W. V. D. KELLEY.

SUBTRACTIVE AND ADDITIVE COLOR PHOTOGRAPHY.

APPLICATION FILED FEB. 8, 1917.

1,278,162. Patented Sept. 10, 1918.

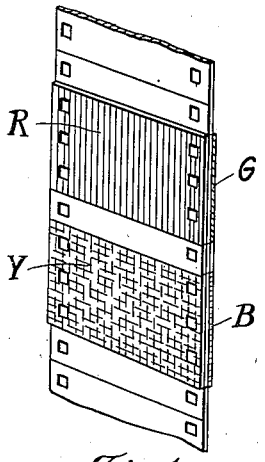

Fig. 1.

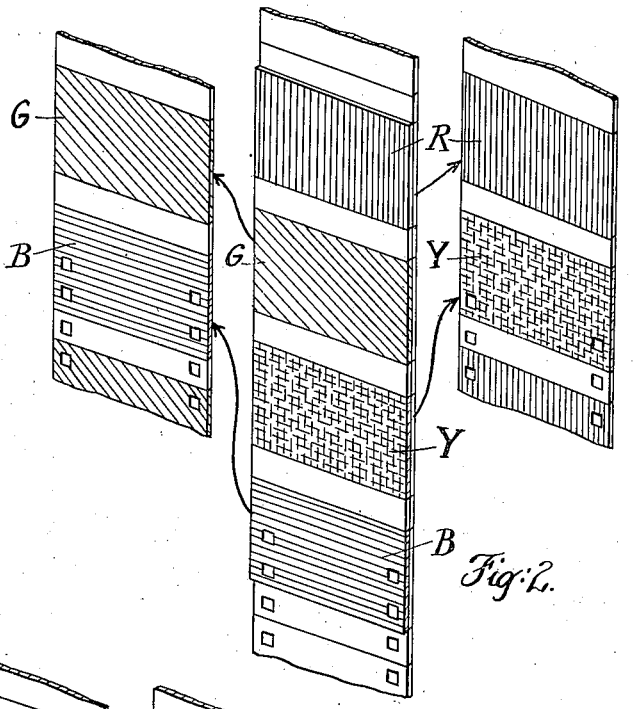

Fig. 2.

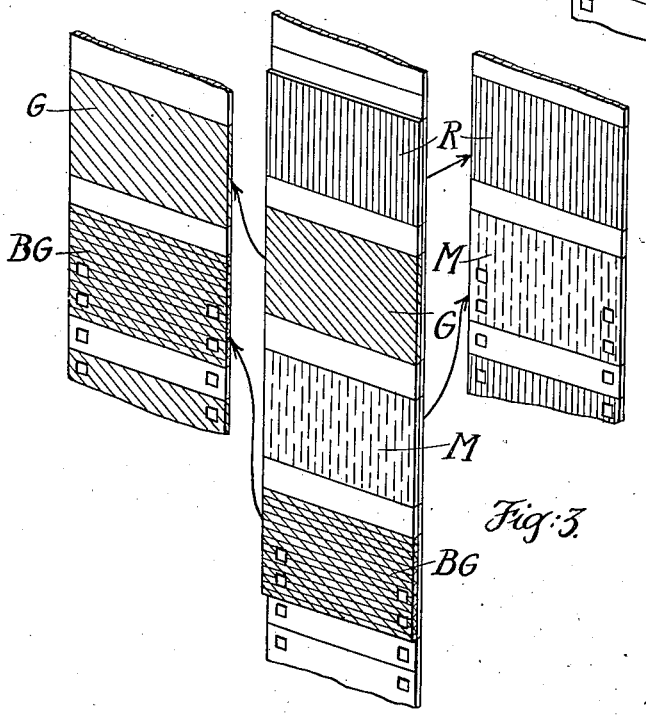

Fig. 3.

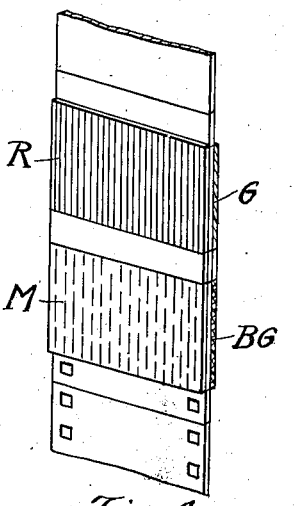

Fig. 4.

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UNITED STATES PATENT OFFICE.

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SUBTRACTIVE AND ADDITIVE COLOR PHOTOGRAPHY.

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To all whom it may concern:

Be it known that I, WILLIAM V. D. KELLEY, a citizen of the United States, and residing at Brooklyn, county of Kings, and State of New York, have invented new and useful Improvements in Subtractive and Additive Color Photography, of which the following is a specification.

This invention relates to colored motion pictures, and has particular reference to an improved method and product whereby pictures can be quickly made, and projected on any standard projector without special attachments so as to accurately reproduce natural colors. By this invention, pictures may be taken and exhibited the same day. A four color record, especially if the colors are narrow banded, is difficult to project one at a time in succession, yet for the best effects in projection, the four color record has several advantages over either two or three color records. By this invention, the negatives record complementary colors, and preferably at least two complementary pairs of colors form each complete record, or set of images. Having obtained a four color value record by using a four color screen, for example, and in order to reduce the difficulty of projection, the four images recording four color values are reduced to two areas each carrying two color value records. This reduction is effected by a printing process, whereby the yellows and reds of a four color cycle may be printed on one side, and the greens and blues on the other side, so that a red record on one side overlies a green record on the other side, and adjoining is a yellow record overlying a blue record. These records are then developed and constitute the projecting positive capable, when colored, of being run in an ordinary projector without a color screen. Where the effect of a three color screen is desired, the positive is similarly made from a four color value negative, and consists of red and magenta images on one side, overlying green and blue-green images on the other. In each instance, the overlying pairs are complementary, so that when both pairs are projected, natural colors are reproduced.

In the accompanying drawings,

Figure 1 shows a projecting positive embodying the invention,

Fig. 2 shows a four color value negative,

Fig. 3 shows a modification, and

Fig. 4 shows the projecting positive made therefrom.

The negative of Fig. 2 has four color value records R, G, Y, B, corresponding respectively to red, green, yellow, and blue, and may be made in the manner described in patent to Wohl and Mayer No. 1,122,344. The reds and yellows belong on one side of the spectrum, or to the red family of colors, and the greens and blues belong on the other side of the spectrum, or to the green family of colors, and a red color preferably alternates with or overlaps a green color, as shown. Having made and developed such a negative having ordinary panchromatic emulsion, the next step is to form the positive shown in Fig. 1, in which one side contains all the green color value records G and B printed in recurring series, and the other side contains all the red color value records R and Y printed in recurring series. This printing is effected by a double printing mechanism which feeds the negative twice as fast as the positive so as to skip alternate pictures while printing on one side of the double coated positive film. The double coated film is then twisted through 180° so as to enable the other side to be printed with the other set of color value records. Thus the red color value records on one side overlie and register exactly with green color value records on the other side, and the succeeding section similarly consists of a yellow color value record overlying a blue color value record. As soon as the film is developed, fixed, and washed, it is passed to a bleaching bath to reduce the silver to silver iodid. This acts as a mordant to certain dyes, causing these dyes to take and thereby coloring the film. The film is then dried, and after one side of the film is covered with a removable resist preventing access of the dye thereto, as the red family color value records, the other side having the green family color value records, is col-

ored red-orange, then the dyed side is covered and the process repeated with the other dye on the other side, as green-blue giving in one case the desired red-orange color, and in the other, the desired green-blue color. The record of the reds is thus dyed green-blue, and the record of the green-blues is dyed red, complemental colors being used in producing the color positive records. This produces two superposed records, one having a range of colors deeper in the blue, and less in the red, and the other with less strength in the blue and more in the red. Each composite positive section is made upon the subtractive principle and will be deficient in complete color rendering, but the deficiency will be completed in projection by the following record, so that succeeding records are complementary, each two records completing the color rendering according to the principle of additive mixture of lights. Instead of coloring the positives by a dye mordanted by silver, other methods may be used, such as one wherein the gelatin is hardened in proportion to the amount of silver present, and then using a dye which only affects the gelatin in proportion to its softness. This method is well known and does not need further particular description. If desired, one color may be obtained by mordanting, and the other by absorption in the gelatin of the emulsion.

The removable resist can be in the form of a grease removable by solvents such as turpentine, or mechanical in the form of a yielding surfaced wheel around which the film is passed in tight contact with the wheel surface so that the dye can only act on one side at a time. The method of dyeing by mordanting above described is well known, having been described by Richard in 1896 and in various later publications. The dyes may be basic or acid, or a combination of basic and acid dyes.

Instead of taking all the pictures on one film, the taking camera may have two films, one recording values for the red family and the other for the blue-green family. Also, separate printing negatives may be made from the original negative if the records are in succession on a single strip film, instead of using a double printing machine as above described, one negative having the red color values, and the other having the green-blue values. Instead of using double coated film for the projecting positive, single coated film may be used for one set of color values, then colored, then emulsify the same surface again, or the other side, then print the second set of color values, and then dye with the second color. Also, any other method of pairing the colors may be used, but the method here described gives excellent commercial results.

In Figs. 3 and 4 the invention is shown applied to a color process producing negatives recording red, green, magenta and blue values in succession. This is reduced to a two color projecting positive. The red and green color value records in a three color process are practically pure colors, and are combined in the projecting positive so as to produce a complete color rendering, minus the blue-violet. The blue-violet record is in the succeeding section, and is made up of magenta on one side, and blue-green on the other, which, when combined give the correct blue for a three color process, that is white minus red and green. Such successive records when projected combine to give beautiful reproductions of the original colors. The red and green in Figs. 3 and 4 when projected give yellow, while the magenta and blue-green give blue when projected, but when projected in succession, white is produced on the curtain by the principle of additive lights.

In methods heretofore proposed for producing complementary colored images for projecting positives, it has been difficult to keep the records balanced, there being a tendency either to preponderance of red, or of green-blue. In this process red-orange can be intentionally favored in one set, and green-blue in the other, but the required balance to produce white will be imparted in projection.

This invention permits of quick commercial work, and gives accurately colored pictures, capable of being projected on any standard projector without special attachments. Negatives can be taken, and the positives exhibited the same day. The invention has decided advantages for commercial projection where the completed positive is colored ready for use without screens, since the complications due to screens are avoided. Various other methods and apparatus may be used besides those illustrated herein without departing from the scope of the appended claims.

What I claim is:

1. A photographic strip carrying on each image area a plurality of non-complementary color value records, the records on a plurality of image areas additively recording complete color.

2. A photographic strip carrying in separate coatings on each image area non-complementary color value records, each coating carrying the records of one color family, a plurality of image areas additively recording complete color.

3. A photographic positive record comprising successive image areas each having different subtractive color value records, each two successive areas being dyed in complementary colors and additively producing complete color in rapid projection.

4. A photographic strip carrying in coat-

ings on opposite sides of each image area non-complementary color value records, one coating carrying recurring records of a plurality of colors in one color family and the other coating carrying recurring records of a plurality of colors in a complementary color family, a plurality of image areas additively recording complete color.

5. The method of producing projecting positives carrying the colors in gelatin coatings, which consists in recording the two families of color in cycles of four negative color values, printing one family of records on adjoining areas of one side of double coated film, reversing the negative and printing on the other side of the double coated film the other family of colors, coloring all of the printed records on one side in one color, and the records on the opposite side in another color complemental to the first color, the pairs of records on each area forming an incomplete color record on the subtractive principle but two successive areas blending in projection on the additive principle, to reproduce a picture in substantially natural colors.

6. Process of making a colored photographic motion picture film transparency for viewing by transmitted light which consists in recording the negative records on single coated stock in cycles of four color values, printing all of one family of color records upon one side of a double coated sensitized film, printing the other family of color-records on the opposite side of said double coated positive, with the images in register, and treating one side of the double coated positive to convert the images into color and the opposite side into a color complemental to the first so that the blending of each two successive records present to the eye a motion picture reproduction in substantially its natural colors.

7. Process of making colored photographic motion picture film from a negative record having cycles of red, yellow, green, and blue color values consisting in printing in register all of the red-yellow images on one carrier, and all of the green-blue value images on another carrier, treating one of said carriers to convert the images carried thereby into one color, and treating the other carrier to convert the images carried thereby into a color complemental to the first, so that the blending of each successive pair of such color pictures present to the eye a picture in substantially natural colors.

8. Process of making a colored photographic motion picture strip from a negative carrying cycles of color values composed of two colors from each of two families, consisting in printing in register by contact printing, all of one family of pictures on one side, and all of the other family of pictures upon the opposite side of a transparent base coated with sensitive emulsions on each side, treating one side to convert the different images thereon to a color complemental to their family color, and treating the reverse side to convert the differing images thereon to a color complemental to their family color, such images being colored on the subtractive principle, so that complete color rendering is secured on the additive principle when each two areas are projected.

9. The method of producing projecting positives carrying the colors in gelatin coatings, which consists in recording the two families of color in cycles of four negative color values, printing one family of records on adjoining areas of one side of double coated film, reversing the negative and printing on the other side of the double coated film for the other family of colors, covering one side with a resist and coloring the records on the other side with one color, covering the colored side with a resist and removing the resist on the other side, and then coloring the latter side with a color complementary to the first color.

10. The method which consists in recording a cycle of four colors on successive image areas, and reproducing pairs of said color records in superposed relation on two image areas of a second record to record complete color.

11. The method which consists in recording a cycle of at least three colors on successive image areas, and superposing prints of non-complementary color records on each area of a second record, such that each two successive areas contain complete color values.

12. The method which consists in recording a cycle of at least four colors from two families on successive image areas, printing said four records on two image areas of a second record, and coloring each of said printed records with a color complementary to the family color values carried thereby.

13. The method which consists in recording a cycle composed of two red family colors and two green family colors on four successive image areas, printing a red family color record and a non-complementary green family color record on each area of a second record, and coloring the respective red and green prints to render each two image areas of said second record complementary.

14. The method which consists in recording a cycle composed of at least three colors, printing two of said color value records on one area of a second record and the remaining color value record or records on the succeeding image area, and coloring the printed images with complementary colors without rendering the images on each area complementary but rendering the combined images of each two areas complementary.

15. A photographic record comprising successive image areas each having different color value records dyed through the agency of the silver present with complementary colors, successive areas being additively complementary.

16. A photographic projecting positive comprising successive image areas each having superposed non-complementary color value records printed directly from color value negatives, the color value records composing each pair of successive image areas being complementary in pairs and the adjoining images of each pair being of like color family.

17. A photographic projecting positive comprising a base having an emulsion on each side and a plurality of image areas, successive areas of one emulsion carrying differing color value images of one color family similarly colored with a complementary color, and successive areas of the other emulsion carrying differing color value images of said latter family color similarly colored with the family color of said former images, each two successive areas additively producing complete color in projection.

In testimony whereof, I have signed my name to this specification this 7th day of February, 1917.

WILLIAM V. D. KELLEY.