United States Patent

Jarmar

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[54] **ILLUMINATION ARRANGEMENT FOR RECORDING AND/OR REPRODUCTION IN COLOR**

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[73] Assignee: **Sveriges Radio Aktiebolag,** Stockholm, Sweden

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[30] **Foreign Application Priority Data**

Oct. 9, 1968 Sweden 13595/68

[52] **U.S. Cl.** **315/298,** 315/296, 315/297, 355/35, 355/37

[51] **Int. Cl.** **H05b 41/39**

[58] **Field of Search** 315/152, 153, 154, 296, 297, 315/298; 355/35, 37, 70, 88

[56] **References Cited**

UNITED STATES PATENTS

2,438,219 3/1948 Johnston..............................355/37

FOREIGN PATENTS OR APPLICATIONS

506,727 5/1939 Great Britain..............................355/88
253,968 12/1948 Switzerland..............................355/37

OTHER PUBLICATIONS

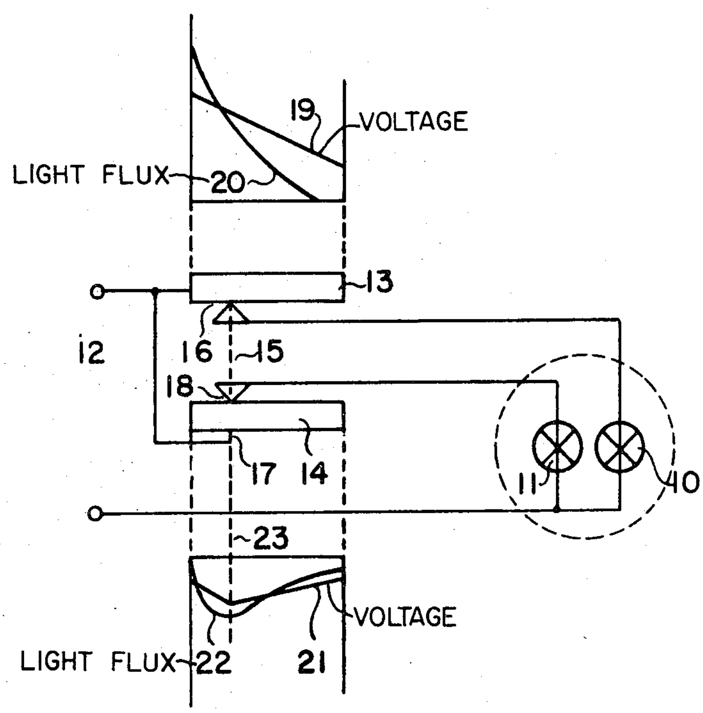
" Brightness Variation Without change of Colour–Temperature," European Broadcasting Union Review, Part A–Technical, April 1969, No. 114, pp. 78 and 79.

Primary Examiner—Raymond F. Hossfeld
Attorney—Larson, Taylor and Hinds

[57] **ABSTRACT**

An illumination arrangement for use in connection with picture recording or reproduction in color. The device automatically compensates for changes in the spectral composition of the light at various light intensities. In one embodiment, the device includes a first lamp and a second, smaller, lamp, the lamps being coupled such that a change in the color temperature in one direction of a first lamp is compensated for by a change in the color temperature of a second lamp, the change in the color temperature of the second lamp being such in its direction and amount, to compensate for the change in color temperature of the first lamp.

18 Claims, 8 Drawing Figures



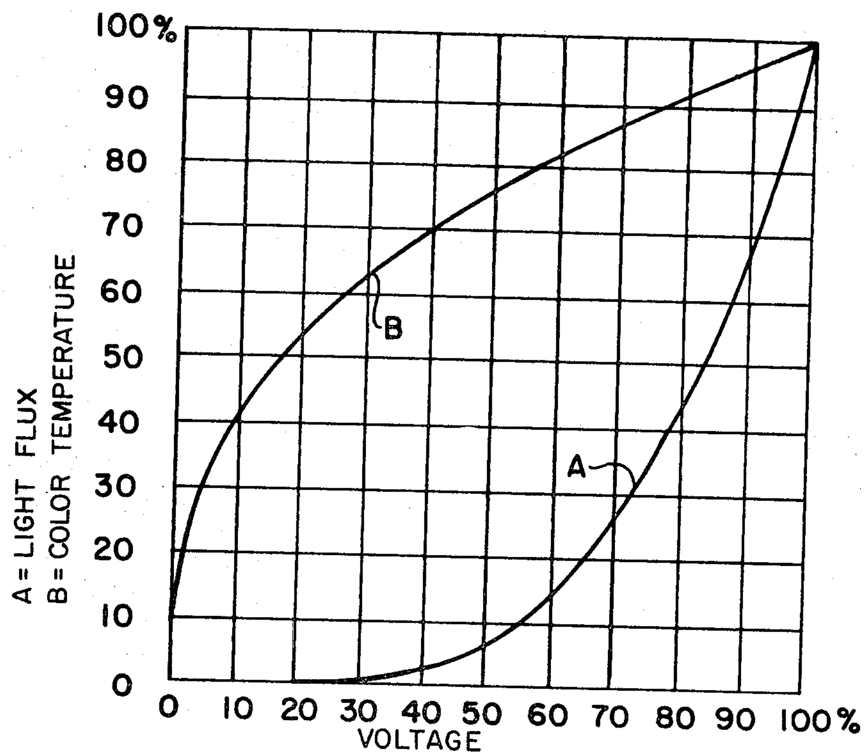

100%
90
80
70
60
50
40
30
20
10
0
A = LIGHT FLUX
B = COLOR TEMPERATURE
B
A
0 10 20 30 40 50 60 70 80 90 100%
VOLTAGE

Fig. 1

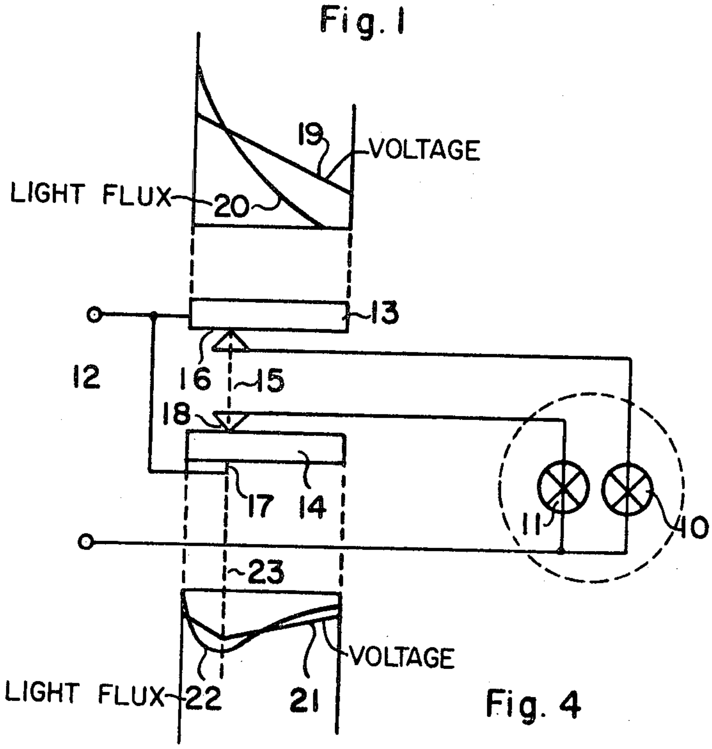

19
VOLTAGE
LIGHT FLUX
20
13
12
16
15
18
17
14
11
10
23
VOLTAGE
LIGHT FLUX
22
21

Fig. 4

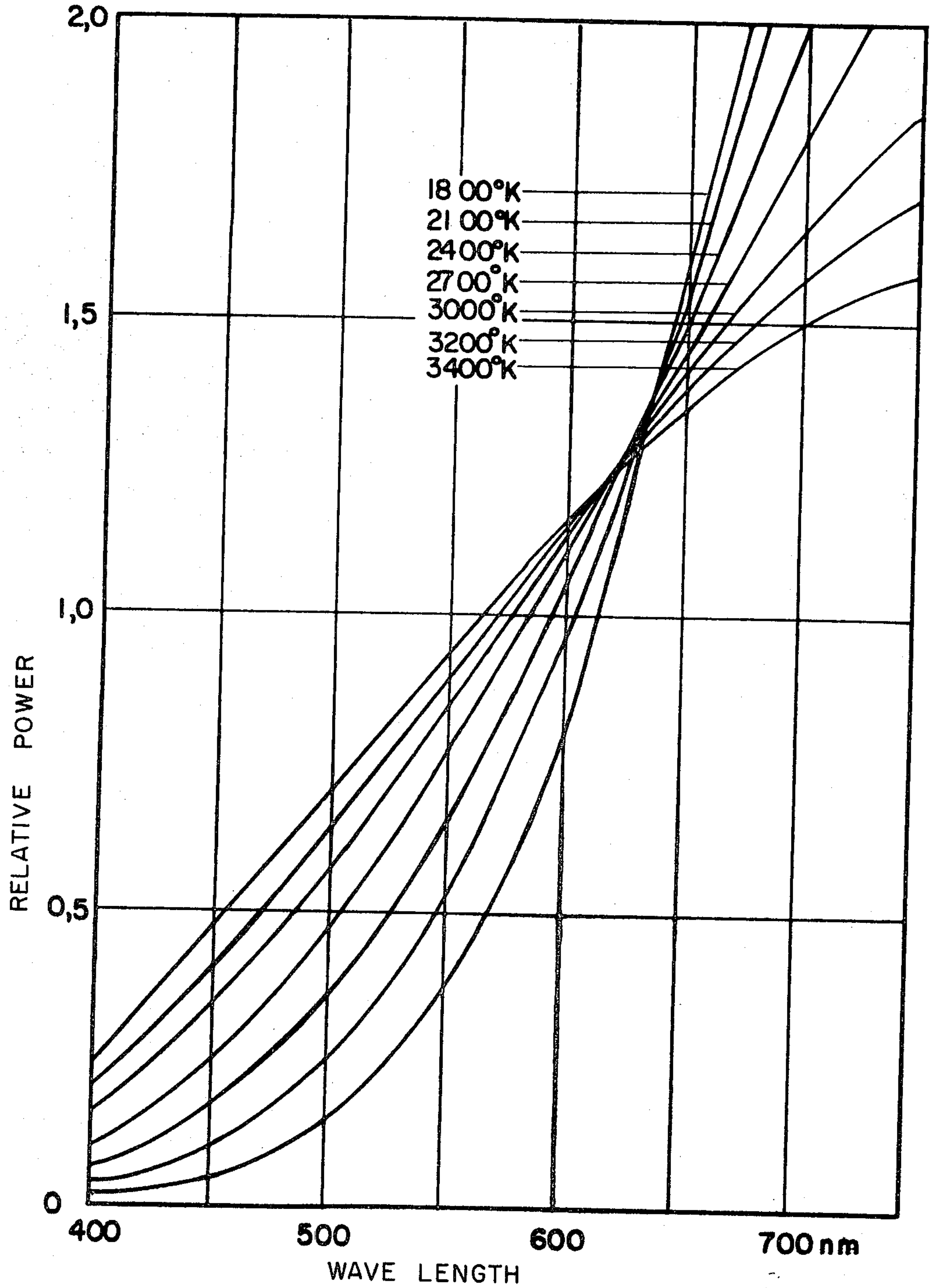

2,0
1,5
1,0
0,5
0
RELATIVE POWER
1800°K
2100°K
2400°K
2700°K
3000°K
3200°K
3400°K
400
500
600
700 nm
WAVE LENGTH

Fig. 2.

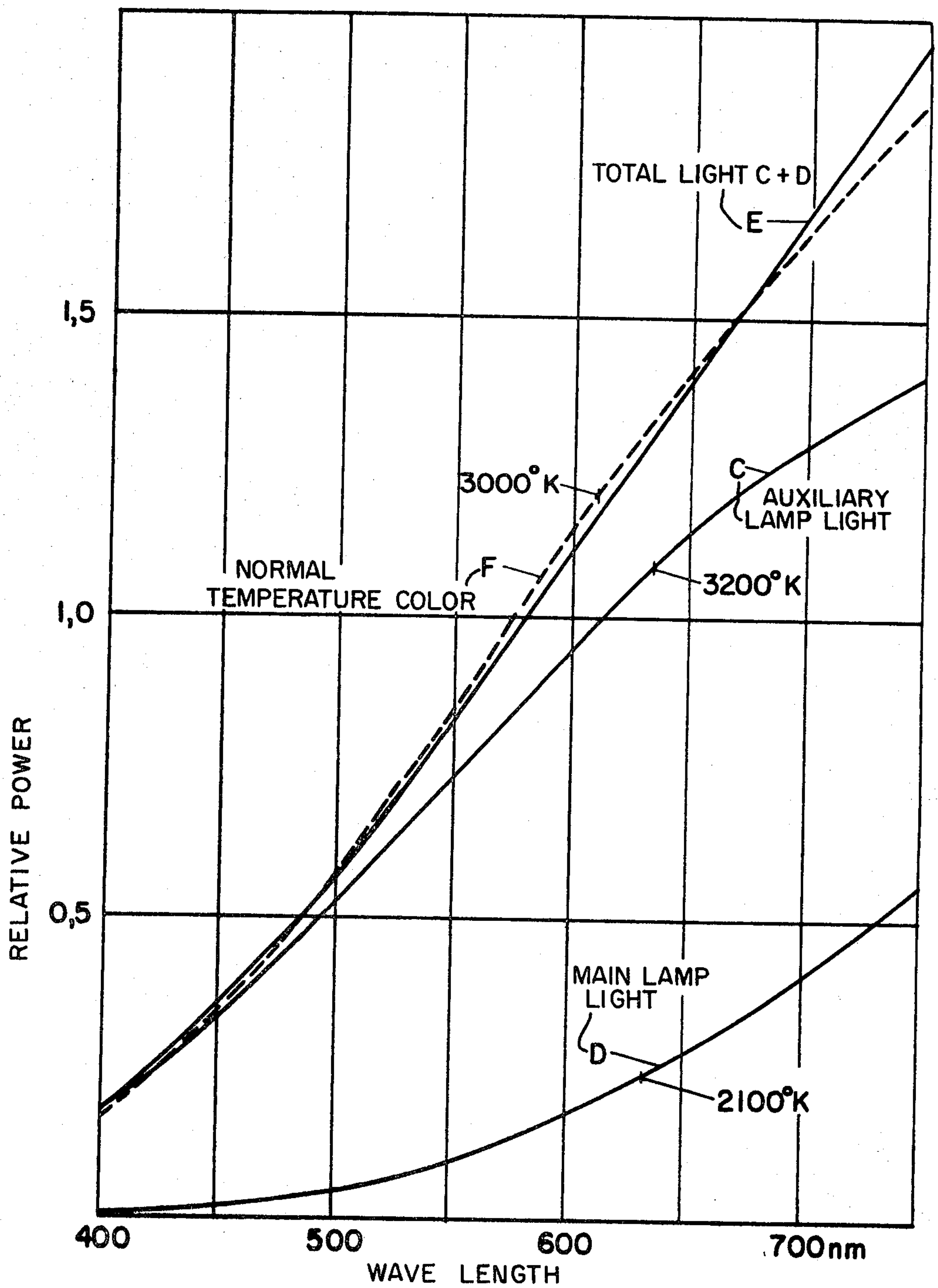

TOTAL LIGHT C + D
E
1,5
3000°K
C
AUXILIARY
LAMP LIGHT
NORMAL
TEMPERATURE COLOR
F
3200°K
1,0
RELATIVE POWER
0,5
MAIN LAMP
LIGHT
D
2100°K
400
500
600
700nm
WAVE LENGTH

Fig. 3.

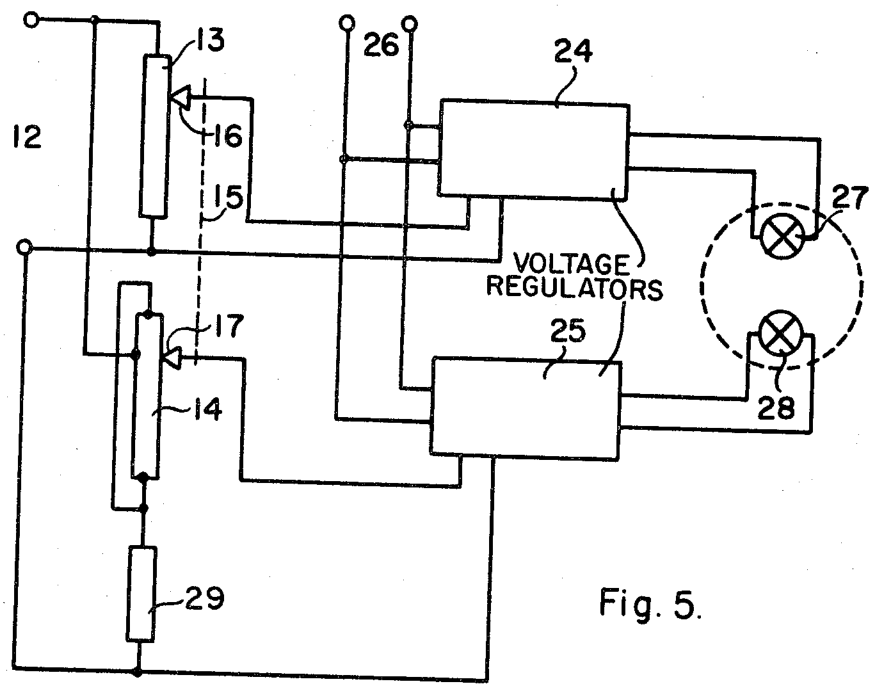

12
13
16
15
17
14
29
26
24
25
VOLTAGE
REGULATORS
27
28

Fig. 5.

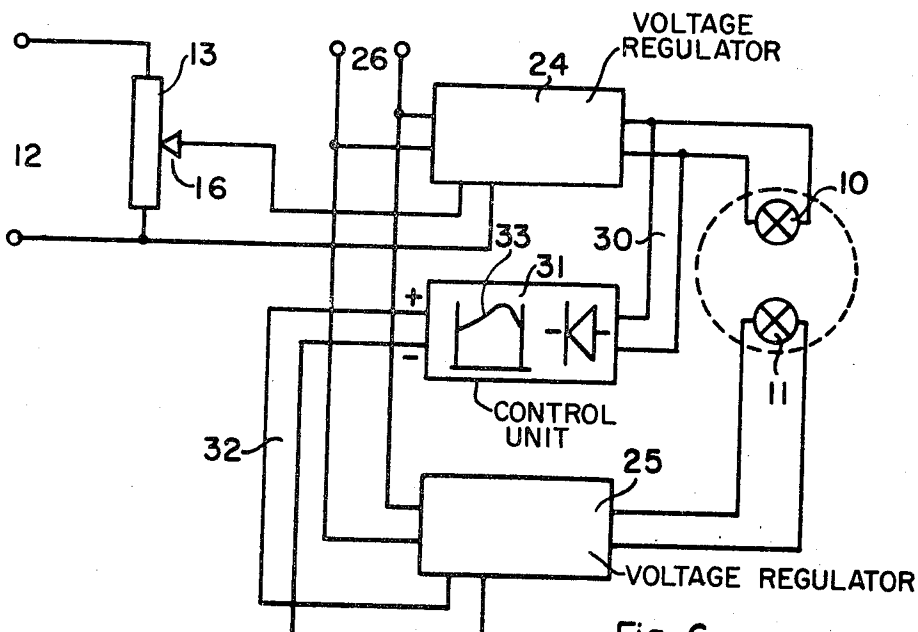
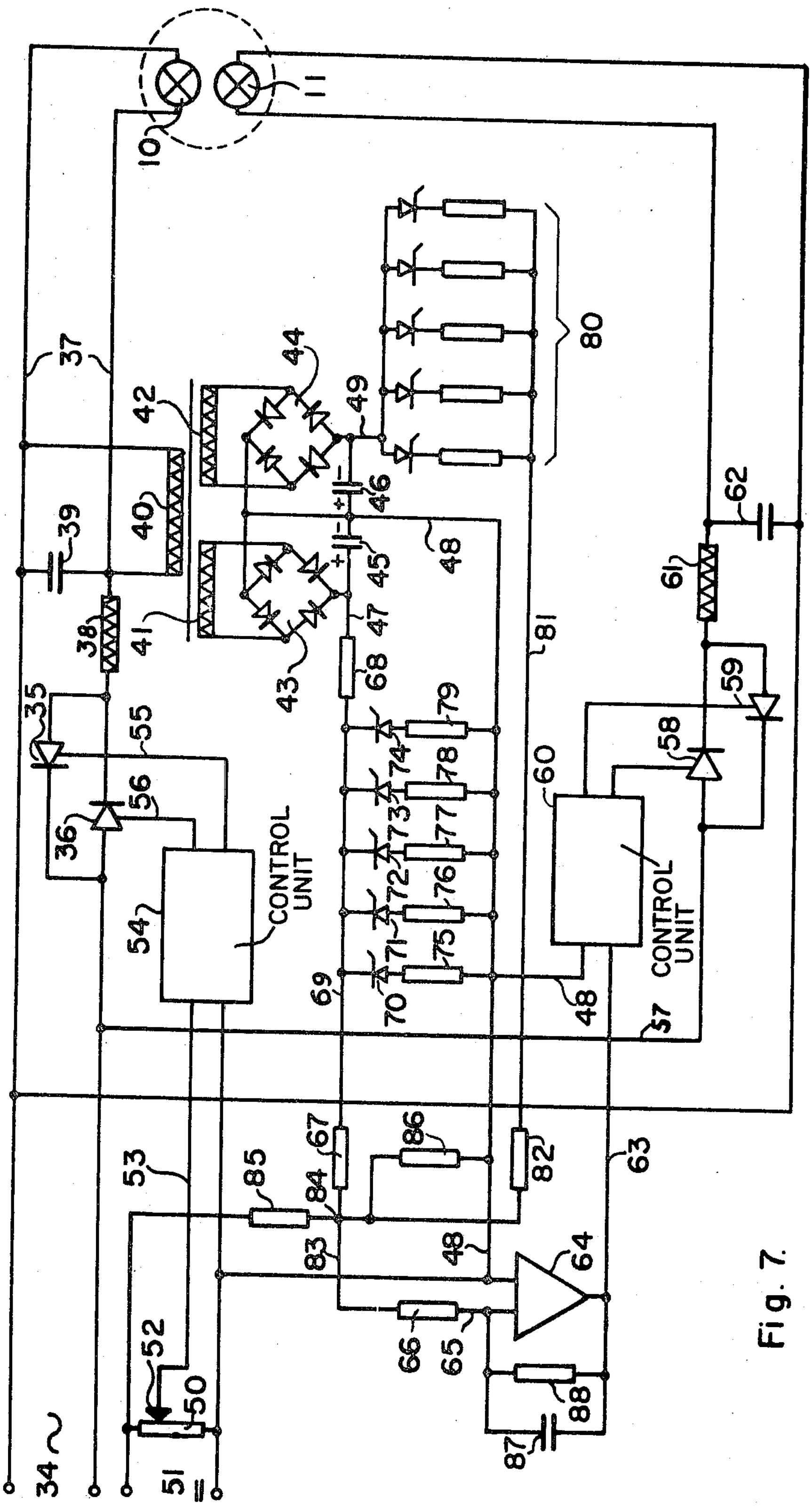

12
13
16
26
24
VOLTAGE
REGULATOR
10
33
31
30
+
−
CONTROL
UNIT
11
32
25
VOLTAGE REGULATOR

Fig. 6.


CONTROL UNIT
CONTROL UNIT
10
11
34 ~
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
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61
62
63
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65
66
67
68
69
70
71
72
73
74
75
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78
79
80
81
82
83
84
85
86
87
88

Fig. 7.

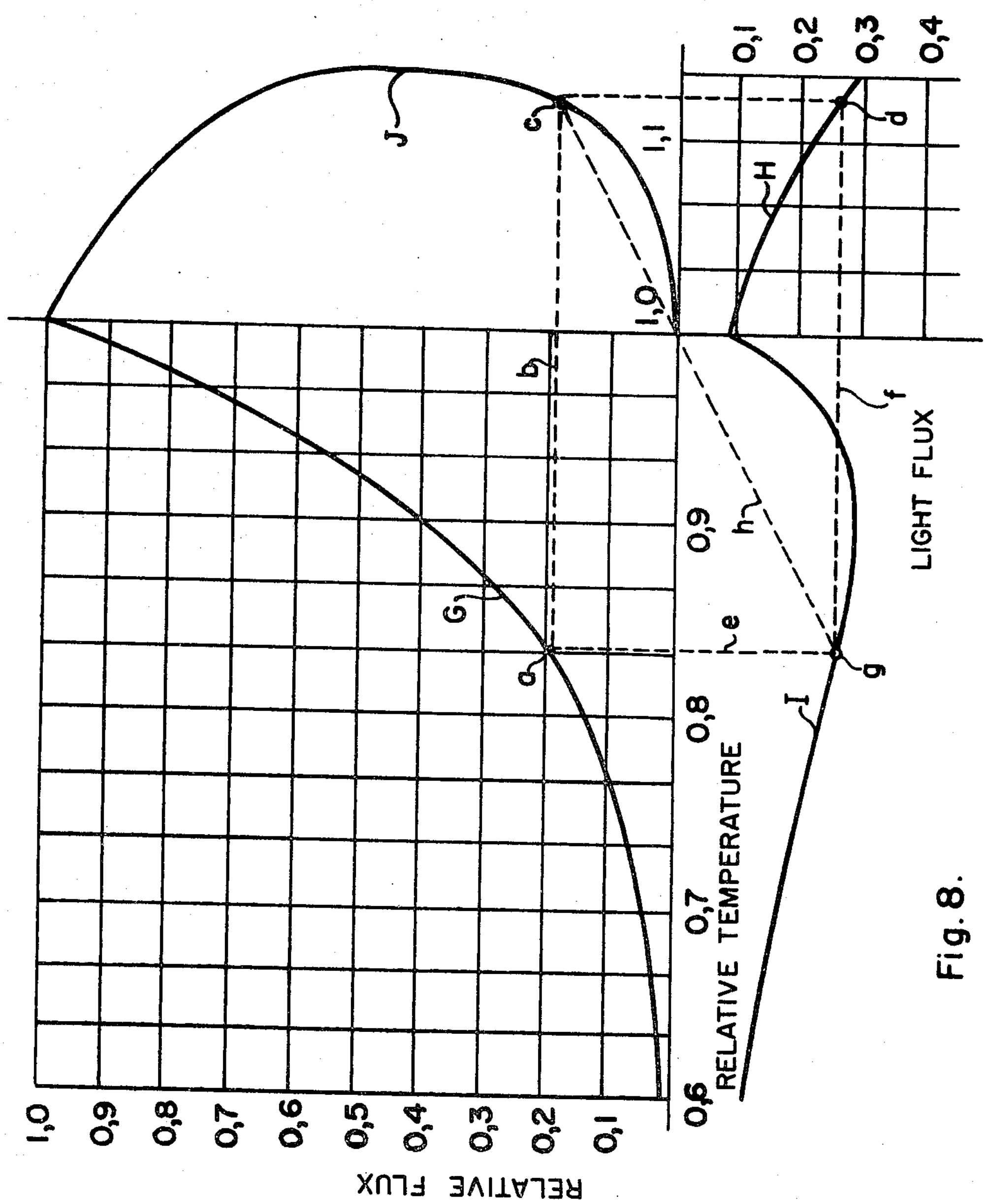
RELATIVE FLUX
1,0
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
RELATIVE TEMPERATURE
0,6
0,7
0,8
0,9
1,0
1,1
LIGHT FLUX
0,1
0,2
0,3
0,4
J
G
H
I
a
b
c
d
e
f
g
h

Fig. 8.

ILLUMINATION ARRANGEMENT FOR RECORDING AND/OR REPRODUCTION IN COLOR

In color photography and color recording for reproduction by means of television and in many similar cases, a control of the light intensity must take place successively. This control, as a rule, takes place by changing the voltage fed to an incandescent lamp. However, it is well known that at a change of this voltage the color distribution in the spectrum of said incandescent lamp is also changed, usually in such a way that an essentially stronger proportion of red light will be created, the lower the voltage is chosen. This variation in color distribution within the used light, of course, may be compensated for by a change of the sensitivity of the recording apparatus for different colors. As a rule, this simple method is for practical reasons not available, because one cannot repeatedly change film in a camera so that the used film will be of the correct chemically optical composition, and also one cannot work with suitable adjustment filters, nor can one during a recording for television change the amplification of the three basic color amplifiers, because the changes in light intensity which occur will usually happen too often, too quickly, and too unexpectedly.

Therefore, there is a strongly felt need for an illumination arrangement, which is created in such a way that it will automatically at all existing light intensities give one single spectrotechnical composition of the light.

In this connection it will be helpful to discuss the term "-color temperature," which is rather difficult to define but which is often used in the art. A typical temperature of the incandescent wire in a lamp will be about 3,000° K. At this temperature the lamp will give off a light, which has a predetermined spectral composition, which is often understood to be completely white, although this is certainly far from correct. If one decreases the voltage, then the temperature of the incandescent wire will also decrease, and simultaneously the color of the incandescent wire is changed, or, as one could also express it, the gravity point of the illumination given off is displaced in a direction towards red. One then says, that the lamp has got a lower color temperature, which should, as a matter of fact, be understood the way that the lamp has got a lower temperature, which is combined with such a change of color, which regularly will enter at a decrease of the temperature. In a corresponding way, a lamp may of course also be given a higher color temperature, whereby the gravity point within the color spectrum will be displaced in direction into the blue or violet.

In the vicinity of the normally existing color temperatures one counts with a tolerance amount of about ±100° C., which means, that no disturbing color error setting will exist in the reception, if the temperature should vary upwardly or downwardly by the said amount of tolerance of 100° C. This tolerance value, of course, will not have validity at lower color temperatures, which differ very essentially from the normal color temperature.

The present invention now refers to an illumination arrangement, by means of which one may control the color intensity and the illumination by changing the voltage without thereby changing the color temperature to a further extent than a change within the allowed limits of tolerance.

According to the invention, at least two lamps are arranged in such a coupling that a change of the color temperature in one direction of one, essentially greater, lamp will be followed by a change of the color temperature of the other, essentially smaller, lamp, the latter change being so adapted as to its direction and amount, that it causes a compensation of the change of color temperature of the first-mentioned lamp.

The first-mentioned lamp will in the following be called the "main lamp", whereas the latter lamp will be called the "compensation lamp." . However, it is obvious that the invention is not limited to one single main lamp and one single compensation lamp, but that complete batteries of lamps of each kind may exist, and that the lamps in one and the same battery may not even necessarily be subjected to the same color temperature change. On the other hand, one can, of course, also simplify the form of execution in the way that one will use one single lamp unit which, in a way known per se, for lamp," known from the automobile head lamp, contains two incandescent wires. Such modifications, of course, will also fall within the scope of the present invention.

The light fluxes from the two lamps should be combined into one single light beam. By suitable adaption between the light intensities of the two partial light beams one can then change the color of each partial light beam, so that in spite of the variations in the light intensity of the total light flux, its color, or as one used to say, its color temperature, will remain constant. By this is meant that the color composition will remain constant at a state corresponding to the normal color temperature of the lamps, although the color temperature of the one lamp has increased and the color temperature of the other lamp has decreased. As a matter of fact, one is here placed before an equilibrium relation with the desired color temperature as a reference point. A weak light flux in a greater temperature difference from the desired temperature thus may compensate as far as regards the color composition a smaller temperature difference in the other direction of a stronger light flux and vice versa.

The invention will be further described below in connection with the attached drawings, which show different embodiments of the invention. However, it is understood that the invention is not limited to the arrangements thus shown in the drawings and further described below, but that other modifications may occur within the frame of the invention.

In the drawings:

FIG. 1 shows a normal diagram showing the variation of the color temperature as well as of the light flux with a change of the voltage of an incandescent lamp.

FIG. 2 shows a family of curves, indicating the spectral energy distribution in wavelength with the incandescent temperature as an arbitrary magnitude, measured as a function of the relative power, and

FIG. 3 shows one of the curves of the curve family according to FIG. 2 as well as the corresponding curve for a light flux composed of the flux from two lamps according to the invention, as the sum of the two partial light fluxes also shown in FIG. 3.

FIG. 4 shows a simple arrangement, by means of which one may with allowable approximation achieve a substantially constant color temperature independently of the variation in light flux, whereas

FIGS. 5 and 6 show a couple of different arrangements, more advanced for the same purpose, in block diagram.

FIG. 7 shows a complete diagram of a system of the last mentioned kind, in which, however, such means which are already commonly known have been shown in block diagram for simplification of the description.

FIG. 8 finally, shows an auxiliary diagram, which may be used for the calculation of the numerical values of the magnitudes contained in the diagram according to FIG. 7.

The diagram according to FIG. 1 refers to a known lamp having an incandescent wire, the normal temperature of which was 3,000° K. at normal voltage. The voltage scale runs along the horizontal axis and is divided into percent of the normal voltage. Also the vertical axis is divided into percent of the normal value, viz regarding the curve A of the light flux and regarding the curve B of the color temperature. It is seen, that the one curve is concave upwardly, whereas the other one is strongly convex upwardly.

It is also seen from FIG. 1, that at a decrease of the voltage from its normal value, the light flux according to the curve A will sink very strongly, whereas, on the other side, the color temperature will sink only rather slowly in the beginning, later on however still quicker. When the voltage has been decreased to about 20 percent, the light flux, by which is meant the flux of the light, observable by the human eye, is mainly equal to zero. Simultaneously the color temperature has decreased to about 53 percent. Below this value, the radiation from the incandescent lamp will thus mostly have infrared character, said radiation not being visible to the human eye. The change, which took place from normal color temperature (100 percent) to the color temperature (53 percent) corresponding to red and infrared radiation, however, is so great that it cannot be allowed. Also an essentially smaller variation will essentially exceed the allowed range of tolerances. This is most easily seen, regarding that the voltage value, which has been indicated by 100 percent corresponds to 3,000° K., and that the tolerance range was put at ±100° corresponding to 3.3 percent.

Detailed statements about the displacement of the different light wave lengths and the relative power represented by them at different temperatures of the incandescent wire will be seen from FIG. 2. The relative power thereby is plotted along the vertical axis, whereby the normal value is assumed to be at 1.0. The curves, thus, show its variation up to the double of the normal value. The simultaneously occuring wave length displacement is read along the horizontal axis.

The curve shown in FIG. 2, valid for a color temperature of 3,000° K., is reproduced in FIG. 3 by a dotted line. It is now assumed that a main lamp, The color temperature of which has been decreased to 2,100° K. by lowering its voltage and light flux, should get a compensation for its loss of color temperature by means of an auxiliary lamp, having the color temperature of 3,200° K. By the equilibrium relation already mentioned, which, of course, is approximate one may get the result that the lamp the color temperature of which is 2,100° K. should give about 18 percent of the total light flux whereas the other lamp should give about 82 percent. Curve D in FIG. 3 now has a surface integral, which is 18 percent of the surface integral of the curve in FIG. 2 corresponding to the temperature 2,100° K., whereas the curve C has a surface integral representing 82 percent of the surface integral of the curve, which applies in FIG. 2 to 3,200° K. Adding now the two curves C and D, you will get the curve E. This rather exceedingly well agrees with the normal color temperature curve, which is thus reproduced by the dotted curve F. Assuming that the curve F as to its contents of light power represents the maximum light of the lamp combination, then, of course, the real value of the curve E will be essentially less than the curve F. The two curves, however, only indicate relative values, which means that their surface integrals have been made equal in order that one should be capable of comparing them and of seeing if they have the same or essentially different color temperatures.

A simple control device which can be used for a rather coarse manual control of the two lamps is shown in FIG. 4. The main lamp is there indicated by **10** and the compensation lamp by **11**. Both of these lamps are connected to the power mains **12** through one resistor **13** or **14**, resp. These two resistors are variable and are controlled in common by means of one single control means, indicated by the dotted line **15**. The resistor **13** is arranged as a conventional rheostat, so that when its slider **16** is moved to the right in the drawing, then the resistance will increase and consequently the voltage remaining for the incandescent wire of the lamp **10** will decrease. The main conductor, however, is not connected to the terminal of the resistor **14** of the compensation lamp **11** but to an intermediate point **17**. When the slider **18** of the resistor **14** is exactly opposite to this connection point **17**, the compensation lamp will therefore get full voltage, but if one moves the control means **15** in the one direction or in the other one, resistance will be connected in series with the compensation lamp, and its current will decrease. The purpose of this will be further explained below in connection with FIG. 8.

When the slider **16** is moved over the rheostat **13** the voltage is changed, for instance according to the curve **19** (FIG. 4), and simultaneously the light flux is changed according to the curve **20** (FIG. 4). The corresponding curves for the function of the rheostat **14** are formed, as far as regards the voltage by the curve **21** and as far as regards the light flux by the curve **22**. The curve **22** is calculated in a way, which will be evident from the following, so that it will cause as far as possible compensation for the change of color temperature in the main lamp **10**.

When winding the resistor screw of the rheostat **14** one should take care, as far as needed, the winding turns within different parts should be placed at unequally distances from each other. By this step one will get an opportunity of influencing the run of the curves **21** and **22**. In the ideal case, as a matter of fact, the curve **21** should not be composed by two straight lines, as it has been shown in FIG. **4** for simplification of the description. Even with a voltage variation curve, which is composed in this way by two straight line parts, however, one will get a rather well acceptable result.

The arrangement now described functions mainly in the following way: At full light the main lamp **10** will give a light flux corresponding to what was indicated in FIG. **2** by the value 1.0. Its color temperature then is equal to the working or normal color temperature, also indicated by the value 1.0. In this position, the compensation lamp **11** should be tuned to the working color temperature, and its light flux should suitably be in the order of magnitude about 0.1. If now the voltage of the main lamp **10** is decreased, then the light flux from this lamp will also decrease; simultaneously, however, also its color temperature is changed. For compensation of the decrease of the color temperature the compensation lamp **11** must get a higher voltage. Thereby the color temperature of this lamp does not only increase, but also its light flux. Due to the compensation lamp being rather small as compared with the main lamp, however, the increase of light will not be as great as the decrease of light flux from the main lamp, and the total light flux consequently becomes smaller. When the voltage of the main lamp **10** has been decreased such, that its color temperature has decreased to 0.9, the moment from the main lamp is the highest one. Consequently one will have to give the highest voltage to the compensation lamp in this state, corresponding to the position **23** on its rheostat **14**. At continuous decrease of the voltage of the main lamp **10**, the voltage of the compensation lamp must also be decreased for maintaining correct color composition, initially a little stronger but thereafter successively weaker. Finally, the main lamp becomes completely dark, whereas the compensation lamp will still show a light radiation having a voltage and a color temperature which are identical with the one which existed at the beginning of this operation.

In the starting position, the composed light flux has in this case an intensity of 1.0+0.1=1.1, and in the final position, when only the compensation lamp is carrier of visible light, the intensity was 0.1, which means that the total light intensity has decreased in the proportion of 1/11 of the maximum light flux. This is under normal circumstances completely sufficient for the lighting changes which may be required. During all of this variation of the light flux, the color composition or the "color temperature" has thus been kept constant, and a picture having correct colors is thus obtained.

FIG. **5** shows a further development of the basic idea of the arrangement according to the present invention as shown by means of FIG. 4. In this arrangement voltage regulators have been placed between the mains **26** on the one hand and the main lamp **27** as well as the compensation lamp **28** on the other hand. These voltage regulators in the simplest case, comprise controlled rectifiers, which are controlled in much the same way as the device according to FIG. **4**, and therefore the different details have been provided with the same reference numerals. For improving the control power of the rheostat **14**, however, a fixed resistor **29** has been connected in series with this rheostat, whereby it is possible to connect one terminal of the fixed resistor **29** to one main terminal and the other terminal to the two ends of the rheostat **14**, whereby this will be subjected to a fixed current, which does not vary with the load of the compensation lamp **28**, and whereby only the control voltage, without any substantial consumption of current, is derived from the slider **17** in the voltage regulator **25**. This means a more sure and a more reliable control method. Of course, as the rheostat **13** of the main lamp **27** has also been replaced by a voltage divider coupled resistor, also this will be subjected to a constant current, and only the control voltage, without any substantial consumption of current, will be derived to the voltage regulator **24**.

This arrangement may be further improved by causing the control voltage of the main lamp **10** to determine in cascade coupling the control voltage of the compensation lamp **11**, see FIG. **6**. Also in this case the control voltage is obtained between the conductors **12**, but the voltage required for feeding the lamp is obtained from the main **26**. Two voltage regulators are provided as was the case according to FIG. **5**, but in this case only the voltage regulator **24** is controlled by means of the potentiometer **13** with the slider **16**. The output voltage from the voltage regulator **24** is in this case conducted over the conductors **30** to a control unit of such character, that it will revert the control voltage between the conductors **30** to a control voltage of another value between a pair of conductors **32**, running to the voltage regulator **25**. The control unit **31** is of such a character that the output voltage from the voltage regulator **24** will be reverted according to a nonlinear function in agreement with curve **33**, the horizontal axis of which represents the input voltage over the conductors **30**, and the vertical axis of which represents the output voltage over the conductors **32**. Consequently, lamp **10** will be provided with a variable voltage, the value of which is determined by the voltage regulator **24** in agreement with the adjustment of the potentiometer **13**, whereas simultaneously but in a controlled nonlinear relation, the lamp **11** is provided with a voltage, suitable for the compensation.

It should be explained in this connection why curve **33** in FIG. **6** or the curve **22** in FIG. **4**, resp., has the shape, seen in the figures concerned. When the voltage of the lamp **10** is decreased, the color composition of the light produced by lamp **10** changes to a state, containing more red and less blue and violet. For compensation thereof the voltage of the compensation lamp should be increased, so that it shows a color, containing proportionally less red and more blue and violet. Initially one therefore increases the voltage of the compensation lamp, simultaneously as one decreases the the voltage of the main lamp. At a given decrease of the voltage of the main lamp, this will perhaps still show a stronger participation of red light, but simultaneously the light intensity of the main lamp has decreased so strongly, that the composition lamp will give off a continuously increasingly proportion of the total light flux. If one should thereafter continue to increase the voltage of the compensation lamp and to decrease the voltage of the main lamp, then the redish light of the main lamp would play a completely subordinated roll in comparison with the successively increased light intensity of the compensation lamp, and the total light flux would be overloaded by blue and violet light from the compensation lamp. It is therefore necessary, at a given value of the voltage relation between the two lamps, to decrease the voltage of the compensation lamp, so that this will have regained its normal color temperature at the moment, that the main lamp becomes completely dark, in other words the voltage of the compensation lamp should at this moment again have been decreased to its initial value. The light from the compensation lamp will therefore be the only remaining light.

There is no difficulty to calculate or to graphically construct a curve according to which the voltage of the compensation lamp should vary in the above-mentioned way, once one knows the curves for the mutual dependence of the voltage and the color temperature as well as the light flux existing at each individual voltage from each of the lamps. The construction of the curve **22**, FIG. **4**, or the curve **33**, FIG. **6**, therefore is a purely graphical construction step, which every man skilled in the art may execute, once he has knowledge about the principle of the present invention. FIG. **7** shows a complete wiring diagram of a system according to the invention, which principally agrees with the system shown in block diagram in FIG. **6**. The main for operation of the lamps is here indicated by **34**. This main is an alternating current main of constant voltage. For each of the two lamps **10** and **11** there is a pair of controlled rectifiers **35** and **36** as well as **58** and **59**, which are connected in the traditional way in pairs in parallel with each other but in opposite directions. One of these rectifier pairs is controlled by means of the control unit **54**, and the other rectifier pair is controlled by means of the control unit **60**. Such control units are priorly known for other purposes. They work in such a way, that a variation of the adjustment on the input sides of the control units causes a variation of the time displacement of ignition pulses, which are fed over the conductors **55** and **56** to the controlled rectifiers **35** and **36** or by means of corresponding conductors are fed to the controlled rectifiers **58** and **59**. The control procedure manifests itself in the present case in a direct voltage, which is fed to the control unit **54** or **60**, resp. over the conductor **53** or **63**, resp., controlling the magnitude of the output voltage obtained after the rectifiers **35** and **36** or **58** and **59**, resp. Between the controlled pairs of rectifiers **35** and **36** or **58** and **59**, resp., on the one hand, and the lamp **10** or **11**, on the other hand, there is an equalization filter comprising a series inductance **38** with parallel condenser **39** and a series inductance **61** with parallel condenser **62**, resp. Thereby, the path of current to the two lamps **10** and **11** is described. It will now be described, how the voltage to the two lamps **10** and **11** may be controlled.

The potentiometer **50** is connected to the direct voltage between the terminals **51**, which is exclusively used for a control voltage. It is without any decisive importance to this invention, how this control voltage is created, but it may suitably be created by rectification of the voltage in the main **34** after suitable down-transformation. The slider **52** on the potentiometer **50** is connected to the conductor **53**, and this conductor runs to the control unit **54** and in this way controls the voltage of the lamp **10**.

From the conductors **37**, between which there is lamp voltage, also voltage is derived to a transformer, the primary winding **40** of which being magnetically coupled to two secondary windings **41** and **42** insulated from each other. Each secondary winding is connected to its individual full-wave rectifier, for instance as shown in the drawing, a Graetz-bridge **43** or **44**, resp. The minus terminal of the bridge **43** is connected to the plus terminal of the bridge **44**, whereas the plus terminal of the bridge **43** and the minus terminal of the bridge **44** are connected to each other through a couple of equalization condensers **45** and **46**, so that negative voltage is obtained at the conductor **49**, so that the conductor **48** will function as ground, and so that positive voltage is obtained at the conductor **47**. These voltages should be used for controlling the voltage to the lamp **11**, but as they are directly proportional to the voltage across the lamp **10**, these voltages must first be varied, so that the voltage feeding the lamp **11** will be adapted to the form of the curve **22** in FIG. **4** or the curve **33** in FIG. **6**, resp., which are determined in advance with knowledge about the properties of the lamps **10** and **11**.

The control unit **60** in this case is controlled by the voltage difference between the conductor **48**, on the one hand, and a conductor **63**, on the other hand. The conductor **63** is fed from an amplifier **64**, the one input side of which being formed by the conductor **48** and the other input side being formed by the conductor **65**. In the conductor **65**, a protection resistor **66** is connected, and the other terminal of this resistor is connected through the conductor **83** to the contact point **84**. Between the point **84** and the conductor **48**, a further resistor **86** is interconnected, and the current through this resistor consequently determines the voltage which is fed to the one input circuit of the amplifier **64**. In addition to the current thus running to the conductor of the amplifier **64**. In addition to the current thus running to the conductor **48** from the direct current terminals **51** through resistor **85** and the resistor **86**, a component of current will also run from the condenser **45** through the resistors **68** and **67** and the point **84**, and this component will further tend to run through the resistor **86** to the conductor **48**. The second component of current runs in the opposite direction through the conductor **48**, the resistor **86**, the resistor **82** and the conductor **81** and the Zener-diode unit **80** to the condenser **46**, provided that the path through the Zener-diode unit **80** interconnected in the arrangement is open. Between the conductors **69** and **48** a further battery of Zener-diodes **70–74** is arranged, tuned for different ignition voltages. Each of the Zener-diodes **70–74** is connected in series with a resistor **75–79**. Both of the Zener-diode batteries thus are composed by a number of Zener-diodes, connected mutually in parallel but tuned for different ignition voltages, each having its individual series resistor.

The function of the arrangement as described up to this point is as follows:

When adjusting the potentiometer **50** to a lower voltage for the lamp **10**, the voltage across the condensers **45** and **46** also decreases. At full voltage on the lamp **10** the voltages across the condensers **45** and **46** is maximum, and all of the Zener-diodes are then conductive. The current, which the voltage across the condenser **45** tries to press through resistor **86**, then is equal to the current which the voltage across the condenser **46** tries to press through the same resistor, although in the opposite direction. These two components of current then compensate each other, and only the current from the terminals **51** will flow through the resistor **86**. When the voltages across the condensers **45** and **46** decrease due to a readjustment of the potentiometer **50**, however one Zener-diode after the other in **80** is extinguished. As a consequence thereof, the component of current which the voltage across the condenser **46** tends to press through the resistor **86** quickly decreases. The second component of current from the condenser **45**, on the other hand, does not decrease as quickly, because initially the resistor in this circuit is not changed. A continuously increasing current will therefore flow through the resistor **86** from the point **84** in the direction towards the conductor **48**. Thus, the effect will be achieved that a decreasing voltage to the lamp **10** will cause an increasing voltage over the resistor **86**. When the last Zener-diode in the aggregate **80** has been extinguished, there is a maximum of current through the resistor **86**. As the voltage drop over the resistor **86** by means of the amplifier **64** influences the control unit **60**, the voltage on the lamp **11** has also increased to its maximum value.

At continuous decrease of voltage on the lamp **10** with the decrease of voltage on the condensers **45** and **46** following therefrom, a second Zener-diode unit will get into operation. One diode after the other one will be nonconductive, which causes, the voltage on the conductor **69** and therefore also across the resistor **86** to decrease less than the voltage on the condenser **45** and thus also less than the voltage on the lamp **10**. When the voltage on the lamp **10** has decreased to zero, only the current from the terminals **51** will flow through the resistor **86** that current is the same value as the one which existed at the beginning of the decrease of the light intensity. The lamp **11** therefore has in this position regained the same voltage which it has when the lamp **10** had maximum voltage.

FIG. **8**, finally, indicates method for determining the curve according to which the voltage on the compensation lamp should vary, and for guidance in the dimensioning of the Zener-diodes as well as of their resistances. The diagram is made in a so-called diagonale diagram. Thus, there are four quadrants having mutually different tasks. The quadrant above the horizontal axis and at left of the vertical axis contains a curve G, which is plotted according to the properties of the main lamp **10**. The horizontal axis indicates the relative color temperature of said lamp, whereas the vertical axis indicates the relative light flux of the main lamp. In the quadrant situated at right of the vertical axis and below the horizontal axis, the light flux of the auxiliary lamp is indicated by the curve H along the vertical axis in a direction downwardly, said light flux being measured in relation to the maximum value of the light flux of the main lamp, and the horizontal axis forms a direct continuation of the scale situated at left of the vertical axis. The curve to be determined is situated in the quadrant, which is positioned under the horizontal axis but at the left of the vertical axis. This curve I thus forms the locus of the light flux of the auxiliary lamp in relation to the color temperature of the main lamp, plotted in direction downwardly along the vertical axis. Finally, a pure auxiliary curve, which is required for the construction, is placed in the quadrant situated above horizontal axis and at the right of the vertical axis. This curve is indicated by J.

Given curves thus are G and H. The sought curve is I. The curve J only is an auxiliary curve without other importance for the invention than the one which will be evident from the following description of the plotting construction.

In this plotting construction one starts from a given, deliberately chosen point on the curve G, for instance the point a. A horizontal line *b* is drawn from this point to a point *c* on the auxiliary curve J, which is assumed by guessing, and from this point a vertical line is drawn downwardly, until it hits the curve H in the point *d*. One now draws a vertical line *e* from the point *a*, also a horizontal line *f* from the point *d*. If the point *c* has been correctly chosen, then the crossing point *g* between the lines *e* and *f* should be situated on the curve I. The check that the construction is correct is obtained by drawing a so-called checking diagonale *h* through the points *c* and *g*. If this runs through the origin, then one has accidentally chosen the point *c* correctly, but normally one cannot count on success the first time, but one has to use a plotting method, by which one will successively get closer to the correct points. After one has in this way determined a first point on the sought curve I one will have to make the same plotting construction starting from another point on the curve G, and successively one will then get the locus for all of the points *g* obtained, which will together form the sought curve I. Guided by this curve one may thereafter construct the parts of the arrangement, which should indicate the correct voltage to the compensation lamp dependent upon the voltage of the main lamp, so that the combined light flux will get constant color temperature.

I claim:

1. Illumination apparatus to be used in connection with picture recording or reproduction in color comprising a first lamp, a second lamp smaller than said first lamp, means for varying the color temperature of said first lamp, means for varying the color temperature of said second lamp, and coupling means for said color temperature varying means such that a change in the color temperature varying means such that a change in the color temperature of said first lamp causes a change in the color temperature of said second lamp, the latter change being sufficient indirection and amount to compensate for the former change.

2. Illumination apparatus according to claim **1** wherein the normal operating color temperature of said first lamp is substantially the same as that of said second lamp.

3. Illumination apparatus according to claim **1** wherein said means for varying the color temperature of said first lamp comprises means for changing voltage to change the light intensity thereof, wherein said means for varying the color temperature of said second lamp comprises means for changing voltages to change the light intensity thereof, said coupling means being arranged to increase the voltage to said second lamp when the voltage to said first lamp is decreased from maximum until a point of at least approximate equilibrium between the color temperatures of these lamps is reached, and to thereafter decrease the voltage to said second lamp on further decrease in voltage to said first lamp.

4. Illumination apparatus according to claim **1** wherein said means for varying the color temperature of said first lamp comprises means for varying the voltage to said first lamp comprising a first variable resistor and said means for varying the color temperature of said second lamp comprises means for varying the voltage to said second lamp comprising a second variable resistor.

5. Illumination apparatus according to claim **4** wherein said first and second resistors each comprise slide means for varying the resistance value thereof, and wherein said coupling means comprises a member linking said slides.

6. Illumination apparatus according to claim 4 wherein at least one resistor comprises a wound resistance wire with a variable winding spacing, the spacing of the windings being such that the color temperature of the combined light from said first and second lamps is substantially constant over the range of resistance values of said resistors.

7. Illumination apparatus according to claim 4 wherein said means for changing voltage of said first and second lamps each further comprises a voltage regulator electrically connected to said variable resistor and to said lamp.

8. Illumination apparatus according to claim 7 wherein the means for changing voltage of said second lamp further comprises a fixed connected in series with said variable resistor.

9. Illumination apparatus according to claim 3 wherein said means for changing the voltage to said first lamp comprises a first variable resistor, and said means for changing the voltage to said second lamp comprises a control unit responsive to the output voltage of said first variable resistor to produce a control unit output voltage fed to said second lamp, the latter output voltage compensating for the color temperatures of said first lamp determined by the setting of said first variable resistor.

10. Illumination apparatus according to claim 9 wherein said means for changing the voltage to said first lamp further includes a voltage regulator controlled by the output voltage of said variable resistor, and wherein said means for changing the voltage of said second lamp further includes a voltage regulator controlled by the output voltage of said control unit.

11. Illumination apparatus according to claim 9 wherein said control unit is supplied with direct current from a first voltage supply and wherein said first and second lamps are each supplied with alternating current from a second voltage supply.

12. Illumination apparatus according to claim 10 wherein each of said voltage regulators comprises two controlled rectifiers connected in parallel in the line supplying current to its respective lamp, said rectifiers being connected in electrically opposite directions.

13. Illumination apparatus according to claim 12 wherein said means for changing the voltage to said second lamp comprises a transformer, the primary winding of which is connected into the conductor supplying current from said voltage regulator to said first lamp, the secondary winding thereof being connected to a rectifier for feeding rectified voltage to said control unit.

14. Illumination apparatus according to claim 13 wherein the voltage from said secondary winding is connected to said control unit through a plurality of Zener rectifiers graded by means of ignition voltage resistors, the rectifier grading providing the correct characteristics for compensation of a change in the color temperature of said first lamp.

15. Illumination apparatus according to claim 14 wherein said transformer includes two secondary windings each being connected to one set of Zener-rectifiers along with control voltage controlled resistors one of said set of Zener rectifiers being intended to cause a rise of voltage to said second lamp required in the beginning of the control range, whereas the other set of Zener rectifiers is intended to cause the decrease of the voltage to said second lamp required at the end of the controlled range, said two sets of graded Zener rectifiers being for this purpose connected in directions electrically opposite to each other.

16. Illumination apparatus according to claim 15 further comprising an amplifier connected in the conduit between the Zener rectifiers and the control unit for said second lamp.

17. Illumination apparatus according to claim 13 wherein said rectifier comprises a double wave rectifier.

18. Illumination apparatus according to claim 17 wherein said rectifier comprises a Graetz-bridges.

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