COLOR SOURCE

Filed May 5, 1965 2 Sheets-Sheet 1

Fig. 1

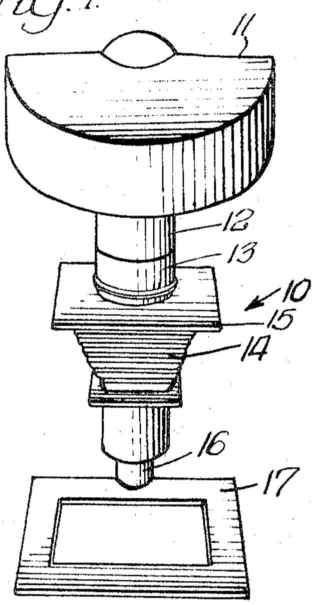

Fig. 2

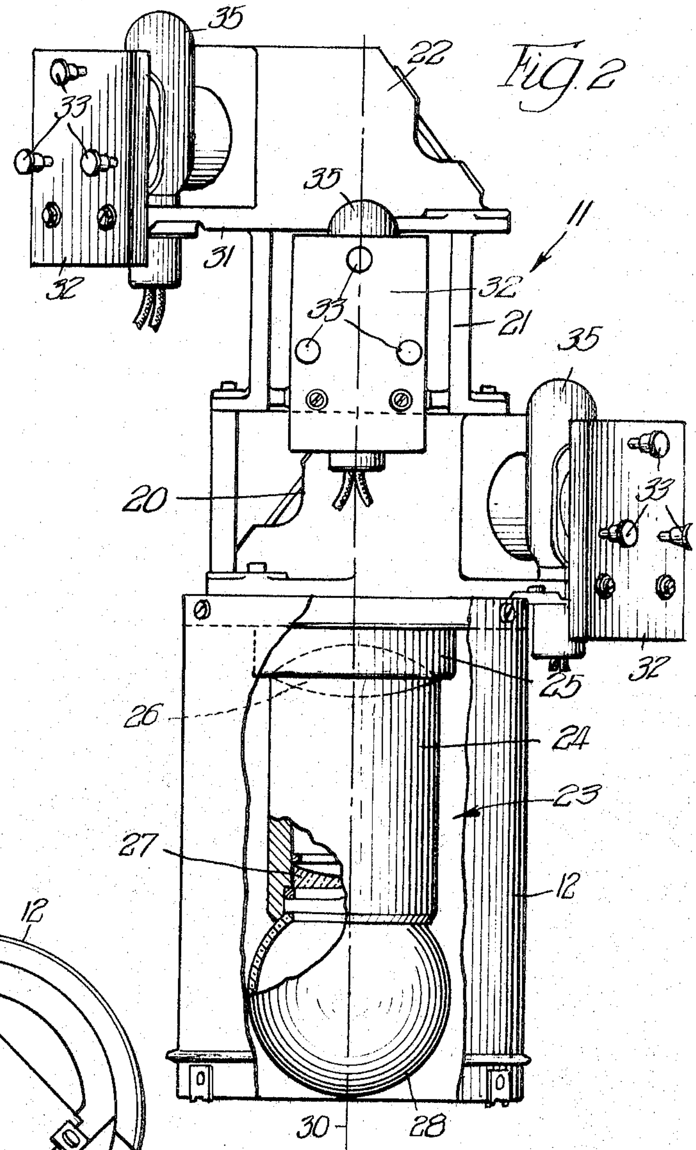

Fig. 3

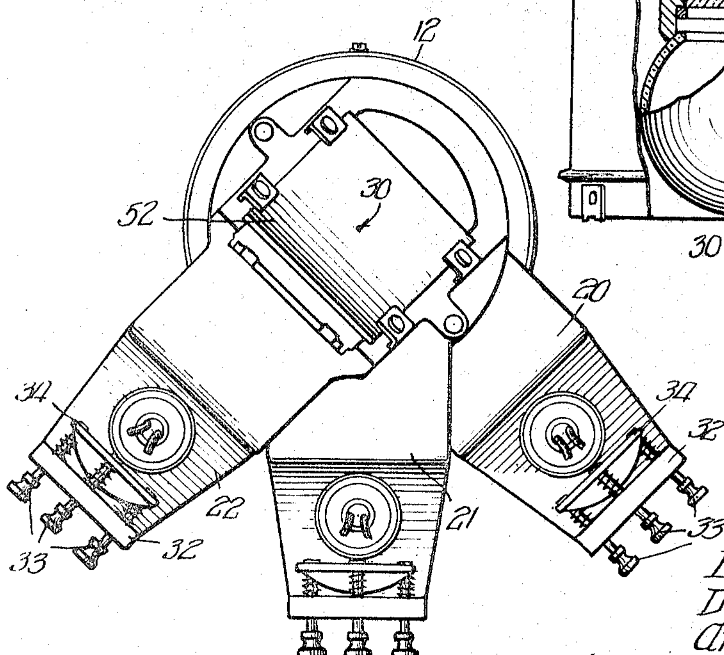

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Fig 4

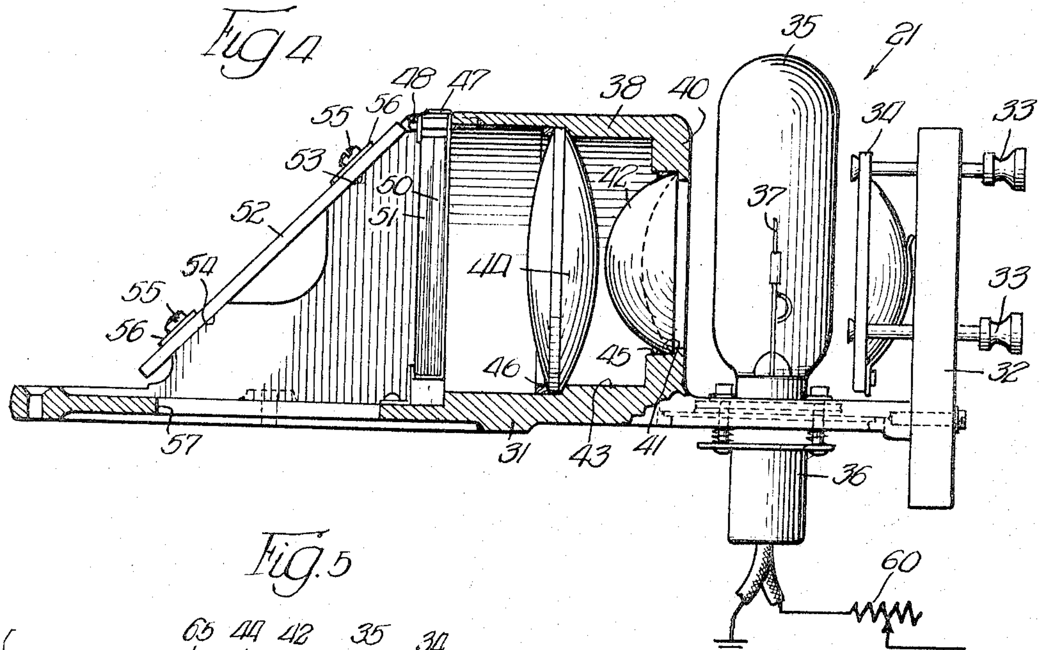
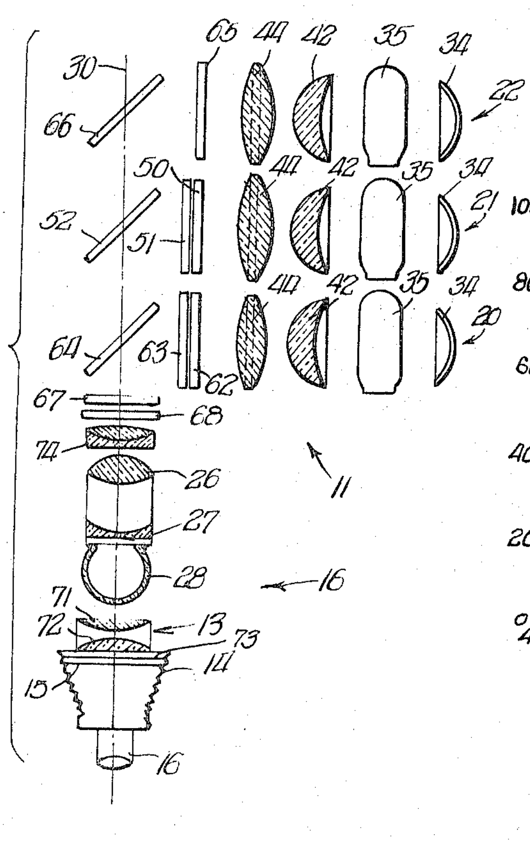


Fig. 5



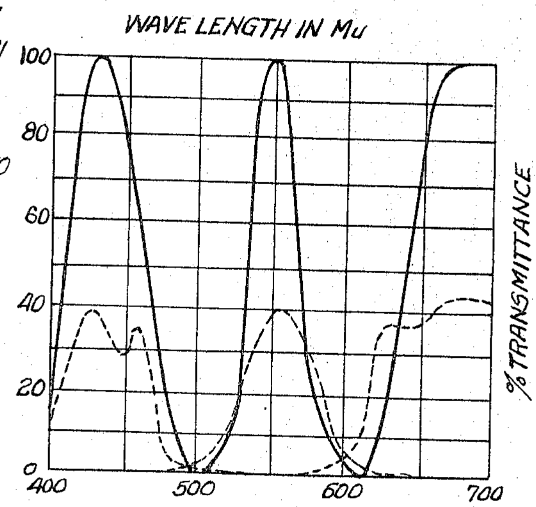


Fig. 6.

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COLOR SOURCE

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16 Claims. (Cl. 88—24)

This invention relates to a color source in general, and more specifically is directed to a new and improved color head which is adapted for use with existing enlarger system, for example, that type system commonly known as a condenser-type enlarger. The present invention is also suitable for use in color analysis, reproduction determination and the like. For convenience, however, it will be described in conjunction with a photographic enlarger and printer system as deficiencies in existing designs were the principal stimulant in its development.

The prior art is replete with a variety of printing techniques, processes, materials and different approaches all aimed at obtaining a successful and expedient method of printing color photographs. Even the most successful of these attempts involves a certain amount of "cut and try" techniques or repeated adjustment and measurement in order to obtain the necessary color balance. This is primarily due to deficiencies or inadequacies of the printing apparatus.

One of the more widely used methods of printing techniques involves multi-layer dye coupling type paper readily available on the open market. The individual layers are sensitive respectively to red, green and blue light to release the dye. Cyan, magenta and yellow layers form the negative film to be printed, which layers are responsive respectively to adjust the level of the red, green and blue light reaching the paper. Such negatives are obtained through the exposure and development of such film known by the trademarks "Kodacolor," "Ektacolor" and the like.

When a negative of the type described is exposed through the use of a conventional white light source, i.e., a conventional light bulb, the sensitive layers of the paper are not only responsive to the specific wave lengths of red, green and blue contained in the white light but will also respond to wave lengths above, below and between the red, blue and green wave lengths. Accordingly, unwanted portions of the white light sensitize the various layers resulting in a print which is somewhat removed in color proportions from the negative.

When light from a single source is used, a true balance between the three colors is almost impossible to achieve because the exposure of each of the respective layers in the paper is dependent upon time and intensity of exposure to the appropriate sensitizing color. As expected, each of the dyes in the paper have different response rates while the interval of exposure is obviously the same for all colors when a single exposure source is used. Various attempts have been made to subtract, by the use of filters, the unwanted light and wave lengths to bring the color balance to a reasonable approximation necessary to obtain a print of at least marginal quality. This procedure is sometimes identified as the subtractive process of color balancing and is vulnerable to a number of criticisms by those working in the field, since it generally requires more exposure time by slowing down the response time of the respective dyes in order to bring the same to a closer common time interval of exposure for each color. The large light losses caused by this as well as the testing and checking prior to printing consume a great deal of the printer's time as well as tying up the enlarger for a considerable period. Even in those cases when a reasonably good color balance is ultimately achieved, it is unstable being susceptible to drift because of the change in value of the filters due to heat, aging, exposure to high intensity light and the like. In summary, while the above technique is not a complete failure, it is far from what could be considered commercially desirable.

Notwithstanding the criticism of the subtractive filtration arrangement, it is in use by photographers since it is the most expedient and convenient of known and operable printing and enlarging systems to date. One specific commercial structure in use today utilizes a subtractive filter system in combination with an integrating sphere and two light sources. The subtractive filters in this design are subjected to the criticisms noted above while the integrating sphere provokes additional criticism since it does not provide the desired fineness of control and leaves something to be desired when the efficiency of the light is analyzed.

In the past when a truly balanced print has been desired, successive exposure of each of the layers has been recommended. In this process, filtered red, green and blue light is transmitted consecutively through the film negative, permitting a higher color purity to be achieved. As a general rule, in this process the color purity has been controlled by the use of filters disposed between the negative and the print paper, with the obvious adverse effect on image definition. Other disadvantages mainly in the time required, exist which makes the successive exposure techniques impossible for competitive type color printing work.

In general, in all systems, subtractive filters have also been undesirable since one filter will properly compensate to remove an unwanted band of color but at the same time will have an adverse effect on the level of color of an adjacent band. In checking the color balance in the subtractive process, it is necessary to insert filters in the path of the light and check each of the respective colors at various positions on the easel to determine and adjust for the exposure time and color balance. A probe, provided with filters, is used to check the intensity of each of the color components. Adjustments may be made by adding or subtracting filters to effect a color balance. Since filters are needed at the probe, the effective light intensity is lowered necessitating a more powerful amplifier, as well as a preamplifier in the probe which adds to its bulk. In addition, a need exists to physically touch the probe to shift from one filter to another. If the probe is moved slightly, as by an accidental bump, it becomes necessary to repeat the color measurement with the former time and effort wasted.

The foregoing problems are but a few examples of the difficulties experienced in the past, which gave impetus to the development of the present invention. During this development, these objectives were attained. The interaction of filters was eliminated in order that the respective color levels could be chosen with a single light probe test. The system was accurate whereby the usual correction factors provided on the box of the printing paper could be readily compensated for, thus making this information more useful. Various switching between and use of subtractive filters in the probe and enlargers was eliminated in order to minimize the number of adjustments, and therefore minimize the possibility of "printer's error." The elimination of the filters in the probe also permitted the use of a simpler probe and lower gain amplifier with the obvious advantageous effect on sensitivity. Elimination of subtractive filters in the enlarger increased the efficiency of the light. In addition, exciting light is refined to the peak response of the individual layers of the photographic paper to avoid simultaneously stimulating adjacent layers. A small but further correction provides refined light whose peaks fall within the range of peak response of the individual layers of the photographic paper and are still within a more sensitive wave length range of known types of phototubes. The system required a minimum number of special parts while making highly efficient use of the available light.

The present invention provides a new and improved color head which solves the above noted problems and achieves all the stated objectives. It is capable of providing an additive light source permitting simultaneous balanced exposure of the sensitive layers of photographic paper since this light source, through a unique lens and multi film filter system, provides a coaxial white light composed of color components which are of a well defined band width and which for all practical purposes are non-overlapping.

Simple adjustment and balance of each of the respective colors may be individually affected without any effect on the intensity of the other colors thus requiring minimum light level testing before printing may begin. The effect of this on the printing time is obvious. The present system is highly accurate and provides means whereby the correction factors given with each supply of printing paper may be used to their fullest potential. With the present system the simplest type of probe and a relatively sensitive low gain amplifier may be used to balance the respective color components to an appropriate level of intensity.

The present invention, through a unique and unobvious solution of the problems enumerated, provides a system whereby the problems of the prior art may be avoided. A number of advantages in addition to those enumerated flow from the novel solution about to be described. A better comprehension of these advantages as well as the salient features of the invention may be had by a consideration of the objects to be achieved and a detailed description of a preferred form of the invention which follows.

It is a principal object of this invention to provide a new and improved color source for photographic printers and the like.

It is another object of this invention to provide a color head which permits simultaneous exposure of multi-sensitive layers of photographic paper, exposure of each layer being easily and accurately controlled.

It is a further object of this invention to provide a new and improved color head which provides a white light source composed of color components of blue, green and red with each of the colors being individually controlled without affecting the other and with each color falling within a wave length band which does not overlap the adjacent color or extend substantially above or below the visible region of wave lengths.

It is a still further object of this invention to provide a new and improved color head which is adapted to replace the light head of an existing enlarger.

It is a still further object of this invention to provide a new and improved color head which provides a white light source composed of the additive primary colors and which has sufficient intensity to permit test equipment of relatively low gain to be used in testing the color balance prior to printing, and further which reduces the time of printing by permitting a simplified adjustment of each of the color levels.

It is a still further object of this invention to provide a new and improved photographic enlarger head which is capable of use with existing condenser type systems and further wherein a novel filter means is provided which permits both "hard" and "portrait" type prints to be printed on the same apparatus.

Further objects will become readily apparent when reference is made to the accompanying drawings wherein:

FIG. 1 is a perspective view of the color head of the present invention applied to a conventional type condenser enlarger;

FIG. 2 is an elevational view of the color head shown in FIG. 1 with the shield removed;

FIG. 3 is a top plan view of the color head as shown in FIG. 2;

FIG. 4 is a side elevational view of one of the light source subassemblies;

FIG. 5 is a schematic diagram of the system shown in FIG. 1; and

FIG. 6 is a graph of light transmittance (in percent) plotted against wave lengths for the visible region with the solid lines representing theoretical calculations taking into account the limitations of measuring phototube while compensating for the three layer peak response and the dash lines representing one workable set of wave lengths taken from the system of FIGS. 1–5.

Referring now to FIG. 1, an enlarger system is represented generally by the reference character **10** including a color head **11** having a condenser adaptor **12** at the lower extremity. A condenser system **13** and negative holder **15** of conventional design are disposed above an adjustable length bellows **14** which terminates in a focusing system **16** positioned above an easel schematically represented by the rectangle **17**.

The color head **11** through use of the condenser adaptor **12** and unique optical design may be used with any known type of system which heretofore has used a single light source. The optical design and geometry of the present invention is such that it terminates and presents the appearance to the condenser assembly of being a single white light point source evenly diffused into a perfect circle while in actuality being composed of three distinct colors of readily identifiable and well defined wave lengths.

Referring now to FIG. 2, the color head **11** is illustrated with the case or shield removed, generally displaying three separate light sources **20**, **21** and **22** arranged in vertical relationship above the condenser adaptor **12**. Each of the light sources has an optical and geometric axis which intersects a common vertically disposed central axis **30** coincidental with the geometric axis of the cylindrical condenser adaptor **12**. Expressed another way, horizontal planes passing through the axis or center of each of the light sources **20**, **21** and **22** are vertically spaced and parallel to each other and intersect a vertically disposed central axis **30** at right angles.

The condenser adaptor **12** is broken away in FIG. 2 to illustrate a semisphere subassembly **23** which is also broken away to illustrate the mounting arrangement. The semisphere subassembly includes a mounting tube **24** held in a bracket **25** which is disposed below the light source **20**. The mounting tube **24** houses an aspheric lens **26** at its upper end and a plano-concave or negative lens **27** at its lower end. A diffusing semisphere **28** is suspended from the lower end of the mounting tube **24**.

Suitable retaining means may be provided to hold the lens in the position shown with the dimension between the two lenses **26** and **27** being carefully and accurately controlled. When the lower end of the color head **11** is viewed in elevation, the appearance of an ordinary single light source is presented making it suitable to replace a single light source.

As seen in the top plan view of FIG. 3, the sources **20**, **21** and **22** are arranged about a central axis **30**, angularly spaced in azimuth by 45°. As seen in FIGS. 2 and 3, the central axis **30** is coincidental with the geometric axis of the mounting tube **24** and condenser adaptor **12**. The importance of the coaxial arrangement of each of the light sources **20**, **21** and **22** will become apparent.

The angular spacing of the light sources **20–21**, among other things serves to allow the separation between each of the individual lamps contained in the light source within good design geometry in order to facilitate a good cooling or heat dissipation during operation of the enlarger. To enhance this effect, a blower (not shown), is mounted in a convenient location remote from the enlarger support or pedestal and supplies cooling air through a flexible tube (not shown) to cool the color head 11. Through the remote mounting, vibrations inherent in the operation of the fan, particularly when it becomes worn from use, will not be transmitted to the enlarger head to cause a vibration during printing.

Referring now to FIG. 4, the light source 21 is illustrated with parts in section to present a clearer understanding of the more detailed features. A light source holder or mount 31 may be formed in any suitable manner by machining, casting or the like. The holder 31 is provided with an upstanding bracket portion 32 which threadably mounts a plurality of thumb screws 33 for movement along their respective axes in response to rotation. The thumb screws 33 at their inner end mount a spherical mirror 34 which may be adjusted towards and away from a lamp 35 mounted in a lamp socket 36 on the light source holder 31. The lamp 35 is of a type known as having a prefocused base so that when inserted in the socket 36, the filament 37 will be in the same location relative to the base for all lamps within a specified close tolerance.

The light source holder 13 is provided with an annular chamber 38 terminating adjacent the lamp 35 in an inwardly projecting flange 40, counterbored as at 41 to receive a positive meniscus lens 42. An enlarged bore 43 adjacent the lens 42 has an enlarged counterbored portion to form a mount for a double convex lens 44. The lens 42 is held within the counterbored portion on the flange 40 by a retaining ring 45 while a larger diameter retaining ring 46 holds the double convex lens 44 in its mounting in the counterbored portion of the enlarged bore 43. Each of the counterbored portions is very carefully machined in order that the lenses 42 and 44 may be accurately placed relative to each other and the lamp 35. The positive meniscus lens 42 serves to initiate collimation of the light from the lamp 35 and for convenience will be identified as a first collimator. The double convex lens 44 serves to collect and arrange light rays from the first collimator 42 into parallel rays and will be identified as the second collimator.

As is well known in optics, when theoretically designing a light system, it can be assumed that the light sources are point sources and light is uniformly passed by each lens. However, in actual practice where the sources are lamps, the filaments have a finite dimension, and chromatic aberration is normally experienced. In systems where the light intensity levels are of low order, for all practical purposes the size of the filament can be ignored as well as aberration. However, in an enlarger system such as the present where a high level of light is required, the filament size will run on the order of about several millimeters square. Accordingly, the collimating system shown was developed to accommodate this finite size of the filament and avoid aberration or non-uniformity in the intensity of the beam of light when viewed in cross section.

At the outer end of the bore 43 is provided a filter mounting means or holder 47 which is held in place by suitable mounting means such as the screws 48 received in tappings in the holder 31. Two permanent filters are shown at 50 and 51 clamped within the filter mounting means 47 and serve to refine the collimated white light from the lamp 35 into a selected color having a wave length falling within selected limits for one of the additive primary color components.

An additional filter 52, which is sometimes referred to as a dichroic filter, is held to machine surfaces 53 and 54 on the light holder 31 by means of screws and clamps 55 and 56 respectively. The dichroic filter 52 is arranged at a perfect 45° angle relative to the collimated light so that the incident and reflection angles are equal to 45° thereby to direct collimated and filtered light through the aperture 57 in the holder 31. The aperture 57 has its center coaxial with the central axis 30, as do the apertures on the light sources 20 and 22.

The light source 20 is physically identical to the light source 21, and differs optically only in the selection of filters to be substituted for equivalent filters 50, 51 and 52. Similarly, light source 22 is physically identical to light source 21 with the exception that a single filter is substituted for the two filters 50 and 51, and a dichroic having a different reflectance wave length is substituted for the dichroic 52.

The spherical mirror 54 may be adjusted at the factory to focus the maximum amount of light from the filament 37 of the lamp 35 back to the filament so it is directed toward the first collimator 42. Through the use of a prefocused base 36, the lamp 35 when no longer operative, may be readily replaced by a similar lamp without affecting the optical relationship of the filament 37 relative to the collimating lens system. The collimating lens system, composed of the first collimator 42 and double convex lens 54 forming the second collimator, collimates the light into parallel bundles, directing it to the filters which by selection reject all light above and below selected wave lengths. A better understanding of the optical characteristics and types of lenses and filters will be given when FIG. 5 is described.

The intensity of the lamp 35 may be adjusted by the variable resistance shown schematically at 60. In a typical case this resistor comprises a 75-ohm 225-watt resistance to provide a good range of intensity adjustment. Additional resistors may be placed in series and factory adjusted to obtain a reduced operating voltage to the lamp 35 for long life. A preheat circuit may be provided to keep the filaments warm and further extend their life. With the arrangement shown, the power to the lamp 35 may be varied to raise and lower the intensity level for purposes noted above.

Ordinarily resistance control of light in enlargers has not been successfully used in the past even though highly desirable, because it served to change the color temperature of the lamp. For example, the blue colors change at a faster rate than the reds. Due to the novel system of filters, the refined light band is relatively narrow, and any shift of intensity of one color has no effect on the other colors. The advantages of resistance control are self-evident permitting a wide range of intensity levels to be selected with unequaled ease.

In FIG. 5 the enlarger system 10 is illustrated in schematic form and like reference numerals have been given to common elements including the first and second collimators 42 and 44, lamps 35 and mirror 34 of each of the respective light sources 20, 21 and 22. In light source 20, vertical filters 62 and 63 are provided to filter the collimated white light into a band falling between about 610 millimicrons and into the infrared region or about 740 millimicrons. The upper limit will be defined by a subsequent filter. A 45° dichroic filter 64 is arranged in parallelism with the dichroic 52 and disposed in the path of the collimated light so that the angles of incidence and reflection will be equal to 45°.

Contrasted with the lower light source 21, the upper light source 22 is provided with a single vertically disposed filter 65 which is sometimes referred to as a 90° filter. The angularly arranged filter or dichroic 66 is located relative to its collimated light source such that the angles of incidence and reflection of the collimated light will be exactly equal to 45° which is parallel to the dichroics 52 and 64. All of the dichroics 52, 64 and 66 are arranged so that the angle of reflection of each will be coincidental with the central axis 30 to provide a refined coaxial white light.

The 90° or transmitting filters 50, 51, 62, 63 and 65 allow only light of a specified or definite wave length to pass and are chosen and identified by their transmittance value. Conversely the dichroics or separating filters 52, 64 and 66 are chosen to reflect only the desired color of light while transmitting or passing all that is not reflected. When figured on the basis of 100%, or perfect transmittance, and contrasted to colored glass, dyes and other type filters, the multi film filters selected absorb practically no light. Their transmittance at any selected wave length in the spectrum is determined by their reflecance at that wave length and accordingly when either of these factors is adjusted, the other increases or decreases in a compementary manner.

In the present system the filter **65** is designed to reflect all visible light above about 480 millimicrons. It transmits a preponderance (90%) of visible light wave lengths falling between about 380 and 425 millimicrons. The associated dichroic or separating filter **66** passes almost all visible light above about 610 millimicrons while wave lengths below this value are reflected along the axis **30**. The lower range of the spectrum is reflected including ultraviolet rays which may be present, however, these are filtered out as will be seen. A preponderance of reflectance (over 90%) is experienced in the band from about 400 to 560 millimicrons.

Filters **50** and **51** are chosen to transmit light having a wave length falling generally between 520 and 600 millimicrons being what is commonly known as the wave length band for green light. The associated dichroic or 45° separating filter **52** is designed to pass all light above and below the noted wave length and to reflect a band width of about 500 to 590 millimicrons at a 90% reflectance capability. Accordingly, the green color component is well defined and readily identified.

Multi film filters **62** and **63** in the lower light source **20** are chosen to pass all light above about 600 millimicrons including some wave lengths extending into the infrared range. The associated dichroic filter **64** has a reflectance characteristic to reflect virtually all wave lengths above 630 millimicrons at 90% reflectance while transmitting other wave lengths. Accordingly, the separating or dichroic filter **64** serves to trim the lower end of the band by some 30 millimicrons to further separate it from the adjacent green component.

A 90° filter **67** is provided to suppress ultraviolet wave lengths or those wave lengths below about 400 millimicrons passing all visible wave lengths above. A second filter **68** acts as a heat absorber to transmit with about 50% or greater efficiency, those wave lengths falling substantially within the visible region between an upper limit of 700 and the lower ultraviolet cut off of 400 millimicrons effected by filter **67**. Accordingly, higher value wave lengths of infrared will be substantially suppressed with a small controlled portion passed. Unwanted ultraviolet light which is normally considered to be below 400 millimicrons is sharply cut off.

When the light sources **20**, **21** and **22** which are red, green and blue respectively, are energized, refined white light consisting of three identifiable and individually controllable well defined color components will be generated. At printing intensities, each of the colors is non-overlapping with adjacent colors. Light source **22** will provide to the aspheric lens **26** light falling within 400 to 480 millimicrons with a peak transmittance falling slightly below what in theory is identified as pure blue. In a similar manner, the light source **21** will provide the green component of light which will be blended with the light from the blue source **22**. This light has a wave length of about 520 to 590 millimicrons with a peak or maximum transmittance experienced at about 550 millimicrons as seen in dotted lines in the graph of FIG. 6. The lower light source **20** will provide the red component of light, since it has a wave length of from about 600 millimicrons out into the infrared range slightly in excess of 700 millimicrons.

All three light sources, due to the selection and arrangement of the filters will provide a coaxial band of light of uniform intensity. It can be appreciated that each of the separating filters **52** and **64** has a trimming effect on the color component reflected from the sources disposed above the same. The accurate collimation provided by the unique collimating lens selection and arrangement, directs the light to the filters at the proper incident angle. This is very critical as it avoids resonance conditions which arise when the light strikes the filter at non-unform incident angles, a common occurence when the light is not collimated. The light rays of the three color components are blended together with the unwanted portion of ultraviolet filtered out through the filter **67**. The infrared wave lengths are controlled by the suppressor **68** to permit a small percentage to pass to enhance printing.

The aspheric lens **26** is of a special design to focus the blended color components to a focal point which is coincident with that of the negative lens **27**, the latter serving to evenly diffuse or spread the light to fill the semisphere **28**. If desired, the plane surface of the plano-concave lens **27** may be etched, sand blasted, or the like to provide a diffusing surface to fill the semisphere **28** with light. Obviously, a separate diffuser may be provided as an alternative, however, ideally the diffuser should be as close to the plane surface as possible. The semisphere **28** is a sphere truncated substantially above the geometric center and may also be provided with a diffusing type etch, sand blast, coating or the like on either the interior or exterior surface or both. It serves to diffuse the light evenly to the condenser system **13** containing the usual condenser lenses **71** and **72** both of which are of conventional design and serve the conventional function. When viewing the semisphere **28** back through the edges of the condenser lens, a perfect circle of light is seen which indicates that the light is uniformly received by the condenser system from the source for transmission to the focusing lens **16**. Accordingly, more uniformity in intensity at the corners of the print will be experienced.

The negative holder **15** receives the negative and in addition has sufficient vertical clearance to accommodate an additional filter which will be described. A color compensating lens **74** may also be provided immediately above the aspheric lens in those situations wherein enlargements of unusual size are to be made. This lens is indicated in the diagram at **74** and includes a plano-concave lens receiving a double convex lens. As indicated, one side of the double convex lens is formed on a greater radius than the side abutting the plano-concave lens. As is well known, chromatic aberration exists in lenses resulting from the differences of the index of refraction at different wave lengths. By the compensating lens **74** formed of glasses having different refractive indices, the focal point of the upper and lower wave lengths are brought into coincidence and the intermediate wave length (green) also coincides fairly accurately. In this manner fall-off or loss of light at the corners of the photograph can be maintained uniform for all sizes. As pointed out previously, the light level around the margin of the photograph is substantially equal to that in the center. In printing pictures in the popular sizes, the color compensating lens is not needed and may be omitted.

In FIG. 6, the solid line represents a theoretical curve of the three additive colors as measured by a spectral photometer, which are arbitrarily assigned a value of 100 percent. The dash lines represent one workable solution to separating the wave lengths by the lens, filter and diffusing system described above. The losses in intensity result from several factors common to optical systems. These include intersurface reflections, scattering, absorption of light and the performance of the reflecting filters being somewhat less than one hundred per cent or perfect. This loss however is not critical so long as the actual curves are maintained within the given wave lengths, as the level of intensity for each lamp can be individually adjusted.

In operation, when initially set up for printing, an approximation of the color balance to be set on each of the various primary colors must be made. Several prints of a given negative are run in sequence with visually selected changes in the color adjustment effected, until such time a high quality print having the desired balance is obtained. Suitable scales are provided on the variable resistances 60 so that the finally desired adjustment may be noted. At this time the probe is placed on the easel and the intensity of each color is checked with a suitable adjustment made to null the meter (not shown) on the amplifier (not shown) for recording or memorizing the proper level of intensity of each of the respective colors for the printing paper used. Printing may now commence.

When changing from the first negative to subsequent negatives the light measuring probe may be placed on the easel and the resistance adjusted to return the meter on the amplifier to zero for each of the respective colors. Adjustment of one color does not affect the others. In this manner an appropriate color balance for each negative may be rapidly and readily obtained with a single test.

When the supply of paper has been exhausted, and a new supply is opened, the corrective factors given with the new supply may be noted. Compensation for changes in corrective factors relative to the previous box may be readily obtained by appropriate resistance adjustment to add or subtract the numerical color corrective color compensating factor on the meter scale. Printing may resume without the cut and try method to establish a proper color balance. It can be appreciated that color corrective factors will be now more meaningful in the present system since once the desired balance between colors is obtained, corrective factors of new paper supplies may be compensated for through a simple adjustment.

Of considerable importance in the measurement of the intensity of the respective colors in the selection of a wave length which is optimum for exciting the paper, and also within what is known to be the most sensitive range for the measuring phototube. This is a phenomena best illustrated by an example. In the infrared region above 700 millimicrons, known types of phototubes are relatively insensitive while the paper is quite sensitive and responsive. Accordingly, the peak of the wave length in red region is controlled by filter selection to fall between the peak response of the known types of paper which is quite broad, and the responsive wave length of known type of phototubes. The same applies to the selection of peak wave lengths for the other colors in the color source. Accordingly, the wave length of each color at its peak will fall between the peak response of the tube and paper. Accordingly, measurement of the intensity of each color prior to printing can be achieved to predetermine with great accuracy the intensity of the exciting light providing advantages formerly not available.

When portrait work is to be done, a second diffuser is inserted above the negative as at 73 in the space provided. This diffuser is a clear plastic having embossments which diffuse a small portion of the collimated light to illuminate the side walls of negative scratches. When used in combination with the system above described and placed immediately above the negative in a conventional type of condenser enlarger, it provides a soft portrait type diffusion to the print, obliterating minor skin blemishes and the like without interfering with the trueness of the flesh tones, eye color, hair color and other features.

After a consideration of the foregoing description of the invention, it becomes apparent that the objectives set out above are readily achieved. It will become obvious to those skilled in the art that modifications may be made without departing from the inventive concepts embodied herein. Therefore, only such limitations should be imposed as are indicated by the spirit and scope of the appended claims.

We claim:

1. A color head adapted for use in condenser type enlargers, said color head comprising three light sources disposed at different elevations, multi film filter means to separate light emitted from each of said light sources into light rays having wave lengths falling within a band identifying separate color components, said multi film filter means including means to blend said separated color components into a coaxial white light ray of transversely uniform intensity, and lens means adapted to receive said coaxial white light and focus the same at a focal point coincidental with the focal point of a negative lens means for uniform transmission to a condenser system of an enlarger.

2. The color head of claim 1 wherein diffusing means is disposed between said negative lens means and said condenser system of said enlarger, said diffusing means including a semispherical type diffuser.

3. A color head adapted for use in condenser type enlargers, said color head comprising three light sources disposed at different elevations, multi film filter means to separate light emitted from each of said light sources into light rays having wave lengths falling within a band identifying separate color components, said multi film filter means including means to blend said separated color components into a coaxial refined white light ray of transversely uniform intensity, lens means adapted to receive said coaxial refined white light and focus the same at a focal point coincidental with the focal point of a negative lens means, first diffusing means adjacent said negative lens means to diffuse said coaxial refined white light, and second diffusing means adapted to diffuse said coaxial refined white light for uniform transmission to a condenser system.

4. A color head adapted to provide refined coaxial light for use in photographic enlargers, said color head comprising a plurality of light sources, means to collimate light from each of said sources into a beam of transversely uniform intensity, a first filter means disposed in the path of each of said collimated light rays to separate light from each of said light sources into one component of three primary colors of red, blue and green, second filter means disposed at an angle to each of said first filter means to reflect and trim light from said each of said first filter means into a more sharply defined component of the primary colors while simultaneously mixing said components into a beam of coaxial light rays of uniform intensity, and means to diffuse said light rays for uniform transmission to a condenser system.

5. The system of claim 4 wherein a negative holder is provided below said condenser system and a diffuser is mounted above said negative holder for use in printing portraits.

6. A color head particularly adapted for use in condenser type enlargers, said color head comprising three separate light sources disposed at different elevations, collimating means adjacent each of said light sources, multi film filter means to separate collimated light from each of said light sources into a single refined light ray, each of said light rays having a wave length defining one of three color components consisting of blue, green and red, said multi film filter means including means to blend said refined color components into a coaxial and further refined white light ray of transversely uniform intensity, second filter means in the path of said coaxial white light to reject wave lengths above and below visible wave lengths, lens means to focus said coaxial refined white light at a focal point coincidental with the focal point of a negative lens means, first diffusing means adjacent said negative lens means to diffuse said white light, and second diffusing means adapted to spread said light for uniform transmission to a condenser system.

7. The color head of claim 6 wherein said light sources are arranged so that the light source of the green color component is disposed above the light source of the red color component and the light source of said blue color comopnent is disposed above both of the previously mentioned light sources whereby said means to blend said refined color components into a coaxial refined light ray will further trim each of said color components.

8. A color control head adapted for application to a condenser-type of enlarger, said color control head comprising three light source means arranged in vertically spaced planes, individual intensity control means for each of said light source means, first and second lenses positioned closely adjacent said each of said light source means to collimate light into parallel rays, the first of said lenses being a positive meniscus lens and the second of said lenses being a double convex lens having the focal point thereof coincidental with the focal plane of said first lens, first multi filter means disposed perpendicular to the path of each of said collimated rays to filter said light into collimated rays having a relatively narrow and identifiable band width, each of said light rays from each of said light source after passing said first filter means having a wave length which differs from the other light source means to provide light of the primary color components, second multi filter means disposed at an angle to each of said collimated and filtered light rays from each of said light sources, each of said second multi filter means being angularly disposed relative to said collimated and filtered light rays whereby each of said light rays will be reflected off of said second multi filter means to form a single light ray of uniform transverse intensity, aspheric lens means disposed in the path of said white light ray to direct said white light ray to the focal point of a plano-concave lens, a diffusing type means adjacent said plano-concave lens to diffuse said white light ray passing through said plano-concave lens and semispheric means to receive light passing through said diffusing means to further diffuse said light for passage into a condenser system.

9. A color control head adapted for application to a condenser type of enlarger in lieu of an existing light head, said color control head comprising three light source means arranged one above the other, each of said light source means having first and second lenses disposed adjacent said light source means to collimate light emitted from said light source means into perfectly parallel rays and direct the same to an axis disposed at an angle to said rays, multi filter means disposed in the path of said collimated light to reject all light falling outside a given band width, whereby three collimated light rays of diverse band widths will be disposed in substantially parallelism in different elevations, second multi filter means disposed at an angle to each of said collimated and filtered light rays, each of said second multi filter means being angularly disposed relative to said axis and to the collimated and filtered light ray whereby a portion will be reflected off of said second multi filter means, said portion of said light ray reflected off of each of said multi filter means being directed parallel to said axis in a single coaxial white light ray of uniform intensity, aspheric lens means disposed in the path of said white light ray and being adapted to direct the same to a negative lens system having its focal point disposed at the focal point of said aspheric lens, first diffusing means disposed on one side of said negative lens and a second diffusing means to receive light from said diffusing means and spread it for uniform transmission to a condenser system.

10. A color source adapted to provide refined light composed of three primary additive colors to an enlarger, said color source including first, second and third light sources arranged in parallel planes, each of said light sources including a lamp adapted to emit light of variable intensity, a collimating system adapted to collimate said light emitted from said lamp into a beam of parallel light rays, first filter means disposed in the path of said light rays to reject a portion of said collimated light of an unwanted wave length, second filter means disposed at an angle to said collimated light passed by said first filter means, said second filter means passing all light of an unwanted wave length while reflecting light of desired wave length, said second filter means of said first, second and third light sources being arranged in coaxial parallelism, said second filter means of said second light source being further characterized by passing a preponderance of light reflected from said second filter means of said first light source, said second filter means of said third light source being further characterized by passing a preponderance of light reflected from the second filter means of said first and second light sources thereby to provide a coaxial refined collimated beam of light, third filter means to further refine said light primarily in the wave lengths outside the visible region, and means to collect and diffuse said refined light for transmission to an enlarger.

11. The color source of claim 10 wherein said means to collect and diffuse said light includes an aspheric lens, and a color compensating lens is disposed between said aspheric lens and said third filter means to provide uniformity in light intensity when printing enlargements of substantial size.

12. The color source of claim 10 wherein said collimating system of each of said sources comprises a positive meniscus lens and a double convex lens, said positive meniscus lens being disposed adjacent said lamp, said lenses being adapted to arrange light rays emitted from said lamp into a parallel beam at right angles to said first filter means.

13. A color source adapted to provide refined light composed of additive color components of red, blue, and green, said color source including three light sources disposed at different elevations, each of said light sources including a lamp having a filament with a finite dimension, collimating means to collect unrefined light emitted from said filament and arrange it in parallel rays of transverse uniformity, a first filter means associated with each of said light sources and adapted to reject a portion of said unrefined light while transmitting the remaining portion of said light, a second filter means associated with each of said light sources, said second filter means being disposed in the path of collimated light transmitted by said first filter means, said second filter means associated with each source being arranged in coaxial relation whereby light rejected by each of said second filter means will be arranged in blended coaxial relation with light rejected by each of the remaining filter means, third filter means disposed in the path of said blended coaxial light to further refine the same, and lens means to collect said light and diffuse the same into a semispherical diffusing means for transmission to a condenser system.

14. A color source adapted to provide light having blended components each of which is refined to a non-overlapping wave length, said color source comprising three light sources disposed at different elevations, each of said light sources emitting unrefined light from a filament of finite dimension, a collimating system to collect said light and arrange it in a parallel beam of substantially transverse uniformity, a first multi filter means adjacent each of said collimating systems, said first multifilm filter means refining light from each of said sources into additive primary colors of refined light having wave lengths corresponding to that of red, blue and green, a second multi film filter means associated with each of said light sources and reflecting the primary colors of light, said second multi film filter means of said red source passing blue and green light from two of said sources, said second multi film filter means of said green source passing blue light from one of said sources, third

filter means adapted to reflect ultraviolet wave lengths while suppressing infrared wave lengths thereby providing a collimated beam of light composed of three additive primary colors of readily identifiable and non-overlapping wave lengths, aspheric lens means adapted to receive said refined light and direct it to a negative lens means, and semisphere means receiving said light for transmission to an enlarger system.

15. The color source of claim **14** wherein said first, second and third filter means provide blended red, blue and green light, each of which has a peak response intermediate that of known types of paper to be printed and known types of measuring phototubes.

16. A color head adapted for use in condenser type enlargers, said color head comprising three light sources disposed at different elevations, multifilm filter means to separate light emitted from each of said light sources into light rays having wave lengths falling within a band identifying separate color components, said multi film

filter means including means to blend said separated color components into a coaxial white light ray of transversely uniform intensity, said multi filter means selecting wave lengths in each of said bands of said separate colors which fall between the known peak response of the paper to be printed and that of known types of phototubes, and lens means adapted to receive said coaxial white light and focus the same at a focal point coincidental with the focal point of a negative lens means for uniform transmission to a condenser system of an enlarger.

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