No. 884,254. PATENTED APR. 7, 1908.

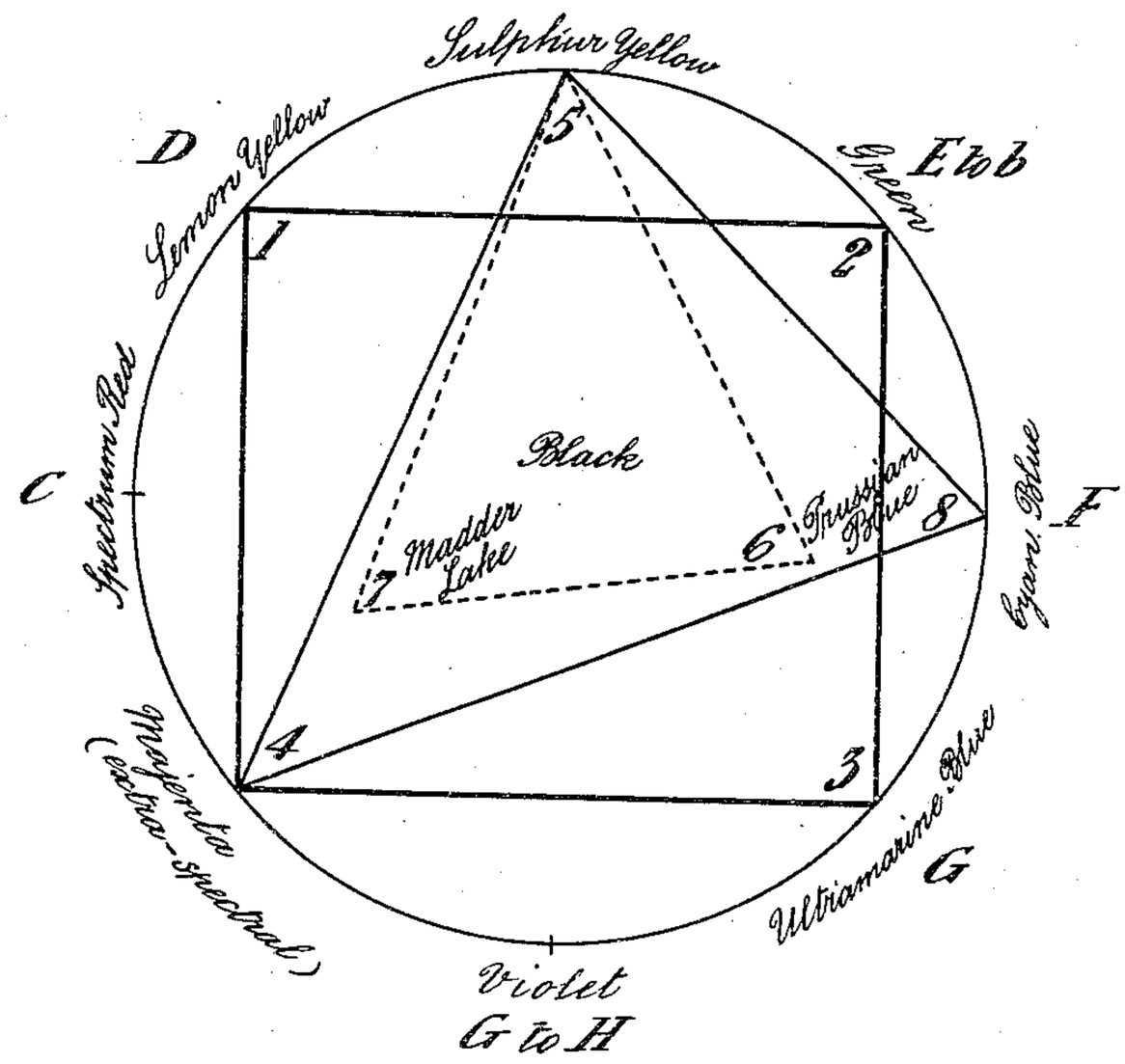
C. G. ZANDER.

PROCESS OF PHOTOMECHANICAL REPRODUCTION OF COLORS AND THE RESULTANT ARTICLE.

APPLICATION FILED FEB. 6, 1905.

2 SHEETS—SHEET 1.

Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 2.

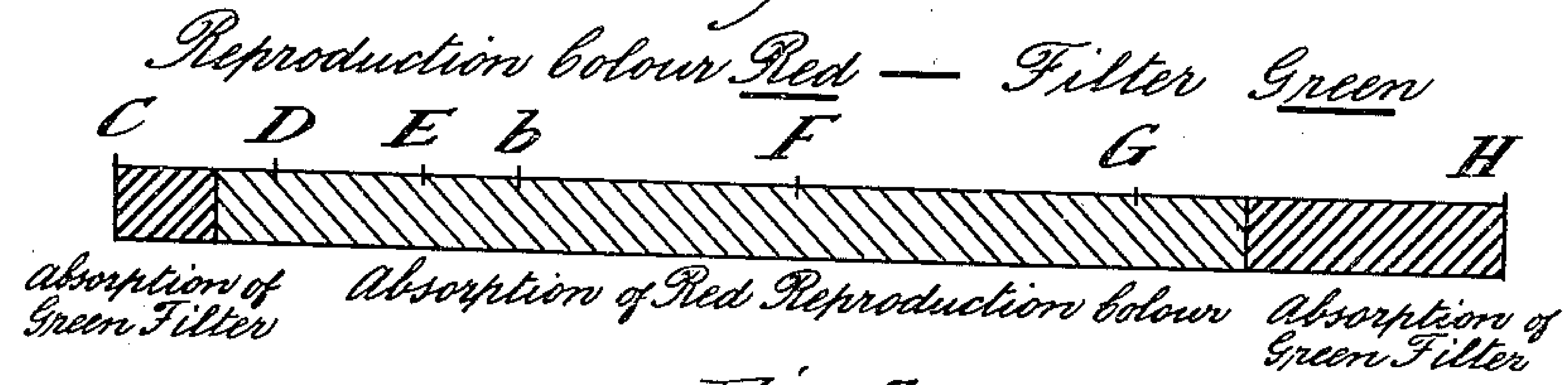


Fig. 3.

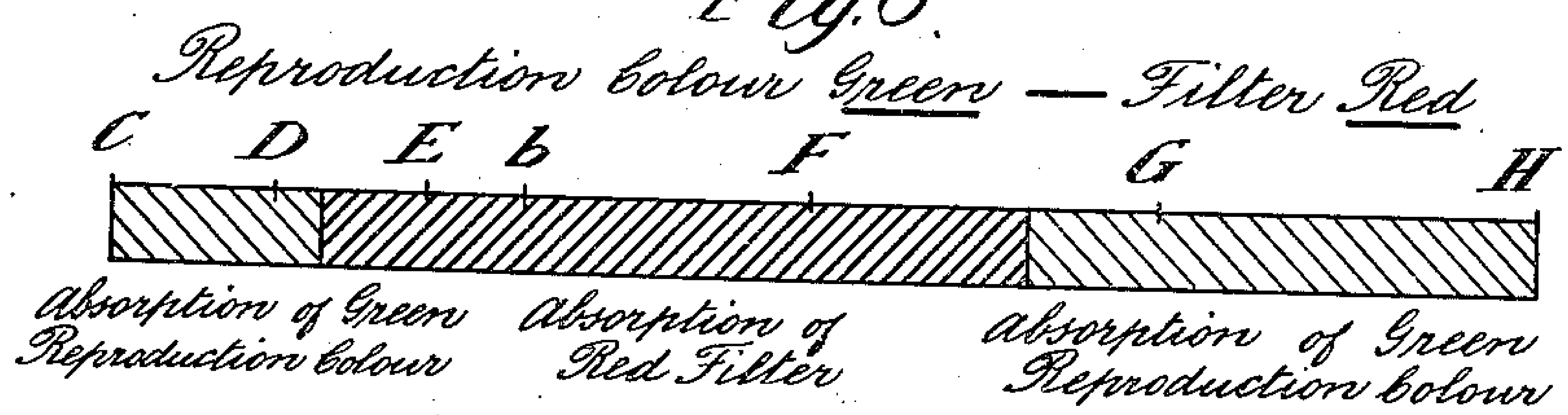


Fig. 4

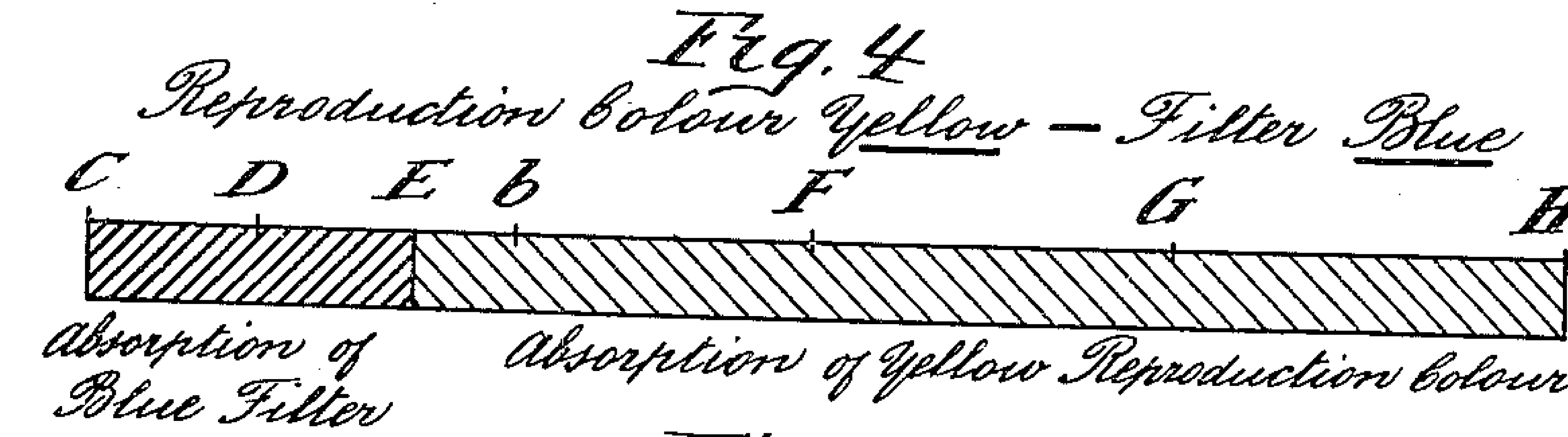


Fig. 5

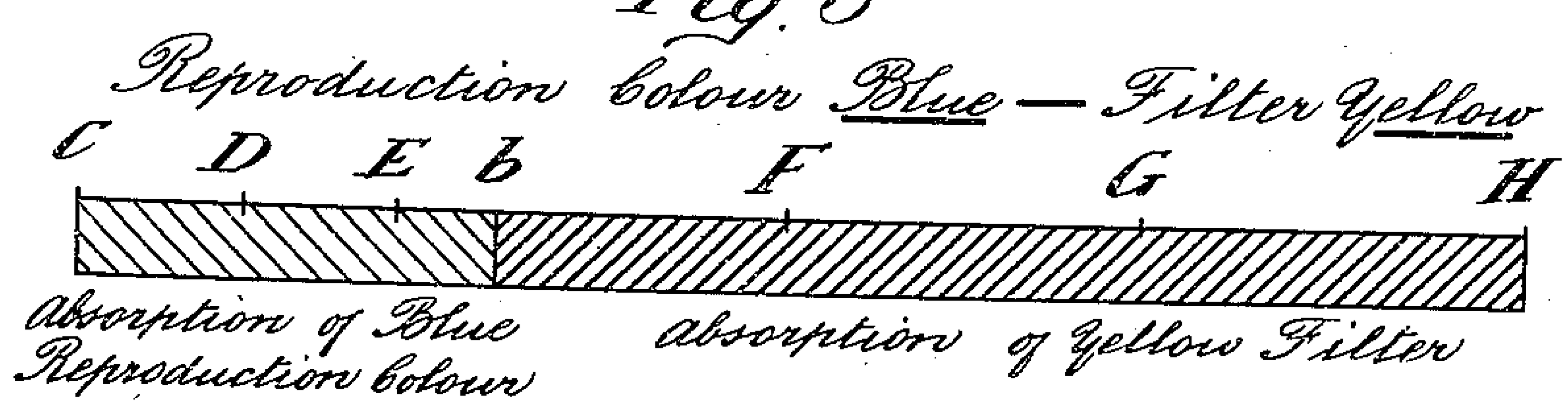
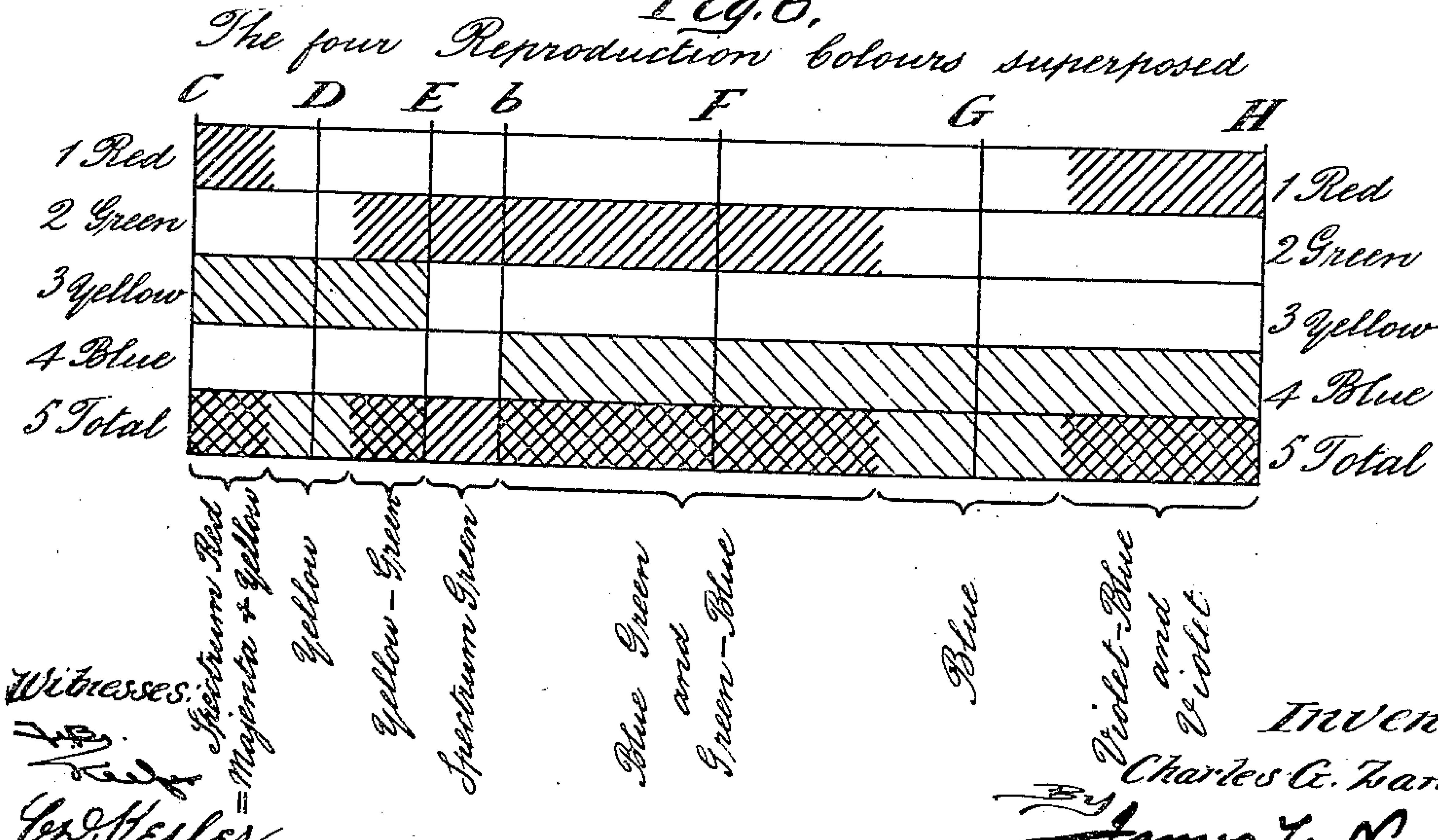


Fig. 6.



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UNITED STATES PATENT OFFICE.

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PROCESS OF PHOTOMECHANICAL REPRODUCTION OF COLORS AND THE RESULTANT ARTICLE.

No. 884,254. Specification of Letters Patent. Patented April 7, 1908.

Application filed February 6, 1905. Serial No. 244,486.

To all whom it may concern:

Be it known that I, CHARLES GUSTAV ZANDER, a subject of the King of Great Britain, residing at 2 Portland road, Finsbury Park, in the county of London, England, have invented a certain new and useful Process of Photomechanical Reproduction of Colors and the Resultant Article, of which the following is a specification.

This invention relates to an improvement in the process of photo-mechanically reproducing colors and the resultant article, whereby the range of mixed color which can thereby be reproduced is very considerably extended, the reproduction of homogeneous grays and of dense black or neutral gray is greatly facilitated, and other incidental effects and results are secured. These results are obtained by the practical application of a new and improved color scheme which is applicable to every process of photo-mechanical color reproduction, such as typographic block-printing in half-tone, line and the like, photo-lithography (either from stone or metal plates) collotype, photo-gravure, Woodbury type, and the like, and also to the reproduction, by super-position, of transparencies in color.

The principles underlying the invention are discussed with reference to the accompanying drawings, in which:—

Figure 1 is a comparative diagram of the mixing areas of the improved complementary scheme, and of the commercial and theoretical three color reproduction schemes. Figs. 2, 3, 4, and 5 are diagrams illustrating the overlapping of the color records and showing the relative positions of the reproduction colors and selective color filters according to the improved scheme and their absorption in the spectrum. Fig. 6 shows the result of the superposition of the spectra of Figs. 2, 3, 4, and 5.

The color scheme adopted is based on the assumption that there are four fundamental or mono-chromatic constituent color of a continuous white light spectrum, by mixtures of which in suitable proportions any color in nature can be reproduced. The hues of these four colors are approximately indicated by the popular terms:—magenta red, lemon yellow, emerald green, and ultramarine blue. Of these, the three last are found in the spectrum of white light occupying the positions corresponding approximately to the so-called Fraunhofer lines D, E to *b*, and about midway between F and G respectively. The magenta red is not apparent in the continuous spectrum but is or approximates to that color which is known as extra-spectral purple and is obtained (diluted with white) by overlapping the red and violet ends of the spectrum in the well-known manner. It is, in fact, the fundamental or mono-chromatic color which when combined with yellow gives spectrum red, and when combined with blue gives spectrum violet. It will be found that these four fundamental color can be grouped in two pairs of complementary color, viz. red and green, and yellow and blue, so that when the elements of either pair are mechanically mixed, as by printing or staining, they produce black, while the effect of their optical combination is the sensation of white light.

Although the hues above specified by their popular names give very satisfactory results, they may be departed from to some extent without detrimentally affecting the results obtained to any great extent, and such departure may be necessary or advisable in certain circumstances, as for example, when it is desired to use more permanent pigments as reproduction color than those which most nearly yield the four fundamental hues described. Thus, one or more of the following substitutions may be made: carmine for magenta, sulfur yellow for lemon yellow, peacock green for emerald green, violet blue for ultramarine. At the same time it is to be noted that the hues selected respectively for the red and green pair and for the yellow and blue pair should be as nearly as possible complementary to each other. The allowable variation in the four fundamental colors and the spectral position of the preferred colors are best expressed by reference to their wave-lengths. Thus, for the yellow may be used any or all of the hues having wave-lengths between 6000 (10.7 m. m.) and 5600 (10.7 m. m.); for green, any or all of the hues having wave-lengths between 5500 (10.7 m. m.) and 5000 (10.7 m. m.); for blue, any or all of the hues having wave lengths between 4900 (10.7 m. m.) and 4200 (10.7 m. m.); while the limits of the red are defined by the complementary color of any or all of the hues of spectrum green between wave-lengths 5500 (10.7 m. m.) and 5000 (10.7 m. m.). The preferred hues may similarly be defined as those correspond-

ing to wave-lengths 5890 (10.7 m. m. about D line), 5220 (10.7 m. m. about E ½ *b*) and 4580 (10.7 m. m. about F ½ G), together with the color complementary to that of wave-length 5220 (10.7 m. m.)

The fact that either of the two pairs of proposed complementary colors is already sufficient to produce black or gray, which is impossible with any two colors at present in use for photo-mechanical color reproduction, these being essentially non-complementary, enables the reproduction of dense black or gray to be readily accomplished, and the increased "mixing area" resulting from the use of the herein described color scheme greatly increases the range of mixed color available and the reproduction of subdued shades and tints.

These features are illustrated in Fig. 1 of the accompanying drawings, in which the circle represents a continuous spectrum bent on itself to overlap the red and violet ends so forming the chromatic or color circle, which will contain in its area all possible hues arising from the mixing of the several spectral colors. The relative positions of the Fraunhofer lines and spectrum colors are approximately shown by the letters and names appropriate thereto.

The comparative mixing areas of the four-color process of the present invention (in which the fundamental, or monochromatic, colors are theoretically identical with the spectral colors indicated at 1, 2, 3, 4, in Fig. 1) and of the theoretical or fugitive "three-color process" (in which the fundamental, or monochromatic colors are theoretically identical with the spectral colors indicated at 4, 5 and 8 in Fig. 1) are respectively shown in Fig. 1 by the square 1, 2, 3, 4, and the triangle 4, 5, 8 (which is of much smaller area); that is to say, the invention greatly increases, theoretically, the range of mixed colors available, as also the reproduction of the subdued shades and tints, in the same proportion as the area of the square is greater than the area of the triangle, for the square and the triangle respectively contain only those hues that are possible from the mixing of the spectral colors indicated at their angular points, while any shades that cannot be imitated by the mixing of said colors will be outside the areas of the respective figures. Practically the increase is greater since the mixing area of the usual "three-color" process is limited, commercially, to the area of the smaller, or dotted triangle, 5, 6, 7 in Fig. 1, where the radial or shade positions of the madder lake and Prussian blue colors, with respect to the spectral colors, are, for the sake of comparison, estimated approximately.

In carrying the color scheme into practical effect, the requisite photographic color-records or negatives are made by using a combination of suitable color-sensitive photographic plates and selective color filters, each of which, roughly speaking, should pass all the colors of the spectrum with the exception of the respective reproduction color, the latter being represented in the negative or film as more or less clear glass or film according to the density of that particular color on the original, whereby are produced monochromatic records in hues respectively approximating to the complementaries of the four proposed reproduction colors. From these negative color records, printing positives (blocks, plates and the like suitable for the various printing processes) or transparencies are made for reproduction respectively in their proper color. It is advisable in these color records that there should be overlapping in the green and red records in the region both of the D and of the G lines, and in the yellow and blue records in the region of the lines E and *b*. These overlappings, the extent of which is discretionary and may be determined empirically, produce corresponding gaps at D, G and E to *b* in the positives, whereby the production of the yellow, spectrum green and blue respectively may be effected. The overlapping of the color records is illustrated in diagrams 1, 2, 3 and 4 of Fig. 6, and the result in the production of the spectrum color is shown in diagram 5.

The choice or making of suitable color sensitive photographic plates, color filters, their spectroscopic measurements, correct exposure and kindred technical manipulations are matters of detail which present no inherent difficulties to persons skilled in the art, and as such form no essential part of the present invention. Similarly the selection of suitable dyes, pigments or ink for the reproduction color is also a matter of experience and judgment, and in some cases expediency, but in any case the limits of color herein described should not be exceeded.

Having thus described this invention and the best means I know of carrying the same into practical effect, I claim:—

1. A process for the photo-mechanical reproduction of colors which consists in producing photographic color records or negatives taken on four suitable color-sensitive plates or films, each of a character to be unacted on by a different one of a group of four fundamental or monochromatic colors constituting two pairs of complementary colors and in employing said records or negatives for producing printing positives for reproduction respectively in their proper color.

2. A process for the photo-mechanical reproduction of colors in which the requisite photographic color records or negatives are taken on four suitable color-sensitive plates or films, constituting two pairs of complementary colors (blue and yellow and green

and red) which are defined respectively as any hue of the continuous spectrum of white light between wave lengths 4200 and 4900 (10.7 m. m.), the hue complementary thereto, any hue between wave lengths 5000 and 5500 (10.7 m. m.) and the hue complementary to said last hue.

3. As an article of manufacture, a color reproduction from photographic negatives taken on four suitable color sensitive plates or films, each of a character to be unacted on by a different one of a group of four fundamental or monochromatic colors, which constitute two pairs of complementary colors (blue and yellow) and (green and red).

4. As an article of manufacture, a reproduction in colors produced by photo-mechanical processes in which the negatives are taken on suitable color-sensitive plates or films through selective color filters consisting of four fundamental or mono-chromatic colors constituting two pairs of complementary colors, (blue and yellow and green and red) which are defined respectively as any hue of the continuous spectrum of white light between wave lengths 4200 and 4900 (10.7 m. m.) the hue complementary thereto, any hue between wave lengths 5000 and 5500 (10.7 m. m.) and the hue complementary to said last hue.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

CHARLES GUSTAV ZANDER.

Witnesses:
JOSEPH MILLARD,
WALTER J. MERTEN.