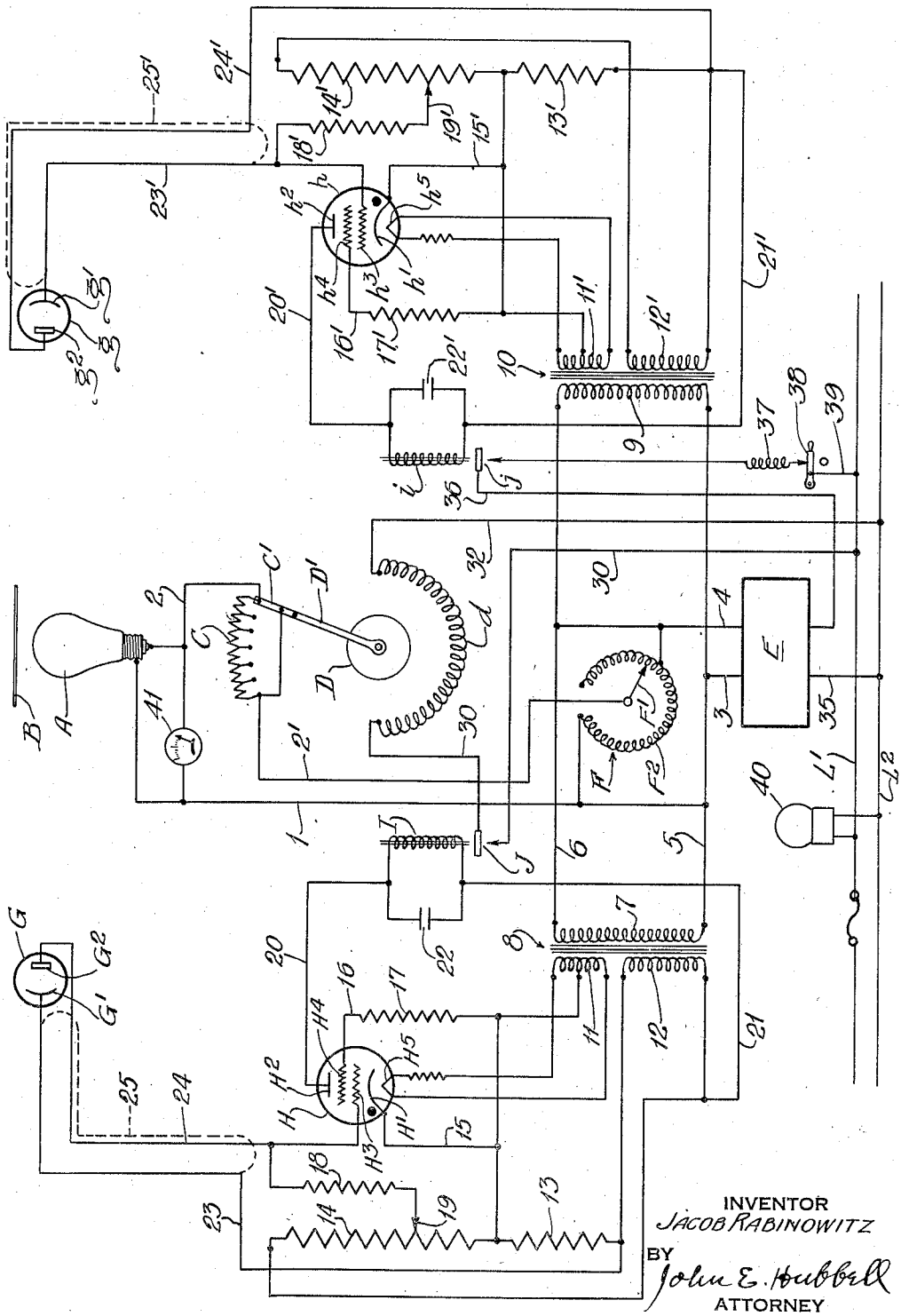
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LIGHT COLOR TEMPERATURE CONTROL

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LIGHT COLOR TEMPERATURE CONTROL

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The general object of the present invention is to provide a simple and effective method of, and means for controlling the filament temperature of an incandescent lamp employed to provide the light transmitted through a colored negative or other transparency to print a colored reproduction of the transparency image or design on a properly sensitized, natural color, paper or other printing medium. Such color printing is hereinafter commonly referred to as "colored transparency printing."

It has long been known that in colored transparency printing it is practically essential to employ a printing light of the proper color temperature. The expression "color temperature" as used herein, is an expression used to identify the color composition or character of light by reference to the temperature at which a "black body" emits light having such color composition or character. As those skilled in the art know, the color temperature of light emitted by an incandescent electric lamp having a tungsten filament is different from the actual temperature of said filament. Color temperature is customarily stated in Kelvin scale degrees. In respect to its color composition or character, the light emitted by the bulb of such a lamp appears to differ somewhat from the light emitted by the lamp filament because of the filter screen action of the coating which is invariably formed on the inner surface of the lamp bulb or transparent envelope in the normal use of such a lamp as a result of filament deterioration or wastage. Such a coating seems to have a color filter action which reduces the ratio of red to blue rays in the light transmitted.

In colored transparency printing, a suitable color temperature of the printing light is essential to the attainment of the proper color balance in the finished prints, it is also essential of course to use a printing light of proper intensity. Specific objects of the present invention are to provide for the automatic maintenance of a suitable intensity and color temperature of the light used in printing from a particular colored transparency onto a particular sensitized medium printing material notwithstanding the progressive increase in the thickness and opacity of the coating on the inner wall of the lamp envelope or bulb during the operative life of the lamp.

In practice, moreover, the proper color temperature needed for colored transparency printing depends not only upon the color characteristics of the transparency, but also on the color sensitivity of the sensitized paper or other printing material on which the print is made. As is well known, manufacturers of sensitized paper or analogous printing material used in color photography do not produce printing material of uniform color sensitivity. In printing colored pictures it is therefore necessary to take into account and correct for variations in the color sensitivity of the sensitized material on which the pictures are printed. Such variations customarily occur whenever a new emulsion or light sensitive coating material is put into use. Heretofore, it has been the practice of manufacturers of photographic colored printing material to specify the sensitivity characteristics of each piece of color printing material sold, and to prepare a new specification whenever use is made of a new light sensitive emulsion.

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In each such specification, the manufacturer has customarily included instructions concerning the light filter or light filter combination which should be used in printing on the material to which the specification pertains. Such instructions have referred to light filters because, heretofore, in colored transparency printing, it has been customary to attempt to compensate for variations in color temperature and in the light sensitivity of the material on which prints are made, by the use of light filters interposed between the lamp and the colored transparency. That method of regulating the printing light color is inefficient and unsatisfactory. Filters reduce the amount of light transmitted through the transparency and thereby increase the necessary exposure period required with a given printing light intensity. Moreover, a light filter is ordinarily subject to change by the light transmitted through it and its control of the effective color of the light transmitted is unstable. Furthermore, such a filter cannot automatically compensate for the progressively changing transparency of the lamp envelope, and cannot compensate for the effect of variations in voltage of the source of lamp energizing current source.

In the preferred form of the invention, I make use of a phototube receiving light emitted by the printing lamp and operating through suitable relay mechanism to gradually increase the filament current as required to keep the intensity of the light received by the tube approximately constant notwithstanding the gradually increasing light screening effect of the coating on the inner wall of the lamp bulb. The relay mechanism required for the regulation just described may be relatively simple since with a suitable automatic regulation of the supply voltage, the

only photoelectric tube needed is in the direction to increase the filament current to compensate for increases in the opacity of the bulb coating.

As the filament current is increased by the regulation just described, the light emitted by the filament and transmitted through the lamp bulb gradually changes in composition as a result of an increase in the ratio of blue rays to red rays in the light. A small change in color composition is practically unimportant, but in ordinary use the color change in the light transmitted through the light bulb becomes great enough to be seriously objectionable, while the lamp is still operable to transmit enough light to the photocell G to energize the latter.

A specific object of the invention is to provide simple and effective means for automatically determining when the printing lamp becomes inoperative to emit an adequate amount of light of practically acceptable color composition. This object may be achieved by measuring the filament current or voltage increase required to maintain the intensity of light emission and replacing the lamp on a predetermined increase in said voltage or current. In a preferred form of the present invention, however, I employ a second photoelectric tube so formed as to be more responsive to blue light rays than to red light rays, and provide relay means for interrupting the lamp circuit or operating a signal device when the increase in the blue rays in the light emitted by the lamp makes its replacement desirable.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages, and specific objects attained with its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

The one figure of the drawings is a diagram illustrating a preferred form of the invention.

In the drawing, A represents an image projector lamp used to transmit light to sensitized paper or other printing material (not shown) through a colored negative or transparency B. The lamp A may be, and ordinarily is, a tungsten filament incandescent lamp. As shown, the lamp is energized by alternating current supplied to the lamp terminal conductors 1 and 2 and automatically regulated, as hereinafter described, by means including a rheostat C and a rotatable relay device D, which adjusts the rheostat contact C' to increase or decrease the amount of resistance C in circuit of the lamp. As diagrammatically shown, the device D is the rotor of an electric motor which angularly adjusts an arm D' carrying the contact C' in the direction to reduce the amount of resistance in the lamp circuit when the motor winding *d* is energized.

The rheostat C connects the lamp terminal conductor 2 to a conductor 2'. The output terminal 3 of an automatic voltage regulator E, which may be of known type, is connected to the lamp terminal 1 through a distributing conductor 5. The conductor 2' is connected to the terminal 4 of the regulator E through a manually adjustable voltage regulator F. The latter is an autotransformer, or so-called Variac comprising a contact arm F' and a winding F^2 along which the contact F' is manually adjustable. The conductor 2' is directly connected to the contact arm F'. As shown, the conductor 1 is connected to one end of the winding F^2 and the conductor 4 is connected to that winding at a point intermediate its two ends. The conductor 4 is also connected to a distribution conductor 6.

As shown, one end of the conductor 5 is connected to one terminal, and the corresponding end of the conductor 6 is connected to the second terminal of the primary winding 7 of a transformer 8. The opposite ends of the conductors 5 and 6 are connected to the opposite terminals of the primary winding 9 of a second transformer 10. The two transformers 8 and 10 may be, and are shown as identical in form and operating characteristics. They serve as isolation transformers to separately energize two control circuits, one of which operates to energize the winding *d* and the other of which operates to deenergize the lamp A as hereinafter described. The control circuit energized by the transformer 8 includes a high vacuum phototube G, and an electronic amplifying valve or tube H having in its output circuit the winding I of an electromagnetic relay. The second control circuit includes a high vacuum phototube *g*, an amplifying valve or tube *h*, and the winding *i* of a second electro-magnetic relay.

As shown, the tube or valve H is a thyratron having a cathode H', an anode H^2, a control grid H^3, a screen grid H^4 and a heater filament H^5. The transformer 8 has two secondary windings 11 and 12. The winding 11 supplies current to the filament H^5. The terminals of the winding 12 are connected by resistances 13 and 14 in series with one another. The terminal 15 of the cathode H' is connected to the connected ends of the resistances 13 and 14, and to a center tap of the transformer secondary 11, and is connected through a resistance 17 to the terminal 16 of the screen grid H^4. Ordinarily, the resistance 17 is much larger than the resistances 13 and 14. The control grid H^3 is connected through a resistance 18 and an adjustable contact 19 to the resistance 14 at a point along the length of the latter, which may be varied by adjusting the contact 19. The resistance 18 may be smaller than the resistance 17 but may well be much larger than the resistances 13 and 14. The relay winding I is connected in the output circuit of the tube H, one terminal of the winding I being connected by a conductor 20 to the anode H^2, and the other terminal of the winding I being connected to the cathode H' by a conductor 21, the transformer secondary 12 and the resistance 13. A by-pass condenser 22 is connected in parallel with the winding I.

The terminal of the transformer secondary 12 directly connected to one terminal of the resistance 13, is connected by a conductor 23 to the cathode G' of the high vacuum phototube G. The other terminal of the transformer secondary 12 is connected to the anode G^2 of tube G through a portion of resistance 14, the contact 19, the resistance 18 and a conductor 24. The latter directly connects the anode G^2 of the photocell G to the control grid H^3 of the tube H. As shown, the body portions of the conductors 23 and 24 are included in a coaxial cable 25.

With the connections described, it will be apparent that during the supply potential half cycles in which the tube H is conductive, a decrease in the intensity of the light from the lamp A received by the cathode of the phototube G will decrease the current flowing to the

phototube anode G^2 through the upper portion of the resistance 14 and the resistance 18, and thereby make the control grid H^3 less negative relative to the cathode H'. In consequence, the average current flow through the relay winding I increases on a decrease in the intensity of the light rays transmitted from the lamp A to the cathode G' of the phototube G.

When the current flowing through the relay winding I increases to a predetermined value, it closes the normally open relay switch J, and thereby closes an energizing circuit for the motor winding *d*. Thereupon the motor D is set into operation in the direction to reduce the resistance C in series with the lamp terminal 2. The motion of the relay motor D thus initiated, terminates as soon as the increase in the voltage impressed on the lamp A increases the intensity of the light transmitted to the phototube G to its normal value and thus restores the normal condition in which the output current of the tube H flowing through the winding I is too small to maintain the switch J closed. The energizing circuit for the winding *d*, established when the switch J is closed, comprises a conductor 30 connecting one terminal of the winding *d* to the A. C. supply conductor L', and a conductor 32 connecting the second terminal of the motor winding *d* to the A. C. supply conductor L^2. As shown, the switch J is included in the conductor 30.

The tubes *g* and *h* are associated with a control circuit which includes circuit elements 11' to 25' like, or generally similar to the circuit elements 11 to 25, respectively, of the control circuit associated with the tubes G and H. While the tube *h* may be a duplicate of the tube H, and the control circuit including the tube *h* is generally similar in character to the control circuit including the tube H, the resistances 13', 14', 17' and 18' associated with the circuit including the tube *h*, differ in their relative values from the resistances 13, 14, 17 and 18. In particular, the resistance 13' is ordinarily many times as great as the resistance 13, and the resistance 18' may be only a tenth of one megohm while the resistance 18 may well be several megohms.

Moreover, the control circuit associated with phototube *g* is such that an increase in the intensity of the light rays received by the cathode *g'* results in an increase in the output current of the tube *h*. To this end the terminal 21' of the transformer secondary 12' which is connected to the anode h^2 of the tube *h*, is also directly connected by the conductor 24' to the anode g^2 of the tube G, whereas in the circuit first described the terminal of the secondary winding 12 directly connected to the anode H^2 of the tube H is not directly connected to the anode G^2 of the tube G, but is connected thereto through a portion of the resistance 14 and the resistance 18. The cathode *g'* of the phototube G is connected to the second terminal of the transformer secondary 12' through the resistance 18' and a portion of the resistance 14'. In consequence, an increase in the light transmitted from the lamp A to, and operatively effective on, the cathode *g'* of the tube *g*, and the resultant increase in phototube current, makes the control grid h^3 of the tube *h* increasingly positive relative to the cathode *h'*. This increases the output current of the tube *h*, and the increase in said current eventually becomes sufficient to energize the relay winding *i*.

In addition, the phototubes G and *g* are so made that an increase in the ratio of blue rays to red rays in the light emitted by the lamp A tends to increase the current flow through the tube *g* relative to the current flow through the tube G. That ratio is increased by an increase in the filament temperature of the lamp A. In consequence, the filament temperature increase required to maintain the current flow through the phototube G approximately constant as the opacity of the lamp bulb coating increases, tends to progressively increase the current flowing through the phototube *g*.

My observations on the performance of apparatus of the character disclosed, have lead me to the opinion, moreover, that the deposit or coating on the inner wall of the lamp bulb acts as a color filter screen which passes a relatively greater amount of blue rays than red rays. In any event, as the deposit or coating on the inner wall of the bulb of the lamp A thickens, the regulation effective to maintain a constant current flow through the tube G results in an increase in the current flow through the tube *g*.

In the arrangement shown when the increase in the current flowing through the phototube *g* results in the operative energization of the winding *i*, the normally closed relay *j* opens. This opens the input circuit of the automatic regulator E and thereby deenergizes the lamp A and the control circuits respectively associated with the tubes G and H and *g* and *h*. In the arrangement shown by way of example in the diagram, one input terminal 35 of the regulator E is directly connected to the supply conductor L^2, and the second input terminal 36 is connected to the supply conductor L' through the relay switch *j*, a hold-in relay winding 37, a switch 38 and a conductor 39. The switch 38 as shown is biased for movement into its open position. However, with the switch *j* in its normal closed position, the switch 38, when manually adjusted into its closed position, is retained in that position so long as the hold-in relay winding 37 is energized. When the relay winding *i* is operatively energized and opens the switch *j*, the hold-in relay winding 37 is deenergized and the manual switch 38 is moved by gravity or other bias force, into its open position in which it remains until manually returned to its closed position. So long as the switch 38 remains open the only element of the control system shown in the drawing which is energized by the supply conductors L' and L^2, is the pilot lamp 40 employed to show whether those conductors are or are not energized.

In the intended operation of the apparatus illustrated in the drawing, the voltage regulator E operates to maintain a substantially constant voltage between its output terminals 3 and 4, notwithstanding the normal and to be expected fluctuations in the voltage difference between the supply conductors L' and L^2. The normal voltage difference between the regulator output terminals 3 and 4 may vary with conditions, but ordinarily that voltage difference may be 117 volts or so. The autotransformer F is normally adjusted to maintain a voltage difference between the conductors 1 and 2' which is appreciably higher than the output voltage of the regulator E, and which may well be between 125 and 135 volts.

The voltage impressed on the terminals 1 and 2 of the lamp A is normally held below the output voltage of the regulator F by the rheostat C. With a lamp A of the type and character normally used, the voltage impressed on the lamp terminals in the initial condition of the lamp A, may be of the order of 100 volts. A shown, a voltmeter 41 indicates the last mentioned voltage.

The voltage initially impressed on the lamp terminals may be varied by adjustment of autotransformer regulator F to vary the light color in accordance with the requirements of the printing operation to be effected. Some adjustment of the control circuit contacts 19 and 19' should ordinarily be made whenever the device F is adjusted to vary the potential difference between the terminals of the lamp A. The effect of the adjustment of the contact 19 along the resistance 14 is to vary the magnitude of the current through the phototube G required to operatively energize the relay winding I. Similarly, the adjustment of the contact 19' up or down along the resistance 14' varies the current through the photoelectric tube *g* required to operatively energize the relay winding *i*.

The general operation of the apparatus shown diagrammatically in the drawing will be apparent from foregoing explanations. It may be summarized as follows:

With the contact arm F' and the sliding contacts 19 and 19' properly adjusted for the conditions of use, the rheostat arm C' will be at or adjacent the right-hand end of its adjustment range when the lamp A is new and there is no filament deposit or coating on the inner wall of the lamp bulb. The continued use of the lamp results in some disintegration of the lamp filament and a resulting deposit or coating of the inner wall of the lamp bulb or envelope. Ordinarily, that coating progressively increases, and results in a progressive decrease in the transparency of the lamp bulb throughout the operative life of the lamp. The coating thus tends to progressively diminish the light transmitted by the lamp A to the cathode of the phototube G.

Whenever the increase in the deposit on the lamp bulb reduces the light transmission to the tube G so as to significantly decrease the current flow through that tube, the output current of the amplifier tube H is sufficiently increased to energize the relay winding I. The resultant closure of the switch J energizes the motor D for operation in the direction to give a counter-clockwise adjustment to the rheostat arm C' of sufficient magnitude to increase the light emission of the lamp as required to restore the current flow through the phototube G to its normal value, whereupon the operation of the motor D is interrupted. The rheostat arm C' is thus given successive small adjustments in the counter-clockwise direction throughout the operative life of the lamp.

Initially, and until the useful life of the lamp is practically finished, the current flow through the phototube *g* is too small to energize the relay winding *i*. Eventually, however, the increase in the blue ray component of the light transmitted to the phototube *g*, increases the current flow through the tube *g* sufficiently to so increase the output current of the amplifier tube *h* that the relay winding *i* is energized. When the winding *i* is thus energized the normally closed switch *j* is opened and the hold-in relay winding 37 is thereby deenergized. On the deenergization of the winding 37, the switch 38 turns into its open position and thereby opens the in-put circuit of the automatic regulator E and thereby deenergizes the lamp A and the control apparatus. When, thereafter, the lamp A is replaced by a lamp in good condition, the apparatus can be restored to its normal position by the manual closure of the switch 38. When that switch is then closed the hold-in relay winding 37 is operative to hold the switch in its closed position.

While in accordance with the provisions of the statutes, I have illustrated and described the best forms of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the forms of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a projection printer, the combination with an electric lamp comprising a filament enclosed in a transparent envelope and emitting light used in reproducing a color picture, of means controlling the color temperature of said light comprising electric supply means, a lamp current regulator arranged for progressive adjustment through which said filament is connected to and receives current from said supply means, a phototube receiving light emitted by said filament, phototube energizing means for passing an electric current through said phototube which varies in magnitude with the intensity of the light received by said phototube and relay mechanism responsive to said current magnitude for progressively adjusting said regulator to increase the current through said filament as required to maintain the current flow through said phototube approximately constant notwithstanding a progressive increase in opacity of the coating formed on the inner wall of said envelope as the period of lamp use increases.

2. In a projection printer, the combiantion with an electric lamp comprising a filament enclosed in a transparent envelope and emitting light used in reproducing a color picture, of means controlling the color temperature of said light comprising electric supply means, a lamp current regulator arranged for progressive adjustment through which said filament is connected to and receives current from said supply means, a phototube receiving light emitted by said filament, phototube energizing means for passing an electric current through said phototube which varies in magnitude with the intensity of the light received by said phototube, relay mechanism responsive to said current magnitude for progressively adjusting said regulator to increase the current through said filament as required to maintain the current flow through said phototube approximately constant notwithstanding a progressive increase in opacity of the coating formed on the inner wall of said envelope as the period of lamp use increases, a second phototube to which light emitted by said lamp is transmitted and which is more responsive than the first mentioned phototube to the blue light ray component of the light emitted by the lamp and relay means controlled by said second phototube for effecting a control action on a predetermined increase in the blue light ray component of the light emitted by said lamp.

3. A combination as specified in claim 2, in which the control action effected by the second phototube interrupts the supply of current to said lamp.

4. In an image projector, the combination with an electric lamp comprising a filament and a transparent envelope enclosing said filament emitting light used in reproducing a transparent

color image, of means controlling the color temperature of said light comprising electric current supply means including an automatic voltage regulator and manually operated voltage changing means, a lamp current regulator through which said filament is connected to and receives light from said supply means, a phototube receiving the light emitted by said filament, phototube energizing means for passing electric current through said phototube dependent in magnitude on the intensity of the light received by the phototube, relay mechanism responsive to said current flow magnitude for adjusting said current regulator as required to maintain the current flow through said phototube approximately constant notwithstanding the variation in transparency of the coating formed on the inner wall of said envelope as the period of lamp use increases, a second phototube to which light emitted by said filament is transmitted and which is more responsive than the first mentioned phototube to the blue light ray component of the light emitted by the lamp and relay means controlled by said second phototube for deenergizing said lamp on a predetermined increase in the blue light ray component of the light emitted by said lamp.

5. The method of controlling the color temperature of light emitted by an electric lamp comprising an incandescent filament and a transparent envelope enclosing said filament and on the inner wall of which a coating is deposited during and as a result of the operation of the lamp, the method which consists in transmitting light emitted by said lamp to two phototubes, one of which is more responsive than the second to the blue ray component of said light, supplying electric current to said filament at a rate varying on and in accordance with variations in the response of said second phototube to the light transmitted thereto so as to thereby maintain said response practically constant, and producing a controlling effect by said one phototube when the response of the latter to the light transmitted to it indicates a predetermined increase in the blue ray component of the last mentioned light.

6. In printing colored pictures by transmitting light through a colored transparency from a light source consisting of an electric lamp comprising an incandescing filament and a transparent envelope enclosing said filament and on the inner wall of which a coating is deposited during and as a result of the operation of the lamp, the method of controlling the color temperature of the light emitted by said lamp which consists in transmitting some of the light emitted by the lamp to each of two phototubes, one of which is more responsive than the second to the blue ray component of light transmitted to it, supplying electric current to said filament at a rate varying on and in accordance with variations in the response of said second phototube to the light transmitted thereto, so as to thereby maintain said response practically constant, and interrupting the use of said lamp as said light source on a variation in the response of said one lamp to the light transmitted thereto produced by a predetermined increase in the blue ray component of the last mentioned light.

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