March 4, 1947. A. N. GOLDSMITH 2,416,919

TELEVISION APPARATUS

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Fig. 1.

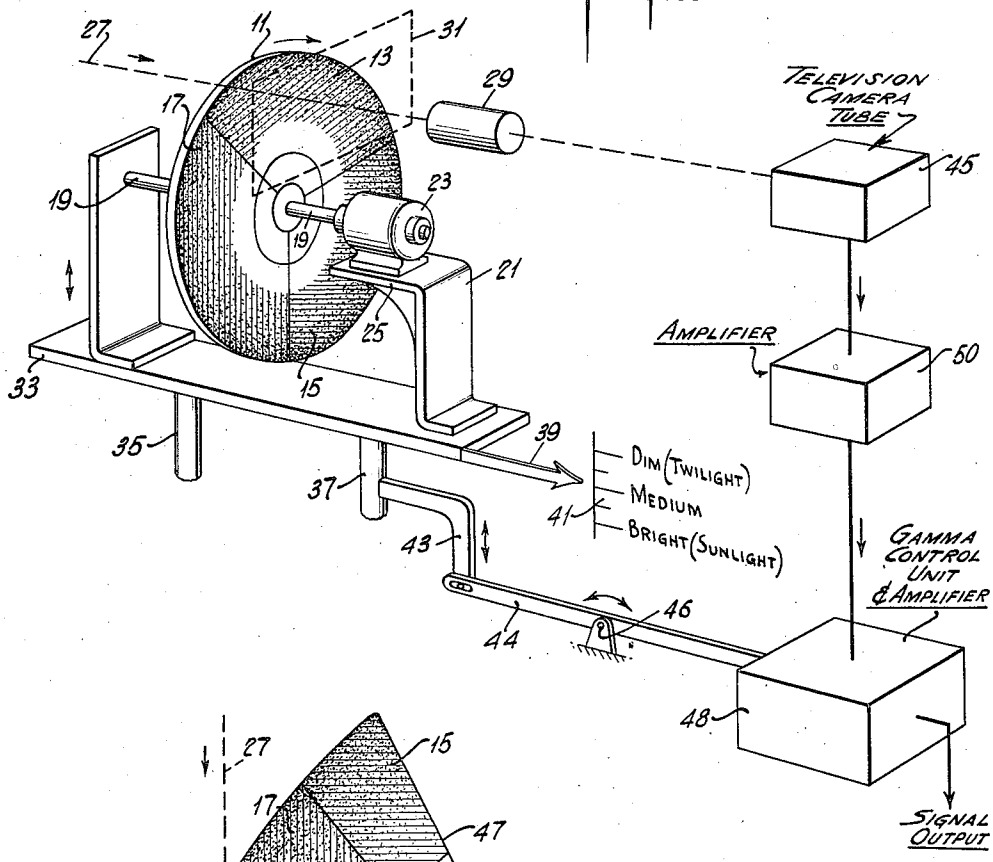
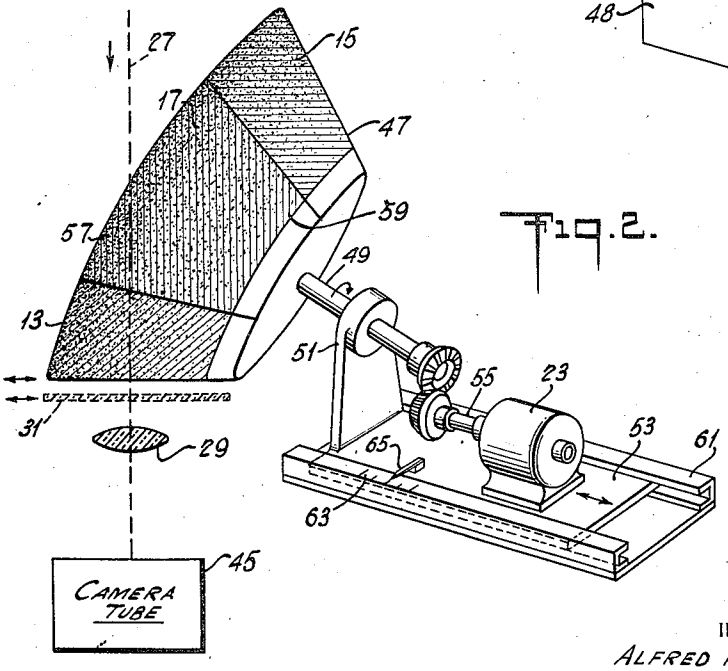


Fig. 2.



INVENTOR
ALFRED N. GOLDSMITH.
BY H. G. Grover.
ATTORNEY

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Fig. 3.

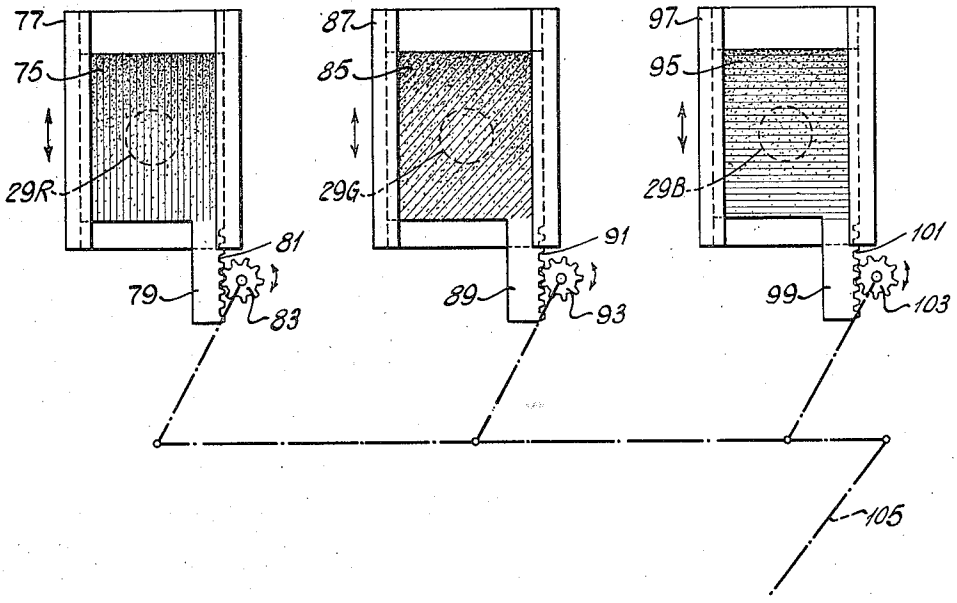


Fig. 4.

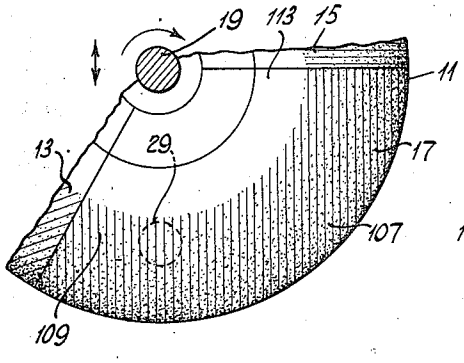
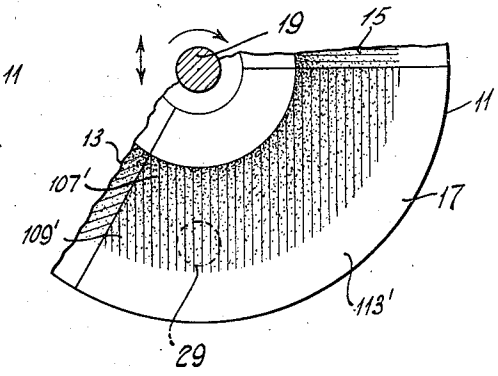


Fig. 5.



INVENTOR
ALFRED N. GOLDSMITH.
BY H. S. Grover
ATTORNEY

March 4, 1947. A. N. GOLDSMITH 2,416,919

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Fig. 6.

Fig. 7.

INVENTOR
ALFRED N. GOLDSMITH.
BY H. S. Sawyer.

Patented Mar. 4, 1947

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UNITED STATES PATENT OFFICE

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TELEVISION APPARATUS

Alfred N. Goldsmith, New York, N. Y.

Application December 16, 1944, Serial No. 568,458

18 Claims. (Cl. 178—5.2)

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This invention is directed to color television systems and to color photographic systems. The invention to be disclosed sets forth as its major concept that of controlling the color saturation of images produced in color television or photographic systems. In particular the invention finds primary application in connection with color television systems which are of either the so-called "sequential type" where there is a cyclic change between the several component colors utilized to effect the color representation, or which are of the so-called "simultaneous type" where each of the component-color images is simultaneously analyzed and reproduced.

The invention to be described herein will set forth arrangements to permit the transmission, the reception, the recording and the reproduction of television images, scenes, pictures, likeness, maps, and the like in color where the images have any desired degree of color saturation. The saturation may extend over the complete range from full-color representation through the so-called pastel or reduced or lightened color shades to a black and white monochrome image.

The method and system to achieve the said objectives will be dependent upon an appropriate use of adjustable color filter assembly. These filters may be of the disk, drum, film or similar type which are arranged to come within the field of view of an optical system and thereby resolve the light forming the image into suitable frames of fields of the color separation process.

Where the color television system is one of the so-called simultaneous multicolor type, the image forming light rays of a number corresponding to the number of selected component colors are passed simultaneously and independently through component color filters of each chosen component color. The color filters may each be of the so-called wedge or graded type so that in accordance with its position in the optical path the absorption may be caused to vary from full absorption for any one component color up to a complete transmission of that color, or, in other words, the filter is clear. For the simultaneous type of color television system, the several separate component color filters may be moved in unison or associatively within the image forming light beams to care for changes in illumination of the subject, as will hereinafter be described.

A color television system of the so-called sequential multicolor type is operated according to a somewhat analogous principle except that the component color filter reveals the light to an image receiving plane in the several chosen component colors in sequence. Then, as will herein be shown and pointed out, by adjusting the location of the sequentially changing filter area within the image forming light beam path and relative to the optical axis of the system the absorption of light may be controlled and varied from full absorption, as with a simultaneous system, through the pastels to a complete transmission.

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For reasons of simplicity and in order to define the invention in one of its various forms, the arrangements herein to be described will be referred to in terms of tricolor operation, although it should be understood that the invention will apply equally to bi-color or quadri-color principles, as well as to systems utilizing component primary colors of high saturation only. In addition, the invention herein to be described shall be understood as relating also to those systems using not only component primary colors of high saturation but also key images in black and white as one component of the complete image.

Often the key image section will also consist of a graded black and white filter which will operate simultaneously with the other component color filters. The graded black and white filter or a filter of a graded nature of any other color, where a color other than black and white is used as the key color, can readily be formed from a wedge type of device, as will herein later be described.

In the more common forms of tricolor processes of color television or color photography, it has been the practice in the art to produce the individual separation images of the component colors by the aid of suitable color filters through which the image forming light beams are caused to pass. Color filters of this character are of relatively high saturation and transmit, accordingly, only a limited and relatively narrow portion of the spectrum to any appreciable extent. Illustratively, the green filter, which may be considered as one of the component colors of a tricolor system, transmits green light only effectively, although it transmits blue and yellow light usually to a limited extent but it transmits scarcely any violet or orange-red light. It thus becomes evident that filters of this character absorb a very considerable portion of the thereon incident light. As a matter of fact, it is due to these filter characteristics primarily that the necessity for such greatly increased illumination of objects in color television and color photography is required, as compared to the corresponding illuminations which are entirely adequate for black and white operations.

An idealized component color filter in a tricolor system would, of course, absorb two-thirds of the light incident thereon and transmit only one-third. Such "rectangular-cut" filters are not, however, even remotely realizable in practice so that the filters which actually become available for use absorb even more than two-thirds of the incident light with the absorption usually approaching 90% which leaves only approximately 10% of the otherwise available light actually usable in color television or color photography as the result of such drastic filtering operations.

On the other hand, if the absorption of light by the several component color filters of the system is reduced by a decrease in the intensity and the saturation of the color layer at such filters more light will naturally reach the light responsive surface such as the photoelectric surface of a television camera tube or the photographic film of the photographic camera. This light will, of course, form the component color image, but, on the other hand, the saturation or purity of the produced colors will be correspondingly diminished due to the reduction in absorption and, because such reduced saturation color filters pass light effectively over a much wider spectral range and they do not provide the same degree of discrimination between colors and for the reproduction of saturated or bright colors as do the filters having higher saturation and greater light absorption.

Continuing with filters having even still lighter colored filter areas the color saturation of the images of the final light image is still further reduced with the production of the so-called pastel tints or, differently expressed, there is produced essentially a black and white image which is faintly tinted with colors suggestive of the more saturated actual colors. Lastly, the individual color filters are made completely transparent so that there is, of course, no actual color filtering operation taking place and no color saturation is obtained so that a black and white image finally results corresponding to the transmission and reception of identical component-color images.

Where the color saturation or absorption of the various component filters is gradually diminished to correspond to a gradual increase in the spectral transmission to both sides of the maximum transmission point it is desirable and usually necessary to increase the contrast, gradation or the gamma of the individual color separation images in order to produce a satisfactory pastel image or finally a black and white image. It is a well known fact that a suitable gamma for color images is approximately unity, whereas transmission arrangements for black and white images, which are dependent upon the lights and shades for their simulation of the relative brightness of the differently colored areas, there should be more "contrasty" images and thus the gamma should usually exceed unity. Accordingly, if the saturation of the color filters is reduced it is desirable that the contrast of the corresponding images that are produced shall be increased correspondingly.

This invention provides so that if the saturation of the component color filter is reduced and the light transmission therethrough is increased suitable arrangements provide for changing the brightness controls in the television color system or the exposure or aperture controls in color photographic systems. Such changes as the foregoing usually will involve modifications in the

exposure controls which will serve to adapt the photosensitive surface to an appropriate linear response characteristic in accordance with the increased range of illumination or brightness falling thereon as a result of the changes in saturation of the component color filters.

This effect may be achieved by shifting the gamma response of the transmitter system at times when filter changes are introduced so that by variation of the amplifier response, for instance, the gamma may be varied from unity or even slightly less than unity with full color, for example, to a value greater than unity for black and white. The effect may be obtained automatically by a uni-control arrangement between the filter position control mechanism and the amplifier in the case of television operations.

It has always been one of the difficulties experienced in connection with color television or color photography that sufficient illumination to enable said color images to be picked up or recorded under normal lighting conditions in the latter portion of the afternoon or early portions of the morning is lacking so that the practical utility of the system is reduced. The present invention provides compensation for these conditions and, to illustrate by way of example, if it be desired to transmit television images or to record motion picture records in color which shall be representative of a football scene or game occurring in the autumn and on a November afternoon, it will be appreciated that a brilliantly colored and satisfactory image may be produced during the early part of the game and perhaps until as late as 4:00 o'clock in the afternoon. By that time, for the assumed period of the year, the normal lighting may have waned to such an extent that television pick-up with high saturation filter units becomes difficult and electrical noise incidental to the television transmission becomes troublesome. At the same time, the reduced outdoor illumination on the actual scene correspondingly reduces the importance of color rendition.

Carrying the consideration still further, and with the example given, toward the end of the assumed football game and still later in the afternoon, the outdoor lighting will, in general, be far too dim to enable a satisfactory color television pick-up or color photographic recording to be obtained, while at the same time, the actual importance of color change in the actual scene will have been still further greatly reduced because the change in the intensity and color of the daylight at that time. To effect a more satisfactory transmission under such circumstances, this invention provides an arrangement whereby through a modification or an adjustment in the operation it will be possible initially to transmit full color images to be followed later by pastel colored images due to a reduction in the color absorption of the several filters of the system and later to restrict the transmission on an image pick-up system to a black and white response. These reductions in the color values and the changes from full color to the pastel shades and next to the black and white would permit additional light to reach the photosensitive or light sensitive image receiving arrangements and thus compensate largely for the decreased natural illumination. It is, of course, contemplated that the reverse procedure may readily be adopted and for increasing light conditions such as would occur on changing from a dark condition due to clouds,

smoke or the like to a brilliant sunlight illumination the color saturation would be increased.

Even when ample light is continuously available for full color television or color photography it is often desirable for aesthetic, dramatic or psychological reasons to change, alter or modify the saturation of the component color filter, through an adjustment of the color taking arrangements. The invention herein to be set forth in more detail in what is to follow is capable of taking into account these circumstances and is arranged to provide for filter modification or change under such circumstances.

As another example of conditions when a change in illumination or a change between full color and black and white through any intermediate set is desirable, it will be readily recognized that because of the somewhat psychological relationship between moods and colors, it is frequently possible to exemplify such states merely by the color density of the images. These factors can be exemplified by bearing in mind that a brightly colored image may, in general, evoke a cheerful, expansive or encouraging mood, while arrangements developing the pastel colored picture usually would produce a more limited or delicate emotional response. Lastly, the black and white image, particularly of an appropriate gradation range, may produce a more somber or restrained effect.

Thus, the present invention if adapted to television studio or motion picture technique is capable of simulating changes which otherwise could not be achieved.

It, accordingly, becomes an object of this invention to provide apparatus and means whereby variations in the color saturation is due to the change in the availability of a required amount of light for high fidelity color or where it is desired to simulate changing light conditions or moods.

It is a further object of the invention to provide a color television or a color photographic process in which the effects of changing light conditions as affecting color saturation may be obtained in a suitably controlled and, if desired, changing cyclic manner.

It is also an object of the present invention to provide a system and means whereby simultaneous multicolor television or color photographic methods may be effected with changes in the color saturation of the light image influencing the light sensitive apparatus or elements.

A still further object of the invention will be found to involve the use of manual or automatic controls of the color saturation in color television or color photographic apparatus throughout the range between the deepest colors of the selected components for providing accurate multicolor relations and a transition to complete black and white for monochrome operation.

A further object of the invention is that of providing a system wherein either automatic or manual controls of the contrast of the component color separation images may be achieved so that the individual multicolor images are appropriately varied throughout the transition period from full color to monochrome operation in either direction.

A further object of the invention is to provide either for the automatic or manual control of the brightness of the component color separations during any transition change and to have the brightness control unit related to the contrast control.

A further object of the invention is to provide a system wherein color filters in receiver units will effectively be automatically removed at time periods when monochrome images are transmitted by reason of the insertion of a transparency in the image forming light beam path in the scanning operation.

A further object of the invention is that of providing a color balancing filter unit in combination with color separation units of saturations varying from full color to practically a complete transparency for monochrome transmission. The color balance filter will correct automatically for variances in response of the light sensitive medium upon which the impinging light rays impinge to form an image.

A further object of the invention is that of providing suitable complementary filter units which shall operate jointly with the main filter units and the color balancing filter unit, if used, to effect a linearity of operation and response from the photosensitive or light responsive image receiving area so that the effect of illumination variances may uniformly be controlled.

A further object of the invention is that of providing suitable component color separation units in the form of disks, drums, flexible strips, slides or the like to distinguish between the different selected component colors for the multicolor operation and to provide means whereby these units may be adjusted relative to an optical system to achieve the foregoing objects.

Other objects of the invention are those of providing a simplified adjustment means to shift the filter unit relative to the optical axis to the system thereby to provide changes in the light absorption of the filter area included in the optical path.

Other objects are those of providing a color saturation control system for television or photographic use which is relatively simple in its arrangement, which is highly effective in its operation and which is readily adaptable to use without considerable modifications in presently existing forms of such apparatus.

Other objects and advantages of the invention will, of course, become apparent and at once suggest themselves to those skilled in the art to which the invention is directed when the following specification and claims are read in connection with the accompanying drawings, wherein:

Fig. 1 exemplifies one form of color saturation control system particularly adapted for a television use;

Fig. 2 is a modification of the arrangement of Fig. 1 wherein a filter drum unit is used to replace the filter disk unit of Fig. 1;

Fig. 3 is a still further modification of the arrangement of Fig. 1 utilizing three separate control filter units from which the several selected component colors are derived;

Figs. 4 and 5 show two different forms for the filter disk sections of the arrangement of Fig. 1 in which Fig. 4 provides a filter with a maximum color absorption toward the outer edge with a transparency on its inner edge arrangement and the arrangement of Fig. 5 provides for maximum color absorption on the inner edge of the filter disk and a minimum absorption or full light transmission along the outer edge of the disk, and,

Figs. 6 and 7 respectively are curves to show more particularly the operation of the system, with Fig. 6 representing conditions of color absorption where the filters vary from maximum saturation to low saturation or pastel rendition

and on down to zero saturation represented by a transparency, and Fig. 7 diagrammatically illustrating transmission of the filters for different conditions of illumination as regards the color of light and the shift thereof from white light (as assumed with Fig. 6) to a more reddish (orange) light, which may be regarded illustratively as being the conditions prevailing at the time of sunset or conditions present under normal incandescent lighting.

Referring now to the drawings and first to the arrangement of Fig. 1, there is exemplified therein a tricolor sector shaped rotary disk filter 11 for use in combination with either a cyclic color television or a cyclic cinematographic system. The disk 11 is composed of a plurality of separate sections 13, 15 and 17 with the outer edge of each section extending along the periphery of the disk for about 120°. Any equivalent or operative form of disk filter may alternatively be used. For purposes of illustration, it may be assumed that the filter section 13 is green to transmit green light while the filter section 15 may be assumed to be blue-violet to transmit blue light and the filter area or section 17 may be assumed as being red to transmit red light. The complete filter unit is supported on a spindle or shaft 19 which, if desired, may have its ends supported in bearing members (not shown) carried in the support members 21.

For purposes of illustration the disk may be assumed to be driven by means of a motor 23 which is preferably so arranged that it drives the spindle 19 either directly or through a suitable gearing or other drive arrangement (not shown). Where the motor drives the spindle 19 directly, the spindle may form a part of the motor rotor, so that if it be desired that the system shall transmit color television images or produce color motion picture films at a rate of twenty-four films per second, the driving motor 23 may be driven at a speed of 1440 R. P. M. The motor 23 may be supported in any desired manner but preferably is attached to a suitable base member 25 which, in turn, is secured to the upright support member 21. Provision is made for so driving the motor as to relate the driving speed to the deflection frequency and among the various ways that this effect may be achieved reference may be made purely by way of example to Bedford Patent No. 2,137,010, granted November 15, 1938, wherein there is disclosed a system which will control the frequency of an electron impulse generator circuit with respect to the frequency of a current flowing in a power line utilized for driving a motor operating in conjunction with a suitable rotary element in order that an interlock between the rotational or deflection frequency and the power supply frequency may be achieved. It is, of course, to be understood that other means may be utilized as desired, and the reference to the Bedford patent is purely by way of example.

In an arrangement of the character herein disclosed, it will also be assumed for purposes of reference that light from an image (not shown) is directed along the path indicated by the arrow 27 to pass through the component color separation filter disk unit 11 and the optical system 29 to reach either a light sensitive element, surface or electrode of a television camera tube 45 or the light sensitive motion picture film of a motion picture device. In either case, the optical system 29 may be of any suitable character which is so arranged to direct the light rays that pass through the component color filter disk 11 as to form an image thereof on a suitable camera tube 45 or other light sensitive surfaces or to form the image upon a photographic film.

As the disk 11 rotates in the direction indicated by the arrow, different color component sections progressively intersect the optical axis of the lens system and thus regulate thereby the color of the light which passes through the optical system 29 to form an image upon either the light responsive arrangement of the camera tube (not shown) or the film of the photographic camera device (not shown). Where television operations are concerned, the camera tube scanning operations to produce the television signals are carried forward in known manner.

There may be interposed between the filter disk unit 11 and the optical system 29 a color compensating or balancing filter arrangement 31. This filter unit 31 is of such character as to correct the non-uniformity of response of either the camera tube in the television system or the photographic film in a photographic system, since it has been known for some time that neither photoelectric surface of the camera tube nor the film emulsion surface of the photographic film usually respond equally to all colors of light in that their response is not normally completely panchromatic.

A color filter to provide the color balance or compensation is disclosed in more detail by my copending patent application, Serial No. 512,119, filed November 29, 1943, in which a color balancing filter has been set forth, and particularly so in connection with its use in combination with the component color separation filter, the optical system and the light responsive target of a television camera tube or a photographic film emulsion. It is, therefore, to be understood that the present disclosure contemplates the inclusion of such a color balancing filter, where desired, and, particularly so, when areas of maximum light absorption are interposed in the optical path. In any event it is to be understood that any motion of the color balancing filter relative to other elements shall be such that the color balancing filter remains stationary during any one cycle of use of the component color separation filter and the color balancing filter includes usually low saturation or low light absorption sections of the selected color components, including white, where desired, in order that by adjustment of the area of each of the color balancing filter sections which encompass the optical path, a correction in the light values of the component-color images shall be applied.

The end support elements 21 of the motor and filter assemblies are supported from a main base member 33 which is arranged in the form of the system as herein illustrated by way of example so as to be capable of motion in a vertical or transverse plane relative to the optical system 29. The directions of motion in the up and down or transverse directions are indicated by the arrows adjacent the base member 33. The support elements or rods 35 and 37, for instance, carry the complete assembly heretofore described. These rods are arranged so as to be adapted to move upwardly and downwardly through the control of any desired form of mechanical linkage. In one form, for example, the support elements 35 and 37 will be assumed to terminate in rack sections with which suitable pinions may be arranged to mesh so that by turning the pinion an upward or downward motion of the assembly may be effected. The complete operational form which has been

above disclosed is such that with the filter arrangement of the assembly in its lower position will exhibit the deepest color saturation filter sections transverse to the optical path or axis through the lens system 29. This, for instance, might represent conditions of transmission for maximum lighting as would be represented, for instance, between the highest intensity studio lighting or for the most brilliant daylight conditions. By way of an indication of these conditions and for a guide in adjusting the disk 11, a pointer 39 may be attached to the support base member 33 so as to move upwardly and downwardly therewith relative to a scale 41. The pointer 39 in its lowermost position relative to the scale 41 will then indicate that the filter or component color separation disk 11 is being utilized under conditions of the most brilliant light, whereas its uppermost position relative to scale 41 will indicate that the complete assembly has been elevated with regard to an assumed photographic optical system 29 so that the color areas of minimum filter density of the component color separation disk 11 are included in the optical path. This latter position thus would represent conditions of dim light and color absorption would be at a minimum or approach at least a transparency which would represent black and white.

It is evident from what has been stated above that if the position of the color separation disk 11 is varied relative to the optical axis of the system, provision should be made to control the contrast or brightness control in the transmitter unit or amplifier where the device is being used for color television transmission. This may be done by setting or varying the gain of the amplifier appropriately in accordance with the light intensity projected through the optical system 29. This control is so arranged that the contrast of the image for transmission is progressively increased with reductions in brightness of the impinging light image while maintaining the linearity of response of the photosensitive target area of the camera tube or of its associated amplifier or of the video signal modulator. The separate control unit for this purpose may be in the form of a link or the like, which is diagrammatically represented by the control element 43, which is arranged to operate in accordance with the position of the support element 33 so as to vary either or both the contrast and brightness controls of the apparatus.

The control element 43 may be considered as being pivotally attached to a lever element 44 which may have its fulcrum at point 46, and so linked and arranged as to vary the gamma control element (not specifically shown) contained within the control unit and amplifier 48. Video or image signals representing the output from the camera tube 45 are appropriately amplified, the blanking and sync signals are added, and the D. C. components reinserted in a conventionally known manner in a unit herein illustrated for convenience as the amplifier 50. The output of such a unit 50 is then fed into the gamma control unit 48 which may be of the type shown and described particularly by U. S. Patent No. 2,326,907, for instance, which was granted to K. R. Wendt on August 17, 1943. The control lever element 44 which turns about the pivot point 46, as above stated, may then be assumed to be connected to vary a suitable resistor in the gamma control unit and amplifier 48 to set the gamma for transmission in accordance with the color density of the

filter areas which are included in the optical path. To effect such a control of the gamma, for instance, it will be understood that the variation will result by the motion of lever 44 varying a resistor (not shown) which would correspond to resistor 67 which is illustrated by Fig. 4 of the above mentioned Wendt Patent No. 2,326,907.

Output signals to energize a transmitter or any other communication channel may be derived in any known manner, for example, as also shown by the same Wendt patent.

Reference may now be made to Fig. 2 of the drawings wherein it will be seen that a modification of the arrangement of Fig. 1 has been illustrated. Again, as in Fig. 1, the image forming light beams are projected along a path 27 (the optical axis, for instance) through the appropriate color filter and thence, through an optical system, conventionally represented at 29, to fall upon the light sensitive mosaic of the television camera tube 45 or a photographic film contained within a motion picture camera or even the film contained within a still camera. As in the arrangement of Fig. 1, the color filter unit interposed in the image forming light beam path serves to present different color filter areas in a cyclic or sequential order within the optical path so that different color lights are presented to the light sensitive surface upon which the image is formed. The arrangement of Fig. 2 provides a modification in that use is made of a color filter drum unit 47 which will replace the color disk light filter unit 11 of Fig. 1. The color filter drum unit 47 comprises a plurality of surfaces formed as light filters. These filter areas are the surfaces 15 adapted to transmit the red image, the surface 17 for transmitting the blue image, and the surface 13 for transmitting the green image.

The complete drum assembly, as shown, is arranged to turn upon a support spindle or drive shaft 49 which is carried in an appropriate bearing member 51. The drive shaft 49 is turned by a motor 23 which is carried upon a support base 53 and the rotor element of the motor turns the motor shaft 55 which is arranged through appropriate gearing (not shown), such as bevel gears, to rotate the shaft 49 at either the speed of the motor or at a reduced or increased speed. As was explained in connection with the arrangement of Fig. 1, the filter sections 13, 15 and 17 are graded in density so that the most dense filter area, for instance, is near the rim 57 of the drum 47 whereas the clearest or most nearly transparent section of each of the filters is near the drum hub 59. Accordingly, if the motor 23 and its support element 53 is moved back and forth in the directions shown by the arrows in the support frame 61, it is apparent that the motor, the complete bearing assembly, and the drum 47 will all be shifted laterally so that different density filter areas come within the image forming light beam path 27 to vary the color range of the light image reaching the television camera tube 45 or the photographic film where camera recordings are made in much the same manner as the raising or lowering of the support platform 33 in Fig. 1 provided different densities of filter in the image forming light beam path.

So that the conditions of filter transmission to the camera tube or photographic film may be measured readily, a scale 63 is indicated on the support base 61 and the indicator pointer 65 carried on the adjustable frame 53 indicates by its position on the scale the general relationship of color filter density instantaneously interposed in

the light beam path. No arrangements have been shown, for reason of convenience, for moving the support base 53 relative to the support element 61 but it is to be understood that any form of crank or gear drive or even, where desired, electric motor drive arranged to be capable of reversal may be utilized. Mechanical drives of this nature are well known and readily can be set up to provide interrupted reciprocal operations so that further details need not be shown with respect to the systems of either Fig. 1 or Fig. 2.

There may also be interposed in the image forming light beam path 27 a second filter unit 31 which may function as a color balancing, color compensating filter or a diversified color filter. Arrangements of this type have already been explained in connection with the showing of Fig. 1 and such a filter may or may not be used as desired. The color balancing filter, as already stated, is disclosed and claimed in detail in the copending patent application, Serial No. 512,119, above referred to.

The arrangement of Fig. 3 shows in a most conventional manner the adaptation of the system to a simultaneous tricolor operation. To effect a simultaneous tricolor operation the image forming light beam is split, in known manner, for instance, into three distinct paths. Then, at some suitable point in each of the separate light paths, the component color separation filters are located so that the image forming light beams passing along each optical path toward the photosensitive surface of the television camera tube or the photographic film of the photographic camera to form the light image thereon must pass through these filters. Thus, each formed optical image will be of a different component color.

For reasons of simplicity and because systems for effecting this form of light beam control are known, they are not illustrated herein. However, the illustration of Fig. 3 is intended to indicate the manner in which the component color absorption due to the filters in the image forming light beam paths may be varied for each color simultaneously. It will be appreciated that there are many ways to provide the different density filters which are conventionally represented by Fig. 3. In one form they may be constituted as wedges with a maximum saturation at the uppermost edge and the minimum saturation at the lowest edge, or, if desired, the reverse arrangement is equally as desirable. The filter is positioned, as in the arrangement of Figs. 1 and 2, close to the objectives used for forming a light image upon the light sensitive surface of either the camera tube or the photographic camera. Alternatively, the filter may be positioned at any other point in the image forming light beam path so long as the image forming light beam is focused upon the light sensitive surface and the image forming light beam passes through a relatively small fraction of the filter area so as to enable adequate color asturation control to be effected.

When using the modification shown by Fig. 3, it will be assumed that the image forming light beam has been divided or split into three distinct paths so that the light beams which are to form the red image pass through an optical system conventionally represented at 29R, while the green image will be formed from the light rays passing through the optical system 29G, and, likewise, the blue response will be effected by reason of the remaining light rays passing through the optical system 29B. The filter units 29R, 29G and 29B are located in the same general relationship with regard to each of the optical systems for effecting separation of the red, the green and the blue images. The filters, as above noted, are preferably of the wedge variety and arranged to encompass considerably more area than the optical system itself.

The red filter 75 is positioned within a support frame 77 so as to be capable of motion within the support frame in an up-and-down direction, for instance, or its equivalent, as indicated by the arrows. The filter also may have an extension 79 provided at one end. This end is preferably formed as a rack unit 81 so as to be capable of meshing with the pinion 83 whereby when the pinion is turned in a clockwise direction, for instance, the filter area 75 may move upwardly relative to the assumed stationary optical system 29R in order that less dense filter areas shall be included in the optical path. Similarly, a counterclockwise rotation of the pinion 83 will bring a more dense filter area within the range of the optical system 29R. Thus, it is evident that a controlled rotation of the pinion 83 meshing with the rack 81 is capable of adjusting the position of the filter 75 relative to the optical system.

Similarly, the green filter area 85 is positioned within a support frame 87 so as to be capable of motion relative to the optical system 29G in a manner like that explained for the red filter. Here again, the green filter 85 is formed with one extending end 89 on which rack teeth 91 are provided for meshing with the drive pinion 93, as explained with regard to the red filter. Lastly, the blue filter 95, which also has its most dense color area in the region corresponding to the dense areas of filters 75 and 85, is positioned to be supported within the frame 97. This filter, like the filters 75 and 85 already described, has an extending end portion 99 formed into a rack 101 which is arranged to mesh with the pinion 103 so that rotation of the pinion in a counter-clockwise or a clockwise direction will bring a less dense or a more dense filter area within the range of the optical system 29B.

Since it is desirable that the filters move in unison so as to bring more dense or less dense areas within the optical paths, the several pinions 83, 93 and 103 are shown as being unicontrolled, which is indicated by reason of the dot and dash lines connecting them.

For the purpose of conventionally indicating that the brightness and/or contrast controls used in the television transmission systems may be varied simultaneously with a shift in the filter positions relative to the optical systems, there has been shown conventionally a connection 105 which it will be assumed leads to the control of all of the television amplifier units used with the simultaneous system. This may be accomplished by virtue of a control of a potentiometer, for instance, which will shift the control of an appropriate discharge tube in well-known manner or change the operating characteristics of a discharge tube in a well-known manner, and as explained in connection with Fig. 1, so that for simplicity of illustration, the complete assembly is not shown.

It will be apparent that there are many possible wedge arrangements for color filters which are capable of use in connection with arrangements of the types shown by all of Figs. 1, 2 and 3. The schematic showing of Fig. 4 illustrates one such form of filter.

It will be assumed that the filter unit of Fig. 4

corresponds to one section 17, for instance, of the filter disk 11 of Fig. 1. Accordingly, the filter is capable of up-and-down motion in the direction shown by the arrows while rotating on its drive shaft or spindle 19. With the disk portion shown, the optical system 29 is indicated as covering an area somewhat internally of the disk so that an intermediate color absorption occurs. The segmental sector of the filter shown by Fig. 4 indicates that an area 107 nearest the periphery of the disk has maximum color absorption. There is then a gradation in density of the filter so that at the center area 109, for instance, there is a range of intermediate absorption and then toward the most central portion of the disk there is an area 113 which is substantially a transparency. It is, of course, to be understood that this is shown also merely by way of example in order to illustrate the general arrangement of the system. The actual width of any one color absorption range is in no way critical for the effect of the color filter is that of the average density included within the viewing aperture of the optical system 29. In connection with an arrangement of this type, it will, of course, be appreciated that where there is an area such as that shown at 113 which is substantially a transparency, the filter unit can be utilized to effect black and white transmissions with the same equipment normally adapted to color use.

The arrangement of Fig. 5 is substantially the reverse of that shown in Fig. 4, with the main modification being that the transparency 113' now appears at the edge of the disk whereas the most dense filter area 107' is internally located on the disk while an intermediate area 109' is located as in Fig. 4 at an intermediate area. This is to illustrate the variance permitted in the location of the different color absorbing areas. In any event, it should be apparent that the showing of these figures is merely illustrative.

The curves of Figs. 6 and 7 are intended to illustrate more particularly the operation of the system. Fig. 6 shows generally the effects of filter shifts in position relative to the optical system for it will be seen that the absorption of the different filters blue, green and red, for instance, vary in accordance with the saturation of that filter and, accordingly, in shifting from maximum saturation where full color rendition is provided to a low saturation which will bring about a tinted or pastel rendition, the absorption of the different filters may vary within a very substantial percentage range. Lastly, when a transparent area, such as 113 or 113', is placed in the optical path, it will be appreciated that no absorptions take place in the different colors for there is no color selectivity.

The curves of Fig. 7 are intended to indicate that where the light is of one predominant color, for instance, less absorption will take place in that color than in the other colors. With this condition, it may be assumed that where the light is representative of a sunset condition so that the red and orange colors predominate, there will be relatively little absorption of that color light by the red filter whereas the absorption will be greater for green and greatest for blue. Compensation for this condition is effected generally through the use of the color balance filter arrangements of the type hereinabove referred to in my copending application, Serial No. 512,119. Under these conditions, the color balancing filter will be utilized in conjunction with the color separation filter in the manner already above explained.

The foregoing description sets forth information relating to preferred forms of color separation filters, but it should be understood that these suggested forms are merely illustrative of the filter unit rather than limiting as regards any particular unit.

Broadly speaking, the invention, as constituted by this disclosure, should be understood as embodying any variable density color absorbing medium of either a solid or a liquid type or of types wherein mechanical adjustments or the like may be made to vary the filter characteristic. One form of filter, in addition to those above described, which may be utilized to this end, may comprise, for instance, a disk such as that shown by Fig. 1 with a series of color strips arranged about the periphery and extending inwardly from the disk edge toward the center. Such strips then may be varied systematically by increasing (or even decreasing) the width, the closeness or the density, or all three, to effect the results obtained with the graded type filter used as the example in Fig. 1. If, for instance, the filter is composed of a series of uniform density strips or bands, these may all be of like width, but, for instance, the concentration of the strips or bands may decrease from the outer edge of the disk inwardly toward the center so that there is a varying proportion of color and substantially transparent media included in a plane transverse to the image forming light beam.

It will be appreciated that since the filter element in all cases is located in a region reasonably close to the optical element, it can be regarded as being positioned in an out of focus plane so that no image thereof is formed on the target area, which target area may comprise the light sensitive element of the television camera tube or a photographic film of a photographic device. Under such circumstances, an integrating effect is obtained so that the effective filter density is determined in proportion to the amount of filter elements instantaneously included in the optical path.

In another form, the invention may comprise a plurality of wedge elements which are capable of being moved in and out relative to each other. In this form, the disk unit, such as that shown by Fig. 1, will usually have the thickest portion of the wedge toward its periphery and the thinnest portion toward its center. Then, by means of a separate external holder which holds a second wedge element, a movable wedge may be positioned in and out so as to overlap to a greater or lesser extent the disk wedge itself. In this way, it will be appreciated that the wedges may be systematically varied in position relative to each other so that by the conjoint motion of the filter areas of all component colors relative to the optical path, the desired degree of color separation may be effected.

Further, with regard to the color separation, it will be appreciated that for representations where action takes place rapidly, the different component color separation filters should be included in the optical path in the sequential system at a rate sufficiently high so that image representations in the several component colors are produced at a rate high enough so that in the image reproduction, flicker effects are not apparent. Usually, the shift or change in the saturation properties of the component color separation filter will be effected at a relatively

slow rate compared to the color separation rate and this may be regarded as a color gradation control as contrasted with the color separation control.

Other forms of filter units may readily be adopted and these might include, by way of example, filters of the liquid type where the amount of liquid included from time to time is such as to affect the results of the disk arrangement of Fig. 1, for instance. Various forms of pump apparatus to effect this result may readily be used in known manner. Thus, it is believed to be clear that with regard to the particular type of filter herein illustrated, wide variances may be elected and, therefore, the invention is to be understood to reside not in the particular type of filter, but in the feature of providing the color separation filter of co-related density which is interposed in the image forming light beam path to effect color separation and then, in the motion of that filter to effect the result of a density change in the color absorption of light.

The foregoing description has made clearly apparent the fact that color saturation control operations may be effected by both simultaneous multicolor and sequential multicolor operations and for either television operations or for film recordings in color. Accordingly, within the disclosure of these specifications, it should be understood that where reference is made throughout to a target area, it shall be understood to mean either a film surface or a television tube target. Also, the reference to a television camera tube and its target is to be understood as embodying either a single camera tube for effecting the result or a plurality of camera tubes simultaneously functioning in such a manner as to be particularly useful for simultaneous operations. In this latter instance, however, a multiplicity of camera tubes may, when appropriately scanned, effect sequential operations where all the different component colors are simultaneously scanned on the target areas of individual tubes or target areas in a single tube and the cyclic or sequential progressive change from one color to another is effected on all of the camera tube targets with the signal outputs resulting from the scannings, the different target areas then being delayed by appropriate time delay controls to cause the output signals to add together for sequential operations over a single channel, or the signal outputs resulting from scanning the several target areas may be transmitted simultaneously for all colors over a plurality of communication channels to effect simultaneous operation.

Thus, in these specifications where reference is made to a target element of a camera tube or the like, it will be understood that the target element may be the target element of a single camera tube or the separate target elements of a plurality of camera tubes or, lastly, to effect the multicolor operations, the target element may be a single unit formed into individual sections which each respond particularly to the light of one component color only, and where a multiplicity of scanning beams may scan the different sections simultaneously and cophaseally and in synchronism so that simultaneous operations are easily realized or the individual sections of the target may be scanned in sequence by a single scanning beam. In all instances, the electrical signal output resulting from the scanning of the target of the camera tube is arranged to be directed through an appropriate pre-amplifier and all other well known associated amplifiers such as those conventionally represented in Fig. 1, for instance, as the amplifier 50, from which the video or image signals are transferred to further amplifiers, such as the amplifier 48, and, in most instances, are later caused to modulate a suitable carrier frequency for transmission over communication channels to desired receiving points or to relaying points from which the communication operations are carried forward to more remote points.

It is, therefore, to be understood that the invention is to be regarded in a broad sense and insofar as possible, the claims hereinafter appended are to be understood as covering either or both simultaneous and/or sequential operations and references to target areas may include a multiplicity of target areas in separated tubes or all included within a single tube as well as to include the film target and references to camera tube target areas similarly will include all of the target types above enumerated.

In the light of the foregoing disclosure, it will become apparent that many and various modifications may be made in the specific structure shown. Therefore, it should be understood that the present disclosure is to be regarded as illustrative and not limiting and in such manner that all such modifications may be made, provided they fall fairly within the spirit and scope of what is hereinafter claimed.

I claim:

1. In a color saturation control system wherein light rays representative of an optical image are directed to form image representations on a suitable light responsive target element, the combination comprising a plurality of component color separation filter elements each positioned in a non-image forming plane in the path of light rays to the target, each of said filter areas having a progressively and predeterminedly changing color absorption ratio in the selected component colors with the absorption ratio varying between limits of substantially full color and substantially a transparency, and means to effect a conjoint variation of the color separation filter light absorption areas effectively included in said light ray path for each component color in any desired degree between substantially full color and a substantial black and white.

2. In a color saturation control system wherein light rays representative of an optical image are directed to form image representations on a suitable light responsive target element, the combination comprising a component color separation filter element including at least one section of each selected color component and means to include each filter individually in non-image forming planes in the path of the light rays to the target area, each of said component color filter areas having a progressively changing light color absorption ratio in its individual component color which varies in a predetermined manner between limits of full component color absorption and a substantial transparency, and means to effect a conjoint variation of the color separation filter light absorption areas included in the light ray path to the target for each selected component color in any desired degree between full color and a substantial black and white.

3. In a color saturation control system for television wherein light rays representative of an optical image are directed to form image representations on a suitable light responsive target element of a camera tube, the combination comprising a plurality of component color separation

filter elements each positioned in a non-image forming plane in the path of the light rays, each of said filter areas having a progressively and predeterminedly changing color absorption ratio in the selected component colors with the absorption ratio varying between limits of substantially full color and substantially a transparency, and means to effect a conjoint variation of the color separation filter light absorption areas effectively included in said path of light rays for each component color in any desired degree between substantially full color and a substantial black and white.

4. In a color saturation control system wherein light rays representative of an optical image are directed along multiple paths to form image representations on suitable light responsive target areas to receive the light, the combination comprising a component color separation filter element positioned in a non-image forming plane in each of the light ray paths, each of said filter areas having a progressively and predeterminedly changing color absorption ratio in the selected component colors with the absorption ratio varying between limits of substantially full color and substantially a transparency and each of the filters being adapted to transmit for full color substantially only one component color light, and means to effect a conjoint variation of the color separation filter light absorption areas effectively included in the light ray path for each component color in any desired degree between substantially full color and a substantial black and white.

5. In a color saturation control system for television wherein light rays representative of an optical image are directed to form image representations on a suitable light responsive target of a camera tube element which is suitably scanned to provide electrical signal outputs representative of the optical image, the combination comprising a plurality of component color separation filter elements each positioned in a non-image forming plane in the light ray path, each of said filter areas having a progressively and predeterminedly changing color absorption ratio in the selected component colors with the absorption ratio varying between limits of substantially full color and substantially a transparency, means to effect a conjoint variation of the color separation filter light absorption areas effectively included in the light ray path for each component color in any desired degree between substantially full color and a substantial black and white, and means operable under the control of the filter adjustment means to vary the effectiveness of output response from the camera tube so that a substantially constant predetermined gamma value is obtained over the complete range of color saturation.

6. In a color saturation control system wherein light rays representative of an optical image are directed to form image representations on a suitable light responsive target element, the combination comprising a multi-section component color separation filter element having at least one filter section of each selected color component and means to include each filter individually in non-image forming planes in the path of the light rays to the target area, each of said component color filter areas having a progressively changing light color absorption ratio in its individual component color which varies in a predetermined manner between limits of full component color absorption and a substantial transparency, means to present the different filter component color areas in the light ray path in a predetermined cyclic order to reveal the image light to the target in the different component colors, and means to effect a conjoint variation of the color separation filter light absorption areas included in the light ray path to the target for each selected component color in any desired degree between full color and a substantial black and white.

7. In a television color saturation control system wherein light rays representative of an optical image are directed along a predetermined optical path and through appropriate optical media to form image representations on a suitable light responsive target element of a television camera tube so that with a scanning of the target video signals representing the optical image are developed, the combination comprising a component color separation unit including at least one filter element of each selected color component, drive means sequentially to include each filter element of the filter unit individually in a non-image forming plane in the path of the light rays to the camera tube target area, each of said component color filter areas having a progressively changing light color absorption ratio in its individual component color with the said ratio varying in a predetermined manner between limits of full component color absorption and a substantial transparency, adjustable drive positioning means to effect a conjoint variation of the color separation filter light absorption areas included in the light ray path to the camera tube target for each selected component color in any desired degree between full color and a substantial black and white.

8. In a television color saturation control system wherein light rays representative of an optical image are directed to form image representations on a suitable light responsive target element of a camera tube, which element is scanned at a predetermined rate to produce image signal outputs for transmission which represent the original image, the combination comprising a color separation filter element including at least one filter section of each selected color component and means operating to include each filter section individually, sequentially and cyclically in a non-image forming plane in the path of the light rays to the camera tube target area so that the camera tube signal outputs represent a cyclic succession of different component color images, each of the said component color filter sections having a progressively changing light color absorption ratio in its individual component color which varies in a predetermined manner between limits of full component color absorption and a substantial transparency, and means to effect a conjoint variation of the color separation filter light absorption areas included in the light ray path to the target for each selected component color in any desired degree between full color and a substantial black and white.

9. The system claimed in claim 8 comprising, in addition, a contrast control means operating under the control of the filter variation means to control the effective signal output so that a predetermined and desired gamma of the color separation images is maintained over the entire color-saturation range for all component colors.

10. The system claimed in claim 1 comprising, in addition, a brightness compensating color balance filter unit also positioned in the light

ray path to the camera tube and in an out of focus position therein to provide substantially constant response from the camera tube throughout the range of color saturation.

11. The system claimed in claim 1 comprising, in addition, a brightness compensating color balance filter unit also positioned in the light ray path to the camera tube and in an out of focus position therein to provide substantially constant response from the camera tube throughout any selected range of color saturation, and brightness control means included in the light ray path to control the level of signal output for varying color separation filter saturations so that the contrast range of the produced image signals is controlled and the desired gamma of the individual component color image signal series is maintained at a predetermined value over the entire color saturation range.

12. A color separation filter control system for sequential forms of tricolor color responsive systems wherein light rays representative of an optical image are directed through optical media to form an optical image of a subject on a suitable light responsive target element comprising the combination of a plurality of component color separation filter elements each located in a non-image forming plane transverse to the path of the image forming light rays directed toward the light responsive target, each of said filter areas having a progressively changing color absorption ratio in its individual component color with the absorption ratio varying between limits providing substantially a transmission of one component color only and substantially a transparency to transmit all component colors, means to move the plurality of filters sequentially within the optical path to select the instantaneous component color light which is directed to the target and so that the selected component light colors are changed at a relatively rapid rate, and means to effect a conjoint variation of the color separation filter color absorption areas effective in each component color in any desired degree between substantially full color and a substantial black and white with the change being effected at a slow rate relative to the component color separation process.

13. A color separation filter control system for sequential forms of tricolor color television systems wherein light rays representative of an optical image are directed through optical media to form an optical image of a subject on a suitable light responsive target element comprising the combination of a multi-section filter unit having a plurality of component color separation filter elements each located in a non-image forming plane transverse to the path of the image forming light rays directed toward the light responsive target, each of said filter areas having a progressively changing color absorption ratio in each of its individual component colors with the absorption ratio varying between limits providing substantially a transmission of light rays of one component color only and substantially a transparency to transmit light of all component colors, means to move the plurality of filters sequentially within the optical path to select the instantaneous component color light which is directed to the target and so that the selected component light colors are changed at a relatively rapid rate, and means to effect a conjoint variation of the color separation filter color absorption areas effective in each component color in any desired degree between substantially full color and a substantial black and white with the change being effected at a slow rate relative to the component color separation process.

14. A color separation filter control system for sequential forms of tricolor color television systems wherein light rays representative of an optical image are directed through optical media to form an optical image of a subject upon the light responsive target element of a television camera tube comprising the combination of a multi-section filter unit having a plurality of component color separation filter elements each located in a non-image forming plane transverse to the path of the image forming light rays directed toward the light responsive target of the camera tube, each of said filter areas having a progressively changing color absorption ratio in its individual component color with the absorption ratio varying between limits providing substantially a transmission of one component color only and substantially a transparency to transmit all component colors, means to move the filter unit within the optical path so that the individual filter elements of the plurality are cyclically and sequentially included within the optical path to select the instantaneous component color light which is directed to the camera tube target and so that the transmitted selected component light colors are changed at a relatively rapid rate, and means to effect a conjoint variation of the color separation filter color absorption areas effective in each component color in any desired degree between substantially full color and a substantial black and white with the change being effected at a slow rate relative to the component color separation process.

15. The system claimed in claim 14 comprising, in addition, a brightness compensating color balance filter unit also positioned in the light ray path to the camera tube and in an out of focus position therein to provide substantially constant response from the camera tube throughout the range of color saturation.

16. The system claimed in claim 14 comprising, in addition, a brightness compensating color balancing filter unit also positioned in the light ray path to the camera tube and in an out of focus position therein to provide substantially constant response from the camera tube throughout any selected range of color saturation, and brightness control means included in the light ray path to control the level of signal output for varying color separation filter saturations so that the contrast range of the produced image signals is controlled and the desired gamma of the individual component color image signal series is maintained at a predetermined value over the entire color saturation range.

17. In a saturation control system wherein light rays representative of an optical image are directed through suitable component color filter elements located in a non-image forming plane in the light ray path to form image representations on a suitable light responsive target element, the method steps comprising progressively and predeterminedly changing the color absorption ratio of the filter areas in the selected component colors with the absorption ratio varying between limits of substantially full color and substantially a transparency, and then conjointly varying the color separation filter light absorption areas effectively included in the light ray path for each component color in any desired degree between

substantially full color and a subtantial black and white.

18. In a color separation filter control system for sequential forms of tricolor color responsive systems wherein light rays representative of an optical image are directed through optical media and a plurality of component color separation filter areas located in a non-image forming plane transverse to the image forming light rays so that an optical image of a subject is formed on a suitable light responsive target element comprising the steps of progressively changing the color absorption ratio of the filter areas in the individual component colors with the absorption ratio varying between limits providing substantially a transmission of one component color only and substantially a transparency to transmit all component colors, sequentially and rapidly moving the filter areas sequentially within the optical path to select the instantaneous component color

light which is directed to the target and so that the selected transmitted component light colors are changed sequentially, and then conjointly varying the color separation filter light absorption areas effective in each component color in any desired degree between substantially full color and a substantial black and white at a slow rate relative to the component color separation process.

ALFRED N. GOLDSMITH.

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