

Aug. 28, 1962

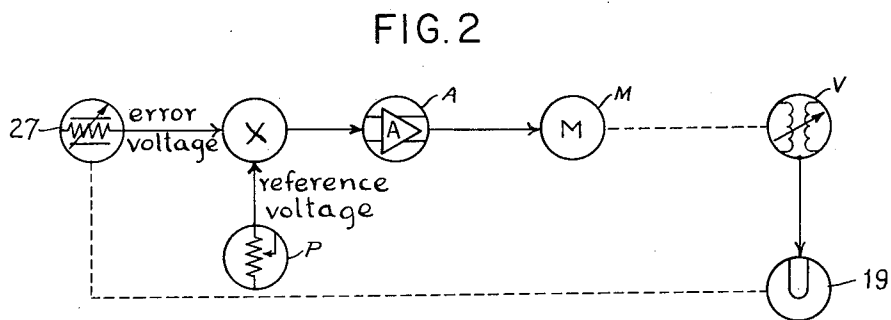
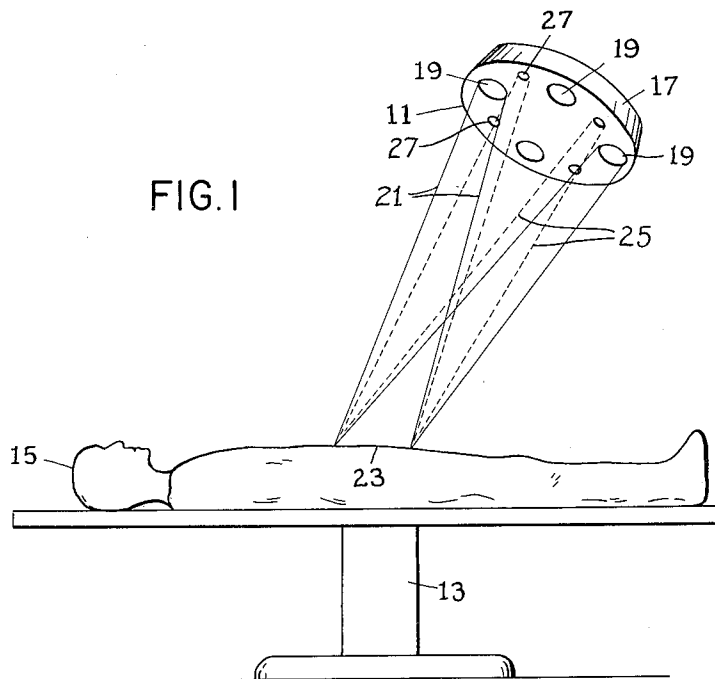
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3,051,869

VARIABLE INTENSITY LAMP

Filed Jan. 8, 1959

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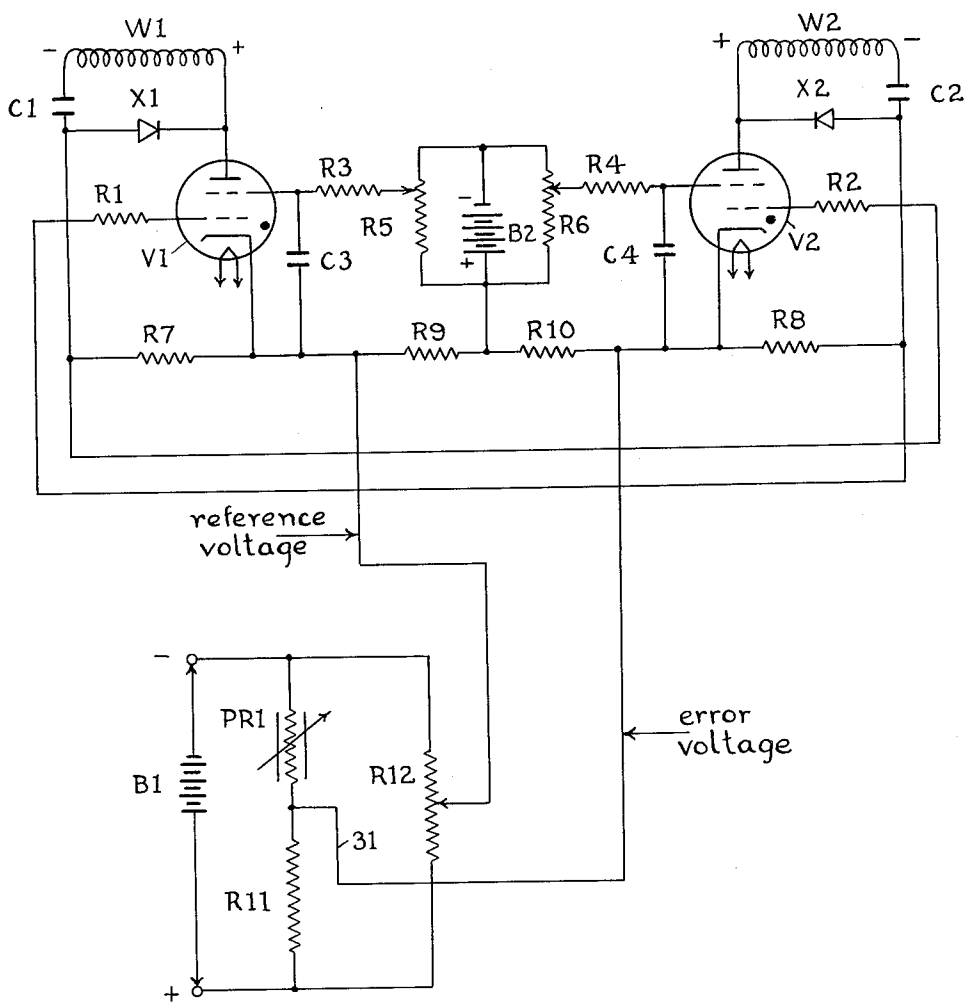
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VARIABLE INTENSITY LAMP

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FIG. 3



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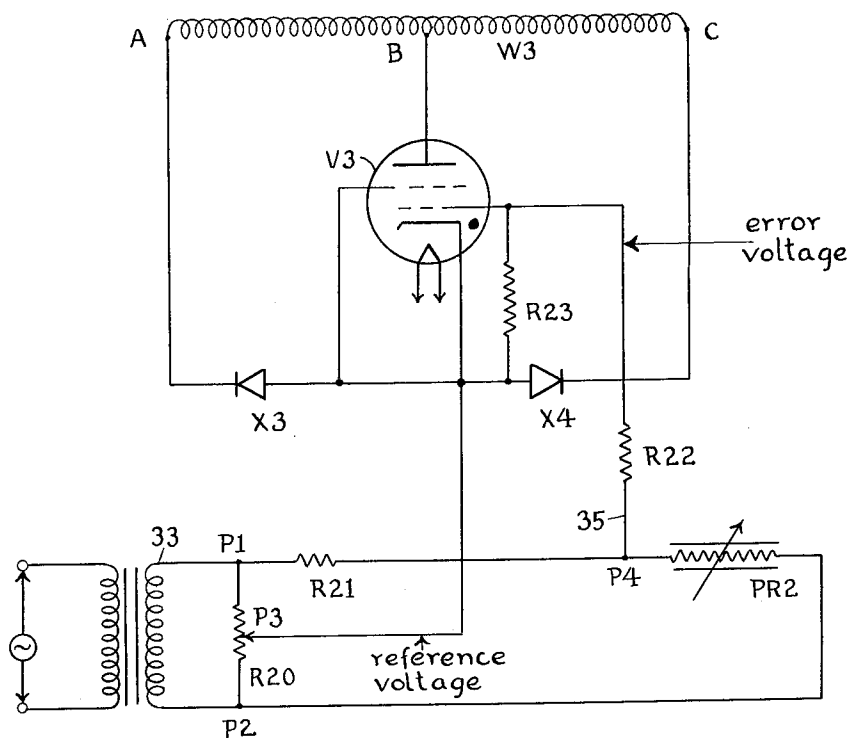
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FIG. 4



3,051,869

VARIABLE INTENSITY LAMP

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The present invention relates to a variable intensity lamp and, more particularly, to an automatically controlled variable intensity lamp for producing an illumination of substantially constant intensity at a specified area despite interferences between the area and the lamp or other changes of conditions affecting the illumination of the area. For instance, in an operating room it is desirable that the operative site on a patient lying on an operating table have a substantially constant illumination even though the doctors and nurses cast shadows by coming between the lamp and the operative site or if there should be a failure of some other light source in the room contributing to the illumination of the operative site.

Accordingly, an object of the invention is to provide a generally improved and more satisfactory variable intensity lamp for automatically producing a substantially constant illumination of an area despite changes in conditions affecting the illumination of the area.

Another object of this invention is to provide a new and improved lamp for automatically illuminating an operating table with light of substantially constant intensity despite physical interference by the doctors and nurses between the table and lamp during the course of the operation.

Yet another object is the provision of a new and improved automatically controlled variable intensity lamp responsive to changes in illumination on a particular area so as to vary in brightness accordingly and illuminate the area with light of substantially constant intensity.

Still another object is to provide a new and improved automatically controlled variable intensity lamp responsive to changes in the intensity of reflected light from an operative site on a patient lying on an operating table such as might occur by physical interference of the hospital personnel between the operative site and the lamp, so as to illuminate the operative site with light of substantially constant intensity despite these random interferences.

A further object is the provision of a new and improved variable intensity lamp which operates more economically to provide a substantially constant level of illumination at a particular area despite physical interferences between the area and the lamp and other changes in conditions affecting the illumination of the area.

A still further object is to provide a new and improved lamp for an operating room for facilitating safer and better operations by providing an improved light source.

These and other desirable objects may be attained in the manner disclosed as an illustrative embodiment of the invention in the following description and in the accompanying drawings forming a part hereof, in which:

FIG. 1 is a front elevational view of a variable intensity lamp according to the present invention shown situated above an operating table carrying a patient, the rays from the lamp being indicated in full lines and the reflected light rays being indicated in dashed lines;

FIG. 2 is a schematic of a preferred control system for operating the variable intensity lamp;

FIG. 3 is a circuit diagram of a typical control system in accordance with the schematic of FIG. 2 utilizing a direct current bias supply; and

FIG. 4 is a circuit diagram of a typical system in ac-

cordance with the schematic of FIG. 2 utilizing an alternating current bias supply.

The same reference numerals throughout the several views indicate the same parts.

In FIG. 1 is illustrated a variable intensity lamp 11 constructed in accordance with the principles of the present invention. Although the lamp 11 has general utility wherever it is desired to maintain an illumination of substantially constant intensity in a particular area, it is particularly useful in hospital operating rooms as an overhead light above an operating table. The description will therefore proceed with reference to this preferred use. Accordingly, the lamp 11 is shown in FIG. 1 suspended by means not here depicted, above an operating table 13 on which rests a patient 15 in prone position.

The variable intensity lamp 11 comprises a flanged reflector housing 17 within which are mounted one or more individual lamp units 19, four such units being shown in this figure. The lamp units 19 produce light rays 21 which, as shown by the full lines indicating their path, are directed upon an operative site 23 on the patient 15. The reflected rays from the operative site 23, as indicated by the dash lines 25, are detected by one or more photoresponsive devices 27 mounted in the lamp housing 17, four such devices being illustrated in the preferred embodiment. An appropriate electrical circuit is provided between the photoresponsive devices 27 and the lamp units 19 for maintaining constant the amount of reflected light detected by the photoresponsive devices 27. By this circuit, a decrease of light detected by the devices 27 initiates an appropriate mechanism for increasing the brightness or intensity of illumination of the lamp units 19, whereby the amount of reflected light is correspondingly increased. Of course, a reverse action is desirably taken when the amount of reflected light increases, that is the intensity of illumination of the lamps is decreased until the amount of reflected light reaches a predetermined level. This increase or decrease in reflected light may occur, for instance, if the doctors or nurses tending the patient 15 interpose their bodies between the lamp 11 and the operative site 23, thus casting shadows upon the operative site.

A schematic of a typical system for varying the intensity of illumination of the lamp units 19 so as to produce a substantially constant amount of reflected light detected by the photoresponsive devices 27 is shown in FIG. 2. This system is commonly known as a "closed loop" feedback control system. The photoresponsive device takes the form of a photo-resistor 27 which produces a voltage hereafter known as the error voltage. This error voltage provides a first input to a summing network X. A reference voltage provides a second input to the summing network X and is derived from a potentiometer P. In the summing network X, the error voltage is compared to the reference voltage, the differential output of the summing network becoming the input for a motor control amplifier A. The amplifier A produces a current flow in one or the other of the windings of a motor M connected in series with the amplifier A and the summing network X. A variac V having a wiper arm is actuated by the motor M to cause rotation of the wiper arm, whereby the voltage output of the variac V increases or decreases correspondingly. This output voltage is applied to the lamp 19 to vary the brightness of the lamp 19 to thereby increase or decrease the illumination of the operative site. The increase or decrease in the reflected light from the operative site is again detected by the photo-resistor 27, producing a different error voltage which is again compared with the reference voltage as described above. Thereafter the system operates in a manner already de-

scribed to change the brightness of the operating lamp 19. Actually, the comparison of voltages is a continuous process and when the comparison is nearly equal, that is, when the differential voltage approaches a "null," the amplifier A ceases the production of control signals and the system is in equilibrium. The system is damped by the friction and time lag introduced by the motor-variatic gearing, to prevent instability. The reference voltage produced by the potentiometer P may be adjusted to produce a predetermined intensity of illumination at the operative site.

There are a number of specific circuits which may operate in accordance with the schematic system of FIG. 2. Two of the many possible circuits will be described, one operating from a direct current bias supply and the other operating on an alternating current bias supply.

In the circuit of FIG. 3, a D.C. supply voltage is provided in a convenient manner such as by use of a battery B1. The series combination of a photo-resistor PR1 and a resistor R11 are connected in parallel with the battery B1 and a potentiometer R12. The wiper on the potentiometer R12 is adjusted to supply an appropriate tap-off voltage hereafter known as the reference voltage. To provide an error voltage dependent in magnitude on the resistance of the photo-resistor PR1, a lead 31 is tapped between the photo-resistor PR1 and resistor R11.

The reference and error voltages are applied to a servo-amplifier having connections to the control windings W1 and W2 of a reversible A.C. motor, the speed and direction of rotation of which is determined by the servoamplifier. It is to be understood, of course, that the reversible motor controls the position of the wiper of a variac in accordance with the schematic of FIG. 2. The positive side of the winding W1 is connected to the plate of a thyatron V1. The winding W1 is in series with a capacitor C1, and a rectifier X1 is in parallel with both, the rectifier being conductive in the direction of the plate of the thyatron. In similar fashion, the positive side of the motor winding W2 is connected to the plate of a thyatron V2, and a capacitor C2 is in series with the winding W2, both being in parallel with a rectifier X2 conductive in the direction of the plate of the thyatron.

To provide a reference potential for the tubes V1 and V2, a battery B2 is provided and a pair of potentiometers R5 and R6 are connected across its terminals. The voltage picked off of potentiometer R5 by its wiper is conducted through a resistance R3 to the shield grid of thyatron V1, and in similar fashion the voltage picked off of potentiometer R6 is conducted through a resistance R4 and impressed on the shield grid of thyatron V2. The cathodes of the tubes V1 and V2 are referenced to the shield grids by being connected through resistances R9 and R10, respectively, to the positive terminal of the battery B2. Capacitors C3 and C4 extend between the shield grid and cathode of the tubes V1 and V2, respectively.

The cathode potential of thyatron V1 is impressed through resistance R7 and R2 on the control or signal grid of thyatron V2, the negative side of the capacitor C1 being tapped into this electrical path between the two resistances. In similar fashion, the potential of the cathode of tube V2 is impressed on the control grid of the tube V1 through resistances R8 and R1, the negative side of the capacitor C2 being tapped into this circuit between the two resistances. The reference voltage from the potentiometer R12 is applied to the cathode of thyatron V1, whereas the error voltage dependent on the resistance of the photo-resistor PR1 is applied to the cathode of thyatron V2.

In considering the operation of the servoamplifier, it is to be noted that the motor control windings W1 and W2 are wired into the circuit so that the plate potentials at the thyratons V1 and V2 are in phase. Thus, when

the error and reference voltages are equal, the cathodes of V1 and V2 are also at the same potential and an equilibrium condition exists. The lamps 19 powered by the variac therefore stay at a substantially constant brightness. The potentiometer R12 may be adjusted to supply a desired reference voltage according to the level of illumination desired at the operative site.

A change in the intensity and amount of reflected light from the operative site 23 causes a change in the resistance of the photoresistor PR1 and as a result the error voltage increases or decreases correspondingly. If the error voltage becomes more positive than the reference voltage, then the control grid of V1 will become relatively more positive than its cathode. When the plate of V1 is sufficiently positive V1 will fire. When V1 conducts, current will flow in the circuit from the anode to the cathode, through R7 to C1, through C1 and through W1 and back to the anode. When current flows through R7, the cathode end becomes more positive with respect to the capacitor end. Thus, whenever V1 fires, the control grid of V2, which is connected to the capacitor end of R7 through resistor R2, experiences a sudden increase in negative bias, preventing V2 from firing as long as V1 is conductive. As long as this cathode imbalance exists, V1 fires each half cycle and V2 fires on neither half cycle, and the motor moves stepwise in the direction directed by winding W1. The variac wiper thus moves to a new position to vary the voltage supplied to the lamp units 19 to change correspondingly the illumination supplied to the operative site 23. At the new position of equilibrium, the error voltage becomes substantially equal to the reference voltage, the cathode balance is restored and tubes V1 and V2 are again in equilibrium, holding the variac wiper in substantially the same position.

Should the error voltage become more negative than the reference voltage, tube V2 operates each half cycle in a manner similar to that described above, whereas tube V1 is driven to cut off by having the relatively negative potential of the capacitor end of R8 impressed through the resistance R1 on the control grid of V1. The control motor moves stepwise in a direction directed by winding W2 until a new condition of equilibrium is attained.

A satisfactory servoamplifier has been constructed in which the various components have the following values:

C1, C2=3 mfd.
C3, C4=0.01 mfd.
R1, R2=50K ohms
R3, R4, R9, R10=150K ohms
R5, R6=50K ohms
R7, R8=500 ohms
R11=100K ohms
R12=150K ohms
V1, V2=2D21 or 2D21W thyatron
X1, X2=selenium rectifier
W1, W2=control windings of a Barber Colman reversible A.C. control motor
B1=150 volts direct current
B2=6 volts direct current

In FIG. 4, a circuit using an alternating current bias supply is illustrated and operates in accordance with the schematic system of FIG. 2. The alternating current supply is conventional 110-120 volts, 60 cycles per second. Connected across the A.C. supply is a phase matching transformer 33 preferably having a 1:1 ratio. Across the output coil of the transformer 33 is inserted a potentiometer R20 having a wiper for tapping off a desired voltage, hereafter called the reference voltage. In parallel with the potentiometer R20 is the series combination of a resistance R21 and a photo-resistor PR2. A lead 35 is tapped between these series resistors and taps off a voltage dependent on the resistance of the photo-resistor PR2, hereafter called the error voltage.

A reversible A.C. control motor is provided having a control winding W3 having ends A and C. A center tap

at point B of the winding W3 is connected to the plate of a thyatron V3. The winding ends A and C, which are electrically 180° out of phase, are each connected to the cathode of the tube V3. A rectifier X3 is inserted between the end A and the cathode and is conductive in the direction of the end A. Similarly a rectifier X4 is inserted between the other winding end C and the cathode and is conductive in the direction of end C. The shield grid of the tube V3 is tied to the cathode and therefore has the same potential. The cathode of the tube is connected to the wiper of the potentiometer R20 and thus has the reference voltage impressed on it. The control grid of the tube is connected through a resistance R22 to the tap-off lead 35 and thus has the error voltage applied to it. A by-pass resistor R23 is inserted between the cathode and control grid.

In the operation of the circuit of FIG. 4, the potentiometer is set to give the desired reference voltage according to the level of illumination desired. The control motor having the winding W3, of course, operates a variac wiper supplying power to a lamp unit 19. When the reference and error voltages are equal or substantially equal, the cathode and control grid of the thyatron V3 are substantially at the same potential and the tube does not fire.

The circuit operates in the following manner when the error voltage is not equal to the reference voltage. As an example, let the potentiometer R20 be adjusted so that the wiper is electrically midway between points P1 and P2, these points being at the ends of potentiometer R20 as shown in FIG. 4. If the illumination is such that the resistance of the photo-resistor PR2 has a resistance precisely equal to that of resistance R21, there will be no potential difference between points P3 and P4, point P3 being located at the wiper of potentiometer R20 and point P4 being located at the tap between lead 35 and the connection between resistance R21 and potentiometer PR2. However, if the amount of light falling on PR2 decreases its resistance will increase and the potential of point P4 will approach the potential of point P1. If at this instant the A.C. voltage across transformer 33 is such that P1 is positive, then P4 will become more positive than P3 and there will be an instantaneous positive potential on the control grid of the thyatron. If at the same instant, end A of winding W3 is negative with respect to center tap B, tube V3 will fire, passing current from tap B to the anode of V3, through the tube to the cathode, through rectifier X3, thence to winding end A and through the winding half AB back to mid-point B. The motor will run in the direction controlled by winding half AB. During the next half cycle, point P4 will swing negative with respect to P3 and, although mid-point B will be positive with respect to end C, the tube will not fire because of the negative error signal on the control grid from point P4.

If the resistance of photo-resistor PR2 decreases, due to an increase in illumination, the polarity of point P4 approaches that of point P2 resulting in a phase shift of the error signal with respect to the two halves of winding W3. Thus, winding half CB will control the direction of rotation.

One can see that the motor operates every half cycle, until the error and reference voltages are substantially equal, at which time equilibrium is again established.

A circuit according to FIG. 4 which proves to be satisfactory has the following values for its various components.

R20=150K ohms
R21=100K ohms
PR2=Clairax CL-402 photo-resistor
R22=100K ohms
R23=1 megohm
V3=2D21W thyatron
X3, X4=Federal IT & T 1004A rectifier

As has already been mentioned, the particular circuits of FIGS. 3 and 4 and the schematic system of FIG. 2 are merely illustrative ways of regulating the intensity of illumination or the brightness of the lamp units 19 as a function of the intensity of reflected light falling on a photo-resistor. In its broader aspects, the invention includes any light sensitive detector or apparatus which produces a signal dependent on the intensity of illumination falling upon it, and any type of device or circuit between the lamp and the light sensitive detector or apparatus which is capable of reacting to this signal to regulate the intensity of illumination of the lamp in dependence thereon.

The preferred apparatus utilizing photo-resistors and a closed loop feedback circuit between the photo-resistors and the lamp is a very satisfactory arrangement because it operates automatically and adjusts quickly to keep the intensity of illumination at the operative site 23 at a substantially constant level. Stated otherwise, the intensity of reflected light striking the photo-resistor is maintained at a substantially constant level. When using a lamp 11 according to the present invention, the operating personnel are able to perform a better, safer and quicker operation because the lighting is more constant and dependable. Because the illumination automatically increases when shadows are cast on the operative site 23, there is no need to manually shift or otherwise regulate the lighting during the course of the operation. The use of the lamp 11 furthermore is economical since the intensity of illumination is not kept at a needlessly high level in order to provide sufficient illumination during times when shadows are cast or the illumination at the operative site is reduced for one reason or another.

It is seen from the foregoing disclosure that the above mentioned objects of the invention are well fulfilled. It is to be understood that the foregoing disclosure is given by way of illustrative example only, rather than by way of limitation, and that without departing from the invention, the details may be varied within the scope of the appended claims.

What is claimed is:

1. A variable intensity lamp for illuminating a particular area subject to varying light reflecting properties comprising a lamp unit and a photo responsive device for detecting the amount of light reflected from the area, means for producing an error voltage dependent in magnitude on the amount of reflected light detected by said photo responsive device, means for producing a reference voltage dependent in magnitude on the amount of reflected light desired at the area, means for comparing said error and reference voltages, and means for utilizing the differential between said error and reference voltages to vary the intensity of illumination of said lamp unit to maintain a substantially constant amount of reflected light from said area to be detected by said photo responsive device.

2. A variable intensity lamp for use in an operating room for illuminating an operative site, subject to varying light reflecting properties, in order to produce a substantially constant amount of reflected light, said lamp comprising a light producing means and a photo responsive device for detecting the amount of light reflected from the operative site, and closed loop feedback system means for varying the intensity of illumination of said light producing means in dependence on the amount of reflected light detected by said photo responsive device to maintain substantially constant the amount of reflected light detected by said photo responsive device, whereby the amount of light reflected from the operative site is kept substantially constant despite physical interferences by the operating personnel between the lamp and said operative site.

3. A construction as defined in claim 2, wherein said photo responsive device comprises a photo-resistor and said closed loop feedback system means includes means for producing an error voltage dependent on the resistance

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of said photo-resistor, means for producing a reference voltage dependent on the amount of reflected light desired from the operative site, means for comparing said reference and error voltages, and means for utilizing the difference between said voltages to vary the power supplied to said light producing means to vary the intensity of said light producing means in proportion to the differential between said voltages.

4. A variable intensity lamp for illuminating a particular area subject to varying light reflecting properties, said lamp comprising light producing means and a photo responsive device, and means between said light producing means and photo responsive device for varying the intensity of illumination of said light producing means in dependence on the amount of light reflected from the area detected by said photo responsive device to maintain the amount of reflected light being detected at a substantially constant level.

5. A construction in accordance with claim 4 wherein said photo responsive device is a photo resistor and said means between said light producing means and said photo responsive device is a feedback system means.

6. A variable intensity lamp for illuminating a partic-

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ular area subject to varying light reflecting properties, comprising a light producing means and a photo responsive device for producing a signal dependent on the amount of reflected light from the area detected by said photo responsive device, means for producing a reference signal dependent on the amount of reflected light desired from the area, and means for comparing said signals and utilizing the differential to vary the intensity of illumination of said light producing means to maintain a substantially constant amount of reflected light from the area.

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