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ELECTRICAL DISCHARGE LAMP

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Fig. 1.

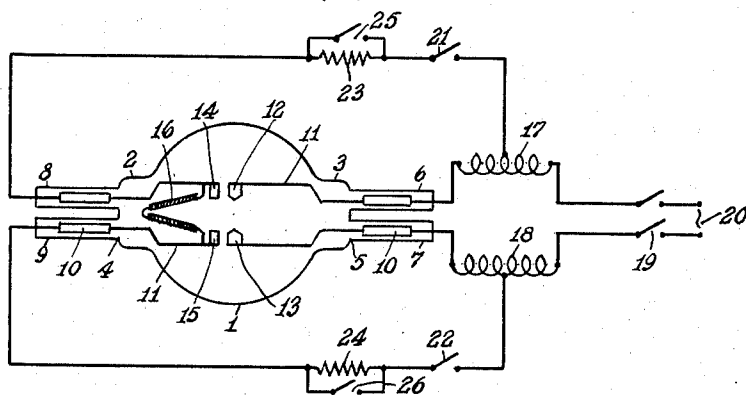
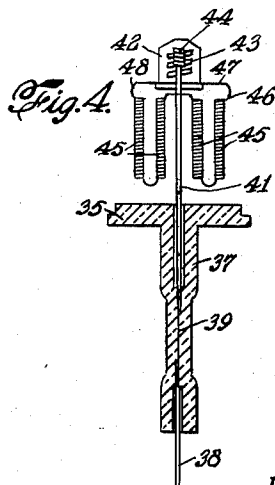
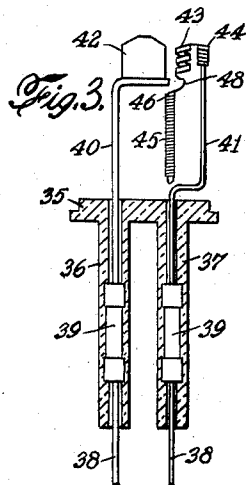
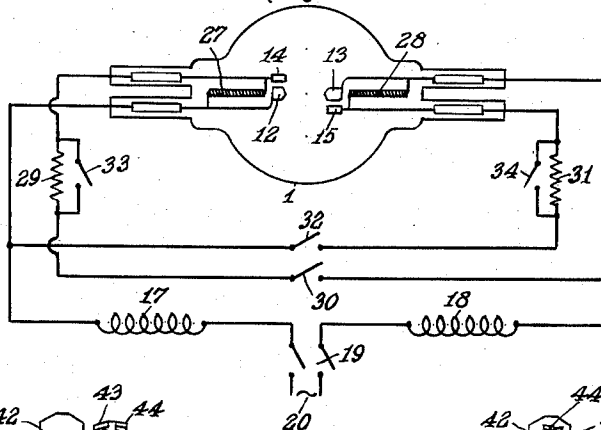


Fig. 2.



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ELECTRICAL DISCHARGE LAMP

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6 Claims. (Cl. 315—48)

The present invention relates to high intensity high pressure mercury vapour and high pressure rare gas lamps which are operated in the pressure range of about 5 to 50 atmospheres and with a high power input per unit length of arc. Such lamps are characterized by a relatively short arc length which, in the high brightness compact source type, may be of the order of a few millimeters only while in the high efficiency type, it may amount to several centimeters depending on the wattage of the lamp and the operating pressure which is considered most convenient. All these lamps are provided with a relatively small bulb of vitreous silica since this is the only material which will stand the high temperatures necessary for their operation.

These lamps are usually provided with a pair of solid incandescent tungsten electrodes, and sometimes, one or two auxiliary electrodes of a similar type are used for starting and run-up, and for warming up of the lamp. Generally, the bulb contains a limited quantity of mercury which, under full operation of the lamp, is entirely evaporated, and a rare gas filling which is necessary for starting the lamp. For color improvement, small quantities of cadmium and zinc are added to the mercury. This invention also relates to lamps of similar design which are filled with the rare gases krypton or xenon under pressures of about 20 atmospheres and which are sources of very high brightness.

As it is known, average life and operating characteristics of these lamps are not satisfactory. Life is greatly reduced by blackening of the bulb wall, which causes poor maintenance and overheating and deterioration of the quartz glass. Run-up time may vary from 5 to 15 minutes, and restarting under normal supply voltage usually takes as much time or more. Hot restarting requires a pulse or damped oscillation with a peak of several thousand volts, the generation of which depends on the use of complicated accessories and in many cases is not convenient.

Blackening of the bulb wall naturally depends on electrode quality. For this reason, in many types of high pressure lamps the electrodes are activated by electron emitting materials like barium, strontium, calcium, thorium, zirconium, hafnium or their chemical compounds, through which electrode performance during operation of the lamps is improved. These activating materials are indispensable for starting at normal line voltage. In high intensity lamps, however, to which this invention particularly relates, these activating materials, if not properly applied, may cause blackening since the electrodes are operated at very high temperatures, and thus an activating material added to them evaporates rapidly and contaminates the bulb wall which, in these lamps, has a relatively small surface area.

The considerable length of run-up time is primarily due to the very low voltage gradient of the initial low pressure mercury vapor discharge with which all high pressure mercury vapor lamps are started. The bulb, therefore, is heated but slowly and several minutes of operation are

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required before a sufficiently high pressure and a higher voltage gradient are formed. In order to improve this condition, the lamp bulb is made rather small, however, in this way the effect of blackening is increased, and during full operation of the lamp the bulb is overheated without necessity. When a cold lamp is started, and during this run-up period, the electrodes are exposed to very unfavorable conditions as their construction is adapted to the high pressure state, and not to cold starting and to the operation of a low pressure discharge. This is both harmful for the electrodes and for the lamp bulb which is blackened by sputtered material each time the lamp is started. Thus lamp life also depends on the number of starts and is generally reduced. Starting under high pressure by means of a high voltage pulse is effected under different conditions but, as the arc is formed between cold electrodes, electrode sputtering is caused both in hot mercury vapor lamps and in high pressure krypton or xenon lamps, and lamp life is particularly affected in cold mercury lamps filled with a rare gas under high pressure. In order to overcome at least some of these difficulties, high intensity lamps are sometimes provided with electrodes composed of a nonactivated part for operating the arc, and an activated part for starting and run-up, or they are provided with separate activated auxiliary electrodes which are used for starting and run-up, and for the operation of an auxiliary arc, however, operation characteristics and lamp life are not appreciably improved by these means.

Since these disadvantages of high intensity lamps are a serious problem for their applications in search lights, general lighting, and in other fields, it is one object of my invention to reduce bulb blackening in lamps of the type referred to, and thus improve their average life; another object is to improve their operating characteristics and to reduce run-up time in mercury lamps; a further object is a lamp which can be started under high pressure with normal supply voltage; still another object is a lamp provided with a novel electrode structure. Other objects and advantages of this invention will become apparent from the description hereinafter following and the drawings forming part hereof in which:

Figure 1 is a schematic representation of a high pressure lamp and circuit therefor according to the present invention,

Figure 2 is a schematic representation of a high pressure lamp provided with a different electrode arrangement and circuit therefor according to the present invention,

Figures 3 and 4 illustrate by way of example a seal and electrode assembly for a lamp according to Figure 2.

The disadvantages of mercury vapor and rare gas high pressure lamps hereinbefore set forth are avoided, according to the present invention, in a high pressure electrical discharge lamp comprising in combination a quartz glass discharge vessel containing a plurality of solid incandescent main electrodes for operating under a pressure of more than five atmospheres, at least one independently operable auxiliary electrode arranged adjacent a main electrode, and at least one metallic conductor of heat resistant material electrically connected to a main electrode and the adjacent auxiliary electrode, or to two auxiliary electrodes, said metallic conductor or conductors being dimensioned to be heated to incandescence by an electrical heating current which has an intensity comparable with the operating current of the lamp, and to consume singly or jointly a voltage of the same magnitude as the operating voltage of the lamp, thereby heating the discharge vessel prior to its operation and producing, when subsequently heated to a high temperature by a momentary elevated starting current, arc discharges between adjacent main and auxiliary electrodes,

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or between pairs of auxiliary electrodes, through which the lamp is started under high pressure.

The formation of an arc discharge across the filament is an undesirable effect commonly observed in gas filled incandescent lamps and greatly favored by a pure rare gas atmosphere and by the presence of mercury vapor, and by electron emitting contaminations of the filament. In lamps constructed according to this invention, this effect is utilized for starting an initial discharge arc which is instantaneously formed, under high metal vapor or rare gas pressure, across a metallic conductor of heat resistant material when heated by an electrical starting current to a very high temperature. As the ends of this conductor are electrically connected to two electrodes this arc transfers itself immediately to the electrodes which may be one main electrode and one auxiliary electrode, or two auxiliary electrodes, where a maximum voltage difference exists. Subsequently, this auxiliary arc is transferred from the auxiliary electrodes to the main electrodes and forms a main arc. This shifting of a high pressure arc is an effect well known in high brightness mercury lamps provided with more than two operating electrodes between which a plurality of arcs is produced. As set forth, this effect is utilized in connection with the generation of arcs across incandescent filaments in order to start a lamp under a high pressure, while starting under low pressure can be entirely avoided, which becomes feasible as, according to this invention, the metallic conductor is so dimensioned as to dissipate a considerable energy through which the lamp is quickly heated and a high pressure mercury vapor atmosphere can be formed prior to starting of a discharge. The nature of this invention will be explained in more detail in connection with the examples illustrated by the drawings which refer to a lamp provided with one pair of main electrodes and one pair of auxiliary electrodes showing two different arrangements of one and of two metallic conductors, respectively. The invention, however, is not restricted to this number of electrodes or metallic conductors as it can be applied with the same results and advantages to other high intensity lamps utilizing a different number of electrodes.

As shown in Figure 1 which illustrates one possible way of carrying out the invention, a high pressure lamp consists of an approximately spherical quartz glass discharge vessel 1 provided with short necks 2 and 3, and quartz glass seals 4 and 5 carrying separate seal elements 6 and 7, and 8 and 9. Each seal element contains a lead-in conductor composed of a molybdenum foil 10 and an electrode supporting wire 11 which is partly embedded in the quartz glass of the seal element, and carries main electrodes 12 and 13, and independently operable auxiliary electrodes 14 and 15, respectively. Main electrodes 12 and 13 between which, during normal operation of the lamp, a high brightness arc of a few millimeters length is operated are composed of sintered bodies or wire coils of pure tungsten as is usual in lamps of this type which are often operated under pressures exceeding 20 atmospheres. The auxiliary electrodes 14 and 15 are preferably arranged at the same distance as the main electrodes, and each is positioned near a main electrode at a considerably smaller distance as shown in Figure 1. Preferably, they are of the preheated type and consist of coiled coils of tungsten wire. If not of this type, they may be composed of a closely wound coiled coil which is slipped over supporting wire 11. According to this invention, a metallic conductor is arranged between the auxiliary electrodes which consists of a tungsten wire coil 16 the ends of which are connected to the coils forming these electrodes, or to their supporting wires. This heating and starting coil 16 is made from a tungsten wire of such diameter and length that it is heated to incandescence by an electrical current equalling the normal operating current of the main arc, and that it absorbs under this condition a volt-

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age drop of the same magnitude as the operating voltage of the arc. Thus, the power dissipated by the coil 16 is of the same order as the power dissipated by the main arc when in full operation and, therefore, it is an efficient heating element through which the discharge vessel can be warmed up prior to starting a discharge. The discharge vessel is carefully evacuated and filled, in the usual way, with a rare gas and a limited quantity of mercury which, under full operation of the lamp, is entirely evaporated. High pressure lamps of this type are often provided with an outer envelope. But this part, or details referring to the basing of the lamp are not shown in the drawings as they are not essential for the present invention.

The lamp is operated with the circuit arrangement illustrated by Figure 1 showing chokes 17 and 18 and a switch 19 through which the main electrodes 12 and 13 are connected to an alternating current source 20 supplying a voltage of 225 volts. In a similar manner, the auxiliary electrodes 14 and 15 are connected to the line across switches 21 and 22 and resistances 23 and 24, and preferably, this auxiliary circuit contains only part of the chokes 17 and 18, as illustrated by Figure 1.

When switch 19 is closed the main electrodes 12 and 13 are connected to the line but no discharge is started as a much higher voltage is required for this purpose. Instead, by closing switches 21 and 22 a current is passed through the coil 16 the intensity of which is determined by the resistance of the coil and by the ballasts and resistances contained in the auxiliary circuit. According to this invention, the electrical characteristics of these elements and of the coil 16 are such that the intensity of this current which may be called the heating current of the lamp, nearly equals the operating current of the arc which is produced at a later stage between the main electrodes, furthermore, diameter and length of the tungsten wire of coil 16 are suitably chosen so that the voltage drop across this coil is of the same magnitude as the operating voltage of the arc, and that it is heated to incandescence. Consequently, the discharge vessel is quickly heated and a mercury vapor atmosphere formed within a short time which attains a high pressure even comparable to the operating pressure of the lamp. Subsequently, the main arc is started between the electrodes 12 and 13 by interrupting switches 21 and 22 and in this way eliminating the auxiliary circuit shunting the main electrodes.

The operation of this starting mechanism requires certain precautions and special measures as will be explained now in more detail. During the heating period of the lamp, arc discharges between the auxiliary electrodes 14 and 15, or across the incandescent tungsten coil 16, are not desirable as under relatively low vapor pressure such discharges would cause bulb blackening and reduce the power dissipation of the coil required for heating the lamp. It is actually very essential that such discharges or any other auxiliary discharge arc be produced during very short periods only of the order of a second or even less. For this reason, the auxiliary circuit is provided with auxiliary or starting resistances 23 and 24 through which the current heating coil 16 is reduced to such an extent that it will operate at relatively low incandescent temperatures of less than 2000° K. during the heating period of the lamp, thus eliminating the danger of arcing while the vapor pressure is still low. When a sufficiently high pressure of one atmosphere, for example, has been formed, which takes less than a minute, these starting resistances are short circuited by closing switches 25 and 26, thus increasing considerably the current passing through the coil which through this high starting current is heated almost instantaneously to a very high temperature of 3000° K. or even more. Immediately, an arc is initiated across the coil which transfers itself to the auxiliary electrodes and which carries a high current controlled by the relatively small ballasts utilized in the auxil-

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ary circuit. This auxiliary arc is maintained during a very short period only as, immediately after its formation, switches 21 and 22 are opened whereby new arcs are initiated between main electrodes and adjacent auxiliary electrodes, and finally, between the main electrodes themselves. The main arc is thus formed instantaneously and under a high pressure, and the lamp attains its final operating characteristics within a very short additional time.

Restarting of a hot mercury vapor lamp is effectuated in the same way by operating the auxiliary circuit and the switches 21, 22 and 25, 26, as indicated, but in this case the heating period may be much shorter, and the heating and starting coil 16 may be operated at once with a high starting current, thus restarting the main arc almost immediately. In other cases, when a high pressure mercury lamp is to be kept warmed up and ready for instantaneous operation of the main arc during any desired length of time, this is simply done by operating coil 16 with the heating current, or with a reduced heating current by means of which a sufficient vapor pressure is maintained without danger of blackening the bulb since the coil temperature produced during the heating period is relatively low. An additional resistance for keeping warmed up, or simmering, is conveniently provided for in the auxiliary circuit.

A heating and starting coil having similar characteristics and producing the heating and starting effects described, may be also arranged between a main electrode and an auxiliary electrode, as illustrated by Figure 2 which refers to the same type of lamp already described, however, in this case a coil 27 is arranged between main electrode 12 and adjacent auxiliary electrode 14, and another coil 28 is arranged between main electrode 13 and adjacent auxiliary electrode 15. Both coils are preferably of equal design and are dimensioned as already explained in connection with the example illustrated by Figure 1. In Figure 2 one possible way of operating the lamp is indicated. According to this circuit diagram, the auxiliary electrode 14 is connected through a resistance 29 and a switch 30 to the main electrode 13, and the auxiliary electrode 15 is connected through a resistance 31 and a switch 32 to the main electrode 12. For starting the lamp, both switches 30 and 32 are closed, and consequently, heating currents are passed through the coils which are heated to incandescent temperatures not exceeding about 2000° K. During this heating period, the currents passing through the coils are reduced by the action of resistances 29 and 31, but the power dissipated in each coil is sufficient to heat up the lamp and to build up a high vapor pressure within a short time. When this is produced, both resistances 29 and 31 are short circuited by switches 33 and 34, thus increasing the heating currents and heating the coils to temperatures above 3000° K. This leads to arcing across the coils and to the formation of auxiliary arcs between electrodes 12, 14 and 13, 15 through which the main arc between main electrodes 12 and 13 is initiated as soon as switches 30 and 32 are interrupted. In this particular case, each coil dissipates about the same power as the main arc during the short starting period when resistances 29 and 31 are short circuited, while during the heating period both coils together absorb a power of this magnitude.

A particularly suitable construction and arrangement of the heating and starting coil and of the auxiliary electrode for a lamp according to Figure 2 is shown in Figures 3 and 4 which illustrate two different views of one of the seals with its electrode assembly. The seal consists of a quartz glass disc 35 provided with seal elements 36 and 37 of which each has a lead-in conductor composed of an outer lead 38, a hermetically sealed press lead 39, and an inner lead 40 and 41, respectively. Inner lead 40 consists of a thick tungsten wire or rod which is partly imbedded in the quartz glass of seal element 36 and thus firmly attached to the seal, and which carries main electrode 42. In a similar manner, lead 41 is con-

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nected to seal element 37 but consists of a molybdenum wire of smaller diameter which supports the relatively high auxiliary electrode 43. This electrode is of the directly pre-heated type and consists of a self-supporting coiled coil comprising three secondary turns, as illustrated by Figure 3. One end 44 of this coiled coil is slipped over the free end of inner lead 41 and welded to it. For the heating and starting coil 45 the coil system of a projection lamp is utilized which is composed of four parallel coil parts arranged in a plane, as illustrated by Figure 4, and occupying the space between inner leads 40 and 41 in a plane which is at right angles with their plane. One end 46 of coil 45 is connected to the inner lead 40 by means of a supporting wire 47 while the other end 48 is directly connected to the free end of the auxiliary electrode 43. Preferably, the coiled coil of this electrode is made from the same primary coil of which coil 45 is composed so that both consist of one piece of tungsten wire. In this way, during the heating period of the lamp, both parts are heated to about the same relatively low temperature, and when the starting current is applied to the coil the auxiliary electrode assumes simultaneously the same high temperature required for starting an auxiliary arc with the main electrode.

Since, according to this invention, an auxiliary electrode is always connected to one end of a heating and starting coil which, by means of end loss, communicates a certain amount of heat to the auxiliary electrode, this electrode may be also of the indirectly pre-heated type and consist of a closely wound coil or coiled coil attached to or slipped over the end of the heating and starting coil. In this case, the auxiliary electrodes are advantageously provided with a small quantity of activating materials such as barium, strontium, calcium, thorium, zirconium, hafnium, or their chemical compounds through which the formation of auxiliary arcs is facilitated during the short starting period of the lamp, while no danger of harmful evaporation of these materials exists as the temperature which the auxiliary electrodes assume during the heating period is relatively low. Since the starting period is of the order of one second, no appreciable evaporation or sputtering which might lead to blackening of the bulb wall is likely to happen, and very small quantities of activating material are needed as in the course of the entire life of the lamp, the auxiliary electrodes are operated during an insignificant lapse of time. For better performance during the operation of the main arc, the main electrodes may be activated with thorium or thorium oxide which are sometimes used in high intensity lamps.

The provision of auxiliary electrodes which are characterized by a special construction, a suitable arrangement and position with respect to the main electrodes, and by a certain degree of activation, is very essential for a safe operation of the lamp. Otherwise, the arcs initiated by the heating and starting coils may form at random, and instead of starting auxiliary arcs between well defined points, may blacken the bulb and burn the coils.

In comparison with customary high pressure lamps, a lamp possessing the electrode structure described in accordance with this invention has greatly improved operating characteristics, which is one of the main objects of this invention. Owing to the effects produced by the heating and starting coils, automatic warming-up for quick operation is provided for in a simple way and run-up time thus greatly reduced, furthermore, as the discharge arc is started under high pressure with normal supply voltages, instantaneous restarting is effectuated without the use of high voltages. Starting current surges and elevated run-up currents are entirely eliminated, which is beneficial for the electrodes and the seals of the lamp. Lamp life is improved by the same means, which is another object, since no discharge is started or operated

under low pressure between cold electrodes while arcs are formed under high pressure and between incandescent elements of the electrode structure, thus blackening of the bulb wall is at least greatly reduced. A lamp according to this invention may be started a larger number of times during lamp life without danger of excessive blackening. It is also very essential in this respect that the bulb can be given a relatively large surface through which lamp life is favored. This has become possible through the use of heating coils which, according to this invention, dissipate a considerable energy sufficient for warming up the lamp and for the formation of a high pressure atmosphere. Therefore, the bulb surface load, that is the quotient of lamp wattage and bulb surface area, can be made less than 15 watts per square centimeter, while in customary lamps the surface load mostly exceeds 25 watts per square centimeter in order to obtain reasonable run-up times. Thus, overheating of the bulb during operation of the lamp is avoided.

In rare gas high pressure lamps, a heating period is naturally not necessary, and a run-up time problem does not exist. However, the electrode structure according to this invention offers the advantage that starting of the arc is greatly facilitated, and that owing to the peculiar starting mechanism connected with the use of an incandescent starting coil and an auxiliary electrode, sputtering of the main electrode is reduced, and thus lamp life is improved. In mercury lamps filled with a high pressure rare gas, the formation of a high pressure mercury atmosphere prior to starting of the arc is very advantageous.

With reference to the circuit diagrams shown in the drawings, the switches 21 and 22 in Figure 1, and 30 and 32 in Figure 2, are preferably magnetic switches which are interrupted when resistance 23, 24 and 29, 31 respectively are short circuited and the currents in the auxiliary circuits raised to high values, while resetting of these switches is effectuated by hand when main operating switch 19 is closed, or automatically by means of some voltage responsive element controlled by the lamp voltage. Resistances 23 and 24, or 29 and 31 consist preferably of temperature dependent semi-conductors having cold resistances which correspond to the desired additional resistances in the auxiliary circuits, and time characteristics for breaking down in accordance with the required heating period of the lamp.

This invention is not strictly limited to high intensity lamps as it may be applied, with some or all of the beneficial effects described, to other types of high pressure lamps for which similar problems relating to operating characteristics and lamp life exist. Nor is it restricted to electrode structures composed of two main electrodes and two auxiliary electrodes in connection with one or two heating and starting coils which are shown by way of example only, or to the electrode constructions, or constructions and arrangements of the metallic conductor illustrated by the drawings, or to the circuit diagrams shown.

What I claim is:

1. A high pressure electrical discharge lamp comprising in combination a light transmissive discharge vessel containing an ionizable atmosphere, a plurality of spaced main electrodes for supporting a main arc therebetween, at least one independently operable auxiliary electrode positioned adjacent a main electrode, at least one heating means having terminals, said terminals being connected to a pair of said electrodes within said vessel, at least one of said pair being an auxiliary electrode, separate electrically conductive leads connected to each of said auxiliary and main electrodes through a wall of said vessel, and switch means connected between said auxiliary electrode and a source of current, whereby said auxiliary electrode is energized independently of said main electrodes.

2. A high pressure lamp according to claim 1, wherein said auxiliary electrode consists of a coiled coil of tungsten.

3. A high pressure lamp according to claim 2, wherein the auxiliary electrode consists of a closely wound coil containing a small quantity of at least one of the activating materials selected from the group consisting of barium, strontium, calcium, thorium, zirconium, hafnium, and chemical compounds thereof.

4. A high pressure lamp according to claim 1, including a pair of said independently operable electrodes each positioned adjacent a main electrode, and a tungsten coil connecting said auxiliary electrodes within said vessel.

5. A high pressure lamp according to claim 1, wherein said heating means is a tungsten coil connecting one of said main electrodes and one of said auxiliary electrodes within said vessel.

6. A high pressure electrical discharge lamp comprising in combination a light transmissive discharge vessel containing an ionizable atmosphere, a plurality of spaced main electrodes for supporting a main arc therebetween, at least one independently operable auxiliary electrode positioned adjacent a main electrode, at least one heating means having terminals and being dimensioned to be heated to incandescence by an electrical heating current which has an intensity comparable to the operating current of the lamp, said terminals being connected to a pair of said electrodes within said vessel, at least one of said pair being an auxiliary electrode, separate electrically conductive leads connected to each of said auxiliary and main electrodes through a wall of said vessel, and switch means connected between said auxiliary electrode and a source of current, whereby said auxiliary electrode is energized independently of said main electrodes.

References Cited in the file of this patent

UNITED STATES PATENTS

1,956,599	Sperti	May 1, 1934
2,007,923	Braserton	July 9, 1935
2,094,848	Roberts	Oct. 5, 1937
2,103,034	Inman	Dec. 21, 1937
2,263,171	Hays	Nov. 18, 1941
2,304,907	Sperti	Dec. 22, 1942