

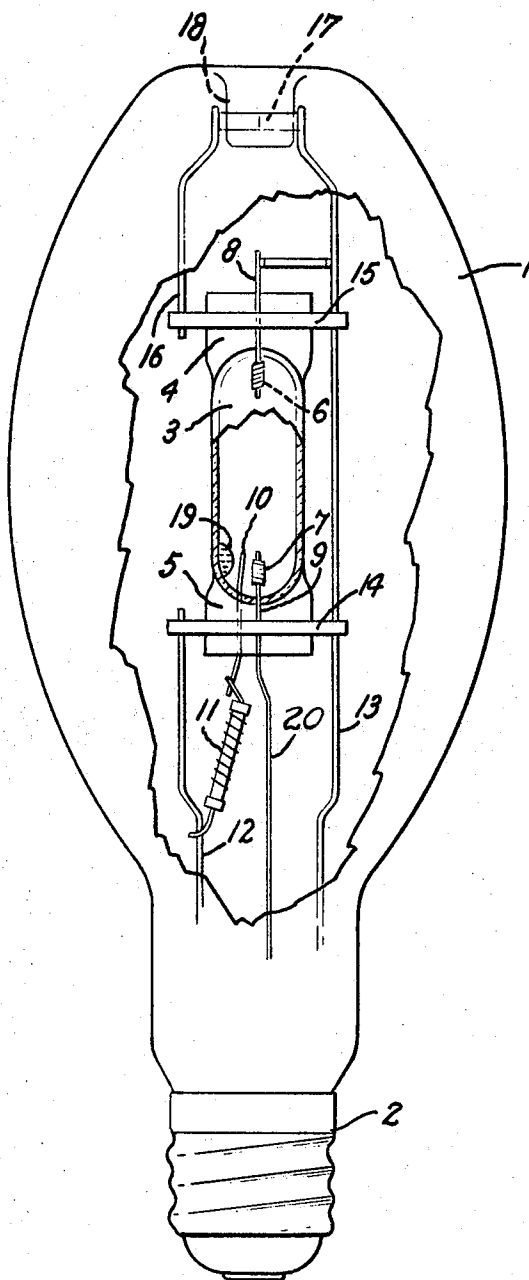
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MERCURY-METALLIC HALIDE VAPOR LAMP WITH REGENERATIVE CYCLE

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## MERCURY-METALLIC HALIDE VAPOR LAMP WITH REGENERATIVE CYCLE

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### ABSTRACT OF THE DISCLOSURE

An improved mercury-metallic halide arc discharge lamp in which sputtering and evaporation of electrode material and deposition thereof upon the inner bulb wall, with resulting bulb wall darkening and reduced electrode life, is counteracted by addition, to the vaporizable charge within the bulb, of a quantity of the halide of a metal having a principal valence of at least two. Dissociation of this halide greatly enhances existence of a regenerative halide transport cycle and maintains electrodes intact and the bulb wall clean.

The present invention relates to vapor arc discharge lamps of the type containing mercury and one or more vaporizable metallic halides which are dissociated in the heat of an arc between a pair of primary arc-electrodes extending into an evacuable envelope. More particularly, the present invention relates to such vapor arc discharge lamps wherein the evaporation and sputtering of electrode materials from the arc-electrodes to the interior of the bulb wall in the vicinity of the electrodes is counteracted by an improved regenerative halide vapor-transport cycle which maintains the wall metal-free and greatly increases the life of the arc-electrodes.

Improved vapor-arc discharge lamps for the production of high-intensity, high-efficiency, near white light have been made possible by the invention of the mercury-metallic halide, vapor-arc discharge lamp as is set forth in U.S. Pat. No. 3,234,421 to G. H. Reiling, issued Feb. 8, 1966.

In accord with the teachings of the Reiling patent, the emission of a vapor-arc lamp is obtained from the line-broadened spectra of one or more metals included within the lamp envelope as the halide thereof, generally of the alkali or alkaline earth metals to which has been added color-compensating metal halides such as gallium, indium, thallium, and certain rare earth metals, to produce a pleasing, white emission of high intensity.

In the development of this type of lamp, it has been found that certain other materials, as for example, rare earth metals, thorium, vanadium, scandium, and the like, also can contribute to the production of high-efficiency white light or light of a preselected wavelength in accord with the mechanism described and claimed in the aforementioned Reiling patent.

While such lamps are of great utility and have constituted a long-awaited break-through in the area of vapor-arc illumination, certain problems still exist. One such problem relates to a phenomenon which is experienced in practically all electric discharge devices, namely, the depreciation of the light emission characteristics and, in many instances, the eventual failure of the lamp, due to the sputtering and/or evaporation of metallic particles, from the electrodes or filament contained within the lamps. This metallic matter removed from the electrodes deposits upon the envelope wall in the vicinity of the electrodes, causing the light-transmitting characteristics of the lamp envelope to be decreased. Additionally, the removal of filament or arc-electrode material often causes eventual failure of the lamp by failure of the filament or electrode. In vapor-arc discharge lamps, such phe-

nomenon results in the darkening of the envelope wall in the vicinity of the primary arc-electrodes and may contribute to eventual failure of the arc-electrodes.

Accordingly, it is an object of the present invention to provide improved vapor-arc discharge lamps having improved light transmissive characteristics.

Another object of the present invention is to provide electric vapor-arc discharge lamps having improved light-transmissive characteristics and long arc-electrode life.

Still another object of the present invention is to provide improved mercury-metallic halide lamps wherein removal of arc-electrode material and the deposition thereof upon the inner wall of the lamp envelope is counteracted.

In accord with one embodiment of the present invention, I provide a mercury-metallic halide vapor-arc discharge lamp having an evacuable envelope containing a pair of non-liquid arc-electrodes and a charge, including a quantity of mercury, sufficient upon complete evaporation thereof, to provide a partial pressure of mercury of approximately  $\frac{1}{2}$  to 10 atmospheres. Also within the envelope, I provide a charge of light-emitting material including at least the vaporizable halide, other than the fluoride, of sodium with or without one or more dissociable, vaporizable light-emitting halides which like the sodium halide are dissociated to cause the production of light by excitation of the metallic species thereof. In addition to the foregoing halides, I provide a quantity of polyvalent metallic halide, other than the fluoride, of a metal other than the alkaline metals, the alkaline earth metals, the rare earth metals, and the transition metals, which halide is at least partially dissociated at the operating temperature of the envelope wall to provide thereat a specie, either a subhalide compound or free halogen, which is able to react with any vaporized or sputtered arc electrode material which is deposited on the bulb walls and, by means of the regenerative halide cycle, return the deposited metal to the arc-electrode from whence it came. This regenerative cycle prevents the deterioration of the transmissive characteristics of the bulb wall and the eventual deterioration and failure of the arc-electrodes.

The novel features believed characteristic of the present invention are set forth in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood by reference to the following detailed description, taken in connection with the appended drawing in which,

A vapor arc discharge lamp constructed in accord with the teachings of the present invention is illustrated in vertical view with parts broken away.

In the drawing, a mercury-metallic halide vapor-arc discharge lamp constructed in accord with the present invention includes an exterior, evacuable, light-transmissive envelope 1 mounted upon a screw type contact-making base 2, and including therein an inner arc-containing envelope 3. Inner envelope 3 is light-transmissive; generally cylindrical in shape; hermetically-sealed; and is terminated with pinched-off sections 4 and 5 at the upper and lower ends thereof, which pinched-off sections serve both to hermetically seal the inner envelope as it is fabricated from a tubular member and to make appropriate seals with the lead-in wires to the electrodes contained therein as they pass therethrough. Envelope 1 may be of any suitable high-temperature-resistant light-transmissive substance, as for example Pyrex or Vycor glass. Envelope 3 may be of any similar light-transmissive, but higher-temperature-resistant material, such as fused quartz, Lucalox (U.S. Pat. 3,026,210) or high-density yttria as disclosed and claimed in the copending application of R. C. Anderson, Ser. No. 582,755, filed Sept. 28, 1966, and assigned to the present assignee.

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A pair of arc-electrodes 6 and 7, which may conveniently comprise coiled helical members of tungsten wire or thoriated tungsten wire, or tungsten wire with a sliver of thorium contained therein, or coiled-coil helices, thereof, as is well known in the lamp art technology, are centrally located within interior envelope 3 at opposed ends thereof. Arc-electrodes 6 and 7 are spaced a sufficient distance apart so as to sustain a high-current electric arc therebetween for the vaporization of the vaporizable constituents contained therein and the production of high intensity radiation of appropriate wave lengths. Arc-electrodes 6 and 7 are supported upon electrode lead members 8 and 9 respectively, which are sealed through pinched regions 4 and 5 respectively, in hermetic seal. A starting electrode 10 is located within one end of inner envelope 3 and is sealed through pinched region 5 of inner envelope 3. Starting electrode 10 is connected through a resistance 11 to a lead and support member 12 which is at the same electrical potential with another lead and support member 13, both of which are connected to one contact member of connecting base 2. It will be appreciated, however, that other means than starting electrode 10 may be utilized to start the lamp.

Inner envelope 3 is suspended within outer envelope 1 by means of a simple set of saddle-clamp members 14 and 15 which are dependent from lead and support member 13 and which are securely mechanically fastened about the flattened portions of pinched regions 4 and 5 of inner envelope 3. Lower saddle clamp 14 is connected between support members 12 and 13 and upper saddle clamp 15 is connected between support member 13 and a suspended support member 16 which is connected with a collar 17 which fits over a reentrant nipple 18 within the upper portion or exterior bulb member 1, which collar 16 serves to anchor the upper end of lead and support member 13. One arc-electrode 6 is connected to support member 13, while the other arc-electrode 7 is connected to a separate lead 20 which is connected to the contact member of screw base 2 remaining after lead and support member 13 and 12 are connected to the first-mentioned contact member thereof.

Envelope 3 contains a filler substance 19 which exists in the form of a globule, containing for example, the solid constituents contained therein during the quiescent, non-operating condition of the lamp. The globule is composed primarily of sufficient mercury, so that upon the attainment of suitable operating temperature conditions, the mercury is totally volatilized and the vapor thereof produces a mercury pressure within envelope 3 of approximately  $\frac{1}{2}$  to 10 atmospheres. It is essential in the operation of lamps in accord with the present invention, as well as the lamp of the aforementioned Reiling patent, the disclosure of which is incorporated herein by reference thereto, that, at operating temperatures and pressures of the order of one atmosphere or greater, that no remaining mercury exists in the liquid state within envelope 3. This is because the operating temperature that is required to volatilize the remaining constituents of globule 19 is substantially higher than that which may be obtained if an equilibrium exists between a liquid and vapor phase of mercury within envelope 3. Thus for example, since the boiling point of mercury at atmospheric pressure is approximately 355° C., if any liquid mercury remains in the inner envelope 3 during operation, that temperature is the maximum equilibrium temperature which may exist within the envelope. Accordingly, the quantity of mercury in globule 19 is so established as to insure complete volatilization thereof, so that the high operating temperatures required for volatilization of the remaining constituents of filler 19 may be obtained.

Filler 19 also includes one or more dissociable metallic halides other than fluoride, which are at least partially volatilized at the operating temperature created by the initial volatilization of mercury and the establishment of a mercury arc discharge between arc-electrodes 6 and 7.

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It has been found that for the production of high efficiency, chromatically satisfactory light from mercury-metallic halide lamps in accord with the present invention, the presence of an alkali metal halide, preferably a sodium halide such as sodium iodide, sodium bromide, or sodium chloride is required. Since the light emitted by the alkali halides, and particularly the sodium halides, is generally within the long wavelength portion of the visible spectrum generally in the yellow or red, it is generally desired, for the production of a chromatically pleasing or near-white light, that other metallic halides which are also subject to dissociation and light emission, but which emit light in the shorter wavelength portion of the spectrum, be utilized as a part of filler 19. Thus, for example, ideal near-white light having a lumen efficiency of approximately 90 lumens per watt may be obtained utilizing, as light-emitting constituents, the iodides of sodium, thallium, and indium. The amount of each halide added depends upon the vapor pressure and the dissociation characteristics of the halide. Thus, for example, for a halide which has a relatively low vapor pressure, as for example sodium halide, a sufficient quantity is supplied so that an excess of sodium halide exists within the charge under equilibrium conditions. With other halides, as for example, gallium iodide, which has a relatively high vapor pressure, and is completely volatilized at the operating temperatures of the lamp, a sufficient quantity is provided so that the partial pressure caused by the volatilization of the particular halide varies in a range of approximately 0.1 to 200 torr of the particular halide. If a plurality of halides are utilized, the partial pressure of each attained within the lamp should be a pressure of from 0.1 to 200 torr of each halide.

In the operation of this type of lamp, the bulb walls are located at a distance with respect to the arc-electrodes and the distance between the arc-electrodes is adjusted so that the normal operating condition of the lamp causes the temperature of the inner surface of envelope 3 to be greater than 600° C. and no greater than 1200° C. at its coldest portion. In general, the coldest portion thereof is generally that portion at the extreme end thereof behind the arc-electrodes. For this reason, it is often found desirable to coat the ends of envelope 3 in the vicinity of the arc-electrodes with a reflecting substance so that light radiated toward the end of the lamp is focused back upon the electrode thus keeping that portion of the lamp at a higher temperature than if the radiation were to pass through the ends of the lamp.

Envelope 3 also contains a filling or buffer gas for initial starting of the lamp. Such a filling or buffer gas may, for example, be from 10 to 25 torr partial pressure of an inert gas, as for example argon, which has a relatively low break-down potential.

The general mode of operation of mercury-metallic halide lamps is substantially as follows: When an initial voltage difference of sufficient magnitude is applied to the respective contacts of base 2, a high potential exists between starter electrode 10 and arc-electrode 7; as well as between arc-electrodes 6 and 7. The electric field between starter electrode 10 and arc-electrode 7 is sufficient to cause the break down of the buffer gas and cause a glow discharge therebetween. Since the lamp is generally in a vertical position and since filler 19 is generally in the vicinity of the gap between starter electrode 10 and arc-electrode 7, the initial glow discharge maintained by the buffer gas is sufficient to cause a heating and vaporization of the mercury of charge 19. When a sufficient quantity of mercury has been volatilized so that the conditions of electric field and mercury vapor pressure between arc-electrodes 6 and 7 is appropriate, the mercury is dissociated and a mercury arc discharge is struck between arc-electrodes 6 and 7. At this point, the buffer gas ceases to be of great importance, since the voltage drop in the arc discharge between arc-electrodes 6 and 7 is much less than in the glow discharge between starter electrode

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10 and arc-electrode 7. The mercury arc between arc-electrode 6 and 7 is of sufficient temperature to cause the volatilization of the liquid or solid, but vaporizable, metallic halides within charge 19. These halides are vaporized and are influenced by the high-temperature mercury arc. The high temperature of the mercury arc, which may be of the order of 3000° C., or higher, is sufficient to cause the dissociation of the metallic halide causing the metallic specie to exist within the arc discharge. The metallic species is readily raised to an excited state by the energy within the mercury arc discharge, which causes the characteristic radiative transitions of the metallic specie and the characteristic line spectra of the metal or metals present as radiators within the arc column.

The line emission by the metallic radiators is most generally the resonance line for each of the materials which is the line characteristic of the lowest permitted energy transition from a low level above the ground state to the ground state of the atom. Collision-caused line-broadening between the radiating specie and the atoms of the volatilized mercury within the envelope 3 results in the emission of line-broadened radiation characteristic of the radiating metal, which radiation is of high efficiency and, assuming the appropriate mix of halides has been added, may be essentially white light having a chromatically pleasing characteristic.

As is mentioned hereinbefore, lamps operating under the presently described mechanism are highly effective for emitting high-efficiency chromatically-pleasing light. Unfortunately, however, the metal of the arc-electrodes tends to become sputtered and evaporated from the arc-electrodes and to be deposited upon the electrode walls, greatly diminishing the light transmissiveness thereof. Additionally, the constant removal of metal from the arc-electrodes can lead to eventual destructive dissipation thereof.

It has been found that a vapor transport cycle utilizing the affinity of halogen gases or vapors is useful in reversing such metallic transport. The utilization of such an iodide transport cycle to counteract the effects of wall-darkening in an incandescent lamp is disclosed and claimed in the U.S. Pat. 2,883,571 to Fridrich et al. In accord with that cycle, the halogen gas added into the incandescent envelope combined with metallic deposits upon the envelope wall to form a metal-halogen compound which is dissociated upon contact with the filament, causing a return of the filament metal thereto with the release of the halogen gas which is then free to migrate back to bulb wall to further combine with deposited metal.

Attempts have been made to utilize the halogen transport cycle to regenerate the arc-electrodes of vapor arc discharge lamps of the mercury-metallic iodide type. For some reason, which has not been determined, the mere addition of the halogen vapor in the free state to the charge of envelope 3 has not been effective to cause the regenerative halide cycle to prevent bulb wall blackening and electrode depletion. One possible cause is that the presence of other metallic specie, namely the radiating metals, or the presence of the mercury vapor within the envelope of the lamp may, in some way, cause the halogen present to combine with other metallic specie rather than deposited electrode material upon the bulb wall. Another possibility is that the deposited metal on the bulb walls is too hot to enter into such a cycle. Although it is not known precisely why the addition of the free halide does not function as in the incandescent lamp environment, it is well established that it does not.

In accord with the present invention, I have discovered that it is possible to cause the regenerative halide transport cycle to operate within a mercury-metallic halide vapor discharge lamp if the halogen is added to the lamp in the form of the halide of a metal other than those metals which so far have been found useful as efficient light radiators in this type lamp. Thus, the metallic halide

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added to cause the operation of the regenerative cycle may not be an alkali metal halide, an alkaline earth metal halide, a rare earth metal halide, or a transition metal halide. It has been found that when the halides of metals of Group I of the Periodic Table such as sodium, potassium, and rubidium are utilized, wall blackening results. Similarly, when metals of Group II of the Periodic Table such as zinc, cadmium, strontium, and mercury are added in halide form, bulb wall blackening occurs. Similarly, when halides of metals of Group III of the Periodic Table such as scandium, gallium, yttrium, indium, rare earths, and thallium are added, bulb wall blackening occurs. Likewise, when metallic halides of metals of Group IVb and Vb of the Periodic Table, such as titanium, zirconium, vanadium, and tantalum are added, bulb wall blackening occurs. Similarly, when the halides of transition metals such as iron, nickel, cobalt, and chromium are added, bulb wall blackening occurs. Additionally, when the addition of halide metals of Groups IVb and Vb of the Periodic Table are made, as for example the halides of titanium, zirconium, vanadium, and tantalum, these additives react unfavorably with fused quartz, one envelope material frequently utilized as an envelope for containing the radiating specie in mercury-metallic halide lamps.

In general, I find that the metals which are suitable for addition in the halide other than the fluoride to cause the operation of a halogen regenerative cycle, are halides of metals which have a primary valence of two or greater. These metals will be referred to herein as "poly-valent" metals. The use of the word, "polyvalent," does not mean to imply all metals which have more than one valence, which are more properly referred to as "multi-valent" metals, but it is meant to imply materials which have a valence of two, three, or four. The polyvalent metals utilized in accord with the present invention for addition, as halides, to the charge of a mercury-metallic halide lamp to cause a halogen regenerative cycle to occur are polyvalent metals other than metals of the alkali metals, alkaline earth metals, the transition metals, and the rare earth metals. Preferably, I utilize the halides of tin, lead, antimony, and bismuth, although the halides of germanium and silicon may also be used to advantage.

In general, the metallic halides added to charge 19 to cause a regenerative halogen cycle to occur within a mercury-metallic halide lamp, should be added in a quantity sufficient, upon volatilization thereof at lamp operating temperatures, to result in a partial pressure of the halide within the envelope, of approximately 0.1 to 100 torr.

In the operation of lamps in accord with the present invention, the polyvalent metal halide is volatilized along with the other halides. Although the polyvalent metal of the halide which is added to cause the regenerative halogen cycle to exist, may be observed to contribute some spectroscopic lines to the emission of the lamp, it is not generally a highly efficient radiator; and it need not enter into the complete dissociation and radiative transition which is participated in by the light emitters. Rather, the polyvalent metal halide must have a dissociation characteristic which permits at least partial dissociation thereof at the envelope wall temperature, to cause the creation of a less halogen-rich polyvalent metallic compound, or to cause the complete freedom of halogen specie at the bulb wall.

Although the chemical reaction which occurs at the bulb wall is not fully understood, it is believed that the reaction is most likely a dissociation of the polyvalent metal halide into a very unstable, halogen-rich compound which reacts with the arc-electrode material upon the interior of the bulb wall to cause the creation of a complex metallic halogen compound which is dissociated when contacted by the arc-electrode to cause the deposition of arc-electrode material thereupon and the release of further halogen-rich metallic compound which may

migrate to the inner bulb wall surface to further combine with deposits upon the bulb wall.

Although this mode operation is set forth as one possible explanation of the phenomenon in accord with the present invention, if a further description thereof is later found to be more accurate, it is to be understood that the invention is not predicated upon this explanation. It is, however, essential that the polyvalent metallic halide added to cause the halogen regenerative cycle to occur, must undergo at least a partial dissociation at the temperature at the inner portion of the bulb wall in order that the halogen regenerative cycle occur.

An added advantage found in the utilization of the polyvalent metallic halides utilized in accord with the present invention to cause a regenerative cycle within mercury-metallic halide vapor lamps is that, these lamps, in which sodium is a nearly essential element for obtaining high efficiency and good chromatic results, tend to be deleteriously affected by the corrosive action of hot sodium vapor. Thus, for example, if the lamp envelope is of fused quartz, sodium in its elemental form, at high temperature in contact with the quartz, tends to diffuse into the quartz and attack it chemically. Irrespective of the material from which the lamp is made, metallic sodium at high temperatures tends to be exceedingly destructive to the metal-to-glass or metal-to-ceramic seals which surround the electrodes at the point of entry into the envelope. Thus, any contribution which reduces the contact between dissociation-freed elemental sodium is greatly beneficial in lamps of this type. The utilization of the polyvalent halides in accord with the present invention, causes the creation, by virtue of the at least partial dissociation of the polyvalent metallic halide at the bulb inner wall surface, a nonreducing, oxidizing atmosphere to exist in the vicinity of the bulb wall inner surface, including the portions at which the seals are made. This oxidizing atmosphere tends to favor any sodium which may be present thereat existing in a relatively stable compound form rather than in the highly-reactive elemental form.

Accordingly, the utilization of the polyvalent metallic halides, which at least partially dissociate at the temperature of the bulb walls under operating conditions and which create thereat an oxidizing atmosphere, greatly enhances the lamp life in preventing attack of the bulb walls and bulb seals by highly reactive heated elemental sodium, which is an essential element for high-efficiency, good chromatic characteristic mercury-metallic halide vapor discharge lamps.

The polyvalent metallic halides utilized in accord with the present invention must be inorganic halides, since it is found that organic halides are not chemically compatible with the existing system within the mercury-metallic halide vapor arc discharge lamp.

In the operation of mercury-metallic halide vapor arc lamps prior to the present invention, even in the presence of free-halogen vapor, as for example, bromine, chlorine, or iodine, in an attempt to make use of the halogen regenerative cycle, it has been observed that the free halogen acts deleteriously in that it tends to combine with the cooler, less active arc-electrode material along the shank of the arc-electrode in the vicinity of its entry into the envelope, in preference to the electrode metal on the bulb walls, and to deposit this arc-electrode material at the hotter, more reactive tip of the electrode, rather than removing the deposited arc-electrode material from the bulb walls. This harmful, free-iodine regenerative cycle does not occur in accord with the present invention since the polyvalent halides in accord with the present invention which results in the useful halide cycle are active to combine with electrode material at the wall, preferably since they are dissociated, at least partially, at the bulb wall by the temperature thereof.

One lamp constructed in accord with the present in-

vention operated at a 400 watt rating and was substantially as illustrated in the drawing. The inner envelope 3 had a volume of 18 cc. and contained a charge of 60 milligrams of sodium bromide, 50 milligrams of stannous iodide, 80 milligrams of mercury, and a partial pressure of 18 torr of argon. The sodium charge resulted in a partial pressure thereof of approximately one torr of sodium bromide, the remainder being in excess to maintain correct partial pressure in case of sodium depletion. The 50 milligrams of stannous iodide resulted in a partial pressure of approximately 0.5 atmosphere of stannous iodide and contained all of the stannous iodide, with none remaining in excess. The 80 milligrams of mercury was completely volatilized in operation and resulted in pressure of approximately four atmospheres of mercury. The lamp, as described above, emitted a radiation that had a golden light due to radiation of collision-broadened sodium lines and the blue radiation of mercury. This lamp operated for 1000 hours with no darkening of the bulb walls and, upon cessation of the test, examination revealed substantially no change in the configuration of the arc-electrodes.

In another lamp constructed in accord with the present invention, a 400 watt rated lamp having the configuration FIG. 1 and a volume of 18 cc., contained a charge of 60 milligrams of sodium bromide, 50 milligrams of stannous iodide, 80 milligrams of mercury, 2 milligrams of thallous iodide, 1 milligram of indium iodide, and 18 torr of argon. This lamp operated to provide a pleasing white light with no darkening of the bulb walls or noticeable deterioration of the electrodes.

Another embodiment of the present invention constructed for a 400 watt rating of operation utilized an 18 cc. bulb 3 and contained a charge of 60 milligrams of sodium iodide, 5 milligrams of stannous bromide, 80 milligrams of mercury, 18 torr of argon, 2 milligrams of thallous iodide, and 1 milligram of indium iodide. This bulb operated to produce a pleasing white light radiation with no darkening of the bulb walls in the vicinity of the electrodes, or elsewhere, nor any noticeable deterioration of the arc-electrodes.

Another lamp constructed in accord with the present invention utilized 60 milligrams of sodium chloride, 5 milligrams of lead iodide, 18 milligrams of mercury, 2 milligrams of thallous iodide, and 1 milligram of indium iodide in an 18 cc. bulb, rated for 400 watt operation. This lamp operated to produce a pleasing white emission and no darkening of the bulb walls or deterioration of the arc-electrodes.

Another lamp in accord with the present invention utilized an 18 cc. bulb rated for 400 watt operation, as illustrated in the drawing, and had a charge of 60 milligrams of sodium iodide, 5 milligrams of antimony iodide, 80 milligrams of mercury, 2 milligrams of thallous iodide, and 1 milligram of indium iodide. The lamp operated to produce a pleasing white light with no noticeable blackening of the bulb walls or deterioration of the arc-electrodes.

Another lamp constructed in accord with the present invention utilized an 18 cc. bulb and was rated for 400 watt operation. Construction was essentially that as illustrated in the drawing. The charge 19 within the envelope contained 60 milligrams of sodium bromide, 10 milligrams of bismuth trichloride, 80 milligrams of mercury, 2 milligrams of thallous iodide, 1 milligram of indium iodide, and 18 torr of argon. This lamp operated to produce a pleasing white light with no noticeable darkening of the bulb wall or deterioration of the arc-electrodes.

From the foregoing, it is apparent that I have discovered a new and useful concept of making improved mercury-metallic halide vapor-arc discharge lamps wherein inorganic, polyvalent metallic halides of metals having a valence of two or greater and excluding metals from the alkali metal group, the alkaline earth metal group,

the metals of Group III of the Periodic Table including the rare earth metals, the metals of Group II of the Periodic Table, Group IVb of the Periodic Table such as titanium and zirconium, and the metals of Group Vb of the Periodic Table including vanadium and tantalum, and having a characteristic of at least partial dissociation at the operating temperature of the bulb walls of lamps in accord with the invention, namely, a temperature of in excess of 600° C. and no higher than 1200° C., operate to cause a regenerative halogen transport cycle within the lamp sufficient to prevent the darkening of the bulb walls or the destruction or deterioration of the arc-electrodes by sputtering or evaporation therefrom.

While the invention has been set forth herein with respect to certain specific embodiments and examples thereof, many additional modifications and changes will readily occur to those skilled in the art. Accordingly, by the appended claims, I intend to cover all such modifications and changes as fall within the true spirit and scope of the present invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A gaseous arc discharge lamp comprising:

- (a) an hermetically sealed, light-transmissive envelope;
- (b) a pair of non-liquid arc-electrodes extending within said envelope;

- (c) a quantity of mercury within said envelope sufficient upon complete vaporization thereof to produce within said envelope a mercury pressure of 1-10 atmospheres;

- (d) a vaporizable light producing charge within said envelope,

(d<sub>1</sub>) said charge including a halide other than the fluoride of a metal selected from the group consisting of lithium, sodium, cesium, calcium, cadmium, barium, gallium, indium, thallium, mercury, zinc, thorium, vanadium and scandium sufficient upon partial vaporization thereof at the equilibrium operating temperature of the lamp to provide a partial pressure of each vaporized metallic halide of approximately 0.1 to 200 torr; and

- (e) a quantity within said envelope of an inorganic halide, other than the fluoride, of a polyvalent metal selected from the group consisting of the metals of Groups IVa and Va of the Periodic Table of the elements,

(e<sub>1</sub>) said inorganic halide being at least partly dissociable at the equilibrium operating temperature of the inner surface of said envelope wall, and being effective to support a halogen transport cycle to keep the inner surface of said envelope free of sputtered electrode metal and to keep said arc-electrodes from destruction by loss of metal by sputtering and evaporation;

- (f) the walls of said envelope being spaced in relation to said arc-electrodes so that during the operation of the interior of said envelope is maintained at a temperature of in excess of 600° C. and no higher than 1200° C.

2. The device of claim 1 wherein the polyvalent metal is selected from the group consisting of tin, lead, antimony and bismuth.

3. The device of claim 1 wherein the polyvalent metal is tin.

4. The device of claim 3 wherein the inorganic halide which is effective to support a regenerative halide cycle is stannous bromide.

5. The device of claim 3 wherein the inorganic halide which is effective to support a regenerative halide cycle is stannous iodide.

6. The device of claim 3 wherein the inorganic halide which is effective to support a regenerative halide cycle is stannous chloride.

#### References Cited

##### UNITED STATES PATENTS

|           |        |          |           |
|-----------|--------|----------|-----------|
| 3,331,982 | 7/1967 | Waymouth | 313—227 X |
| 3,384,774 | 5/1968 | English  | 313—227 X |
| 3,398,312 | 8/1968 | Edris    | 313—227 X |

##### FOREIGN PATENTS

|           |         |                |
|-----------|---------|----------------|
| 900,200   | 7/1962  | Great Britain. |
| 274,989   | 10/1964 | Australia.     |
| 1,110,018 | 4/1968  | Great Britain. |

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U.S. Cl. X.R.

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