fixed resistors which correspond to respective copy paper frames of various sizes and forms.

The invention is also applicable for arrangements wherein the intensity rather than the duration of the partial illumination is varied, or both intensity and duration are varied.

The color correction means **17**, **18**; **19**, **10**; **21**, **22** may be inserted in the circuits of the control means **49**, for example in the circuit of charging capacitor **50**, rather than in the supply circuit of the photocell **1**. Similar changes may be effected in the corresponding circuits of FIG. 2. Similarly, the density compensation means **11–16** need not necessarily be included in the circuit of photocell **1** or photocells **55**, **56**, **57**. Instead they may be inserted in the circuit of charging capacitor **50** (FIG. 1), or in a common supply circuit (not shown in FIG. 2) for the control means **52**, **53**, **54** (FIG. 2).

Many other modifications of the illustrated embodiments are possible, and it is intended that they be comprehended as within the invention as defined by the following claims. For example, the various resistive elements could be replaced by impedance elements, particularly of the inductive type. Accordingly, it is intended that the terms "potentiometer" and "rheostat," as employed in the claims, be construed to cover variable impedances as well. The switches **34** and **39** have been indicated as manually operable, but it should be understood that they could be driven by a suitable commutator driver.

What is claimed is:

1. For use in a photographic color printing apparatus having photoelectric means responsive to a plurality of partial illuminations of diverse colors; illumination control means for controlling said illuminations, comprising, in combination, a color correction network having a plurality of parallel branches corresponding in number to that of said colors, each of said branches including an adjustable impedance; and a copy density compensation network connected to said color correction network and including a plurality of adjustable impedances that are respectively jointly adjustable with the associated color correction impedances, whereby said impedances may be adjusted to vary the individual partial color illuminations while maintaining the total copy density substantially constant.

2. Illumination control means according to claim **1**, wherein said plurality of copy density compensation network impedances are connected in series with each other.

3. An illumination control means according to claim **1**, wherein said color correction network and said copy

density compensation network are connected in series with each other.

4. An illumination control means according to claim 1, wherein each of said adjustable impedances of said color correction network includes a movable contact member and each of said adjustable impedances of said copy density compensation network also including a movable contact member that is operable in unison with the contact member of the associated color correction impedance.

5. An illumination control means according to claim 1, wherein said color correction network includes three parallel branches.

6. An illumination control means according to claim 1, wherein said networks are arranged in such a manner that adjustment of one of said color correction impedances in one of said parallel branches automatically influences the condition of all of said plurality of parallel branches of said color correction network.

7. For use in an apparatus for producing photographically on photosensitive material reproductions of multicolor originals and including means for exposing the photosensitive material to componental illuminations in respectively different colors, a measuring and control apparatus comprising in combination, exposure control means including photoelectric means responsive to illumination of different colors adapted to be derived selectively and separately from a multicolor original and adapted to impinge on said photoelectric means and on the photosensitive material said photoelectric means being responsive to a predetermined critical amount of applied luminous energy and being adapted to limit at least one of the exposure characteristics including light intensity and exposure time accordingly, said critical amount of luminous energy being determinable by adjustment of the operating characteristics of said photoelectric means; a source of electric energy for energizing said photoelectric means; and adjustment means connected between said source and said photoelectric means, said adjustment means comprising first adjusting means coupled to said photoelectric means for varying the reaction of said photoelectric means to varying amounts of light of said different colors impinging thereon and for thereby varying the amounts of light applied during said componental exposures, and second adjusting means coupled to said source and operatively connected with said first adjusting means for further varying the said reaction of said photoelectric means to varying amounts of light, said adjustment means including control means for controlling said first and second adjusting means to adjust the reaction of said photoelectric means to a variation in intensity of illumination by operation of said first adjusting means to control the exposure in a selected one of said colors and to automatically adjust the reaction of said photoelectric means to counteract said variation in intensity of illumination by corresponding operation of said second adjusting means for exposures in the other colors, the rates of adjustment effected by said first and second adjusting means being so chosen that the sum total of the individual amounts of luminous energy applied to the photosensitive material in said different colors remains constant irrespective of any adjustment of said first adjusting means.

8. For use in an apparatus for producing photographically on photosensitive material reproductions of multicolor originals and including means for exposing the photosensitive material to componental illuminations in respectively diverse colors, a measuring and control apparatus comprising, in combination, exposure control means including photoelectric means of variable operating characteristics, responsive to illumination of diverse colors adapted to be derived selectively and separately from a multicolor original and adapted to impinge on said photoelectric means and on the photosensitive material, said photoelectric means being responsive to a predeterminable critical amount of applied luminous energy and being adapted to limit at least one of the exposure characteristics including light intensity and exposure time accordingly, said critical amount of luminous energy being determinable by adjustment of the operating characteristics of said photoelectric means; a source of electric energy for energizing said photoelectric means; and adjustment means connected between said source and said photoelectric means for modifying the operating characteristics of said photoelectric means, said adjustment means comprising a parallel-combination of first adjustable impedance means coupled to said photoelectric means equal in number to that of said diverse colors and corresponding thereto, said first adjustable impedance means being adjustable to vary the operating characteristic of said characteristic of said photoelectric means for an exposure by illumination in the corresponding color, and a series-combination of a plurality of second adjustable impedance means coupled to said source and connected in series with the parallel-combination of first adjustable impedance means, each of said second adjustable impedance means being individually adjustable for further varying said operating characteristic of said photoelectric means, each of said first and second adjustable impedance means including a control means for varying its impedance value, coupling means mechanically coupling the control means of said first impedance means corresponding to the said diverse colors with the control means of said second impedance means in such a manner that adjustment to an increase in impedance value of a selected one of said first impedance means automatically causes a simultaneous adjustment of said second impedance means to a decrease in impedance value, and vice versa, the rates of impedance value variation by actuation of said control means being so chosen that the sum total of the individual amounts of luminous energy applied to the photosensitive material during illumination thereof by said diverse colors remains a constant irrespective of any adjustment of any one of said first adjustable impedance means.

9. For use in a photographic color printing apparatus having a photomultiplier tube responsive to a plurality of partial illuminations of diverse colors: illumination control means for controlling said illumination, comprising, in combination, a color correction network having a plurality of parallel branches corresponding in number to that of said colors, each of said branches including an adjustable impedance; transformer means connected between said color correction network and said photomultiplier tube; and a copy density compensation network connected to said color correction network and including a plurality of adjustable impedances that are respectively jointly adjustable with the associated color correction impedances, and connected in series with each other, whereby said impedances may be adjusted to vary the individual partial color illuminations while maintaining the total copy density substantially constant.

10. For use in a photographic color printing apparatus having a plurality of photoelectric means each responsive to a corresponding one of a plurality of partial illuminations of diverse colors: illumination control means for controlling said illuminations, comprising, in combination, a color correction network having a plurality of parallel branches corresponding in number to that of said colors, each of said branches including an adjustable impedance, each of said adjustable impedances being connected to the photoelectric means corresponding to the same color; and a copy density compensation network connected to said color correction network and including a plurality of series connected adjustable impedances respectively jointly adjustable with the associated color correction impedances, whereby said impedances may be adjusted to vary the individual partial color illuminations while maintaining the total copy density substantially constant, the exposures to illumination in said diverse colors being carried out simultaneously.

11. For use in a photographic color printing apparatus having photoelectric means comprising photomultiplier tubes responsive to a plurality of partial illumination of diverse colors: illumination control means for controlling said illumination, comprising, in combination, a color correction network having a plurality of parallel branches corresponding in number to that of said colors, each of said branches including an adjustable impedance having a movable contact member; a copy density condensation network connected to said color correction network and including a plurality of adjustable impedances each having a movable contact member operable in unison with the contact member of the associated color correction impedance, whereby said impedances may be adjusted to vary the individual partial color illuminations while maintaining the total copy density substantially constant; and a plurality of transformers connected between the corresponding ones of said first impedance means and the corresponding ones of said photomultiplier tubes.

12. For use in an apparatus for making photographic color prints from color transparencies on light sensitive printing material by effecting in each printing operation a plurality of componental color exposures of said printing material through said transparencies by application of light of respectively different colors, a measuring and control apparatus comprising, in combination, adjustable exposure controlling means adapted to automatically limit the amount of light applied during each different componental color exposure to a predetermined value, respectively, corresponding to a predetermined desired density of the print in the corresponding color components thereof so that the sum total of the densities in said different color components of the print has a predetermined value, said exposure controlling means including adjustment means for selectively adjusting the amount of light applied during a selected one of said componental color exposures to a value varying from said predetermined value thereof, and supplemental adjustment means cooperating with said adjustment means for automatically adjusting the amounts of light applied during the other componental color exposures to values differing from said predetermined values, respectively, to counteract the variation in value in such a manner that, irrespective of an adjustment of the proportion between the amounts of light applied during the different componental color exposures and between the resulting densities of the color components of the print, the overall density of the print remains at said predetermined value thereof.

13. For use in an apparatus for making photographic color prints from color transparencies on light sensitive printing material by effecting in each printing operation a plurality of componental color exposures of said printing material through said transparencies by application of light of respectively different colors, a measuring and control apparatus comprising, in combination, adjustable exposure controlling means adapted to limit the amount of light applied during each different componetal color exposure to a predetermined value, respectively, corresponding to a predetermined desired density of the print in the corresponding color components thereof so that the sum total of the densities in said different color components of the print has a predetermined value, said exposure controlling means including adjustment means for selectively adjusting the amount of light applied during a selected one of said componental color exposures to a value varying from said predetermined value thereof, and supplemental adjustment means cooperating with said adjustment means for automatically adjusting the amounts of light applied during all of said componental color exposures to values differing from said predetermined values, respectively, to counteract the variation in value in such a manner that, irrespective of an adjustment of the proportion between the amounts of light applied during the different componental color exposures and between the resulting densities of the color components of the print, the overall density of the print remains at said predetermined value thereof.

14. For use in an apparatus for making photographic color prints from color transparencies on light sensitive printing material by effecting in each printing operation a plurality of componental color exposures of said printing material through said transparencies by application of light of respectively different colors, a measuring and control apparatus comprising, in combination, photoelectric means adapted to regulate said componental color exposures depending upon the amounts of light applied during the individual componental color exposures; adjustable color correction means for varying the amount of light applied during a selected one of said color exposures by varying for said one color exposure the sensitivity of said photoelectric means; and supplemental density compensation means controlled by said color correction means for varying the amounts of light applied during the other color exposures by varying the sensitivity of said photoelectric means to counteract the variation of sensitivity for said other color exposures in such a manner that the overall density of the resulting print remains at a predetermined value irrespective of variations of the densities of the different color components thereof due to adjusted variations of the amounts of light applied during said different componental color exposures.

15. For use in a photographic color printing apparatus having photoelectric means responsive to a plurality of partial illuminations of diverse colors, illumination control means for controlling said illuminations, comprising, in combination, a color correction network having a plurality of parallel branches corresponding in number to that of said colors, each of said branches including an adjustable impedance; and a plurality of adjustable copy density compensation impedances connected to said color correction network and respectively jointly adjustable with the associated color correction impedances, whereby said color correction impedances may be adjusted to vary the individual partial color illuminations while maintaining the total copy density substantially constant.

16. An illumination control means according to claim 15 wherein each of said color correction impedances includes an impedance element and an electrical contact member movable therealong, each of said copy density impedances also including an impedance element and electrical contact member which is operable in unison with the wiper arm of the associated color correction impedance.

17. An illumination control means according to claim 15, wherein adjustment of one of said copy density impedances in response to adjustment of the associated color correction impedance in one of said parallel circuits automatically influences the electrical condition of all of said parallel branches of said color correction networks.

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