

[54] METAL HALIDE DISCHARGE LAMP CONTAINING TIN AND SODIUM HALIDES

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1971, abandoned.

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[51] Int. Cl. **H01j 61/18**

[58] Field of Search..... 313/184, 229, 225

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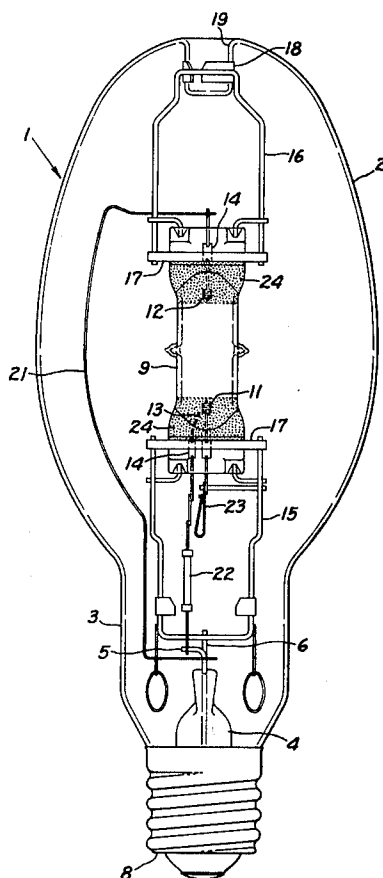
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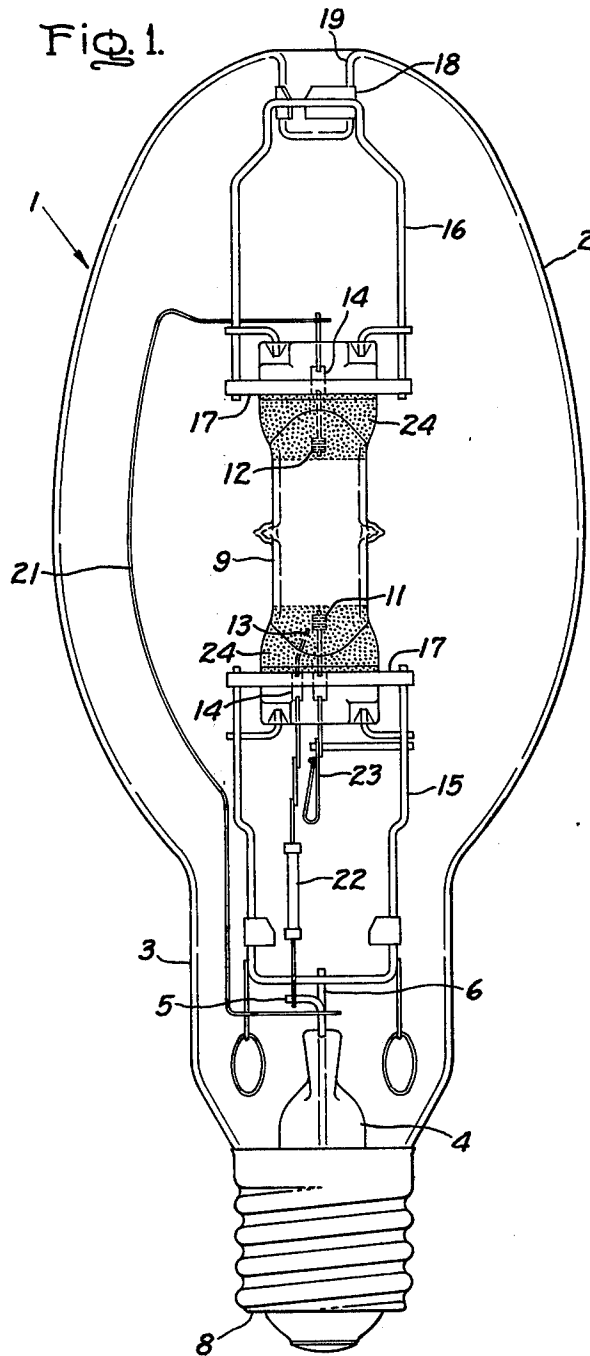
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[57] ABSTRACT

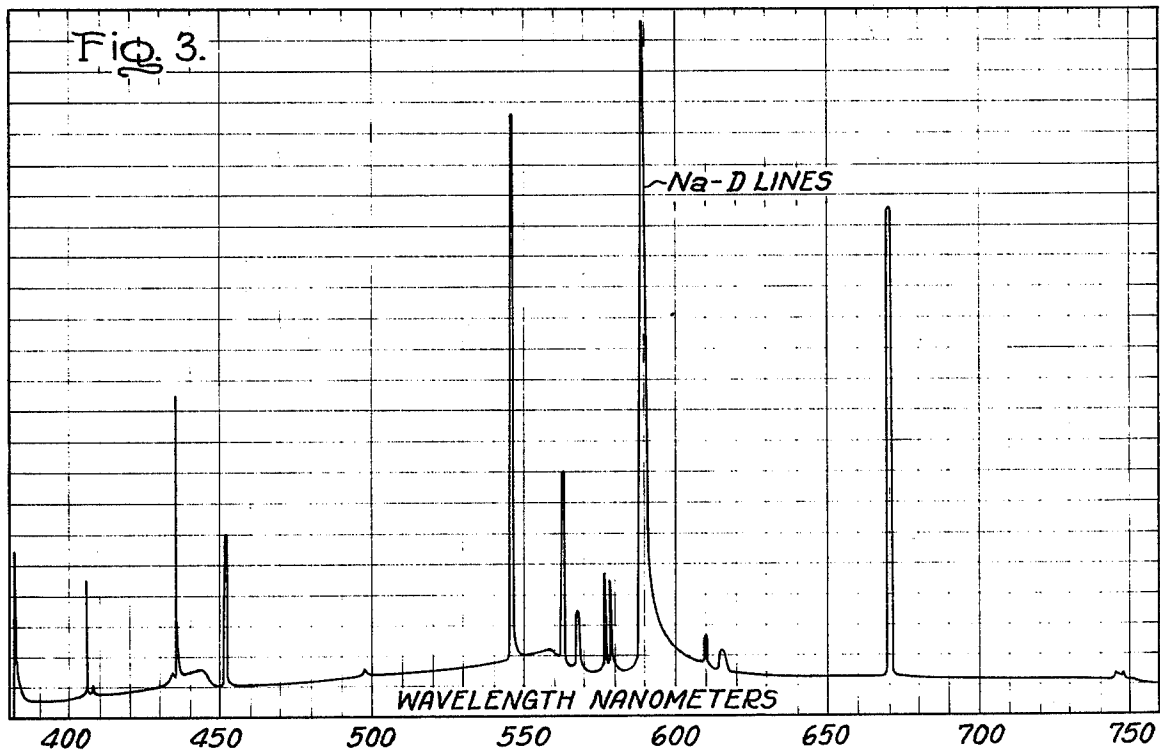
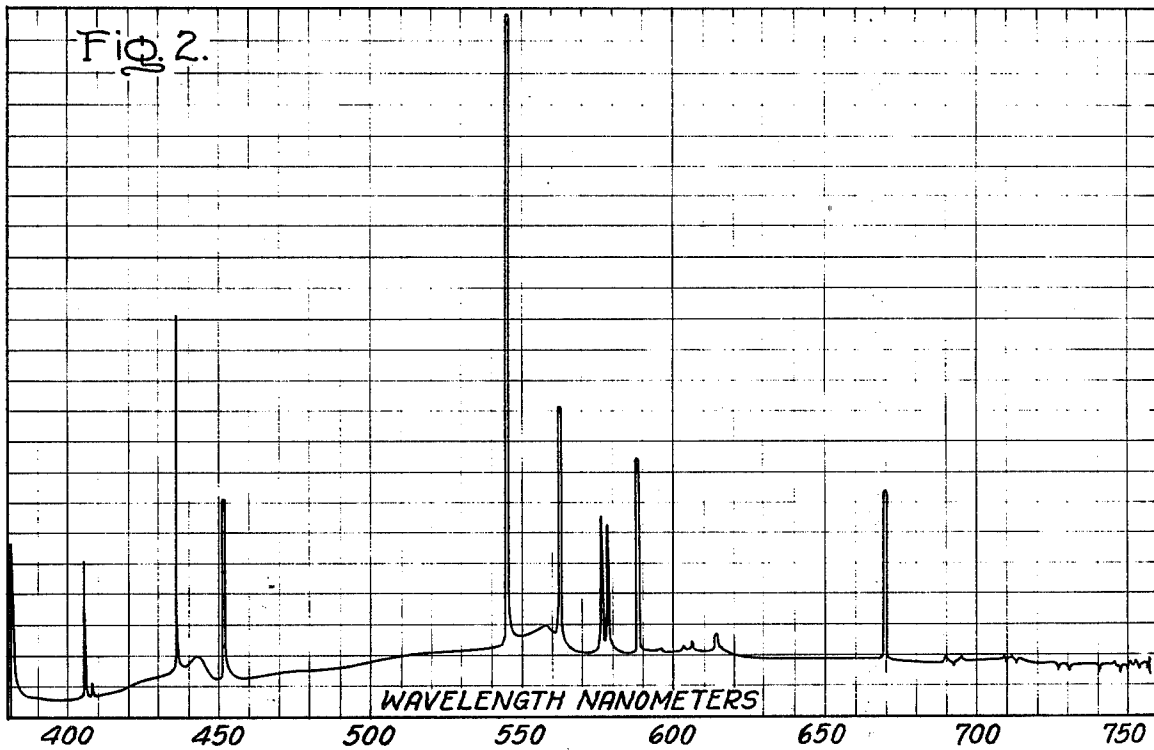
A tin halide lamp containing stannous chloride SnCl_2 , stannous iodide SnI_2 , and mercury which are almost completely vaporized in operation, an excess of tin for thermodynamic stability, an inert starting gas, and a predetermined small quantity of sodium chloride, bromide, or iodide exceeding the quantity vaporized. The lamp exhibits a continuous spectrum on which the broadened sodium D-lines are superimposed. The D-lines shift the color coordinates to the black body locus and simultaneously increase the efficacy for a superior combination of color rendition and efficiency without any reduction in life.

6 Claims, 4 Drawing Figures



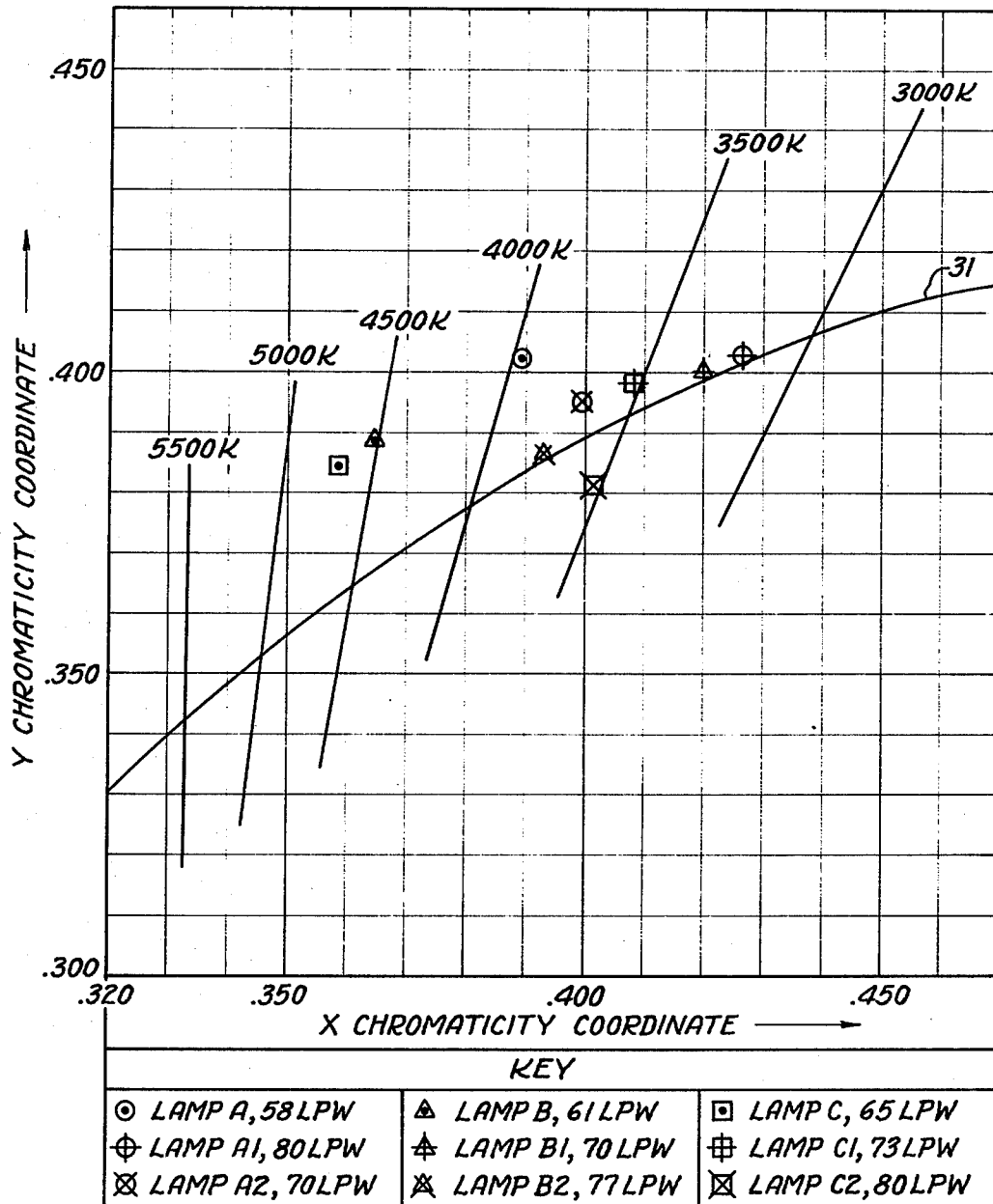


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Fig. 4.



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METAL HALIDE DISCHARGE LAMP CONTAINING TIN AND SODIUM HALIDES

REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of our earlier copending application Ser. No. 200,714 filed Nov. 22, 1971, similarly titled and assigned, and now abandoned.

Cross-reference is made to copending application Ser. No. 121,141 filed Mar. 4, 1971, by D. M. Speros, R. M. Caldwell, and W. E. Smyser, entitled "Metal Halide Discharge Lamp" and similarly assigned and now abandoned, and to copending application Ser. No. 78,484 by D. M. Speros, R. M. Caldwell, R. H. Springer and R. P. Taylor, filed Oct. 6, 1970, entitled "Tin Chloride Molecular Radiation Lamp" and similarly assigned.

BACKGROUND OF THE INVENTION

The invention relates to high pressure discharge lamps and more particularly to lamps of this kind containing mercury vapor and metallic halides.

The high pressure mercury vapor lamp which is extensively used for outdoor and industrial lighting produces radiation concentrated in the yellow-green area of the spectrum. The distinct lack of radiation in the orange and red as well as in the blue results in poor color rendition. In recent years a radical improvement in both color rendition and efficiency has been achieved by adding to the mercury one or more vaporizable metal halides under proper control of loading, temperature and pressure. Such improved lamps are described and claimed in U.S. Pat. No. 3,234,421 to Gilbert H. Reiling, issued Feb. 8, 1966. The preferred metal halides used in combination with mercury have been sodium iodide, thallium iodide and indium iodide. Although with this combination a remarkable improvement in efficiency and color rendition is achieved, the spectrum of the radiation nevertheless consists essentially of the lines of the various metals superimposed on a weak continuum and is not equivalent to natural daylight.

In copending application Ser. No. 121,141 by D. M. Speros et al., filed Mar. 4, 1971, entitled "Metal Halide Discharge Lamp", and assigned to the same assignee as the present invention, there are described and claimed high intensity arc discharge lamps of a molecular radiation type. These lamps contain a filling of mercury, an inert starting gas, stannous chloride SnCl_2 , stannous iodide SnI_2 , and excess tin. In the discharge, molecular species are distributed over very closely spaced energy levels in different electronic states between which radiative transitions may occur. The very closely spaced lines, or band spectra, characteristic of low pressure molecular emission are practically masked at high temperatures and pressures; thus there is produced a very broad continuum with the atomic lines of tin and mercury superimposed thereon.

SUMMARY OF THE INVENTION

The object of the invention is to further improve the color rendition and efficiency of the tin chloride molecular radiation lamp.

In accordance with the invention, we provide, in a high pressure gaseous discharge lamp, a filling containing stannous chloride SnCl_2 , stannous iodide SnI_2 , and mercury in predetermined quantities which are nearly

all vaporized in operation, an excess of tin for thermodynamic stability against attack of the tungsten electrodes by chlorine, an inert starting gas at a low pressure, and a predetermined quantity of sodium chloride, bromide, or iodide exceeding the quantity vaporized. The addition of the sodium D-lines to the preexisting spectrum shifts the color coordinates from the green side of the black body locus substantially to the black body locus and simultaneously increases the efficacy for a superior combination of color rendition and efficiency without any reduction in life. Due to the exceptionally high radiating efficiency of the sodium atom, very little sodium is required in the arc for a sizable contribution from it through the D-lines at 589.0 and 589.6 nanometers. In lamps according to our invention, the discharge sustaining filling includes per cubic centimeter of arc tube volume from about 0.15 to 0.70 milligrams of SnCl_2 , from about 0.60 to 2.50 milligrams of SnI_2 , from about 2.0 to 6.0 milligrams of mercury, at least 0.10 milligrams of tin, and from about 1.0×10^{-6} to 2.0×10^{-5} moles of sodium chloride, bromide, or iodide (0.06 to 1.17 mg. in the case of NaCl), and a small quantity of inert ionizable starting gas.

Whether the fill ingredients are added as listed above or as related compounds and elements should be determined on the basis of convenience. For instance it may be more convenient to add all or part of the SnI_2 as HgI_2 plus additional Sn metal to make up the molar quantity, in which case Hg is reduced by the corresponding molar quantity. Very soon after the lamp has gone into operation, an equilibrium will be established and it will be the same providing corresponding molar quantities have been used.

DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates in side view a jacketed high intensity lamp embodying the invention.

FIG. 2 is a spectral energy distribution diagram of a typical tin chloride molecular radiation lamp without added sodium.

FIG. 3 is a spectral energy distribution diagram of a tin chloride molecular radiation lamp having added sodium chloride in accordance with the invention.

FIG. 4 is a chromaticity coordinate plot of lamps with various fillings to which various quantities of sodium halide have been added in order to pull the color coordinates closer to the black body locus.

DETAILED DESCRIPTION OF INVENTION

Lamp Structure

Referring to FIG. 1, a tin chloride vapor arc lamp 1 in which the invention is embodied generally similar in construction and appearance to the high pressure mercury metal halide lamps sold commercially by applicants' assignee under the trademark "Multi-Vapor". The lamp comprises an outer vitreous envelope or jacket 2 of ellipsoidal form having a neck portion 3 closed by a reentrant stem 4 through which extend stiff inlead wires 5,6. The inleads are connected at their outer ends to the contacts of a screw base 8 and at their inner ends to the inner arc tube 9.

The inner arc tube is made of quartz-like glass or fused silica and has sealed therein at opposite ends main arcing electrodes 11,12 plus an auxiliary starting electrode 13. The electrodes are supported on inleads which include intermediate thin molybdenum foil sections 14 hermetically sealed through the flattened or

pinched ends of the arc tube. The main electrodes 11,12 each comprise a double layer helix of tungsten wire wrapped around a tungsten core.

The arc tube is supported within the outer jacket by a two-part mount, 15 at the base end and 16 at the dome end. Each part comprises a pair of longitudinally extending support rods bridged by metal straps 17 which clamp about the pinched ends of the arc tube. The base end mount part is welded to inlead 6 and serves as a conductor to main electrode 11. The dome end mount part has attached thereto a spring collar 18 which engages a reentrant nipple 19 in the dome end of the jacket. Main electrode 12 is connected to inlead 5 by curving wire 21. Starting electrode 13 is connected to inlead 5 through current limiting resistor 22. A thermal switch 23 consisting of a bimetal is arranged to short circuit auxiliary electrode 13 to main electrode 11 after the lamp warms up. Heat reflective coatings 24, suitably of ZrO₂, are provided on the arc tube ends to assure adequate heating.

By way of example of a preferred embodiment, in one lamp of 175 watt rating wherein the arc tube had an overall body length of about 6.30 centimeters and a volume of about 4.60 cc., the fill consisted of 1.33 milligrams SnCl₂, 3.48 milligrams SnI₂, 3.02 milligrams tin, 22.9 milligrams mercury, 0.60 milligrams sodium chloride, and 20 torr argon at room temperature. It may be more convenient to introduce the fillings as tin chloride, mercury chloride, tin and mercury in which case equivalent molar quantities are used as follows: 1.33 mg. SnCl₂, 4.24 mg. HgI₂, 4.13 mg. Sn, 21.0 mg. Hg and 0.60 mg. NaCl. Yet another alternative is to introduce the filling as mercury chloride, mercury iodide, tin and mercury, in which case the equivalent quantities are 1.91 mg. HgCl₂, 4.24 mg. HgI₂, 4.96 mg. Sn, 19.6 mg. Hg and 0.60 mg. NaCl.

The spectral distribution diagram of the lamp of the previously described preferred embodiment is shown in FIG. 3 whereas the spectral distribution for the same lamp without the added sodium chloride is shown in FIG. 2. The spectra differ primarily by the presence of the broadened sodium D-lines at 589.0 - 589.6 nm. in FIG. 3 which are absent in FIG. 2, with substantially no change in the underlying continuum.

Examples of lamps constructed in accordance with our invention have discharge sustaining fillings as given in Table 1 below. In each series, the parent or first lamp of the series has a tin chloride-iodide, tin, mercury filling which is modified in the derivative lamps by the addition of sodium chloride or iodide.

TABLE 1

Lamp A	Lamp A1	Lamp A2
0.34 mg/cm ³ SnCl ₂ 0.89 mg/cm ³ SnI ₂ 0.93 mg/cm ³ Sn 4.98 mg/cm ³ Hg	To A add 0.33 mg/cm ³ NaI	To A add 0.13 mg/cm ³ NaCl
Lamp B	Lamp B1	Lamp B2
0.29 mg/cm ³ SnCl ₂ 0.76 mg/cm ³ SnI ₂ 0.65 mg/cm ³ Sn 4.98 mg/cm ³ Hg	To B add 0.33 mg/cm ³ NaI	To B add 0.13 mg/cm ³ NaCl
Lamp C	Lamp C1	Lamp C2
0.39 mg/cm ³ SnCl ₂	To C add 0.45 mg/cm ³ NaI	To C add 0.23 mg/cm ³ NaCl

TABLE 1-Continued

Lamp A	Lamp A1	Lamp A2
1.13 mg/cm ³ SnI ₂ 0.65 mg/cm ³ Sn 2.83 mg/cm ³ Hg		

Referring to FIG. 4, the chromaticity coordinates are shown for the various lamps listed in Table 1, in each case for the lamp before and after the addition of the sodium salt. The black body locus 31 is also shown and it will be observed that in each case the addition of the sodium salt increases the x chromaticity coordinate to a very substantial extent, for instance by as much as 0.040, while having little effect on the y chromaticity coordinate. The addition of the sodium salt shifts the chromaticity coordinate into close proximity with the black body locus line.

It is important to limit the quantity of added sodium halide because its vapor pressure is low but should some of the sodium be lost from the arc tube, as by electrolysis through the quartz arc tube wall, the pressure of the halogen remaining behind would rise rapidly. In the case of added NaCl, electrolysis of Na could cause a rise in chlorine pressure, such rise in halogen pressure entailing violent failure of the lamp or rapid erosion of the tungsten electrodes. By limiting the sodium halide charge to 2.0×10^{-5} moles or less per cubic centimeter of arc tube volume, such possibilities are substantially avoided. Another criterion for avoiding excessive halogen pressure rise at end of life is a weight ratio of Na to Sn present in halide form not exceeding about 0.1. Fortunately the exceptionally high radiating efficiency of the sodium atom permits the desired chromaticity shift to be achieved by small amounts of sodium not exceeding the foregoing limits. To achieve the desired chromaticity shift towards the black body locus in the temperature range from 3000° to 5000°K, the weight ratio of added Na to Sn preferably should be from about 0.07 to 0.09. The preferred weight ratio of SnCl₂ to SnI₂ for high efficiency coupled with reasonably long life is from about 0.3:1 to 0.4:1.

The sodium requirement may be added to the lamp either as the chloride, bromide, or iodide, but depending upon the choice of halide in a given SnCl₂-SnI₂ lamp, a different equilibrium composition will result. The introduction of sodium halide to the lamp leads to the equilibrium

$\text{SnCl}_2(\text{f}) + 2\text{NaI}(\text{s}) \rightleftharpoons \text{SnI}_2(\text{g}) + 2\text{NaCl}(\text{s})$ Calculations based on thermodynamic data and experimental observations indicate that for a lamp with a SnCl₂-SnI₂-Hg atmosphere prior to the addition of sodium halide, the minimum change in equilibrium tin halide pressures is obtained when sodium is added in the form of NaCl. Correspondingly it may be noted in FIG. 4 that in every case a greater change is occasioned in the x coordinate when sodium is added in the form of iodide than when it is added in the form of chloride. A specific chromaticity coordinate and color rendition requirement in an SnCl₂-SnI₂-Hg atmosphere may be satisfied using either NaCl or NaI as the additive, but the quantity will be slightly different in either case and may require a readjustment in the proportions of the other fill ingredients. It may also be satisfied by the addition of NaBr.

5

The efficacy of lamps embodying the invention such as lamps A1, A2, B1, B2, C1 and C2 is in excess of 70 lumens per watt. Efficacies up to about 90 lumens per watt have been measured at color temperatures from 3000° to 5000°K. This makes the lamp competitive with all other metal halide lamps in regards to efficacy and at the same time the lamp is significantly superior in regards to color rendition.

The presence of sodium also has the desirable effect of lowering the peak voltage at cyclical reignition. This means an improvement in power factor and the ability to operate on lower cost ballasts.

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

1. A high intensity discharge lamp exhibiting a substantially continuous spectrum in the visible range plus broadened sodium D line radiation comprising a sealed elongated arc tube of light-transmitting material, arc supporting electrodes mounted at opposite ends of said arc tube on inleads sealed therethrough, and a discharge sustaining filling within said arc tube comprising per cubic centimeter of arc tube volume from 0.15 to 0.70 milligrams of SnCl_2 , from 0.60 to 2.50 milligrams of SnI_2 , at least 0.10 milligram of tin, from 2.0 to 6.0 mg of mercury, from 1.0×10^{-6} to 2.0×10^{-5} moles of one of sodium

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chloride, sodium bromide, sodium iodide and mixtures thereof, and a small quantity of an inert starting gas.

2. A lamp as in claim 1 wherein the weight ratio of Na to Sn present in halide form does not exceed about 0.1.

3. A lamp as in claim 1 wherein the weight ratio of Na to Sn present in halide form is in the range of about 0.07 to 0.09.

4. A lamp as in claim 1 wherein the weight ratio of Na to Sn present in halide form is in the range of about 0.07 to 0.09 and the weight ratio of SnCl_2 to SnI_2 is from about 0.3:1 to 0.4:1.

5. A lamp as in claim 1 wherein the weight ratio of Na to Sn present in halide form is in the range of about 0.07 to 0.09 and the quantity of sodium halide is selected to increase the x chromaticity coordinate and shift the color point of the lamp substantially to the black body locus.

6. A lamp as in claim 1 wherein the weight ratio of Na to Sn present in halide form is in the range of about 0.07 to 0.09, the weight ratio of SnCl_2 to SnI_2 is from about 0.3:1 to 0.4:1, and the quantity of sodium halide is selected to increase the x chromaticity coordinate and shift the color point of the lamp substantially to the black body locus.

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