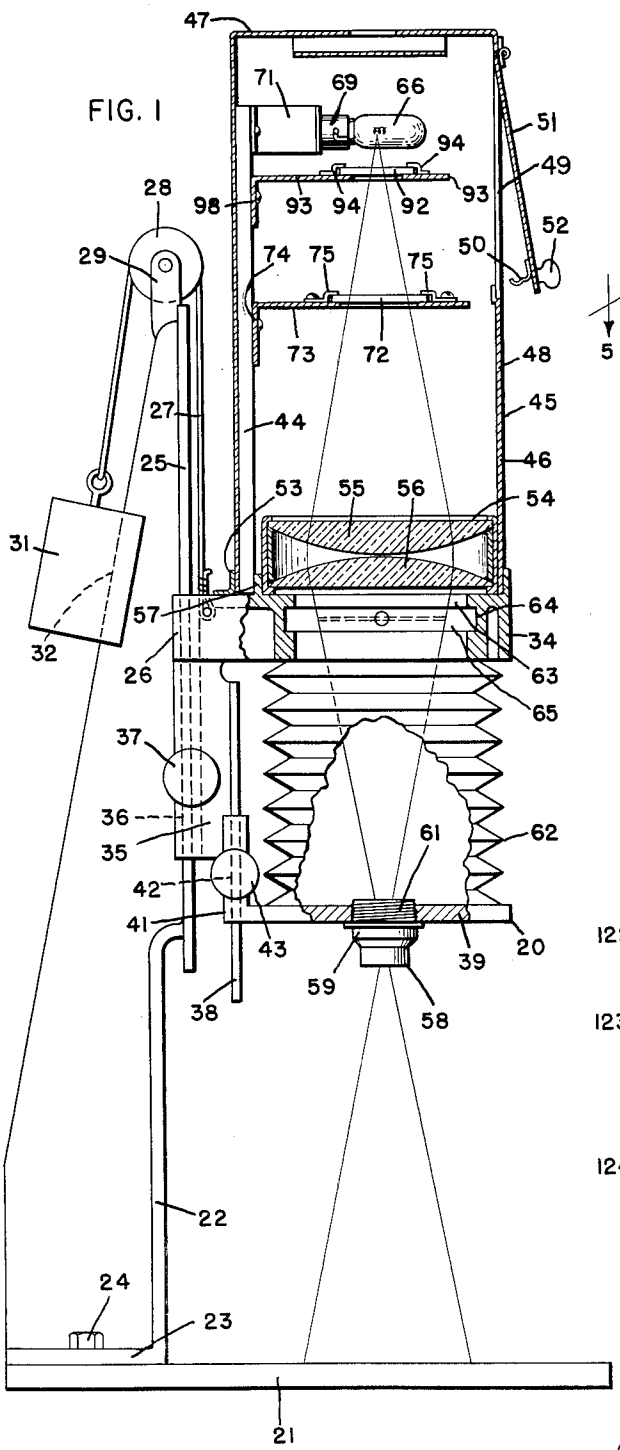
May 23, 1961 R. A. CLAPP 2,985,062

PHOTOGRAPHIC PRINTING APPARATUS

Filed June 20, 1956 4 Sheets-Sheet 1

FIG. 1



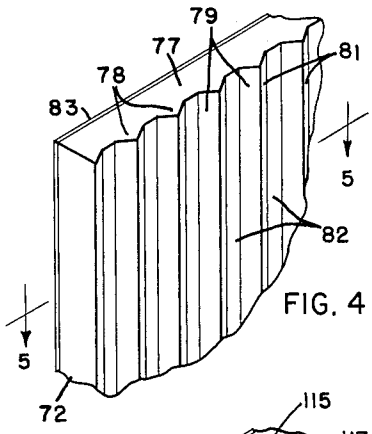


FIG. 4

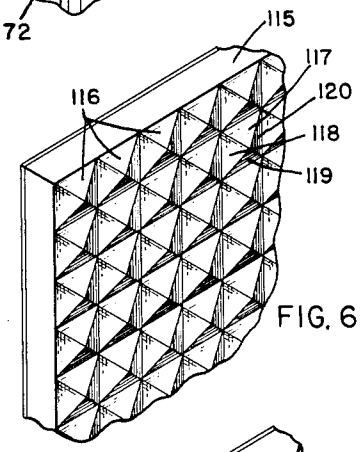


FIG. 6

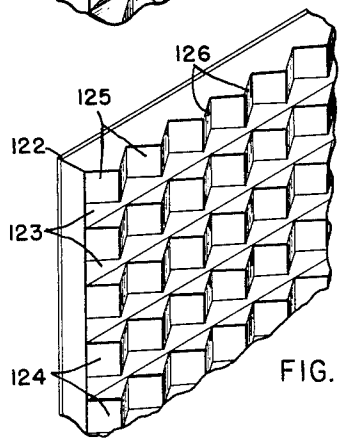


FIG. 7

INVENTOR

ROY A. CLAPP

Caswell & Lagaard

ATTORNEYS

May 23, 1961 R. A. CLAPP 2,985,062

PHOTOGRAPHIC PRINTING APPARATUS

Filed June 20, 1956 4 Sheets-Sheet 2

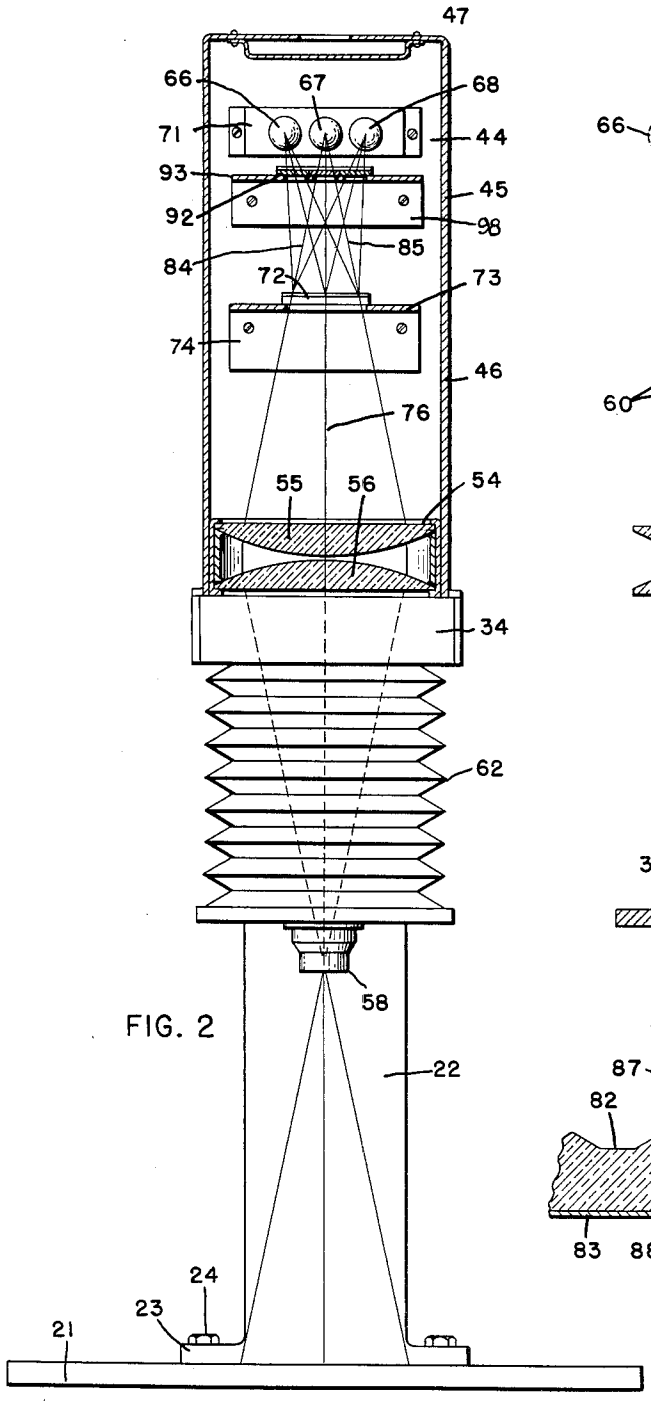


FIG. 2

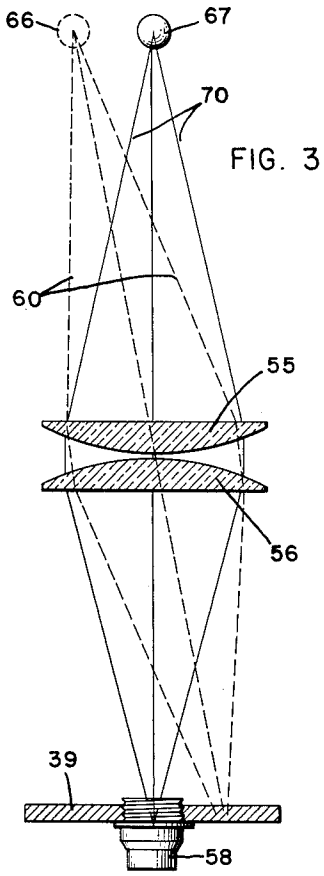


FIG. 3

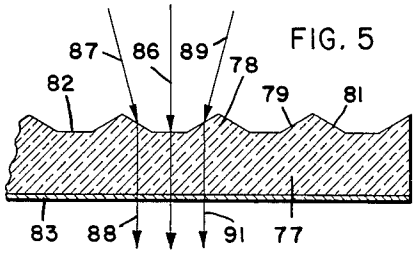


FIG. 5

INVENTOR
ROY A. CLAPP

Caswell & Lagaard
ATTORNEYS

May 23, 1961 R. A. CLAPP 2,985,062

PHOTOGRAPHIC PRINTING APPARATUS

Filed June 20, 1956 4 Sheets-Sheet 3

FIG. 13

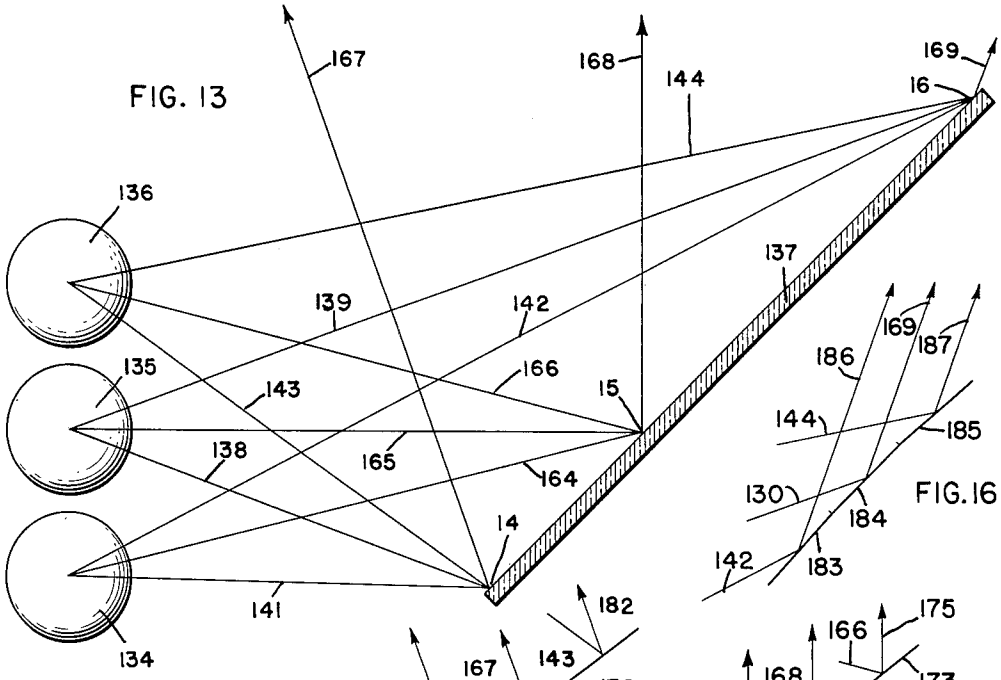


FIG. 16

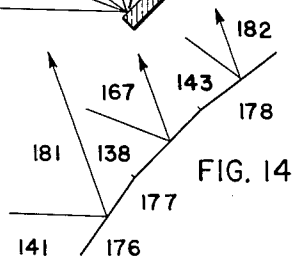


FIG. 14

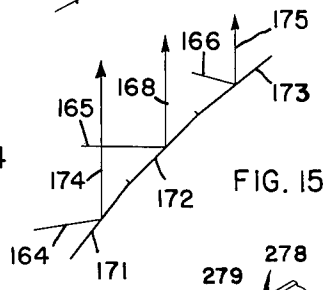


FIG. 15

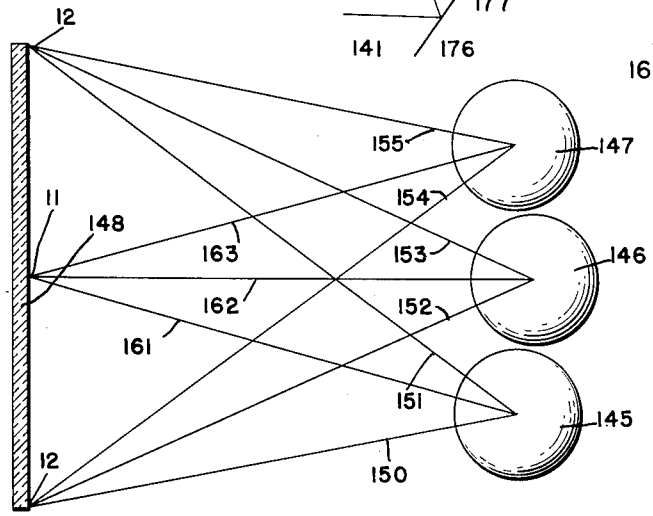


FIG. 10

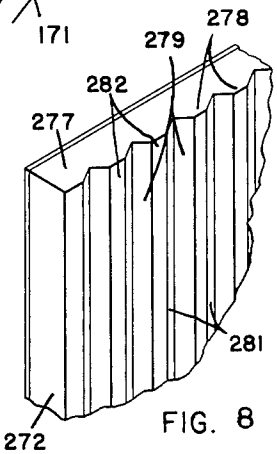


FIG. 8

INVENTOR

ROY A. CLAPP

Caswell & Lagaard

ATTORNEYS

May 23, 1961 R. A. CLAPP 2,985,062

PHOTOGRAPHIC PRINTING APPARATUS

Filed June 20, 1956 4 Sheets-Sheet 4

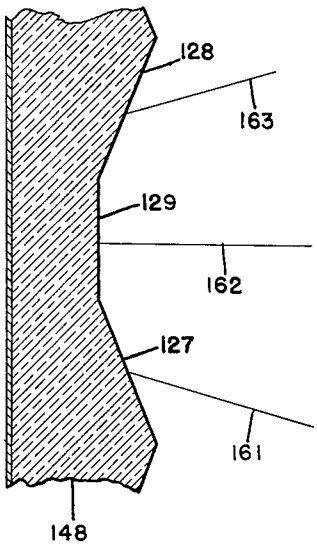


FIG. 11

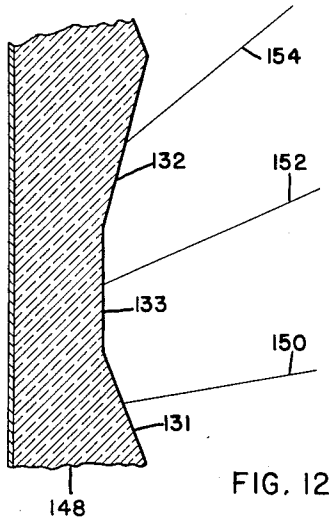


FIG. 12

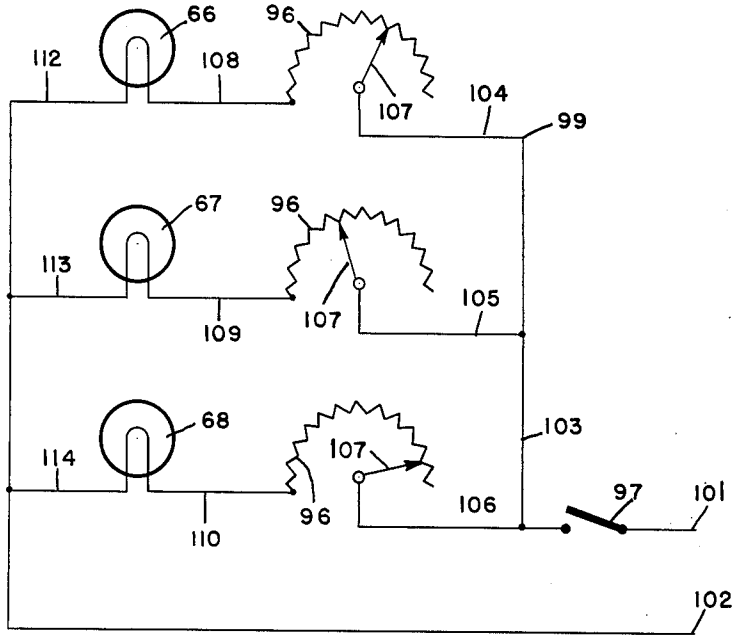


FIG. 9

INVENTOR
ROY A. CLAPP

Caswell & Lagaard

ATTORNEYS

United States Patent Office 2,985,062 Patented May 23, 1961

2,985,062

PHOTOGRAPHIC PRINTING APPARATUS

Roy A. Clapp, Minneapolis, Minn., assignor to Pako Corporation, Minneapolis, Minn., a corporation of Delaware

Filed June 20, 1956, Ser. No. 592,538

1 Claim. (Cl. 88—24)

The herein disclosed invention relates to the art of photographic printing and particularly to apparatus for control of the quality of the reproduced image.

Another object of the invention resides in providing apparatus in which the spectral content of the light used for printing may be controlled.

A still further object of the invention resides in providing apparatus for use in photographic color printing.

An object of the invention resides in providing photographic printing apparatus utilizing multiple sensitized photographic material and an image bearing support and in utilizing a plurality of primary light streams of different qualities combined and directed from the image bearing support to the photographic material.

A still further object of the invention resides in providing a light mixer in which the primary light streams are collected and combined to form a composite light stream directed to the photographic material.

Another object of the invention, when the apparatus is to be used for photographic color printing, resides in providing light filters in the paths of the primary light streams to give the desired color balance in the reproduced image.

An object of the invention resides in providing control means for individually controlling the intensities of the primary light streams to vary the proportion of the primary colors in the printed image.

Another object of the invention resides in the construction of the light mixer.

Other objects of the invention reside in the novel combination and arrangement of parts and in the details of construction hereinafter illustrated and/or described.

In the drawings:

Fig. 1 is a side elevational view of a photographic enlarger illustrating an embodiment of the invention and with portions broken away.

Fig. 2 is a front elevational view of the enlarger shown in Fig. 1 with the lamp housing in section.

Fig. 3 is a diagrammatic view of a conventional optical system of an enlarger.

Fig. 4 is a perspective view of a portion of the light mixer used with the invention and drawn to an enlarged scale.

Fig. 5 is a cross-sectional view of the light mixer taken on line 5—5 of Fig. 4 and drawn to a still greater scale.

Fig. 6 is a view similar to Fig. 4 of a modification of the light mixer.

Fig. 7 is a view similar to Fig. 4 of still another form of light mixer.

Fig. 8 is a view similar to Fig. 4 of another modification of the light mixer.

Fig. 9 is a wiring diagram of the invention.

Fig. 10 is a diagrammatic view of a part of the optical system in which a greater portion of the light from the light sources is utilized.

Fig. 11 is a fragmentary sectional view of the light mixer used with the system shown in Fig. 10 at the

locality indicated by the reference numeral 11 and drawn to an enlarged scale.

Fig. 12 is a view similar to Fig. 11 and indicating the rib form at the locality designated by the reference numeral 12 in Fig. 10.

Fig. 13 is a diagrammatic view illustrating the use of a reflective light mixer.

Fig. 14 is a fragmentary cross-sectional view of the reflector taken at the locality indicated by the reference numeral 14 in Fig. 13.

Fig. 15 is a view similar to Fig. 14 and taken at the locality indicated by the reference numeral 15 in Fig. 13.

Fig. 16 is a view similar to Fig. 1 and taken at the locality indicated by the reference numeral 16 in Fig. 13.

The most common present day color photo-sensitized material consists of three individual layers of emulsion, coated one over the other upon a base which may be of film or paper. These layers are arranged so that they are each sensitive to a certain narrow band of the visible spectrum. The general terms red, green and blue will be used in referring to these bands, without intent to restrict each band to any particular wavelengths. While the arrangement of the layers may vary with different makes of products, they have this in common. Each layer is affected by exposure to light of a particular color. Thus we have one layer which is sensitive only to exposure to a red light, another only to a green light and the third only to blue light. For satisfactory results each of these layers must be correctly exposed, neither too little nor too much. This makes it necessary to independently control the balance of the different color exposures, especially since negatives differ due to variations in their manufacture, exposure conditions, and processing. In printing, these variations must be corrected to secure the best prints. Furthermore since the dyes used in color work are not perfect, there is a certain amount of overlapping of their cut-off points, and a gradual rise and fall either side of their peak transmission, so that with some materials, printing with narrow bands of colored light is better than where a continuous spectrum type of "white" light is used. In general, two methods have been used heretofore to expose prints. One method is to make three separate exposures, one at a time, in sequence. With the negative and paper held motionless, an exposure is made with red light, then a second exposure is made with green light, and finally an exposure is made with blue light. The change in color of the light being done mechanically by inserting a color filter in front of the lens, while the lens is capped by a shutter. It can be seen that with these three separate exposures, one or more of them can be increased or shortened, either by altering the time or the intensity of light. The other method heretofore used, is to make a single exposure to "white" light, which simultaneously exposes each layer, and to control the exposure balance by means of a filter pack. After initially balancing the light source to a normal balance, by cut and try testing, filters are manually inserted or withdrawn to vary the adjustment of the color balance to suit individual negatives. This second method, calls for a supply of filters of different colors, and densities. And further requires some method of guessing the kind and degree of correction required. Further it is time consuming to have to manually change the filter pack to suit different negatives. The present invention provides all of the advantages of both the above methods, while avoiding the faults of either. It operates in the following manner: A separate light source for each emulsion layer is provided. Each of these light sources is individually filtered to supply light which will affect its corresponding layer. This can be done by using lamps made of colored glass, or by the use of standard

filters in front of the lamps. Since each lamp is separately controllable, the color balance can be altered by either increasing or decreasing the voltage to the desired lamp, or by turning each lamp on or off for a different length of time. Since all three exposures are being made at the same time, printing process can be speeded up.

Throughout the description of the invention and the claims the term "image bearing support" has been used and this term is intended to include negatives or positives on transparent or opaque base. Also the term "photographic printing" has been used, and this term is intended to include the printing by light of a positive or negative on sensitized material and from an image bearing support. Again the term "multiple sensitized" is used to denote a printing material having portions of the coating separately sensitized to different colors or other qualities of the light.

The invention has been shown as embodied in an enlarger indicated by the reference numeral 20. This enlarger comprises a table or base 21 which provides the receiving surface for the sensitized material. Issuing upwardly from the table 21 is a column 22 which may be constructed as a casting and which has flanges 23 issuing outwardly therefrom. Cap screws 24 extending through said flanges and screwed into the table 21 hold the column securely attached thereto. The column 22 is provided at the forward face thereof with ways 25 which slidably support a carriage 26. Carriage 26 has attached to it a cord 27 which passes over a pulley 28 mounted for rotation in a bracket 29 at the upper end of the column 22. This cord is attached to a counterweight 31 which is formed with a groove 32. The rearward portion 33 of the column 22 is received within the groove 32 and guides the counterweight 31 for vertical movement.

The carriage 26 comprises a shelf 34 which has extending downwardly therefrom a slider 35. This slider is provided with oppositely facing grooves, one of which is shown in Fig. 1 and designated by the reference numeral 36. A clamp screw 37 screwed into the slider 35 and engaging one of the ways 25 serves to retain the carriage in vertically adjusted position.

The slider 35 is in turn formed with ways 38 which in turn support a lens board 39 for vertical sliding movement relative to the carriage 26. This lens board has a slider 41 formed with facing grooves, one of which is indicated by the reference numeral 42 in Fig. 1. These grooves receive the ways 38. A clamping screw 43 screwed into the slider 41 and engaging one of the ways 38 holds the lens board in adjusted position.

Attached to and issuing upwardly from the shelf 34 is a standard 44 which supports certain of the elements of the invention. A lamp housing 45 is also mounted on the shelf 34 and consists of a lateral wall structure 46 with a top 47 connected thereto. Flanges 53 secured to the lower end of the lateral wall structure 46 serve to attach the lamp housing 45 to the shelf 34. The upper portion of one of the walls 48 of the wall structure 46 is formed with an access opening 49 closed by means of a door 51 hinged to said wall. This door is provided with a knob 52 and a latch 50 for holding the same in closed position.

The enlarger shown utilizes a common type of optical system. However, it can readily be comprehended that any other suitable type of optical system can be employed. The optical system shown utilizes a condenser 54 which comprises two condensing lenses 55 and 56. This condenser is disposed within an annular flange 57 formed on the upper portion of the shelf 34 and is held in place therein by gravity. Cooperating with the condenser 54 is an objective lens 58 which is provided with a barrel 59 having a threaded portion 61 screwed into the lens board 39. Inasmuch as any suitable type of objective lens, such as is now well known in the art, may be employed, the same has not been shown in detail. A bellows 62 is attached to said lens board 39 and also to shelf 34. Shelf 34 has an opening 63 in the same and which passes the light received by the condenser 54 to the objective lens 58. Formed in the shelf 34 and traversing the opening 63 is a guideway 64 which receives a sliding negative holder 65 and which may be removed or inserted into the enlarger as desired thus bringing the negative immediately below the condenser 54.

Illumination for the enlarger is provided by means of three electric lamps 66, 67 and 68 best shown in Fig. 2. These lamps are mounted in sockets 69 attached to a support 71 mounted on the standard 44. These lamps are arranged in close proximity to one another and extend transversely of the lamp housing and are adapted to simultaneously illuminate the condenser 54. These lamps are located substantially at the conjugate focal point of the condenser and the filament of the intermediate lamp lies along the optical axis.

The invention proper utilizes a light mixer 72. The purpose of this light mixer is to direct some of the light from all three lamps to the objective lens. If this mixer were not used the light would travel as shown in Fig. 3. The outer rays 70 of light stream from lamp 67 would of course pass to the objective lens 58, as indicated in full lines. The outer rays 60 of light stream from lamp 66 would, however, be directed as indicated in dotted lines and would reach the lens board outwardly of the objective lens and hence serve no useful purpose. This is corrected by means of the light mixer. The light mixer 72 is plate-like in form and which is attached to a bracket 73 having a leg 74 secured to the standard 44. This light mixer is secured to the bracket 73 by means of clips 75. The light mixer 72 is disposed with its center at the optical axis 76 of the optical system and at a distance of between approximately 3 to 4 times the spacing of the lamp filaments and from the filaments of the lamps.

One form of light mixer used with the invention is shown in Figs. 4 and 5. This light mixer is constructed from transparent plastic having a body 77. A plastic having a suitable index of refraction for the purpose is chosen. One such plastic is polystyrene. This body is formed on one side thereof with a plurality of spaced parallel ribs 78 which extend throughout the length of the same and are of uniform shape throughout their extent. These ribs have angular surfaces 79 and 81 which meet at the vertex of said ribs. On the body 77 and on the same side thereof as the ribs 78 are formed planiform surfaces 82 which are disposed between said ribs and which are parallel to the rear surfaces 83 of the body 77. The surfaces 82 receive the rays from the lamp 67. The marginal rays of the light stream from lamp 67 are indicated by the reference numerals 84 and 85 in Fig. 2. The rays of the said stream reaching the surfaces 82 are directed to the objective. The rays of the light stream from the lamp 66 which strike the surfaces 81 of the ribs 78 are refracted by the light mixer 72 and follow paths parallel with the paths of the rays of the light stream from the lamp 67 and also reach the objective. In a similar manner, the rays of the light stream from the lamp 68 which strike the surfaces 79 of the light mixer are refracted and pass through the same in a direction parallel to the direction of travel of the rays of the light stream from the lamp 67 to reach the objective. All other rays are refracted in a manner to prevent the same from reaching the objective and are lost. In Fig. 5, the central ray 86 of lamp 67 is shown as coinciding with the optical axis of the optical system. The central ray 87 of the lamp 66 is shown as striking the surface 81 and emerging as ray 88 which is parallel to the ray 86. In a similar manner, the central ray 89 of the lamp 68 is shown as striking the surface 81 and emerging as ray 91 which is also parallel to the optical axis.

It has been found desirable to diffuse the light reaching the image bearing support to a slight extent. For the purpose, the rear surface 83 of the body 77 of the

light mixer **72** is ground to form the desired diffusing means.

Mounted between the lamps **66**, **67** and **68** and the light mixer **72** are three light filters **92**, one for each lamp. These light filters are supported on a bracket **93** which has a flange **98** secured to the upright **44**. Clips **94** hold these filters in place. These filters are usually color filters such as ordinarily used in color photography and may consist of the colors, red, blue and green. These filters may be readily removed and others substituted as needed. These filters may be located to intercept the light streams from the various lamps **66**, **67** and **68** and are preferably located at positions fairly close to said lamps. However, the exact location of said filters is not of great consequence. With the above noted invention, it has been found that either broad band or narrow band filters may be used.

For energizing the lamps **66**, **67** and **68** a circuit **99** is employed. This circuit is connected to an electric power source comprising conductors **101** and **102**. In the conductor **101** is connected a switch **97**. This switch may be either a manually operated switch or a time controlled switch as found desirable. A conductor **103** is connected to the switch **97** and other conductors **104**, **105** and **106** are connected to the conductor **103** and to the movable arms **107** of three rheostats **96**. These rheostats are connected by means of conductors **108**, **109** and **110** to the lamps **66**, **67** and **68**. The said lamps are further connected by means of conductors **112**, **113** and **114** to the conductor **102**. By means of this circuit, the brilliancy of any of the lamps **66**, **67** and **68** may be controlled by adjusting the arms **107** of the respective rheostats **96** connected thereto.

The method of operation of the invention and its use is as follows:

It will be assumed that a paper print is to be made from an ordinary transparent negative. In such case, the negative is inserted into the negative holder **65** which is slid in place in the guideway **64** of the shelf **34**. Suitable light filters **92** are mounted on the bracket **93** and held in place by means of the clips **94**. These light filters are selected to give the desired color to each of the light streams emanating from the lamps **66**, **67** and **68**. Also, the intensity of the light from said lamps is individually controlled by the rheostats **96** controlling the brilliancy of said lamps. The type and color of filter used will be such as recommended by the manufacturers of the photographic sensitized material or such filters as found experimentally to be better suited. As to the intensity of the light used, a trial print would be made, and where the print showed lack of brilliance of one color the particular lamp for the filter of that color would be adjusted to give the desired color brilliance. The photographic material is then placed on the table **21** in the proper position and the switch **97** closed for the desired length of time to give the proper exposure. During such exposure, all three emulsions on the photographic paper are simultaneously exposed, and thereafter the paper is developed in the customary manner.

In Fig. 6 a different type of light mixer has been shown. This mixer is particularly adapted to be used with four light streams whose sources are disposed at the vertexes of a square. In this form of the invention, a planiform body **115** of transparent refractive material is used, similar to that used with the light mixer shown in Fig. 4. This body has issuing outwardly from it a plurality of prisms **116** in the form of pyramids. These prisms have triangular surfaces **117**, **118**, **119** and **120** which intercept light rays from the various primary light streams. The angles between the plane of the body and these surfaces are such as to refract the rays transmitted and to combine and direct them to the condenser of the optical system as a composite light stream.

Fig. 7 shows a light mixer indicated by the reference numeral **122** and which is similar to the light mixer **72**. This light mixer, instead of having planiform surfaces running parallel to the ribs, has spaced planiform surfaces **123**, which are at right angles thereto and which intersect the ribs and form a series of short prisms **124**. These prisms are arranged in columns similar to the ribs **78** and the adjoining prisms are arranged in rows. These prisms have angular surfaces **125** and **126** which correspond to and function in the same manner as the surfaces **79** and **81** of the ribs **78** of mixer **72**.

In Fig. 8 still another form of light mixer **272** is shown. This form is similar to that shown in Fig. 4 except that the planiform surfaces **282** thereof are disposed at the apexes of the ribs **278** instead of directly on the body **277** of said mixer. Also, the surfaces **279** and **281** thereof meet at the surface of the body **277**. This mixer operates in the same manner as the mixer **72**.

In the discussion of the invention so far disclosed, it has been assumed that a condenser having a sufficiently small collection angle has been selected, and that the light sources have been positioned close enough to one another so that the pattern of the prism surfaces would be uniform throughout the surface of the plate without introducing serious error in the final result whereby one set of angles could be used for all of these surfaces. If, however, it was desired to use a condenser having a greater collection angle, in order to increase the illumination, such a condenser would have a shorter combined focal length and the distance between the condenser and lamps would be shorter. The light mixer in such case would either have to be made larger or moved closer to the lamps to embrace the entire collection angle. In either case, a uniform pattern of prism surfaces throughout the entire surface of the plate would produce serious error at the margins of the plate. In Figs. 10, 11 and 12, a light mixer **148** for correction of such errors has been diagrammatically shown. In Fig. 10, lamps **145**, **146** and **147** are shown whose outer rays **150**, **151**, **152**, **153**, **154** and **155** intersect the area of the light mixer **148** at the marginal edges **12** thereof. These rays, as noted, subtend a greater angle than the corresponding rays of the other form of the invention shown in Fig. 2. The central rays **161**, **162** and **163** of these lamps are shown as intersecting the light mixer **148** at the center **11** thereof. In Fig. 11, the formation of the prism surfaces at the center of the mixer has been shown. The three surfaces are designated by the reference numerals **127**, **128** and **129**. At this locality the center rays **161** and **163** from the outer lamps are symmetrical with respect to the optical axis and the angles between the prism surfaces **127** and **128** and the plane of the mixer are equal. Fig. 12 shows the prism surfaces adjacent the edge **12** in Fig. 10 which is where the outermost rays strike the mixer. These surfaces are indicated at **131**, **132** and **133**. The surfaces **133** are parallel to the plane of the mixer. However, surfaces **131** and **132** make different angles therewith and these angles are such that the refracted rays are parallel to the corresponding refracted outer rays of the center light stream. Due to the fact that a relatively great number of ribs are employed the angles of the prisms of each rib need not be changed. A group of adjoining ribs can be made of one form and the next group made of another form.

While the normal proportion of the different colors of light constituting the composite light stream may be procured by the use of lamps of proper wattage or by the control of the voltage at the lamps, the same results can be procured by varying the relative widths of the prism surfaces. In Figs. 11 and 12, portions of a light mixer has been shown, which combines light from each of primary streams in approximately equal proportions. To procure this result, the prism surfaces are designed so

that the widths of the portions of the light streams passing through the same are substantially equal. Thus the angular surfaces become wider than the surfaces parallel to the plane of the mixer and those angular surfaces intercepting the light from the lamp farthest from them become wider than those intercepting the light from the proximate lamp.

It will be clear to anyone skilled in the art that the prism forms used in the light mixer, as shown in Fig. 10, must be dimensionally related to the optical system with which it is employed. Such a typical example will now be described. This particular apparatus utilizes a commercial printer having a 90 mm. objective lens and using a 3-element condenser system comprising two 9½" equivalent focal length plano-convex lenses and a single 15½" equivalent focal length bi-convex lens positioned centrally between the plano-convex elements. The central lamp is positioned approximately 5½" distant from the first plano surface of the condenser. The light mixer is 4" by 4" square and may be of any convenient thickness, the thickness employed being ¼". The light mixer is made of polystyrene having an index of refraction of 1.595. The pitch of each complete rib pattern is .1". The surface 129 of Fig. 11 and 133 of Fig. 12 are .03" wide throughout the entire mixer. At the center of the mixer, surfaces 127 and 128 make an angle of 22½ degrees with the plane of the mixer. At the edge 156, the surface 131 makes an angle of 22 degrees with reference to the mixer and surface 132 makes an angle of 14½ degrees. At intermediate positions, the ribs are divided in groups of five, and the construction of the ribs in each group are the same, the angularity of the ribs in the various groups varying between the angles of the ribs at the center and margins of the mixer.

While the invention has so far been described as used with three light sources, the same can be also used with two or more than three light sources. Two light sources would be used with a photographic material which alters in contrast when printed with different colored lights. In such an application, a light mixer similar to that shown in Fig. 4 would be employed, except that the planiform surfaces 82 would be omitted and the adjoining surfaces brought into juxtaposition. Where it is desired to dilute the purity of some of the light streams four light sources may be employed. A light mixer such as shown in Fig. 6 would in such case be used.

In Fig. 13, the invention is shown diagrammatically as applied to a system using a reflective rather than a refractive light mixer. The three lamps are designated by the reference numerals 134, 135 and 136. A mirror 137 is utilized and which generally makes an angle of substantially 45 degrees with the axis of the center ray 165 of the center lamp 135. The outer rays 138 and 139 of the center lamp 135 reach the mirror at the points 14 and 15 and likewise the outer rays 141 and 142 of lamps 134 and the outer rays 143 and 144 of the lamps 136 reach the mirror at these same points. Due to the fact that certain of the rays of certain of the lamps 134 and 135 approach the mirror at different angles the mirror is formed with groups of three reflecting surfaces, one for each lamp, and these surfaces are designed so that the rays of the reflected light beams become parallel to the corresponding rays of the other surfaces. In Figs. 14, 15 and 16, portions of the reflecting surfaces at points 14, 15 and 16 respectively have been shown and which illustrate these surfaces. A portion of the reflecting surface of the mirror 137 at the center 15 thereof is shown in Fig. 15 and has three angularly disposed surfaces 171, 172 and 173. The center ray 165 of the lamp 135 reaches the surface 172 and is reflected from it as ray 168. The center ray 164 of lamp 134 reaches surface 171 and is reflected from it as ray 174. Similarly, the center ray 166 of lamp 136 reaches the surface 173 and is reflected from it as ray 175. All of the three emerging rays 174, 168 and 175 are parallel and lie along the focal axis of the system. In a similar manner, the mirror 137 is formed with surfaces 176, 177 and 178 at the locality 14 shown in Fig. 14 and which receive the lower rays 141, 138 and 143 of the lamps and reflect them into parrallel rays 181, 167 and 182. Also, the mirror 137 is formed at the locality 16 with surfaces 183, 184 and 185 as shown in Fig. 16 and which receive the upper rays 142, 130 and 144 of the lamps and reflect them as rays 186, 169 and 187, all parallel to one another. The rays 167 and 169 symmetrically diverge relative to the ray 168 and are injected into an optical system in the same manner as the rays of the refractive type of light mixer.

The advantages of the invention are manifest. Any desired number of light sources may be mixed in any desired proportion to control color balance. The invention also permits of mixing polarized light. Mixing is accomplished without moving parts. The invention may be produced at a nominal expense and requires no servicing. The invention may be used with a condenser optical system and may be installed in a photographic printer without appreciable reconstruction of the same. The invention may also be used in a color densitometer. The invention is space saving and permits of compactness of design and permits of passing a large percentage of the light emitted.

Changes in the specific form of the invention, as herein described, may be made within the scope of what is claimed without departing from the spirit of the invention.

Having described the invention, what is claimed as new and desired to be protected by Letters Patent is:

In projection photographic printing apparatus utilizing multiple sensitized photographic material comprising illuminating means having three primary light sources spaced from each other in a lateral direction of different colors directed in different directions to a common area, a condenser, a holder for an image bearing support, an objective lens, a photographic material support arranged in sequence, a single transparent substantially planiform light mixer constructed of refractive material and disposed at said area between said illuminating means and condenser, said mixer having a plurality of juxtaposed raised parallel rib portions provided with oppositely extending angular substantially planiform surfaces, said mixer having other substantially planiform surfaces parallel with the plane of the mixer and disposed in proximity to certain of the angular surfaces of the raised portions, said rib portions extending perpendicularly to said lateral directions, said surfaces serving to bend and direct light rays from each light source in a substantially common direction through the condenser, the image bearing support in said holder and the objective lens and to the photographic material at the photographic material support.

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