

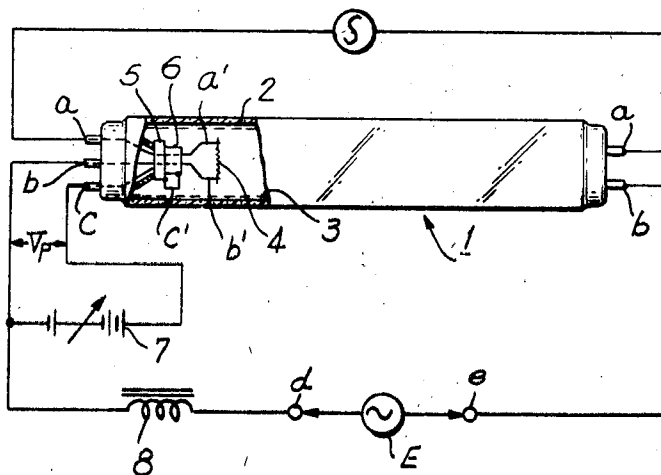
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[45] Patented **July 6, 1971**
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[32] Priority **Aug. 12, 1968, Aug. 21, 1968**
[33] **Japan**
[31] **43/69334 and 43/59766**

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Primary Examiner—Raymond F. Hossfeld
Attorney—Posnack, Roberts and Cohen

[54] **DISCHARGE LAMP DEVICE AND ITS OPERATING APPARATUS**
18 Claims, 22 Drawing Figs.
[52] U.S. Cl. 315/108,
313/109, 313/178
[51] Int. Cl. **H01j 17/22**
[50] Field of Search 313/109,
174, 178, 179, 180; 315/108

ABSTRACT: In a high temperature discharge lamp such as an amalgam-containing fluorescent lamp, the electric potential or an amalgam member is regulated by means of a voltage circuit having thermally sensitive elements to cause a part of the lamp discharge current to flow into the amalgam member for controlling the temperature of the same and hence the mercury vapor pressure within the discharge lamp, so that the light output of the discharge lamp is maintained, for a wider range of ambient temperature variations, substantially equal to the maximum value. When an AC voltage source is coupled to the amalgam member, the phase angle of the applied voltage to the lamp discharge current is selected to obtain favorable control.



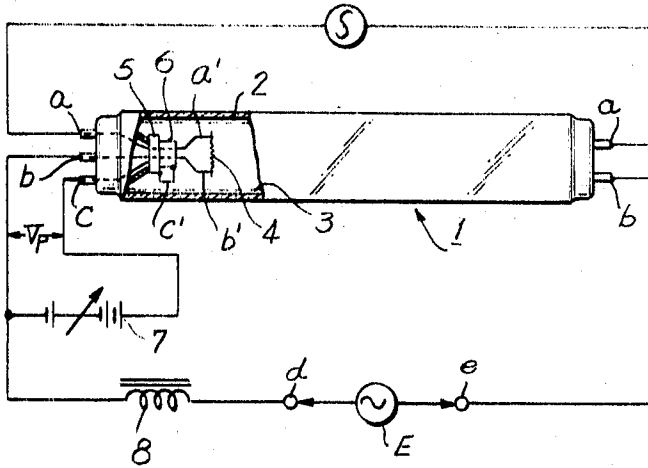


FIG. 1

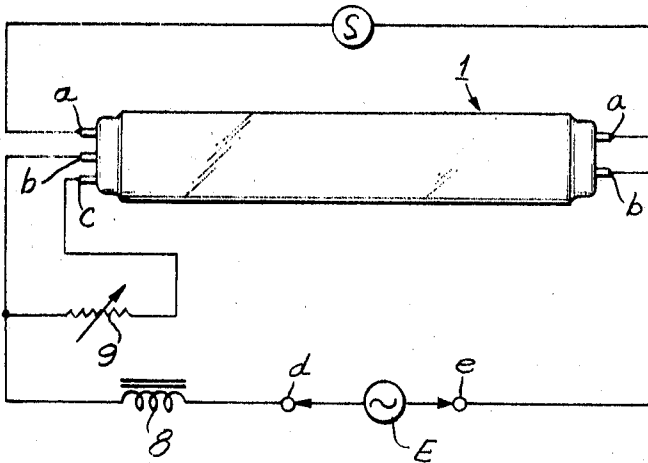


FIG. 2

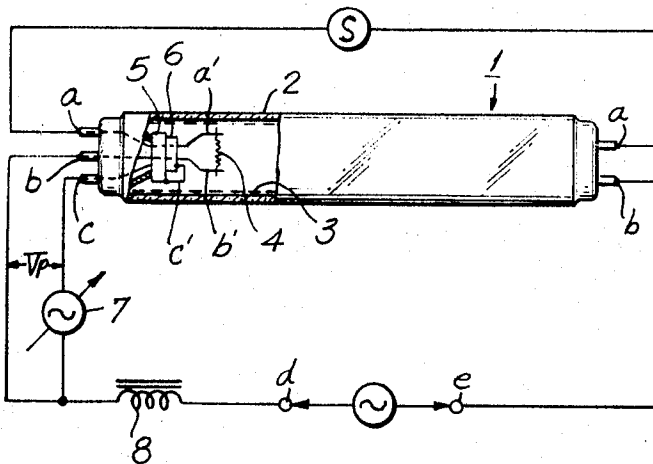


FIG. 3

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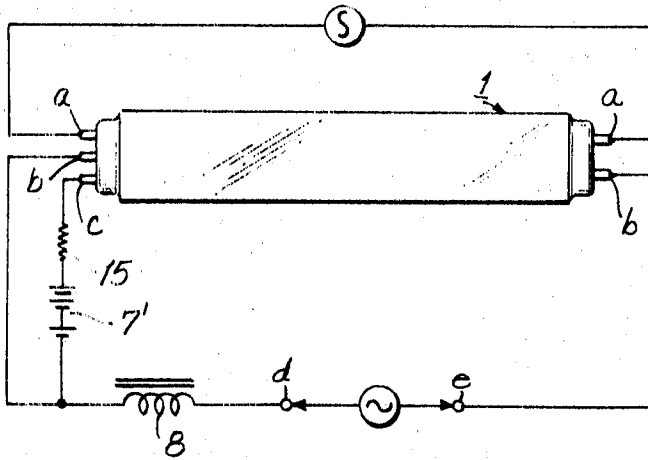


FIG. 4

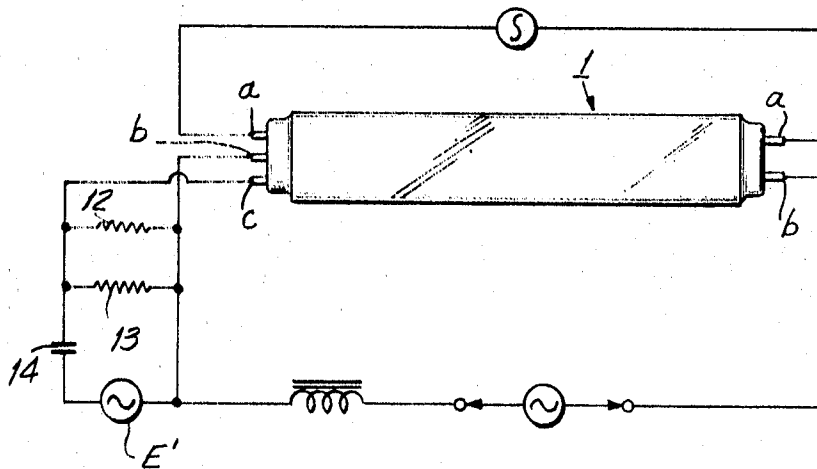


FIG. 5

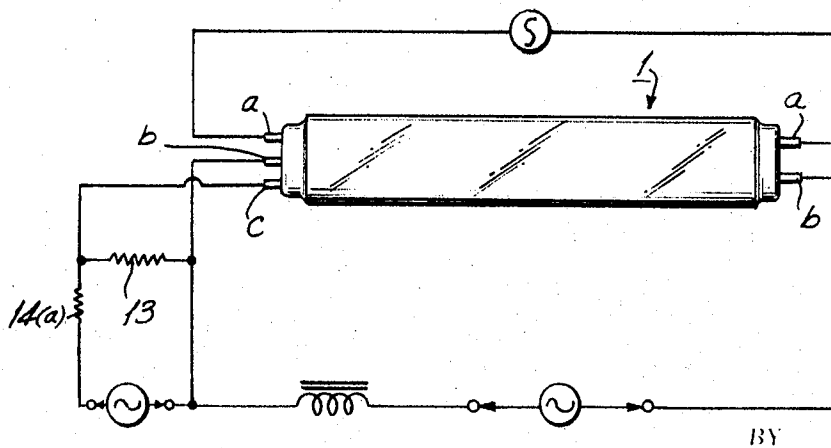


FIG. 6

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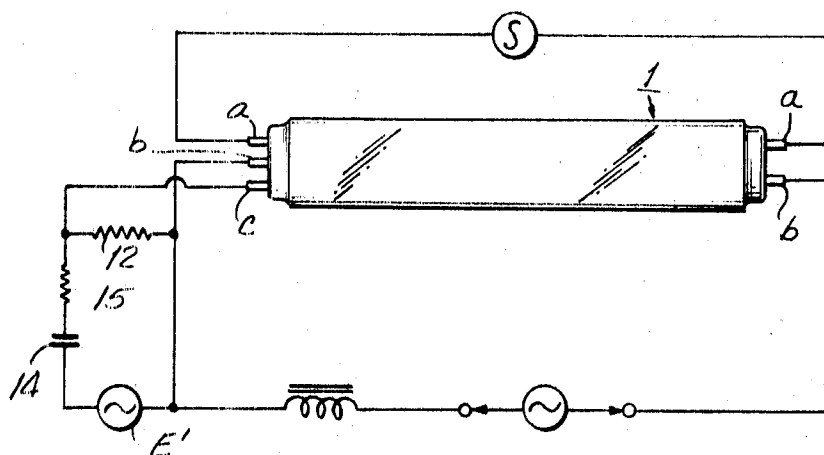


FIG. 7

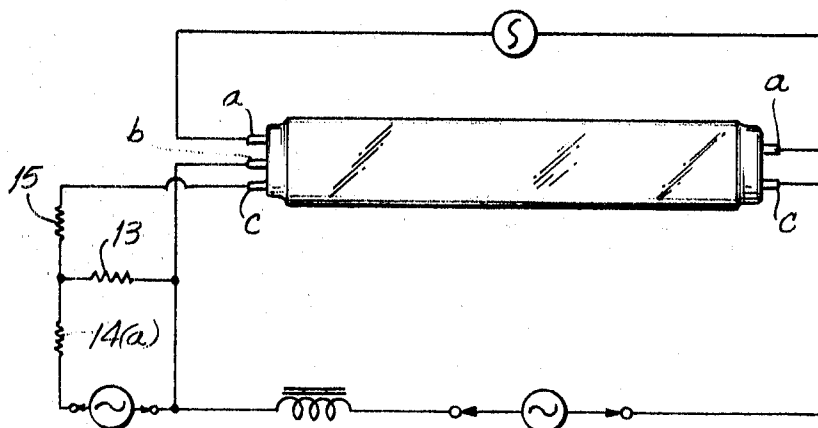


FIG. 8

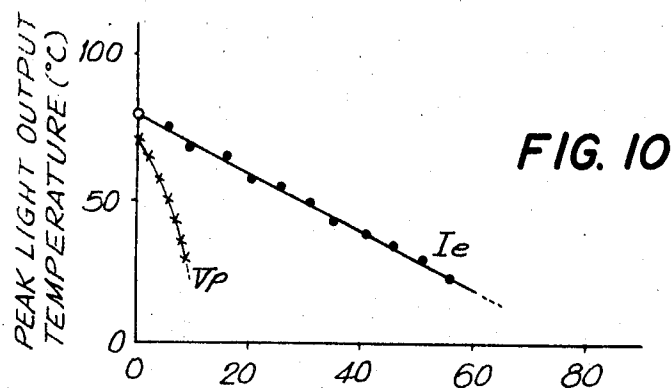


FIG. 10

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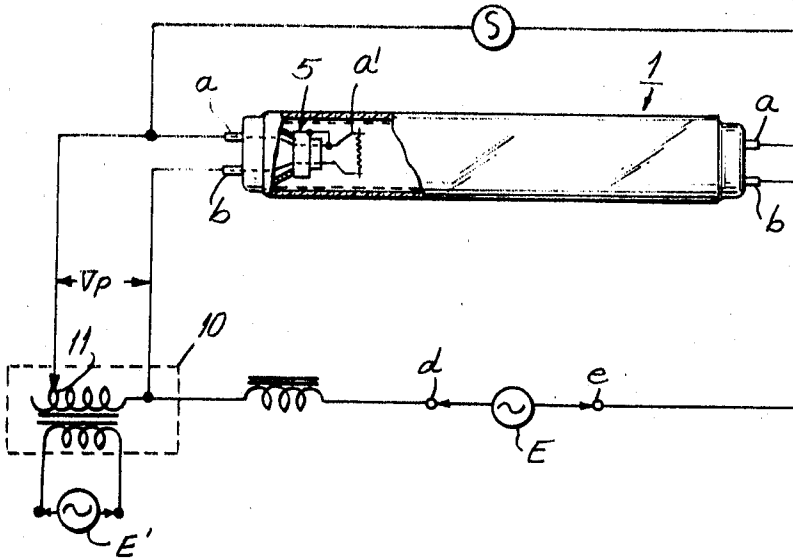


FIG. 9(a)

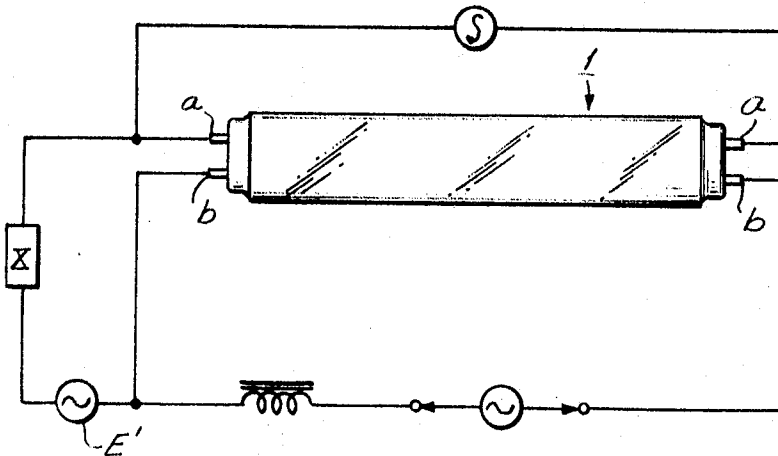


FIG. 9(b)

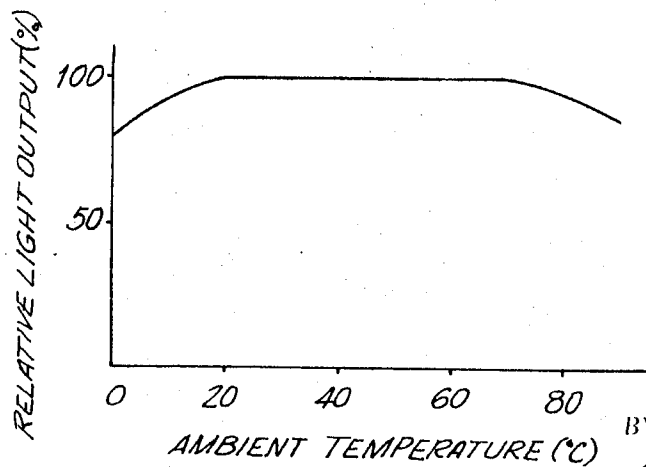


FIG. II

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FIG. 12

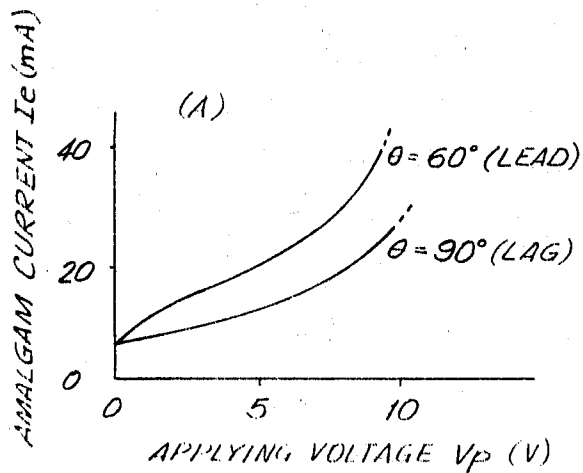
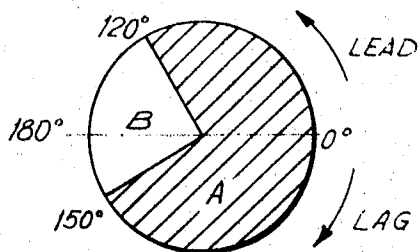


FIG. 13

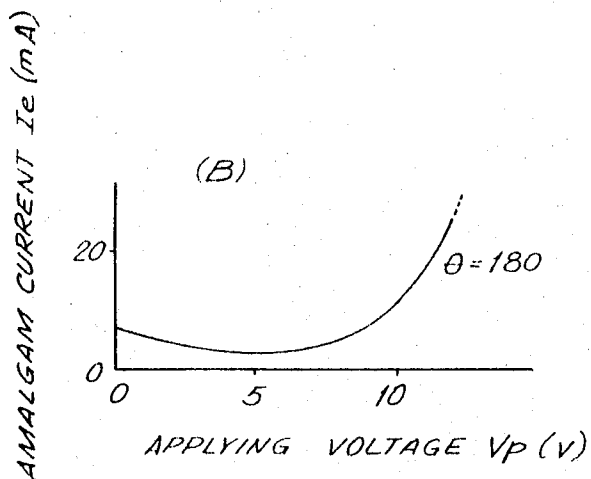


FIG. 14

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FIG. 15(a)

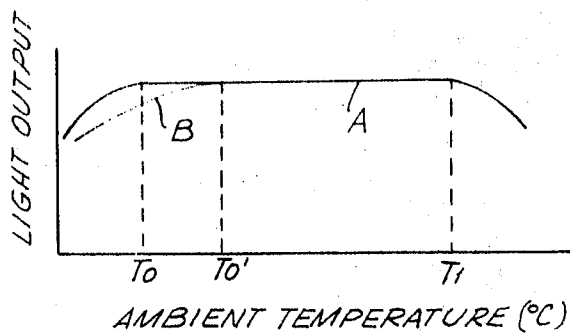


FIG. 15(b)

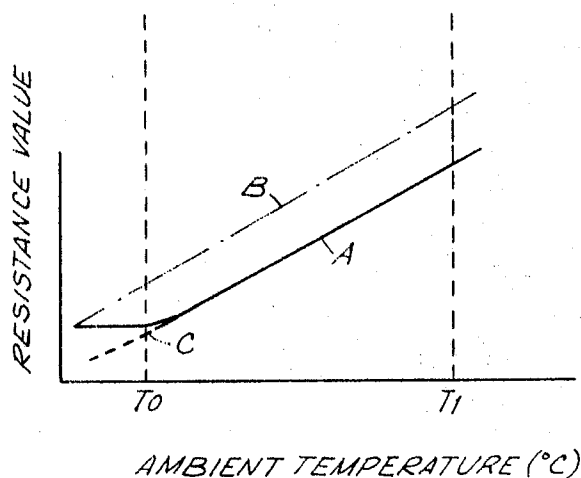


FIG. 16(a)

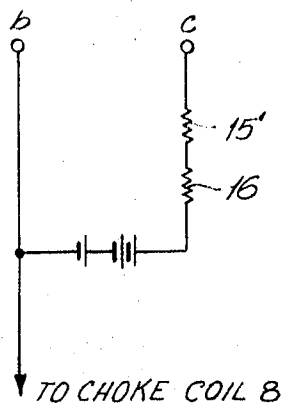
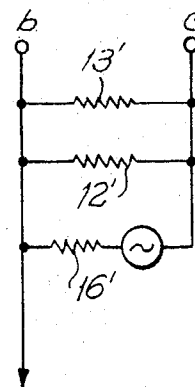


FIG. 16(b)



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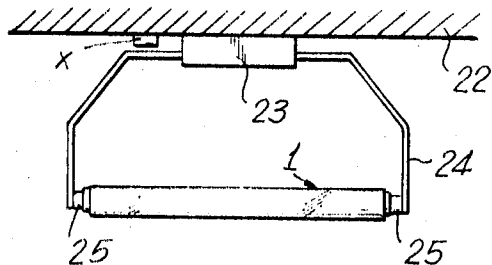


FIG. 17(a)

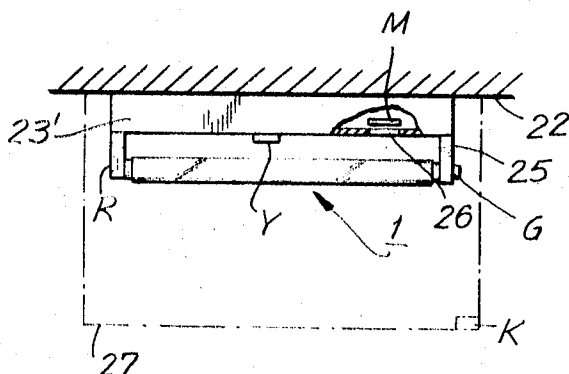


FIG. 17(b)

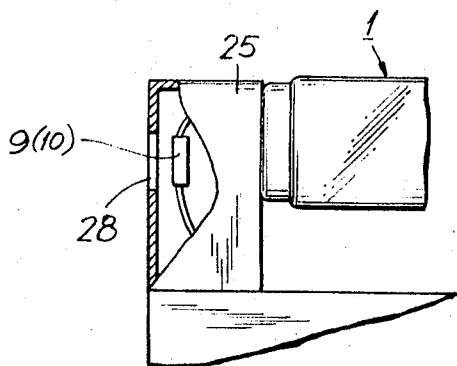


FIG. 17(c)

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DISCHARGE LAMP DEVICE AND ITS OPERATING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to an improved low-pressure mercury vapor discharge device and its operating circuits and more particularly to an amalgam-containing fluorescent lamp the maximum light output of which, normally dependent on ambient temperature variation, can be controlled by applying an electric potential to a mercury-amalgam member in the lamp.

DESCRIPTION OF THE PRIOR ART

It is well known that the efficiency of a fluorescent lamp depends on the mercury vapor pressure therein defined by temperature of the coolest portion of the lamp. The maximum luminous efficiency of a fluorescent lamp is usually obtained when the coolest portion of the lamp wall is maintained at about 40° C., and hence at about 6 microns mercury vapor pressure.

If a discharge lamp is installed within a compact cabinet which is almost completely closed or in a place where the ambient temperature is elevated, lamp efficiency may be decreased as a result of the raising of the temperature at the coolest point. For the purpose of preventing a decrease in lamp efficiency and of maintaining the optimum efficiency of the lamp under all operating conditions, it is necessary to control and maintain optimum mercury vapor pressure within the lamp envelope.

However, it is almost impossible to maintain maximum efficiency over a relatively wide range of ambient temperatures in conventional lamps. Accordingly, this requirement has been comprised within a limited and narrow temperature range.

One well-known method of maintaining efficiency is to deposit mercury amalgam within discharge lamps. Use of mercury amalgam is effective to supplement mercury vapor pressure within the lamp. This technique is particularly remarkable for high-output and very high-output lamp types which are usually installed in a high ambient temperature. In this case, supplementation of mercury vapor pressure by amalgam is greater than by mercury alone. In ordinary and lower ambient temperatures, however, the mercury vapor pressure within a lamp envelope containing amalgam material is lower than that of conventional discharge lamps containing mercury alone, and the efficiency of such a lamp drops severely at ordinary and lower temperatures.

To overcome this problem, it has been proposed to control mercury vapor pressure by varying the temperature of amalgam materials disposed on the inner surfaces of discharge lamps by using heating means attached to the outer surfaces thereof. However, many defects have arisen with respect to such type of structure, and handling and costs are increased. In order to obtain a practical effect, much heating power is required and this makes the structure large and costly. In addition, since the amalgam has been heated indirectly through a glass envelope, the response of the amalgam temperature to variations of heating power is too slow, so that the stabilizing period for light output takes a long time. It is also disadvantageous for the heating means to be attached tightly to the associated lamp envelope for improving heat efficiency and, moreover, the external appearance of the lamp is spoiled.

SUMMARY OF THE INVENTION

In accordance with this invention, an improved discharge lamp is provided to eliminate the above disadvantages. This improved discharge lamp contains a mercury-amalgam member and has a lead-in wire connected electrically to the amalgam for controlling mercury vapor pressure within the lamp. An operating circuit for such lamp is also employed to supply an electric potential to the mercury-amalgam member through the lead-in wire for obtaining the operating temperature to obtain maximum light output of the lamp, which temperature is hereafter called peak-light output temperature.

Further, relative to applying an AC voltage to the mercury-amalgam member, the phase angle relative to the discharge current of the lamp has a great influence on controlling the characteristics of the optimum-light output temperature of a discharge lamp of the above type. The characteristics of the peak-light output temperature may be selected for a desired degree of applied voltage V_p by varying the phase angle θ . For example, it is favorable for relatively lower voltages V_p to select the phase angle in such manner that the applied voltage has a phase angle in the range of 0° θ 120° lead or 0° θ 150° lag relative to the discharge current of the lamp, this being referred to the "anode half-cycle" (which takes place when the electrode adjacent the amalgam is at positive polarity): If the applied voltage V_p has a phase angle in the range of 120° θ 180° lead or 150° θ 180° lag, or the other angles mentioned above, these are effective in the "cathode half-cycle" (which takes place when the electrode adjacent the amalgam member is at negative polarity), which is favorable for other applied voltages V_p . In other words, the temperature for obtaining the maximum light output can be regulated by controlling the voltage phase angle θ within the range of the above limits, irrespective of ambient temperatures for the lamp operation.

Furthermore, to achieve the automatic regulation of mercury vapor pressure during lamp operation, this invention discloses voltage circuits for supplying an electric potential to the amalgam, which circuits comprise a combination of thermally sensitive elements. The resistance-temperature characteristic in the voltage circuit is compensated by using a resistor element having characteristics as discussed hereinafter.

BRIEF DESCRIPTION OF THE DRAWING

A preferred embodiment of this invention will be described with reference to the accompanying drawing in which like reference characters refer to like parts throughout the various figures and in which:

FIG. 1 is a schematic circuit diagram together with a partially sectional view of an amalgam-containing discharge lamp in accordance with a first embodiment of this invention;

FIGS. 2 to 8 are respectively different schematic circuit diagrams for amalgam-containing discharge lamps in accordance with further embodiments of this invention;

FIGS. 9(a) and (b) are respectively different schematic circuit diagrams for another type of discharge lamp in accordance with this invention;

FIG. 10 is a graph showing characteristics of the peak-light output temperature (°C) relative to the electric potential (V_p) of the amalgam and the current (I_e) flowing into the amalgam;

FIG. 11 is a graph showing the characteristic of the light output relative to ambient temperature of a lamp in accordance with this invention;

FIG. 12 is a diagram showing the relationship of phase angles between the applied voltage and the discharge current of the lamp;

FIGS. 13 and 14 are graphs showing the characteristics of applied voltage (V_p) versus current (I_e) flowing into the amalgam for different phase angles;

FIGS. 15 (a) and (b) are graphs of temperature characteristics for the improved circuit;

FIGS. 16 (a) and (b) are examples of circuits for supplying an electric potential to the amalgam; and

FIGS. 17 (a), (b) and (c) are respective side views, with partial sections in FIGS. 17 (b) and (c), of different embodiments, these figures illustrating arrangements of the control elements of this invention.

DETAILED DESCRIPTION

FIG. 1 illustrates a discharge lamp 1 of the invention which lamp comprises a glass envelope 2, a phosphor layer 3 coated on the inner surface of the envelope wall, a pair of filament electrodes 4 (of which one is seen) fixed at the end portions of a pair of supporting wires a' and b' implanted in stems 6 at opposite ends of the envelope, and a mercury-amalgam member

5 connected to a supporting wire c' implanted in one of the stems 6. The mercury-amalgam member 5 is wrapped about the outer periphery of the stem 6.

Supporting wires a' , b' and c' are connected to outer lead-wires a , b and c respectively. Element S is a switching element connected between the outer lead-wires a at opposite ends of the lamp. One of the outer lead-wires b is connected to a terminal d through a choke coil 8 and the other of the lead-wires b is connected to a terminal e . A voltage supply such as a DC voltage source 7 is connected between the lead-wires b and c , and an AC power source E is coupled to the terminals d and e . The DC voltage source 7 may be replaced by a variable resistor 9 as shown in FIG. 2, by an AC voltage source 7 as shown in FIG. 3 or by one of the combinations shown in FIGS. 4 to 9.

The mercury-amalgam member 5 is constructed from a nickel plate of 0.2 millimeters' thickness and 5 millimeters' width having a coating of mercury-amalgam materials and wrapped about the stem 6. Mercury-amalgam forming metals such as indium, cadmium, tin, thallium and so forth and alloys thereof can be utilized.

When the AC source E is connected to the terminals d and e of the above-mentioned circuit, the lamp 1 will be operated by actuation of the switching element S. However, since the DC source 6 is connected between lead-wires b and c to apply a voltage V_p to the amalgam member 5 (i.e., between wires c' and b'), some electrons flow into the amalgam member 5 from the main electron current (or counterflow of the main discharge current) of the lamp while one of the electrodes (which is disposed adjacent the amalgam member and is called hereinafter the neighboring filament electrode) is at a positive polarity or in other words is in the anode half-cycle. Generally, the amalgam member 5 is set at higher potential than the neighboring filament electrode 4, so that some of electrons near the electrode 4 are accelerated to rush into the amalgam member 5. Such electrons flowing into the amalgam member (or the counterflow of amalgam current I_e) causes a rising of amalgam temperature, and hence the mercury vapor pressure within the lamp is controlled.

In other words, when the positive electric potential applied to the amalgam member 5 is higher than the positive electric potential of the filament electrode 4, the amalgam member 5 attracts some of the electrons from near the filament electrode 4, and this produces an increased mercury vapor pressure within the lamp by raising the temperature of member 5.

As a result, the optimum effective temperature for maximum light output can be obtained at lower ambient temperatures as well as at the optimum temperature for which the conventional amalgam-containing lamp is designed. Therefore, if the peak-light output temperature for a lamp containing the amalgam member is designed as high as possible for an applied voltage $V_p=0$, the designated temperature can be shifted to its lower side by increasing the applied voltage V_p or current flowing into the amalgam member 5. Thus, the effective temperature range to obtain maximum light output for operation of the discharge lamp 1 is remarkably extended.

The relationship of the peak-light output temperature and the applied voltage V_p or amalgam current I_e has been measured and is plotted in FIG. 10 in which the peak-light output temperature is indicated, in degrees Centigrade of ambient temperature, at which the maximum light output could be obtained. It appears from this figure that the peak-light output temperature, or the optimum operating temperature under ambient temperatures can be obtained in the range of between about 70° C., at which the main discharge current $I_b=0.5A$, the applied voltage $V_p=0V$ or the amalgam current $I_e=7ma$, and 30° C. at which $V_p=8v$ or $I_e=50ma$. Thus, the optimum operating temperature range can be significantly extended. FIG. 11 indicates such relation of light output versus ambient temperature and a range of ambient temperatures in which the maximum light output can be obtained. It is of merit that the supply of V_p of about 10v peak is easily derived from part of a ballast choke without enlarging the size thereof.

Similar effects are also obtained by the use of a variable resistance 9 as illustrated in a variation of FIG. 2. In this case, an amalgam member 5 (not shown) acts as an auxiliary anode electrode of the neighboring filament electrode 4 during the anode half-cycle, so that certain electrons will flow into the amalgam member 5. Since the electrons flowing into the amalgam is adjusted by varying the resistance value of the resistor 9, the peak-light output temperature of the lamp can be established by adjusting the resistance thereof. It is also desirable to use a thermally sensitive element for the resistance 9 to control automatically the peak-light output temperature.

In another embodiment of this invention shown in FIG. 9(a), a discharge lamp 1 contains an amalgam member 5 attached to a bracing wire a' . In this case a conventional discharge lamp having two instead of three outer lead-wires at each end is provided. The amalgam member 5 attracts electrons because of the application thereto of a higher voltage, from tap 11 of a transformer 10 connected to an AC voltage source E' , than is applied to lead b .

It has also been found that when a supplementary AC voltage source is used as the voltage V_p applied to the amalgam member 5 as illustrated in embodiments of FIGS. 3 and 5 to 9, the phase angle (θ) relative to the main discharge current I_b is important for controlling the amalgam current I_e . Thus, selection of the phase angle also controls the mercury vapor pressure within the lamp, as does the selection of the value of the applied voltage V_p .

For purposes of explanation, the phase angle (θ) between the applied voltage V_p and the main discharge current I_b , can be classified into the two ranges A and B as shown in FIG. 12 due to its V_p-I_e characteristics. For the case of range A, characteristic curves of I_e versus V_p are shown with a parameter of the phase angle in FIG. 13, in which I_e versus V_p curves for two different phase angles of the 60° lead and the 90° lag are illustrated.

On the other hand, when the phase angle (θ) is selected within the range B, a slight amount of amalgam current I_e (or within the range B, a slight amount of amalgam current I_e (or counterflow of electrons) flows into the amalgam member from the other of the electrodes opposed to the amalgam member, hereinafter called an opposite filament electrode, during the anode half-cycle, because the substantial electric potential of the amalgam member over the half-cycle becomes lower than that of the neighboring filament electrode due to selection of the phase angle in the range B. However, the amalgam member entraps some electrons emitted from the neighboring filament electrode during the cathode half-cycle, because the amalgam member substantially takes on a positive polarity over the half-cycle due to the phase angle (θ). Therefore, the amalgam current I_e caused in the cathode half-cycle is mainly used as heating current for the amalgam member.

The I_e versus V_p curve shown in FIG. 14 includes two parts. The first part is that wherein the amalgam current I_e is constant or slowly decreasing in disregard of increasing voltage V_p , and the second part is that wherein I_e is increased in proportion to voltage V_p . As seen from this curve, the second part, which results from applying a voltage V_p which is greater than a certain value, is useful for controlling the temperature for obtaining optimum light output of the lamp.

Since the amalgam temperature can be controlled as mentioned above, the lamp is always operated at the best condition, that is, the peak-light output temperature or the operating temperature for maximum light output is selected freely in the range of about 30° to 70° C. and for 80 percent light output (which is utilizable efficiency) the range can be lowered by about 30° as appears in FIG. 11. Such selection is achieved by varying the value of the phase angle and/or voltage V_p within a certain range. Though there are two voltage ranges for leading and lagging phase angles versus discharge current, this is not a significant difference in that the temperature of the mercury-amalgam member can always be maintained at the optimum for mercury vapor pressure by controlling the electron current.

It should be noted that in the range A, the electric potential of the amalgam member is maintained substantially higher than that of the neighboring filament electrode during the anode half-cycle. Therefore, temperature of the amalgam member is controlled by the amalgam current caused by the main discharge current of the lamp, that is, electrons flowing into the amalgam member from the opposite filament electrode. In range B, the electric potential of the amalgam member becomes frequently lower than that of the neighboring filament electrode during the anode half-cycle, so that little if any useful amalgam current is obtained in this half-cycle. However, amalgam current will flow in relatively large amounts during the cathode half-cycle. Therefore, substantial control of the amalgam temperature is achieved during the cathode half-cycle.

For the purpose of obtaining the peak-light output temperature by varying the phase angle (θ) between the applied voltage V_p and the main discharge current I_p , several circuits for generating the electric potential of the amalgam member (or V_p) can be used as illustrated in embodiments of FIGS. 5, 7 and 9. In FIGS. 5 and 7, the phase angle (θ) is adjusted by a C-R circuit consisting of a capacitor 14 and a resistor 12. In FIGS. 9(a) and (b), impedance value within the closed circuit for generating the applied voltage V_p determines the phase angle (θ). In FIG. 9(b), an impedance component element X is used as a capacitive or inductive impedance. For producing the applied voltage V_p having a given phase angle (θ), it is also well known to use a three-phase power source in such a manner that one phase of the power source is connected directly with the lamp through a choke coil, and a compounded two-phase of the power source is used as a supplemental voltage source through voltage controllers for the each phase and a transformer.

In FIGS. 4 to 8, the peak-light output temperature is maintained automatically at the best condition by controlling means in the circuit for generating the electric potential of the amalgam member. Specifically, it is achieved by the use of thermally sensitive elements such as resistors having particular characteristics of ambient temperature versus resistance.

For instance, a thermally sensitive element having a negative temperature coefficient of resistance, such as a thermistor 13 is connected between the lead wires *b* and *c* together with a resistor 14 (a) as shown in FIG. 6, or a combination of thermally sensitive elements 13 and 15 respectively having negative and positive temperature coefficients of resistance as shown in FIG. 8 may be connected to the lamp. A further circuit shown in FIG. 7 includes a resistor 12 together with thermally sensitive element 15 having a positive temperature coefficient of resistance in series with capacitor 14. Another circuit shown in FIG. 5 includes a thermally sensitive element 13 having a negative temperature coefficient of resistance in parallel with resistor 12 between the lead-wires *b* and *c*, capacitor 14 being connected between power supply *E'* and lead-wire *c*. By these circuits, it is possible to compensate the controllable range, as described, by the use of thermally sensitive elements having positive and negative temperature coefficient of resistance.

In the embodiments shown in FIGS. 1, 2, 3 and 9, the peak-light output temperature is controlled manually. In FIGS. 4 and 5 to 8, the optimum light output can be maintained continuously by automatic control within the range of about 20° C. to 70° C. This is achieved in FIG. 4, for example, by using a voltage circuit having a thermally sensitive element, such as the above-mentioned element 15 having a positive temperature coefficient of resistance in series between supply 7' and lead-wire *c*. In FIG. 4, the resistance value of the thermally sensitive element 15 varies from about 100 to 1000 ohms in the range of 20° to 70° C., and the DC source 7 supplies a voltage of 7v. As a thermally sensitive element 15, it is preferred to use a plurality of small-resistance elements connected in parallel with each other in order to obtain exact sensibility to ambient temperature.

Since the DC voltage is predetermined in this circuit, the applied voltage V_p is given by the value of the element. However, such value is varied by ambient temperature, and the applied voltage V_p is also varied automatically due to ambient temperature. For instance, when the ambient temperature rises, the resistance value of the element 15 is increased by responding to the elevated ambient temperature so as to increase the voltage drop at the element 15. Thus, both the applied voltage V_p for the amalgam member and the amalgam current I_p are reduced. As a result, amalgam temperature, which is also affected by such elevated ambient temperature, can be constantly maintained by reducing the effect of heating the amalgam member. Therefore, the peak-light output temperature is established by controlling of the amalgam current I_p during the lamp operation irrespective of ambient temperature.

In other words, the thermally sensitive element 15 having a positive temperature coefficient of resistance and connected in series, or the thermally sensitive element 13 having a negative temperature coefficient of resistance and connected in parallel, in the circuit for generating the applied voltage V_p , controls the value of the applied voltage V_p due to ambient temperature by increasing or decreasing its resistance.

In FIGS. 5 and 6, the element 13 controls V_p . For instance, the function of the element 13 is explained by the embodiment in FIG. 6 in which a resistor 14(a) having a relatively large resistance is coupled. If the ambient temperature raises, the resistance value of the element 13 is reduced by responding to the elevated temperature. Since resistance of the resistor 14(a) is relatively large and the voltage drop of the element 13 becomes small, the electric potential of the amalgam member is reduced. Then, heating of the amalgam member is suppressed and the mercury vapor pressure is constantly maintained at the best condition.

In FIGS. 7 and 8, both elements 13 and 15 are used for controlling the applied voltage V_p or amalgam current I_p .

With respect to the physical arrangement of the thermally sensitive elements, it has been found that it is important to dispose the same within 23 cm. from the surface of the associated discharge lamp 1 because response to ambient temperatures around the discharge lamp 1 is important for maintaining maximum light output. In tests, fixtures as shown in FIGS. 17(a) and (b) were used. Different positions of the thermally sensitive element were established for varying distances from the surface of the discharge lamp. These positions included site X on the ceiling, site Y on the outer side of the reflecting plate, site M on the inner side of the reflecting plate, site G on the rear portion of the socket, site R on the inner portion of the socket and site K on the inside of the shade. The desired characteristic of light output was obtained within 23 cm. from the surface of the discharge lamp, but lighting efficiency was seriously decreased when the thermally sensitive element was disposed beyond 24 cm.

It is particularly favorable to dispose the thermally responsive element within 12 cm. of the lamp surface whereby a desired characteristic of light output can be obtained in the ambient operating temperature range of about 20° C. to 70° C., as shown in FIG. 11.

Generally, disposing the thermally sensitive element within 23 cm. of the surface of the lamp obtains the desired light output irrespective of lamp wall temperature. With regard to the position of the element, there is no heat influence from the ballast or such. When the thermally sensitive elements are disposed inside of the fixture, it is necessary to provide a hole 26 (FIG. 17(b)) or 28 (FIG. 17(c)) in the surface of the fixture in order to provide for sensitivity to ambient temperatures.

Furthermore, modifications may be considered for the combinations of thermally sensitive elements. Generally, a thermally sensitive element having a positive temperature coefficient of resistance has the characteristic represented by curve C in FIG. 15(b). However, the controllable temperature range for obtaining the peak-light output temperature is limited

between the upper T_1 and the lower T_0 of ambient temperature as shown in FIGS. 15(a) and (b). The upper limit temperature T_1 is determined by vaporization of the amalgam member due to its components, location and the like, and the lower limit T_0 is determined by vaporization of the mercury alone. Since it is impossible to control the mercury vapor pressure by means of the amalgam member at a lower ambient temperature than the lower limit T_0 , when the thermally sensitive element having a characteristic curve C as shown in FIG. 15(b) is used, a problem is raised that a higher voltage V_p is undesirably applied to the amalgam member at an ambient temperature lower than the lower limit T_0 , because such higher voltage V_p or large amalgam current I_e is not useful to control the mercury vapor pressure within the lamp and also causes undesirable sputtering of the amalgam member or ultimate destruction thereof.

For the purpose of overcoming such difficulty, there was investigated the use of a thermally sensitive element having positive temperature coefficient of resistance as indicated by curve B in FIG. 15(b). However, the result was as shown by curve B in FIG. 15(a) wherein it is seen that the lower limit of the temperature range at which maximum light output is obtained is shifted to T_0' . The above described temperature range is thereby decreased.

For improving the temperature range within which the lamp can produce a substantially maximum light output, a thermally sensitive element having a characteristic curve A as shown in FIG. 15(b) can be used for compensation of the lower side of the temperature range.

In particular, the element 15 having a positive temperature coefficient of resistance and connected in series with the DC voltage source 7' as shown in FIG. 4, for example, is so constructed as to have the resistance-temperature characteristic indicated by curve A of FIG. 15(b). As a result, the temperature range for maximum light output is increased. Since the resistance-temperature coefficient of the element 15 at a temperature lower than T_0 is substantially zero as shown by curve A of FIG. 15(b), the part of the discharge current flowing into the amalgam portion 5 and its supporting wire can be substantially suppressed compared with the case of the conventional discharge lamp, and the possibility of causing electrode material to spatter is completely eliminated.

Although in the above description the resistor 15' is employed as the thermally sensitive element, a thermistor 13' having a negative resistance-temperature characteristic can also be used as the thermally sensitive element. The thermistor 13' can be connected as shown in FIG. 16(b) whereby an effect equivalent to that described above is obtained. In this case, the thermistor 13' should have a characteristic of substantially constant resistance at a lower temperature than T_0 and of decreasing resistance at a temperature higher than T_0 .

A resistor 15' having the characteristic indicated by curve C in FIG. 15(b) and a fixed resistor 16 can be employed and combined as shown in FIG. 16(a). If the thermally sensitive element is a thermistor, it can be combined with a fixed resistor (having a larger resistance than the thermistor) 12' and connected as shown in FIG. 16(b).

The invention has been explained for the switching-start type circuit, but it can also be applied to the rapid-start type of circuit. The position of the amalgam within the lamp is not restricted to the lamp end as this has been illustrated in the drawing by way of example only.

As mentioned above, the optimum temperature for a discharge lamp, according to this invention, can be varied over a wider temperature range by controlling the part of the discharge current branching into an amalgam member disposed within the lamp.

What we claim is:

1. Lamp apparatus comprising: a power source; discharge lamp means adapted for operation with a mercury vapor pressure therein to generate light and including an envelope, a pair of electrodes adapted to pass a discharge current therebetween, at least one pair of leads extending through the envelope and connected to each of said electrodes for the

supply of operating power from said power source, a mercury-amalgam member in the envelope, and an additional lead extending through the envelope and connected to said mercury-amalgam member; and operating means connected to said mercury-amalgam member through said additional lead to cause the flow of current into said mercury-amalgam member for adjusting temperature thereof, whereby the light generation of said discharge lamp means can be optimized.

2. Apparatus as claimed in claim 1 wherein said operating means includes means to apply a voltage to the mercury-amalgam member to attract a portion of said discharge current thereto to raise the temperature of said member.

3. Apparatus as claimed in claim 2 wherein the means to apply a voltage is a DC voltage source.

4. Apparatus as claimed in claim 2 wherein the means to apply a voltage is an AC voltage source.

5. Apparatus as claimed in claim 4 wherein the operating means further includes means to adjust the phase relationship between the voltage of said source and said discharge current.

6. Apparatus as claimed in claim 2 wherein the means to apply a voltage is an adjustable source.

7. Apparatus as claimed in claim 2 wherein the means to apply a voltage is a fixed voltage source, comprising an adjustable impedance element coupled between said source and said amalgam member.

8. Apparatus as claimed in claim 5 wherein the means to adjust the phase relationship includes means to adjust the phase of the voltage in a range of 0° to about 120° lead and 0° to about 150° lag relative to the discharge current.

9. Apparatus as claimed in claim 1 wherein said operating means includes a thermally responsive element responsive to the temperature of the discharge lamp means to control pressure adjustment.

10. Apparatus as claimed in claim 9 wherein the thermally responsive element is located within 23 cm. of the discharge lamp means.

11. Apparatus as claimed in claim 9 wherein the thermally responsive element has a positive temperature coefficient of resistance.

12. Apparatus as claimed in claim 9 wherein the thermally responsive element has a negative temperature coefficient of resistance.

13. Apparatus as claimed in claim 11 wherein said element has a substantially constant value in an ambient temperature range which is below the lower limit of the range in which the mercury vapor pressure can be controlled.

14. Apparatus as claimed in claim 1 wherein two pairs of leads are connected to each of said pair of electrodes and said additional lead for the mercury-amalgam member is common with one of said two pairs of leads.

15. Apparatus as claimed in claim 14 wherein said operating means is connected between said common lead power and said source.

16. In a method for the operation of a discharge lamp including an envelope, a mercury-amalgam member within the envelope and adapted for establishing a mercury vapor pressure within the envelope, electrodes at each end of the envelope between which to pass a discharge current, and leads extending into the envelope and at least one of which is connected to said amalgam member, said lamp being characterized by optimum light generation at an optimum operating temperature and by less than optimum light generation when employed in ambient temperatures affecting said optimum operating temperature, the improvement comprising restoring optimum light generation in the said ambient temperatures by applying a voltage to said mercury-amalgam member through said one of leads and controlling said voltage by exterior adjusting means to adjust said vapor pressure.

17. A method as claimed in claim 16 comprising controlling the said voltage by diverting whose phase relationship to the discharge current can be varied a part of the discharge current to heat the member.

18. A method as claimed in claim 16 comprising controlling the said member by applying an AC voltage thereto and adapting the phase between the voltage and the discharge current.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,591,828 Dated July 6, 1971

Inventor(s) Hiroshi Washimi, Ryoichi Imanka

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE SPECIFICATION:

Column 2, line 10: change " 0° or 120° lead or 0° or 150° " to " $-0^\circ \leq \theta \leq 120^\circ$ lead or $0^\circ \leq \theta \leq 150^\circ$ "

Column 2, line 14: change " 120° " to " $-120^\circ < --$ "
line 15: change " θ 180° lead or 150° or 180° " to " $\theta < 180^\circ$ lead or $150^\circ < \theta < 180^\circ$ "

Column 3, line 25: change "6" to "--7--"

Column 4, line 39: cancel in entirety

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,591,828

Dated July 6, 1971

Inventor(s) Hiroshi Washimi, Ryoichi Imanka PAGE -2

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE CLAIMS:

(Claim 15)
Column 8,

line 53: delete "power"

line 54: after "said" insert --power--

(Claim 17)
Column 8,

line 72: delete "said"

after "by" insert --use of
voltage control means for--

delete "whose phase relation-
ship to the"

line 73: delete "discharge current can
be varied"

(Claim 18)
Column 8,

line 76: change "member" to --voltage-
change "thereto" to --whose
phase relationship to the dis-
charge current can be varied--

Signed and sealed this 14th day of March 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents