United States Patent

Bergero

[15] **3,651,246**

[45] **Mar. 21, 1972**

[54] ELECTRO-MECHANICAL COLOR REPRODUCTION SYSTEM

[72] Inventor: **Ramon Bergero**, Los Angeles, Calif.

[73] Assignee: **BSR Optronics Corporation**

[22] Filed: **Aug. 25, 1969**

[21] Appl. No.: **862,588**

[52] **U.S. Cl.** ..... **178/5.2 R**, 40/28 C

[51] **Int. Cl.** **H04n 1/46**

[58] **Field of Search** ..... 178/5.2, 5.2 A; 40/28 C

[56] **References Cited**

UNITED STATES PATENTS

1,072,152	9/1913	Ocampo	40/28 C
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Primary Examiner—Robert L. Griffin
Assistant Examiner—George G. Stellar
Attorney—Spensley, Horn and Lubitz

[57] **ABSTRACT**

An electro-mechanical system for preparing a color matrix for the reproduction of images appearing on a color positive transparency, the matrix defining a pattern of identical red, blue and green spot groupings similar to that utilized in color television interlace scanning, wherein points on the color transparency are selected in accordance with the spacing of the matrix spot groups, these points being optically scanned and the red, blue and green color component intensities at each point detected and used to determine the areas of the similarly colored spots in the corresponding matrix spot group to be blackened in accordance with a color subtraction technique.

16 Claims, 4 Drawing Figures

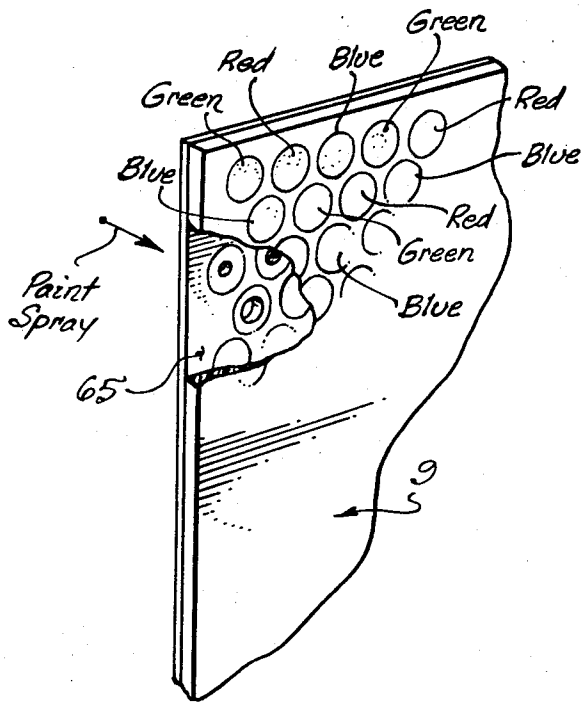


FIG. 1.

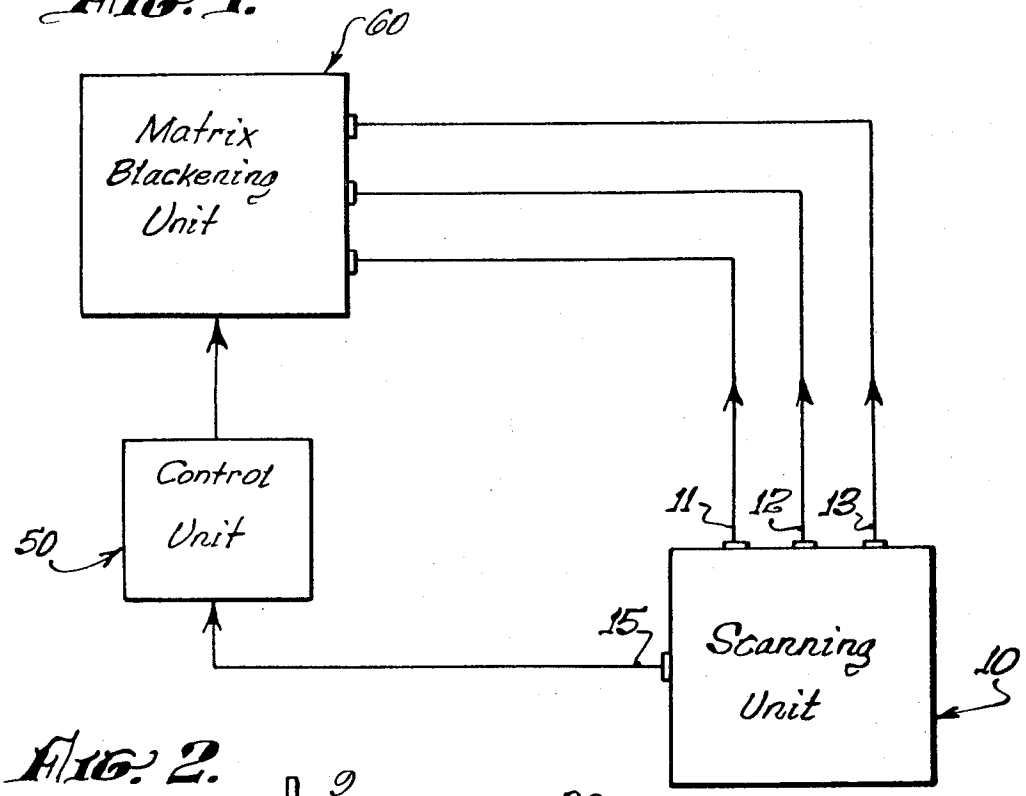
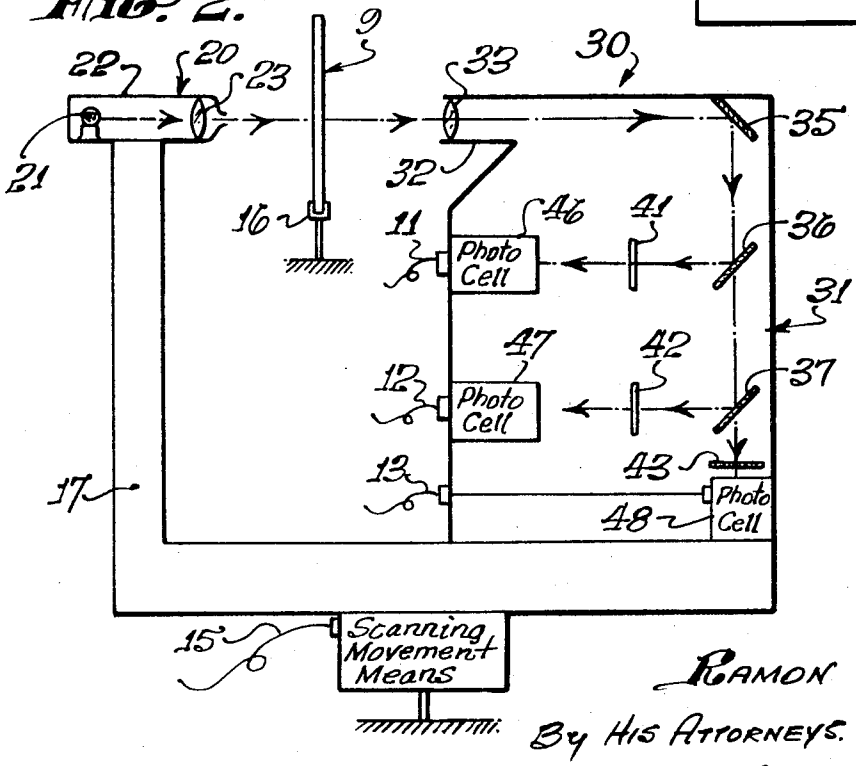


FIG. 2.



INVENTOR.
RAMON BERGERO,
By His Attorneys.
Spensley & Horn.

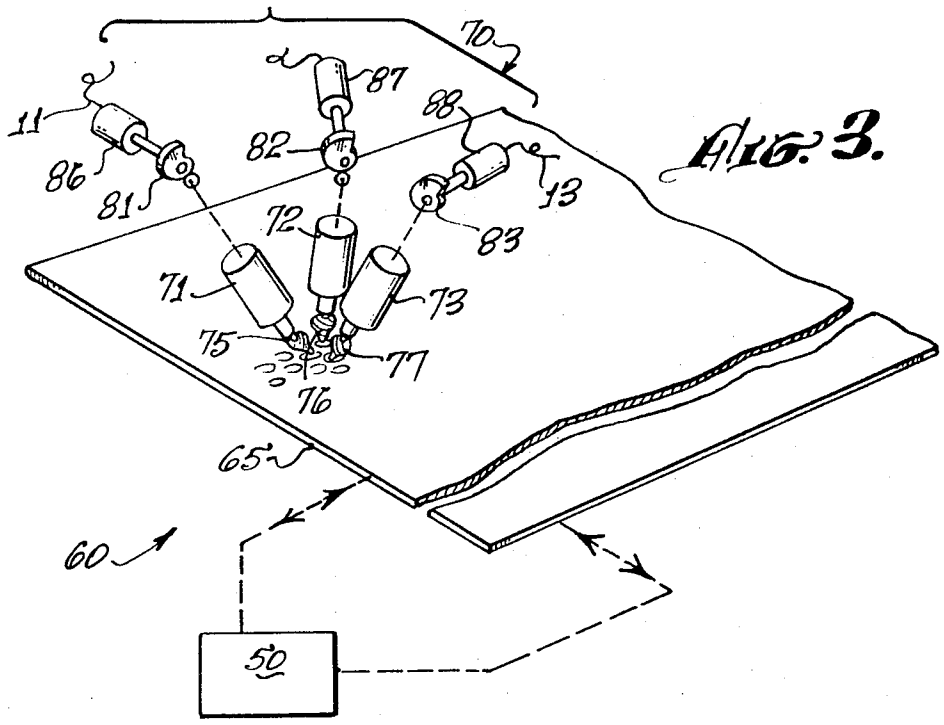


FIG. 3.

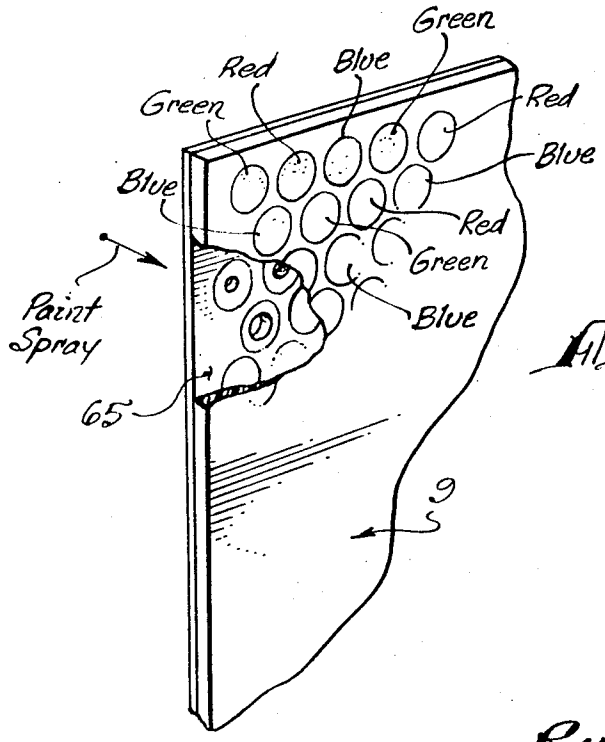


FIG. 4.

INVENTOR.
RAMON BERGERO,

By His Attorneys
Spensley & Horn

ELECTRO-MECHANICAL COLOR REPRODUCTION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to the present inventor's copending U.S. Pat. application Ser. No. 857,277, for a "Color Display System," filed concurrently herewith, said application being a continuation-in-part of abandoned application Ser. No. 728,570, filed May 13, 1968, entitled "Color Sign Mechanism;" however, this application is in no way dependent upon the aforesaid copending application for disclosure support, nor is reference thereto necessary for a full and complete description and understanding of the present invention.

BACKGROUND OF THE INVENTION

In the field of large scale sheet display it has been long customary to print the display information on strips of paper which are then pasted on a billboard in proper registry to form the display. The advent of electrical and electro-optical displays has considerably shortened the time and effort required for a display change; yet these newer systems are not without their attendant disadvantages, particularly in color reproduction applications. In such applications it has been heretofore customary to either utilize a relatively expensive electro-optical projection system or a cumbersome matrix screen of numerous colored light bulbs together with the necessary control system for selecting the bulbs to be illuminated.

In his above referenced copending application the present inventor has disclosed a relatively simple and inexpensive system for color image displays, utilizing a three color spot matrix similar to that utilized in a color television picture tube, the spots being partially blackened to form the desired color image by color subtraction from the red, blue and green matrix spots. The present invention is directed toward an electro-mechanical system for preparing the integrated color image matrix.

SUMMARY OF THE INVENTION

The matrix is prepared for the reproduction of images appearing on a color positive transparency by optically scanning the surface of the transparency in a series of scanning points in the same spatial relationship to each other as the spot groups on the matrix, the intensities of the red, blue and green color components at each scanning point being determined and converted to electrical signals which are used to control mask perforating or blackening substance applicator means which scans the surface of a masking sheet or the matrix surface in synchronism with the optical scanning of the transparency. Thus, either a mask is prepared for registry on the matrix surface preparatory to application of the blackening substance, or the blackening substance is applied directly to the matrix surface without using an interposed mask. Alternatively, instead of applying the blackening substance to the matrix surface through the mask apertures, in which case the mask is removed before matrix use, the blackening substance can be on the mask itself, in which case the mask remains in registry with the matrix during matrix use. In this latter case the mask can be either a "positive" mask (the mask being black and opaque with the areas of the mask apertures being directly proportional to the intensities of the primary colors at the corresponding points on the color transparency), or a "negative" mask (the mask material being transparent with blackened opaque areas inversely proportional to the intensities of the primary colors at the corresponding points on the color transparency). In any case, the electrical signals representative of the intensities of the red, blue and green color components at each scanning point control the mask perforating or blackening substance applicator means determine the areas of the matrix red, blue and green spots which remain visible during matrix use.

The matrix can be of an opaque material for use with a front lit display or can be of a translucent material for a back lit display. The utilization of a blackened mask enables a display change merely be mask replacement, the color matrix remaining undisturbed.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is a block diagram depicting the present invention system in its basic form;

FIG. 2 is a pictorial schematic diagram showing a light transmission means for use in the invention;

FIG. 3 is a pictorial schematic diagram showing a matrix blackening means for use in the invention; and,

FIG. 4 is a perspective view of a portion of a matrix partially masked.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1 of the drawing, there is shown a block diagram of the basic present invention system, the functional units being a scanning unit indicated by the reference numeral 10, a control unit indicated by the reference numeral 50 and a matrix blackening unit indicated by the reference numeral 60.

The scanning unit 10 functions to optically scan the surface area of the color transparency to be reproduced, to detect the intensity of each of the red, blue and green color components at each scanning point and convert them to an electric signal output, the electric signal output indicative of the red color component intensity being indicated by the reference numeral 11, the outputs 12 and 13 respectively indicating the blue and green color component intensities at that scanning point. The scanning unit 10 also produces an electrical control output 15, which actuates the control unit 50.

It is presently preferred to use a matrix having a triangular three spot primary color group pattern similar to that used in color television together with a step interlace horizontal scanning technique, wherein scanning proceeds from point to point horizontally to the end of a scanning line and then horizontally in the opposite direction point to point for the next lower scanning line, the scanning points of one scanning line being offset from those on the next adjacent scanning line in accordance with the well known interlace scanning technique. The scanning unit pauses momentarily at each scanning point to allow the primary color light intensities to be sampled, a scanning line consisting of 280 scanning points in conjunction with 560 scanning lines for the vertical height of the color transparency having been found to provide good resolution. Of course, other scanning parameters can also be used, as can other color group patterns. It is to be understood that the matrix color grouping is in accordance with the scanning parameters selected, i.e., in the illustrative example 280 groups per line with 560 interlaced lines.

The control unit 50 functions to move the matrix blackening unit 60 from one matrix color group to another in synchronism with movement of the scanning unit from one scanning point to the next in response to the scanning unit control output 15, the control unit typically being an uncomplicated electro-mechanical system utilizing microswitches to control motor operation, as will be hereinbelow explained.

As the matrix blackening unit 60 arrives at each successive matrix color group corresponding to the point on the surface of the transparency then being scanned by the scanning unit 10, the primary color intensity signals for that scanning point are fed to it, the blackening unit then functioning to blacken a portion of each of the spots of that matrix group in accordance with the color subtraction technique for color reproduction from the three primary colors, red, blue and green. The blackening of the matrix can be accomplished by the direct application of an opaque blackening substance onto the matrix surface in register with the spots of each color group, or can be accomplished through the preparation of a mask for registry on the front of the matrix, the use of a mask being presently preferred for its relative simplicity and greater versatility.

The mask can be intended for use in blackening the appropriate matrix surface areas, in which case the mask sheet is punched with apertures, the size of the apertures varying in accordance with the amount of color to be blackened off. In such applications the mask can be either a complete mask the size of the matrix or can be in a strip or tape form for masking of only a number of lines at a time. To use this type of mask the mask is placed in registry on the matrix and the blackening substance sprayed or painted on, the matrix surface areas exposed through the mask apertures being blackened to achieve the desired amount of color subtraction, after which the mask is removed.

Alternatively the mask can be designed for use in place in front of the matrix during matrix use, thereby allowing display changes merely by mask changing. Again, an apertured mask can be used, the mask being black and opaque with the apertures allowing the desired amount of primary color to show through; or a mask of transparent material can be used, the mask surface being blackened to provide the desired color subtraction. Obviously, when using an apertured opaque mask the size of the apertures are directly proportional to the primary color intensities at each scanning point, the size of the mask apertures being inversely proportional to the scanning point color intensities when the mask is used only in the application of the blackening substance directly to the matrix surface.

Turning now to FIG. 2 of the drawing a presently preferred embodiment of the scanning unit **10** is illustrated. A positive color transparency **9** is held in a fixed position by a suitable mounting frame, generally indicated by the reference numeral **16**. A movable support **17** has portions projecting on either side of the mounted transparency. Mounted to the support **17** on one side of the transparency is a light source generally indicated by the reference numeral **20**, and mounted to support **17** on the other side of the transparency is a light separator generally indicated by the reference numeral **30**.

The light source consists of a lamp bulb **21** mounted at one end of a tube **22**, the lamp end of tube **22** being closed and the other end of the tube being open. Fitted in the open end of tube **22** is a focusing lens **23**, for focusing the light from bulb **21** into a narrow beam directed essentially coaxially with the tube, the tube being perpendicularly aligned with respect to the color transparency **9**.

The light separator **30** is enclosed in a light tight housing **31** having a tubular projecting portion **32** coaxially aligned with the tube **22** of the light source **20**. Fitted into the end of the tubular portion **32** is a focusing lens **33** to sharpen the light received from light source **20** back into a narrow beam, the beam emitted from the light source being somewhat dispersed as it passed through the color transparency. A reflecting mirror **35** is set at a 45° angle to the light axis to reflect the received beam vertically downward.

The downwardly reflected beam impinges upon a red dichroic mirror **36**, which reflects the red light in the received beam while allowing other colors to pass unreflected therethrough. The red light reflected by dichroic mirror **36** then is directed horizontally (mirror **36** being set at an angle of 45° to the downward vertically directed beam) through a filter **41** which selectively passes red light while impeding other colors and onto a photocell **46**, the electrical output of photocell **46** forming the red light intensity component electric signal output **11**.

Thus the received light beam, minus the red component which has been reflected away by dichroic mirror **36**, proceeds vertically downward where it impinges upon a second dichroic mirror **37**, the mirror **37** being a blue dichroic mirror to reflect away the blue light through a blue-pass filter **42** to a second photocell **47**, the electrical output of photocell **47** forming the blue light intensity component electric signal output **12**.

The remaining light beam, minus essentially the red and blue color components, then proceeds further vertically downward through a green-pass filter **43** and onto a third photocell **48**, the electrical output of photocell **48** forming the green light intensity component electric signal output **13**. In the foregoing manner the respective red, blue and green color component light intensities are sampled and converted into electric output signals whose magnitudes are determined by the light intensities.

The means for effecting the desired scanning movement of the movable support **17**, with respect to the stationary transparency **9** has not been shown in other than block form due to the obviousness of the many suitable techniques, an exemplary description of one technique now being given by way of illustration. An electrical motor driven carriage mechanism, such as that shown in U.S. Pat. No. 2,638,500, issued May 12, 1953, is used to move the support **17** in a horizontal direction, a circular cam properly geared to the motor shaft having two indentations 180° apart providing for microswitch actuation for stopping the motor at each scanning point, another microswitch actuating the means for vertically advancing the carriage when the support **17** reaches the end of a scanning line as well as reversing the direction of a carriage travel. The microswitch which stops carriage movement can also conveniently provide the control output **15**. The electro-mechanical circuitry providing any such desired scanning movement is well known in the art and does not constitute of itself a part of the present invention.

A similar type of electro-mechanical circuit can advantageously be used for controlling movement of the matrix blackening means in synchronism with movement of the scanning unit **10**, the electrical control output **15** serving to actuate the control unit **50**, mechanically actuated microswitches serving to halt blackening unit carriage movement in register with the successive matrix color groups.

FIG. 3 of the drawing schematically indicates a suitable embodiment for a matrix blackening unit, outside of the above-described electro-mechanical movement mechanism, which mechanism can be any one of a number of known devices, such as that shown in aforementioned U.S. Pat. No. 2,638,500. In the presently preferred embodiment a perforated mask is prepared, the mask perforations being inversely proportional to the primary color components at each scanning point on the transparency surface. A sheet mask **65**, which can be of any suitable material such as cardboard or plastic, for example, is mounted beneath a mask perforating unit generally indicated by the reference numeral **70**. The perforating unit generally consists of three electric motors **71**, **72** and **73**, of the type typically used in small hand grinders, each having a respective fluted grinding head **75**, **76** and **77** which cuts a larger aperture the deeper the head is moved downwards through the masking sheet. The three motors are pivotally mounted and positioned so that they are in the same spatial relationship to each other as the color spots in the matrix spot groups, i.e., if the perforating unit was placed in registry with a spot group of the matrix the head **75** would be centered over the green spot, the head **76** over the red spot and the head **77** over the blue spot.

The depth of penetration of the grinding heads is controlled in accordance with the magnitude of the associated color component intensity electric signal outputs **11**, **12** and **13**, the presently preferred technique being to provide the pivotal mounting of each of the motors **71**, **72** and **73** with a constantly increasing radius cam **81**, **82** and **83** (with respect to angular position) mounted on an associated servo motor **86**, **87** and **88** controlled by the appropriate signal output **11**, **12** and **13**. In this manner the color component electric signal outputs control the degree of rotation of the associated servo motor in the blackening unit, the cam position then being changed to in turn control depth of penetration of the grinding heads and hence control of the aperture sizes. It is to be understood that this is only one of many electro-mechanical systems usable, and those skilled in the art will appreciate many other mechanism suitable for use in accordance with the present invention concepts.

In FIG. 4 of the drawing there is indicated how a matrix is masked in accordance with the present invention techniques, the matrix being partially cut away to show the overlying mask

portion. The matrix 9 is faced with a sheet mask 65 perforated in accordance with the present invention techniques. To complete the matrix blackening, black paint is sprayed onto the mask, the exposed surface portions of the underlying matrix then being blackened in the desired manner. After spraying, the mask is removed and the prepared, blackened matrix is ready for use.

Thus there has been described a novel technique for preparation of a color matrix for the reproduction of images appearing on a color positive transparency.

I claim:

1. An electromechanical system for preparing a color matrix defining surface for the reproduction of images appearing on a color positive transparency, said matrix being of the type defining a successive series of identical three color spot groups, each group consisting of a red spot and a blue spot and a green spot, comprising:

a. light transmission means for optically scanning the surface of said color positive transparency and producing, for each of a number of predetermined points on the surface of said transparency, a first electric signal output dependent upon the intensity of a red color component at that point and a second electric signal output dependent upon the intensity of a blue color component at that point and a third electric signal output dependent upon the intensity of a green color component at that point, each of said predetermined points bearing the same spatial relationship to each other as the spot groups of said matrix; and,

b. matrix blackening means coupled to said light transmission means and its three electric signal outputs, for traversing the matrix defining surface to scan the matrix spot groups in synchronism with the scanning of the predetermined points on the surface of the color positive transparency by said light transmission means and for blackening, in a single scanning of each matrix spot group, predetermined portions of the red, blue and green spots of that matrix spot group, the area of the blackened portion of each of the red, blue and green spots of a matrix spot group being determined by the respective intensities of the red, blue and green color components at the transparency scanning point corresponding to that matrix spot group.

2. A system as defined in claim 1, wherein the red, blue and green matrix spot areas are translucent and the blackened spot areas opaque, the matrix being back lit to provide the desired image reproduction.

3. A system as defined in claim 1, wherein said matrix is opaque, the matrix being front lit to provide the desired image reproduction.

4. A system as defined in claim 1, wherein said matrix blackening means includes a masking sheet and mask perforating means coupled to the three electric signal outputs of said light transmission means for perforating said masking sheet with a successive series of three-aperture groups identically positioned and arranged as the spot groups of said matrix, the three apertures of each aperture group being registerable with the three spots of the corresponding matrix spot group, the area of each of the apertures registerable with the red, blue and green spots of the corresponding matrix spot group being determined by the respective first, second and third electric signal outputs of said light transmission means.

5. A system as defined in claim 4, wherein the respective areas of apertures of an aperture group registerable with the red, blue and green spots of the corresponding matrix spot group are inversely proportional to the intensities of the respective red, blue and green color components at the corresponding transparency scanning point, the perforated masking sheet then being positioned contiguous with said matrix with the aperture groups in registry with the corresponding matrix spot groups, the surface portions of the matrix exposed through the masking sheet apertures then being coated with an opaque black substance, after which the masking sheet is removed.

6. A system as defined in claim 4, wherein the respective areas of the apertures of an aperture group registerable with the red, blue and green spots of the corresponding matrix spot group are directly proportional to the intensities of the respective red, blue and green color components at the corresponding transparency scanning point, said masking sheet being of an opaque material and being positioned in front of said matrix and contiguous therewith during matrix use.

7. A system as defined in claim 1, wherein said matrix blackening means includes a translucent masking sheet and means for forming on said sheet a successive series of three black spot groups identically positioned and arranged as the spot groups of said matrix, the three black spots of each sheet group being registerable with the three spots of the corresponding matrix spot group, the area of each of the black spots registerable with the red, blue and green spots of the corresponding matrix spot group being inversely proportional to the intensities of the respective red, blue and green color components at the corresponding transparency scanning point, the so-blackened masking sheet being positioned in front of said matrix and contiguous therewith during matrix use.

8. A system as defined in claim 4, further including position control means intercoupling said mask perforating means with said light transmission means, for selectively positioning said perforating means in register with that spot group of said masking sheet which is in corresponding spatial relationship with the transparency predetermined surface point then being scanned.

9. A system as defined in claim 1, wherein said light transmission means consists of light source means for emitting a narrow white light beam along a first predetermined axis; light separation means for receiving a narrow light beam on a second predetermined axis and selectively producing said first and second and third electric signal outputs; and movable support means for maintaining said light source means and said light separation means in fixed relationship with said first and second predetermined axes being coincident, for mounting said transparency between said light source means and said light separation means intercepting said first and second axes, and for effecting a predetermined relative scanning motion between said transparency and the assemblage of said light source means and said light separation means.

10. A system as defined in claim 9, wherein said light separation means includes a first dichroic mirror for reflecting the red light in a received light beam onto a first photocell, the output of said first photocell providing said first electric signal output; a second dichroic mirror for reflecting the blue light in a received light beam onto a second photocell, the output of said second photocell providing said second electric signal output; and a third photocell for receiving the green light in a received light beam, the output of said third photocell providing said third electric signal output.

11. A system as defined in claim 9, wherein said color transparency is maintained in a fixed position and the assemblage of said light source means and said light separation means is moved to provide said relative scanning motion between them, said relative scanning motion proceeding horizontally from point to point in one direction to the end of that scanning line, and then proceeding horizontally from point to point in the opposite direction for the next adjacent scanning line, said assemblage momentarily pausing at each of said predetermined points.

12. A system as defined in claim 11, wherein said first and second and third electric signal outputs are selectively applied to said matrix blackening means only during the scanning pause at each predetermined point.

13. A system as defined in claim 8, wherein said mask perforating means includes a movable carriage the position of which is controlled by said position control means, said masking sheet being disposed adjacent said carriage; and three aperture forming means mounted to said carriage and spaced from each other in accordance with the spacing of the three spots in each matrix spot group, each of said three aperture forming means being coupled to a different one of said electric

signal outputs for selectively forming an aperture in said masking sheet with the area of the aperture being determined by the electric signal output presented to that aperture forming means.

14. An electromechanical system for preparing a mask for blackening certain areas of a color matrix in accordance with a color subtraction technique in order to prepare the matrix for the reproduction of images appearing on a color positive transparency, said matrix being of the type defining a successive series of identical three color spot groups, each group consisting of a red spot and a blue spot and a green spot, comprising:

a. light transmission means for optically scanning the surface of said color positive transparency and producing, for each of a number of predetermined points on the surface of said transparency, a first electric signal output dependent upon the intensity of a red color component at that point and a second electric signal output dependent upon the intensity of a blue color component at that point and a third electric signal output dependent upon the intensity of a green color component at that point, each of said predetermined points bearing the same spatial relationship to each other as the spot groups of said matrix; and,

b. mask perforating means coupled to said light transmission means and its three electric signal outputs, for transversing the surface of said mask in synchronism with the scanning of the predetermined points on the surface of the color positive transparency by said light transmission means and for perforating said mask, in a single traversal of the mask surface, with a successive series of three-aperture groups identically positioned and arranged as the spot groups of said matrix, the three apertures of each group being registerable with the three spots of the corresponding matrix spot group, the area of the aperture registerable with the red spot of the corresponding matrix spot group being determined by the first electric signal output of said light transmission means, the area of the aperture registerable with the blue spot of the corresponding matrix spot group being determined by the second electric signal output of said light transmission means, the area of the aperture registerable with the green spot of the corresponding matrix spot group being determined by the third electric signal output of said light transmission means.

15. A system as defined in claim 14, wherein said mask perforating means is adapted to perforate one aperture group at a time, the perforating means being movable, said system further including position control means intercoupling said mask perforating means with said light transmission means, for selectively positioning said mask perforating means to form said aperture groups in the desired positions.

16. A method of reproducing, on a color matrix, images appearing on a color positive transparency, said matrix being of the type defining a successive series of identical three-color spot groups, each group consisting of a red spot and a blue spot and a green spot, comprising the steps of:

a. optically scanning the surface of said color positive transparency in a successive series of scanning points in the same spatial relationship to each other as the spot groups of said matrix;

b. determining, in a single scanning of each scanning point, the intensity of the red, blue and green color components at that scanning point;

c. perforating a single sheet of masking material with a successive series of three-aperture groups identically positioned and arranged as the spot groups of said matrix, the three apertures of each group being registerable with the three spots of the corresponding matrix spot group, the area of the aperture registerable with the red spot of the corresponding matrix spot group being inversely proportional to the intensity of red color component determined at the related scanning point, the area of the aperture registerable with the blue spot of the corresponding matrix spot group being inversely proportional to the intensity of blue color component determined at the related scanning point, and the aperture registerable with the green spot of the corresponding matrix spot group being inversely proportional to the intensity of green color component determined at the related scanning point;

d. placing the perforated sheet of masking material contiguous with said matrix with the masking material aperture groups in registry with the corresponding matrix spot groups; and,

e. coating the surface portions of said matrix which are exposed through the masking apertures with an opaque black substance, and removing said masking material from said matrix.

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