Oct. 18, 1955 N. C. BEESE 2,721,285

SPECTROSCOPIC LAMP

Filed May 27, 1953

Fig. 1.

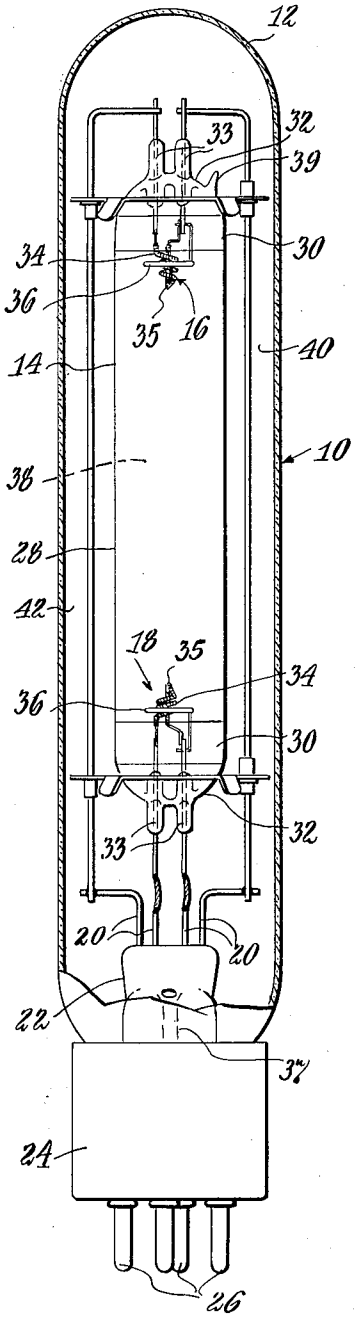


Fig. 2.

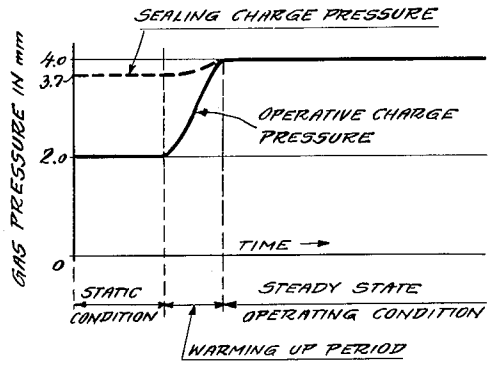


Fig. 3.

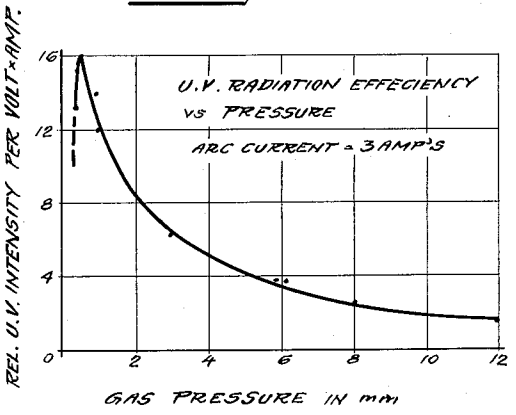
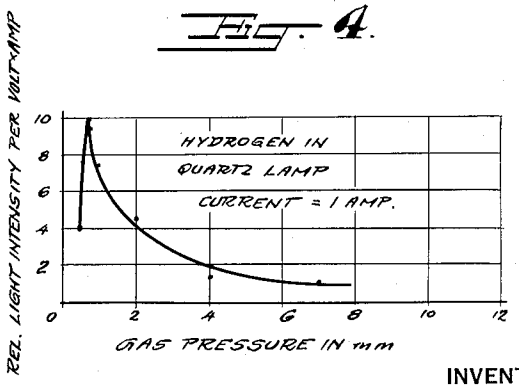


Fig. 4.



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2,721,285

SPECTROSCOPIC LAMP

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Application May 27, 1953, Serial No. 357,674

9 Claims. (Cl. 313—25)

This invention relates to arc lamps and, more particularly, to spectroscopic helium arc lamps.

Heretofore it has been known that helium arc lamps are very useful as a spectrosopic light source, for such lamps produce very sharp spectral lines at 1.08 mu and 2.06 mu in the infrared, 3889 A. U. in the ultraviolet, and several frequencies in the visible spectrum. A spectral distribution for helium may be found in Handbook of Chemistry and Physics, 33rd edition, p. 2303, published by the Chemical Rubber Publishing Company, Cleveland, Ohio (1951).

In most lamps, spectroscopic lamps included, it is, of course, desirable to maintain the highest operating efficiency possible, and to have an output which is relatively constant throughout the life of the lamp. In addition, the life of the lamp should be as long as possible.

Helium spectrosopic lamps preferably operate at relatively high temperatures and wattages, a representative average temperature being 313° C., a representative maximum temperature being slightly above 500° C., and a representative wattage being 225 watts. Because of these relatively high temperatures, the vitreous envelope containing the helium arc is preferably fabricated of fused quartz, which will withstand the high operating temperatures. At these high operating temperatures, however, the fused quartz envelope is quite porous to the light gases, i. e., helium and hydrogen, resulting in a decrease of the helium charge within the quartz envelope. This leakage of the operating charge of helium gas modifies the operating characteristics of the spectroscopic lamp, which lamp, of course, desirably has operating characteristics which are quite stable. Further, it is impossible to maintain the light gas operating pressures which will result in a suitably stable operational efficiency, not only because of the loss of operating gas through the envelope, but because of the "cleaning-up" of the operating gas during operation of the lamp.

It is the general object of the invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of a vitreous outer envelope surrounding the inner fused quartz envelope, and by providing a sealing charge of light gas within the volume enclosed between the two envelopes.

A further object of my invention is to provide a vitreous outer envelope to surround the inner fused quartz envelope and to include between the inner and outer envelopes a reservoir of light gas in order to make up any operating light gases within the inner envelope which may be "cleaned up" during operation.

It is another object of my invention to provide a vitreous outer envelope to surround the inner fused quartz envelope and to include between the inner and outer envelopes a sealing-reservoir charge of helium gas of such pressure that the average operating pressure of the helium gas within the fused quartz envelope and the average pressure during operation of the helium reservoir and sealing gas between the two envelopes are approximately the same.

Yet another object of my invention is to provide an inert gas within the volume bounded by the inner surface of the outer envelope and the outer surface of the inner envelope, in order to facilitate starting.

A still further object of my invention is to provide a discharge lamp with inner and outer envelopes, which lamp has a hydrogen gas reservoir and sealing charge between the two envelopes, and utilizes an operating charge of hydrogen gas within the inner envelope.

Another object of my invention is to provide allowable and optimum limits for the operating pressures of the sealing-reservoir charge and operating charge in my lamp, at which pressures the spectral radiation from the arc discharge will be maintained within the corresponding allowable limits or at an optimum.

The aforesaid objects of the invention and other objects which will become apparent as the description proceeds are achieved by providing a light gas spectroscopic lamp with inner and outer envelopes wherein the light gas discharge occurs within the inner envelope and the volume between the inner and outer envelopes contains a sealing-reservoir charge of light gas, which sealing-reservoir charge has a pressure, during operation of the lamp, approximately equal to the pressure during lamp operation of the operating charge of light gas contained within the inner envelope. In addition, the operating charge may be maintained within allowable limits or at an optimum, which will result in an increased intensity of spectral lines produced.

For a better understanding of my invention, reference should be had to the drawings, wherein:

Fig. 1 is a sectional view of the preferred embodiment of my invention illustrating the double vitreous envelopes, electrodes, lead-in conductors, and necessary electrical connections for my lamp;

Fig. 2 is a graph of the relative gas pressures within the inner envelope and within the volume between the inner and outer envelopes as ordinate vs. static conditions, warming up period, and steady-state operating conditions as the abscissa. The sealing-reservoir gas pressures between the inner and outer envelopes are represented as a dotted line and the operating gas pressures within the inner envelope are represented as a solid line;

Fig. 3 is a graph representing the ultraviolet radiation relative intensity/volt-ampere of the helium arc discharge as ordinate vs. helium operating charge gas pressure in mm. mercury as abscissa. This ultraviolet radiation is largely 3889 A. U.;

Fig. 4 is a graph representing visible light relative intensity/volt-ampere of the hydrogen arc discharge as ordinate vs. the hydrogen operating charge gas pressure in mm. mercury as abscissa.

Although the principles of the invention are broadly applicable to any discharge lamp wherein the operating gas pressures are to be maintained within allowable limits within an envelope which may be porous with respect to said operating gas, the invention is usually employed in conjunction with a spectroscopic helium arc lamp and hence it has been so illustrated and will be so described.

With specific reference to the form of the invention illustrated in the drawing, the numeral **10** indicates the spectroscopic lamp, generally, which lamp comprises an outer envelope **12**, inner envelope **14**, electrodes **16** and **18**, a plurality of lead-in conductors **20**, reentrant press **22**, base **24**, and electrical contact pins **26**. The inner envelope **14** consists generally of a hollow tubular fuzed quartz portion **28**, graded seals **30** fuzed to the end of quartz portion **28**, and a high coefficient of thermal expansion sealing glass **32** fuzed to the ends of graded seals **30**, through which the plurality of lead-in conductors **20** are sealed. As heretofore noted, the hollow tubular portion **28** of inner envelope **14** is preferably of fuzed quartz in

order to withstand the relatively high operating temperatures which may be 300° to 550° C. Quartz cannot be sealed, however, to the tungsten lead-in conductors **20** because of the differences in coefficients of thermal expansion of the quartz and the lead-in conductors. Accordingly, graded seals **30** are provided at either end of the tubular quartz portion **28**, in order to bridge the difference in the coefficients of thermal expansion of quartz and that of the high coefficient of thermal expansion glass seals **32** which are fuzed to the ends of the graded seals **30** and which will form satisfactory hermetic seals with the plurality of lead-in conductors **20**. This practice is very common in the art. The glass seals **32** may be fabricated of any glass which softens at temperatures above 500° C. and has a suitably high coefficient of thermal expansion.

While the glass seal **32** will satisfactorily seal to the lead-in conductors **20**, it is preferable to first bead the lead-in conductors **20** with a glass bead **33** before fuzing the seal **32** around lead-in conductors **20**. It has been found that a glass manufactured by the Corning Glass Works and designated as Corning Code No. 724, which is a sodium-potassium-borosilicate glass, may be satisfactorily beaded onto the lead-in conductors **20**. Between this glass bead **33** and the graded seal **30** it has been found that a glass manufactured by the Corning Glass Works and designated as Corning Code No. 723, which is borosilicate-alumino glass, will be satisfactory as the glass seal **32**. The graded seals **30** are very common and well-known in the art, and consist of a series of glasses running in succession from a low coefficient of thermal expansion at the quartz connecting ends to a relatively high coefficient of thermal expansion at the other ends, in order to bridge the difference in coefficients of thermal expansion between the quartz **28** and the sealing glass **32**, as heretofore noted.

The plurality of lead-in conductors **20** may be fabricated of a refractory metal such as tungsten or molybdenum and are hermetically sealed through the inner envelope **14** and outer envelope **12**. The plurality of lead-in conductors **20** are hermetically sealed through the outer envelope **12** by means of a reentrant press **22**, as is common in the art. The plurality of lead-in conductors **20** may terminate at the exterior of the outer envelope in electrical contact adapters, such as contact pins **26** contained in a base **24** at one end of the outer envelope **12**, as illustrated, or the plurality of lead-in conductors **20** may be sealed through both ends of the outer envelope **12** as is common in the fluorescent lamp art.

The electrodes **16** and **18** are supported by lead-in conductors **20** and are substantially similar to the electrodes disclosed in my Patent No. 2,562,887, dated Aug. 7, 1951, and assigned to the present assignee. The electrodes **16** and **18** are identical and are positioned approximately at opposite ends of the inner envelope **14**. Each electrode **16** and **18** consists of a cathode **34** comprising an oxide coated refractory metal such as tungsten or molybdenum terminating in an electrode tip **35**, and a torroidal anode **36** fabricated of a refractory metal such as tungsten or molybdenum.

The outer envelope **12** may consist of any suitable hard glass which softens at temperatures above 500° C. and is impervious to light gases. "Pyrex" may be used as an outer envelope, if desired. "Pyrex" is a Corning Glass Works trademark for a borosilicate-alumino-sodium-potassium glass. The outer envelope **12** may take any desired shape, but is preferably of a generally hollow cylindrical shape, with one end closed and the other end sealed by a reentrant press **22**, as illustrated. The press **22** also includes a tipped-off exhaust tube **37**, as is common in the lamp art.

Contained within the inner envelope **14** is an operating charge **38** of helium gas which is preferably of the highest purity obtainable which charge is introduced through tipped-off exhaust tube **39**. Contained between the outer envelope **12** and the inner envelope **14** in what may be referred to as a sealing-reservoir volume is a sealing-reservoir charge **40** of helium gas at such pressure that during operation of the lamp the pressures of the operating charge **38** of helium gas within the inner envelope **14** and the sealing-reservoir charge **40** will be approximately equal. It has been found by experimentation that if the foregoing gas-pressures of the operating charge **38** and the sealing-reservoir charge **40** are to be equal during operation of the lamp, in the embodiment illustrated and described, the static or non-operating pressure of the helium operating charge **38** will be slightly more than half the static or non-operating pressure of the helium sealing reservoir charge **40**. Knowing the operating temperatures and the gas constants for the gases involved, the pressures which will be encountered during operation may be readily calculated by Boyle's and Charles' Laws, see Handbook of Engineering Fundamentals, second edition, Eshbach, page 8–15, John Wiley and Sons, Inc., New York (1952).

In Fig. 2 are representative curves illustrating the pressures of the sealing-reservoir charge **40**, shown as a dotted line, and the operating charge **38** shown as a solid line, of helium gas within the envelopes **12** and **14**, during non-operating or static conditions, during the warming-up period, and during steady-state operation. As illustrated, and as heretofore noted, during the static or non-operating condition the pressure of the sealing-reservoir charge **40** of helium gas in the embodiment as illustrated and described will be slightly less than twice that of the non-operating or static gas pressure of the operating charge **38**.

Also contained within the volume between the outer envelope **12** and inner envelope **14** is a starting charge **42** of argon and/or nitrogen gas. It has been found convenient to maintain a static or non-operating total gas pressure between the envelopes **12** and **14** of one atmosphere, and accordingly, if the partial pressure of the helium gas sealing-reservoir charge **40** is to be 4 mm. mercury, the partial pressure of the starting charge **42** will be approximately 718 mm. mercury. The purpose of this starting charge **42** is purely to facilitate starting, for without it, the low pressure of the helium gas sealing-reservoir charge **40** would tend to cause an arcing over the lead wires adjacent the glass reentrant press **22**, rather than permitting the establishment of an arc within the inner envelope **14**.

In Fig. 3 is shown a graph of the relative intensity/volt-ampere of the 3889 A. U. helium spectral line vs. the pressure of the helium operating gas **38** under operating conditions. These intensities were measured with an ultra-violet sensitive photocell, and as plotted represent only relative values for purposes of comparison. As may be seen, the curve is somewhat exponential in nature, having a low relative intensity of 1.8 at 12 mm. mercury pressure of operating gas **38** and a peak relative intensity of 16 at approximately 0.5 mm. mercury pressure of operating gas **38**. As may be seen, the curve starts to break at a relative intensity of 3.8 at about 6 mm. mercury pressure of operating gas **38**. It has been found through experimentation that it is desirable to maintain the operating pressures of the operating gas between about 0.5 mm. mercury and 6 mm. mercury in order to maintain operation of the lamp at the more efficient operating pressures.

Light gas discharge lamps tend to "clean up" or decrease the operating charge **38** during operation, and the pressure of the operating charge **38** will thus gradually decrease during operation both through dispersion of the operating charge **38** through the fuzed quartz envelope, and through the heretofore noted "cleaning up" of the operating charge **38**. It might be possible in some cases to make the inner envelope **14** sufficiently large to enclose a suitable reservoir of light gas in order to maintain the operating charge **38** within allowable limits for a sufficient period of time to give the lamp a reasonable life. Such a larger inner envelope, however, is impractical where a positive column discharge is to be maintained, since such a discharge requires a relatively narrow cross-sectional

configuration in order to satisfactorily form this type of discharge; space limitations are also a consideration. It is for this reason that the outer envelope **12**, which is impervious to light gases, is required, in order to contain a reservoir of light gases to make up that portion of the operating charge **38** which is "cleaned up" within the inner envelope **14**, and to seal the operating charge **38** within the inner envelope **14**.

As may be seen from Fig. 3, if it is desired to operate my lamp at a maximum efficiency, the pressure of operating charge **38** during steady-state operating conditions should be maintained between 0.5 and 1 mm. mercury.

For one specific embodiment of my invention, the following lamp dimensions and gas-fill pressures are given:

Overall length of cylindrical outer envelope.	11″
Average diameter of outer envelope	2″
Overall length of cylindrical inner envelope.	6″
Average diameter of inner envelope	¾″
Distance between electrode tips	3″
Operating helium gas pressure within inner envelope (non-operating conditions—20° C.).	0.25–3 mm.
Partial pressure of sealing and reservoir charge of helium gas between inner and outer envelope (non-operating—20° C.).	0.47–5.5 mm.
Partial gas pressure of starting charge of argon and/or neon (non-operating condition—20° C.).	approx. 70 cm.
Operating voltage	150 volts
Operating current	1½ amps.

Operation

When the energizing potential is applied across the lead-in conductors **20**, a portion of the operating charge **38** between electrodes **16** and **18** will ionize and an arc will strike between the electrodes. When the arc is first struck, the entire lamp is normally at a room temperature of about 20° C., at which temperature the quartz portion **28** of inner envelope **14** is impervious to light gases. As soon as the arc is struck, however, the temperature within the inner envelope **14** will rise sharply, stabilizing at an average steady-state temperature around 310° C. At this average steady-state operating temperature the quartz portion **28** of inner envelope **14** will be at a temperature of about 500° C. and at such a temperature is quite porous to light gases. The sealing-reservoir charge **40** and starting gas charge between the inner **14** and outer **12** envelopes will also heat during operation, but to a much lesser degree because of the increased volume and surface area of the outer envelope **12**. When the steady-state operating conditions have been reached, the pressure of the operating charge **38** of helium gas within the inner envelope **14** and the partial pressure of the sealing-reservoir charge **40** between inner **14** and outer **12** envelopes will be substantially equal. Of course, when steady-state operating temperatures and conditions have been reached, the helium gas will diffuse through the quartz portion **28** of inner envelope **14** with considerable rapidity, but there will be no net flow of helium gas into or out of the inner envelope **14** because of the equal pressures of helium on both sides of the tubular quartz **28**.

During operation of the lamp, a portion of the operating charge **38** will be "cleaned up" as heretofore noted, and the operating charge **38** pressure reduced accordingly. The sealing-reservoir charge **40** will make up this loss, since the partial pressures of the light gas on either side of the quartz portion **28** of inner envelope **14** will be substantially the same during operation. Of course the "cleaning up" will have the effect of decreasing the sealing-reservoir charge **40**, but because of the greater volume of sealing-reservoir charge **40** enclosed between the outer envelope and inner envelope, this gradual decrease in the pressure of the operating gas charge **38** through "cleaning up" does not measurably decrease the life of the lamp or change the operating characteristics. It is obvious that the volume contained between the inner envelope **14** and outer envelope **12** is not limited by design considerations, and, accordingly, within reasonable limits the outer envelope **12** may be enlarged. Thus the operating characteristics of the lamp are not appreciably affected by any change in the helium operating charge **38**. It should be noted that the quartz portion **28** of inner envelope **14** is impervious to the starting charge of the heavier argon and/or nitrogen gas contained between the inner envelope **14** and outer envelope **12**, even at operating temperatures above 500° C. and these heavier gases in no way affect the operation of the lamp, except as concerns starting, as hereinbefore noted.

It will be recognized that the objects of the invention have been achieved by providing a light gas spectroscopic lamp which has a long life, can be operated at constant efficiency, and if desired, the operating efficiency can be maintained at an optimum for long periods of time.

As a possible alternative structure of the preferred embodiment of my spectroscopic lamp, the operating charge **38** and sealing-reservoir charge **40** may be hydrogen. In Fig. 4 is shown a graph of the relative intensity/volt-ampere of the visible spectrum vs. the pressure of the hydrogen operating gas **38** under operating conditions. These intensities were measured with a visible light sensitive photocell, and as plotted represent only relative values for purposes of comparison. As can be seen, the curve is somewhat exponential in nature, having a low relative intensity of 1.4 at 7 mm. operating gas pressure and a peak at a relative intensity of 10 at approximately 0.6 mm. mercury operating gas pressure. As may be seen, the curve starts to break at a relative intensity of 1.6 at about 4 mm. operating gas pressure. It has been found through experimentation that it is desirable to maintain the operating gas pressures between 0.6 and 4 mm. in order to operate the lamp at a more efficient operating pressure. If it is desired to operate at a maximum of efficiency, the operational pressure of the operating charge **38** may be maintained between 0.6 and 0.8 mm. mercury.

While in accordance with the patent statutes one best known embodiment of my invention has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

I claim:

1. A light gas discharge lamp comprising a vitreous sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of light gas contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state light gas arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state light gas arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a light gas sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state light gas arc discharge approximates said average steady-state operating pressure of said operating charge, and a starting charge contained within said sealing-reservoir volume for maintaining said light gas arc discharge within said inner envelope.

2. A spectroscopic lamp comprising a vitreous sealed

outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of helium gas contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state helium arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state helium arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a helium gas sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state helium arc discharge approximates said average steady-state operating pressure of said operating charge, and a nitrogen gas starting charge contained within said sealing-reservoir volume for maintaining said helium arc discharge within said inner envelope.

3. A helium arc lamp comprising a vitreous sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of helium contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state helium arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state helium arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a helium sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state helium arc discharge approximates said average steady-state operating pressure of said operating charge, and an argon gas starting charge contained within said sealing-reservoir volume for maintaining said helium arc discharge within said inner envelope.

4. A discharge lamp comprising a vitreous sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of hydrogen gas contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state hydrogen arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state hydrogen arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a hydrogen gas sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state hydrogen arc discharge approximates said average steady-state operating pressure of said operating charge, and a starting charge contained within said sealing-reservoir volume for maintaining said hydrogen arc discharge within said inner envelope.

5. A spectroscopic lamp comprising a helium gas impervious, vitreous sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of helium gas contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state helium arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state helium arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a helium gas sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state helium arc discharge approximates said average steady-state operating pressure of said operating charge, a starting charge of nitrogen gas contained within said sealing-reservoir volume, and said starting charge and said sealing-reservoir charge having non-operating pressures totalling approximately one atmosphere.

6. A hydrogen discharge lamp comprising a vitreous sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of hydrogen contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state hydrogen arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state hydrogen arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a hydrogen sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state hydrogen arc discharge approximates said average steady-state operating pressure of said operating charge, the average pressure of said hydrogen operating charge during said steady-state arc discharge being from 0.6 to 0.8 mm. mercury and a starting charge contained within said sealing-reservoir volume for maintaining said hydrogen arc discharge within said inner envelope.

7. A hydrogen discharge lamp comprising a vitreous sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of hydrogen contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state hydrogen arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state hydrogen arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a hydrogen sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state hydrogen arc discharge approximates said average steady-state operating pressure of said operating charge, the average pressure of said hydrogen operating charge during said steady-state arc discharge being from 0.6 to 4 mm. mercury, and a starting charge contained within said sealing-reservoir volume for maintaining said hydrogen arc discharge within said inner envelope.

8. A helium discharge lamp comprising a vitreous

sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of helium contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state helium arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state helium arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a helium sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state helium arc discharge approximates said average steady-state operating pressure of said operating charge, the average pressure of said helium operating charge during said steady-state arc discharge being from 0.5 to 1.0 mm. mercury, and a starting charge contained within said sealing-reservoir volume for maintaining said helium arc discharge within said inner envelope.

9. A helium discharge lamp comprising a vitreous sealed outer envelope surrounding a fuzed quartz sealed double-ended inner envelope, said envelopes having inner and outer surfaces and lead-in conductors sealed therethrough, electrodes positioned within said inner envelope and substantially at opposite ends thereof and supported thereat by said lead-in conductors, an operating charge of helium contained within said inner envelope, said lead-in conductors and said electrodes being adapted to have applied thereto an energizing potential for ionizing and converting a portion of said operating charge into a steady-state helium arc discharge between said electrodes, said operating charge having an average steady-state operating pressure during said steady-state helium arc discharge, a sealing-reservoir volume bounded by said outer envelope inner surface and said inner envelope outer surface, a helium sealing-reservoir charge contained within said sealing-reservoir volume and of such magnitude that its average pressure during said steady-state helium arc discharge approximates said average steady-state operating pressure of said operating charge, the average pressure of said helium operating charge during said steady-state arc discharge being from 0.5 mm. to 6.0 mm. mercury, and a starting charge contained within said sealing-reservoir volume for maintaining said helium arc discharge within said inner envelope.

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