Sept. 23, 1952 E. B. NOEL 2,611,883

HIGH-PRESSURE MERCURY VAPOR LAMP

Filed March 27, 1948

Fig. 1.

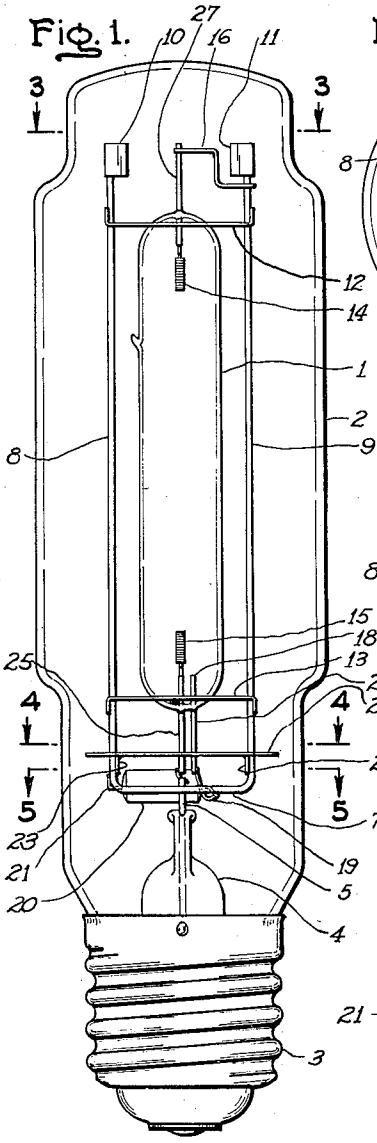


Fig. 3.

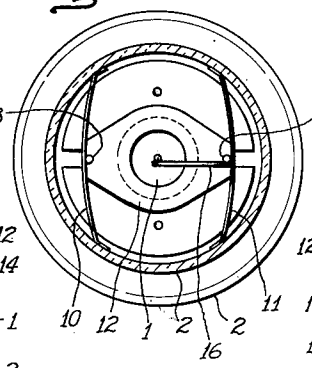


Fig. 4.

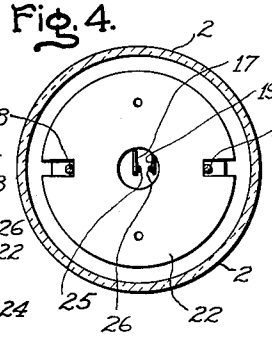


Fig. 5.

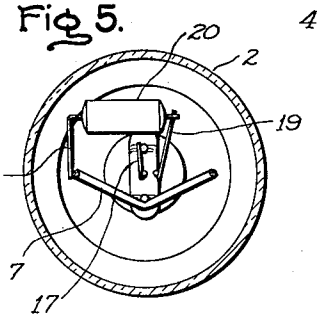
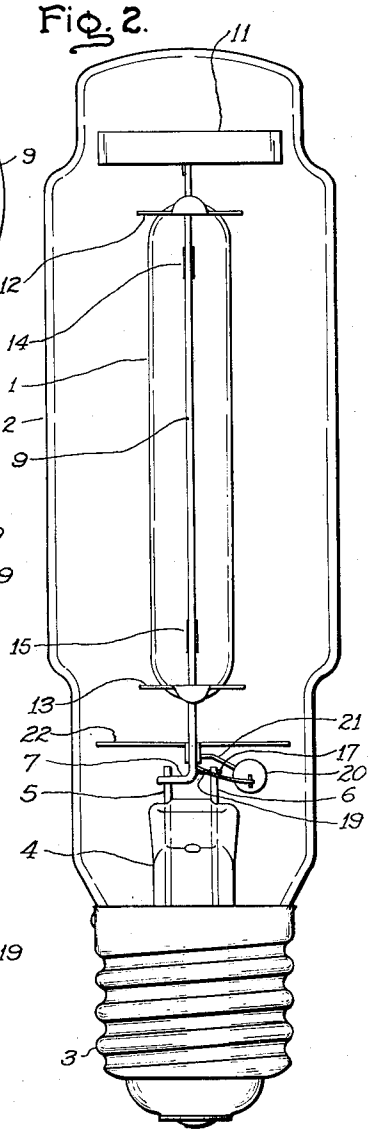


Fig. 2.



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His Attorney.

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UNITED STATES PATENT OFFICE

2,611,883

HIGH-PRESSURE MERCURY VAPOR LAMP

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Application March 27, 1948, Serial No. 17,423

8 Claims. (Cl. 315—112)

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My invention relates to high pressure mercury vapor electric discharge lamps comprising a sealed tubular quartz envelope containing mercury and a starting gas and having electrodes mounted at its ends, and a sealed glass envelope completely enclosing the quartz envelope and filled with an inert gas, such as nitrogen.

Such lamps are commercially available in a variety of wattages, such as 100 to 400 watts; one of such lamps being rated at 250 watts. The 250 watt lamp is available in two types, one particularly suitable for illumination and designated as the C–H5 lamp; the other particularly suitable as an ultra-violet generator and designated as the A–H5 lamp. The A–H5 lamp is used in conjunction with an external filter which absorbs the visible light from the lamp and transmits the ultra-violet light for exciting phosphors on screens, walls, and the like; the so-called "black-lighting." These lamps are of identical structure except for the glass making up the outer envelope or jacket. The A–H5 lamp is provided with a jacket of Pyrex 774 glass having high transmission of near ultra-violet radiation. This glass has the following composition by analysis:

	Percent
SiO_2	81
Na_2O	4
BaO	13
Al_2O_3	2

The C–H5 lamp is provided with a glass jacket which transmits substantially less of the near ultra-violet radiation, is known commercially as 172 glass and which has the following composition by analysis:

	Percent
SiO_2	56.4
Al_2O_3	20.8
Na_2O	1.6
B_2O_3	4.4
CaO	4.9
MgO	11.9

The glass jacket of both lamps is tubular in shape with a uniform outside diameter of about one and three-quarters inches.

In spite of the identical structure of the two lamps, except for the glass composition of the jackets, the useful operating life of the A–H5 lamp is only about one-half that of the C–H5 lamp operating under the same life-testing conditions. That is, when the two types of lamps are operated under like conditions of power input and ambient atmosphere and turned off and restorted no oftener than once every five hours, the rated life of the A–H5 lamp is 1000 hours

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whereas the rated life of the C–H5 lamp is 2000 hours. The A–H5 lamp must be operated in a vertical position to attain its rated life. The starting voltage of the lamps gradually increases during their life until they finally fail to start on the starting voltage impressed on their electrodes by the auxiliary apparatus. Further, the inner surface of the quartz envelope deteriorates and becomes frosted in appearance more rapidly than it should.

The principal object of my invention is to provide a lamp having a longer useful operating life than either of these lamps and other commercial lamps of similar structure. Another object of my invention is to provide such a lamp of longer useful operating life which is readily mountable in existing sockets and fixtures designed for the present lamps. A further object of my invention is to provide such a longer lived lamp which is inexpensively manufactured, which may be used either as an ultra-violet generator in place of the A–H5 lamp or solely as an illuminant in place of the C–H5 lamp and which may be operated in any desired position. Further objects and advantages of my invention will appear from the following detailed description of species thereof and from the appended claims.

The difference in the useful life of the A–H5 lamp and the C–H5 lamp and the comparatively short life of both lamps led to an investigation to determine the cause of the difficulty. Such investigation revealed the presence of hydrogen in the discharge space in the quartz envelope of the A–H5 lamp and it was determined that this gas caused the increase in the starting voltage of the lamp which resulted in its short operating life. It is known that quartz at high temperature is pervious to hydrogen but following the teachings of Bol et al., in U. S. Patent No. 2,094,694 and at page 7, second column, lines 3 to 13 of the patent it appeared that the sealed glass jacket exhausted of air and filled with nitrogen precluded any possibility of the diffusion of hydrogen from the ambient atmosphere through the hot wall of the quartz envelope.

Other investigators have ascribed the difficulty to other causes, such as the nitrogen filling in the jacket diffusing through the hot quartz wall but I have demonstrated that when the discharge space in the envelope is free of hydrogen the starting difficulties disappear. Life test data on my new lamp which includes a ntirogen filled jacket indicates an average useful life of 5000 hours as compared to the 1000 hour useful life of the A–H5 and the 2000 hour useful life of the C–H5 lamp both of which my new lamp replaces.

Knowing the cause of the difficulty, that is, the presence of hydrogen in the quartz envelope, did not solve the problem because the source of the hydrogen was not known and had to be discovered.

I have discovered that the presence of the hydrogen in the discharge space in the quartz envelopes of the A–H5 and C-H5 types of lamps is due to the kind of glass used for the jacket enclosing the quartz envelope. This is totally unexpected since glasses of the type used for the jacket were not known to evolve or transmit hydrogen. The only characteristics considered heretofore in selecting glasses for the jacket has been their light-transmitting qualities and their ability to withstand the temperatures existing thereat in the sizes desired for economy in manufacture and convenience in mounting in fixtures.

Having discovered the source of the hydrogen I have been able to provide a lamp free from the starting difficulties which shortened the life of the prior lamps which it replaces. I have accomplished this by substituting a jacket of different glass than those used heretofore and by lowering the temperature of both the glass jacket and of the quartz envelope during operation of the lamp. Each of these changes produces a marked improvement in the starting and in the operating life of the lamp but for the best results I prefer to incorporate all three changes in the new lamp. Obviously, unless the source of the hydrogen was known to be the glass jacket there would be no reason for making any of these changes.

Whether the hydrogen diffuses through the wall of the glass jacket or is evolved from it is not known. It may be that gases are slowly evolved from the glass during operation of the lamp. Any water vapor evolved from the glass may be broken down into oxygen and hydrogen under the action of the ultraviolet generated by the discharge in the quartz envelope and the hydrogen transmitted by the hot quartz. Whether or not this is the true explanation of this phenomena, I have definitely established that in the lamp of my invention hydrogen is not present in the arc space in amounts sufficient to cause the starting and other difficulties characteristic of prior lamps.

In providing a new lamp to take the place of both the old lamps, I have replaced the Pyrex glass jacket of the A-H5 lamp and the 172 glass jacket of the C-H5 lamp by a commercial glass known as Nonex 772 glass which has the following composition by analysis:

	Percent
SiO_2	72
Na_2O	4
B_2O_3	15
Al_2O_3	1.5
PbO	6
K_2O	1.5

This Nonex 772 glass transmits more of the near ultraviolet radiation than the 172 glass of the C-H5 lamp and almost as much as the Pyrex glass jacket of the A-H5 lamp so that the new lamp may be used for "blacklighting" purposes as well as an illuminant. I have found that the use of a Nonex 772 glass jacket of the same size as the Pyrex 774 glass jacket of the commercial A-H5 lamp provides a new source of visible and near ultraviolet radiations having a useful average life of about 2250 hours, an increase in life of about 120%.

The new knowledge that the hydrogen came from without the quartz envelope indicated that this envelope should be made larger to increase its radiating area and to lower its operating temperature to reduce the rate of hydrogen diffusion through its wall and into the discharge space. Accordingly I have increased the length of the gap between the electrodes in the tubular quartz envelope from 43 to 60 mm. and the inner diameter of the tube from 13 to 15 mm. This increased the cylindrical area of the inner surface of the portion of the envelope surrounding the gap from 17.6 square centimeters to 28.3 square centimeters and reduced the specific wall loading on this portion of the envelope from 14.2 to 8.8 watts per square centimeter so that the operating temperature of the quartz envelope is lowered and the rate of hydrogen diffusion through its wall is reduced. The specific wall loading is determined by dividing the wattage input of the lamp by the area of the surface selected.

I have also increased the size of the portion of the glass jacket surrounding the gap between the electrodes to lower the temperature of this jacket portion during operation of the lamp. Instead of using the tubular jacket of a uniform diameter of one and three-quarter inches of the prior lamps, I use a tubular jacket having ends of this diameter so that the new lamp will go into the existing fixtures for the prior lamps, but having a cylindrical portion of larger diameter surrounding the gap between the electrodes in the quartz tube. This portion of the jacket has a uniform outer diameter of approximately two and one-quarter inches or 57 mm. and is at least as long as the gap between the electrodes.

The specific wall loading on the jacket may be most simply calculated for comparison with that on other jackets by considering the effective radiating area of the jacket as being that of a cylinder of the outer diameter of the jacket, having a straight side as long as the electrode or arc gap and capped at each end by a hemisphere of the same diameter. The specific wall loading on the jacket may be easily determined then by dividing the wattage input of the lamp by the effective radiating area. Where the specific wall loading on the jacket is mentioned hereinafter it will be understood that it is calculated in the above manner. The portion of the jacket and of the envelope surrounding the gap between the electrodes has been selected for calculating the specific wall loading thereon because these portions are the main radiating portions of these members.

So calculated, the effective radiating area of the jacket of my new lamp is 211 square centimeters and its specific wall loading is 1.18 watts per square centimeter. In the A–H5 and C-H5 lamps this effective radiating area, calculated in the same manner, is 121 square centimeters and the specific wall loading 2.05 watts per square centimeter.

In the drawing accompanying and forming part of this specification a lamp of my invention is illustrated in which Fig. 1 is a front elevational view of the lamp; Fig. 2 is a side elevational view thereof; Fig. 3 is a sectional view of the lamp along the line **3—3** of Fig. 1 in the direction of the arrows; Fig. 4 is a similar view along the line **4—4** of Fig. 1, and Fig. 5 is a similar view along the line **5—5** of Fig. 1.

Referring to the drawing, the lamp comprises a sealed inner tubular quartz envelope **1** and a

sealed outer tubular glass envelope or jacket 2 having a screw type base 3 and a stem tube 4 at one end. Two current leading-in wires 5 and 6 are sealed into the stem 4 and are connected to the usual center and shell contacts of the base 3. The quartz envelope 1 is supported in the jacket 2 by a U-shaped wire support, the bottom part 7 of which is welded at its mid-point to the inner end of inlead 5 and the legs 8 and 9 of which extend toward and terminate in the end of the jacket 2 opposite the base end. The transverse resilient braces 10 and 11 are welded to the end portions of the support legs 8 and 9, respectively, and bear against the inner surface of the jacket 2. Two transverse metal bridging supports 12 and 13 are welded to the legs 8 and 9 of the wire support 7, 8, 9 and engage the rounded ends of the quartz envelope 1 to resiliently clamp the said envelope between them. The end portions of supports 12 and 13 are perforated to allow the legs 8 and 9 to pass therethrough and are bent against and welded to said legs 8 and 9.

The quartz envelope 1 has two main discharge supporting electrodes 14 and 15 sealed into opposite ends thereof, one of which 14 is electrically connected to the leg 9 of the U-shaped support by a flexible lead 16 and the other 15 of which is connected to the leading-in wire 6 of the glass jacket 2 by the similar lead 17. The electrodes 14 and 15 are of well known structure and include a tungsten wire on which is wound a finer tungsten wire holding onto the electrode material of higher electron emissivity, such as thorium. An auxiliary starting electrode 18 is sealed into the end of the quartz tube 1 adjacent the electrode 15 and is electrically connected to the electrode 14 by the flexible lead 19, the resistance element 20 and the stiff wire lead 21 which is welded to leg 8 of the U-shaped support to support resistance 20.

A heat reflecting metal disc 22 is mounted on the U-shaped support and is interposed between the stem 4 of the jacket and the adjacent end of the quartz envelope to protect the stem 4 from excessive temperature during operation of the lamp and reduce the temperature at the base 3. The disc 22 is greater in diameter than the distance between the legs 8 and 9 of the support and is cut along parallel lines extending inward a short distance from its edge. The portions between the cuts are bent downward to form a pair of diametrically spaced notches for accommodating the legs of the U-shaped support and to form also a pair of ears 23 and 24 (Figs. 1 and 4) which are welded to the said legs 8 and 9 to hold the disc 22 in place. The center portion of the disc 22 is perforated as shown in Fig. 4 and the current in-leads 25 and 26 for the electrodes 15 and 18, respectively, pass through the opening. The hermetic seals between the quartz tube 1 and the in-leads 25 and 26, as well as that between the in-lead 27 of the electrode 14, are of the type disclosed and claimed in U. S. Patent 2,177,685 issued October 31, 1939, to Bol et al.

The glass jacket 2 contains nitrogen at a pressure of about one-half atmosphere at room temperature. The quartz envelope 1 contains a starting gas, such as argon at a few millimeters pressure, and an amount of mercury such that a mercury vapor pressure in the order of atmospheres is produced and all the mercury is vaporized at a temperature slightly lower than the operating temperature of the quartz envelope. During operation of the lamp the mercury vapor is thus superheated and the mercury vapor atmosphere undersaturated so that the effects of temperature and voltage fluctuations on the light out-put and the operation of the lamp are minimized. Lamps of this type are disclosed and claimed in U. S. Patent 2,247,176, issued June 24, 1941 and assigned to the assignee of this application. The starting and operating characteristics of such lamps are well known so that a detailed description thereof is not needed here for a complete understanding of my invention by those skilled in the art. During operation the electric discharge is of the high pressure type, that is, it is constricted by the high pressure mercury vapor atmosphere so that it does not fill the entire cross-section of the quartz envelope but appears as a luminous chord spaced from the inner wall of the envelope.

To obtain the advantages ensuing from the discovery that the glass envelope is the source of the hydrogen causing starting difficulties and shortening the useful life of prior lamps the jacket 2 consists of the Nonex glass mentioned heretofore and the outer diameter of the enlarged portion of the jacket surrounding the gap between the electrodes 14 and 15, the length of the gap and the inner diameter of the tubular quartz envelope 1 are the same as those specified above for my new 250 watt lamp of 5000 hour useful operating life.

Other glasses may be used for the jacket with excellent results. For example, a glass which transmits the visible and even more of the near ultraviolet radiations than the Pyrex 774 glass is commercially available as Corning glass No. 7991. This glass is highly satisfactory for the jacket and has the following composition by analysis:

	Per cent
SiO_2	74.3
Al_2O_3	3.1
K_2O	1.5
Na_2O	3.7
B_2O_3	13.5
BaO	3.7

Another highly satisfactory visible light and near ultra-violet transmitting glass for the jacket is the commercial Corning 9730 glass having the following composition by analysis:

	Per cent
SiO_2	76.9
Al_2O_3	1.7
Na_2O	4.7
B_2O_3	16.6

It is not necessary to restrict the glasses used in the jacket to those which transmit both the visible and the near ultra-violet radiations from the discharge in the lamp nor is it necessary to exclude the use of the glasses formerly used for the jacket of the H–5 lamps. Substantial improvement may be made in the starting and useful life of the H–5 lamps merely by substituting for the Pyrex 774 glass and 172 glass jackets used before my invention jackets consisting of the same glasses but of larger size so as to reduce the specific wall loading on the jacket to not more than 1.5 watts per square centimeter.

While the discovery of the cause of the difficulty was made in investigating the acute problem presented by the 250 watt H–5 types of lamps, it has resulted in improvement in the lamps of other wattages. For example, I have increased the average useful life of the 400 watt lamp approximately 2000 hours by using a quartz envelope having an inner diameter of 18 millimeters and a gap of 70 millimeters between its electrodes

in place of a quartz envelope having an inner diameter of 15 millimeters and a gap of 60 millimeters between its electrodes and by replacing the tubular Pyrex 774 glass jacket having an outer diameter of 2 inches or 50.8 millimeters by a 7991 glass jacket similar in shape to that shown in the drawing with its enlarged portion having an outer diameter of 2½ inches or 63.5 millimeters. The specific wall loading on the portion of the envelope surrounding the discharge gap is thus decreased from 14.1 to 10.2 watts per square centimeter and that on the jacket from 2.25 to 1.5 watts per square centimeter. Further improvement may be made by increasing the inner diameter of the quartz envelope to 20 millimeters to lower the specific wall loading to 9.1 watts per square centimeter.

Similar changes in the structure of the 100 watt lamp give similar improvement in performance and life. The life of a 100 watt lamp having a quartz envelope with an inner diameter of 6¾ millimeters and a gap of 24 millimeters between its electrodes and having also a Pyrex 774 glass jacket with an outer diameter of 31.8 millimeters may be increased by using a Nonex 772 glass jacket of the same size and a quartz envelope with an inner diameter of 7¾ millimeters and a gap of 30 millimeters between its electrodes. The specific wall loading on the inner surface of the portion of the envelope surrounding the electrode gap is thus reduced from 19 to 13.2 watts per square centimeter and that on the jacket from 1.82 to 1.5 watts per square centimeter.

A 1000 watt lamp made in accordance with my invention has a quartz envelope with an inner diameter of 25 millimeters and a gap of 150 millimeters between its electrodes. The area of the portion of its inner surface surrounding the electrode gap is 118 square centimeters and the specific wall loading thereon is 8.5 watts per square centimeter. The jacket consists of 172 glass, is similar in shape to that shown in the drawing and the enlarged portion thereof has an outer diameter of 3½ inches or 88.9 millimeters. The effective radiating area of the jacket is 668 square centimeters and the specific wall loading thereon 1.5 watts per square centimeter.

It is apparent from my investigations that in an effort to attain a minimum size of light source the former commercial lamps were overloaded even though the vitreous parts thereof were capable of withstanding the high operating temperature of the lamps without softening and that there is a limit beyond which reduction in size cannot be accomplished without encountering the difficulties caused by hydrogen in the prior commercial lamps.

It is desirable, however, to keep the size of the lamp as small as possible for economy in cost of materials, both for the lamp and also for fixtures accommodating the lamp. The large globular sealed glass jackets used abroad and shown in U. S. Patents 2,135,690 and 2,135,702, as well as in Patent 2,094,694 referred to above, all of which patents are assigned to the assignee of the present application, are not necessary nor desirable. The globular glass jackets used abroad are similar in size to the bulbs used for incandescent lamps of the same wattage. An 80-watt lamp, for example, having a globular jacket 80 mm. in outer diameter and a 125-watt lamp having a globular jacket 90 mm. in outer diameter. In contrast, the tubular jacket of my 100 watt lamp has an outer diameter of 31.8 mm. and the tubular jacket of my 250 watt lamp an outer diameter of approximately 57 mm..

Due to the large size and the globular shape of the glass jackets used abroad, the difficulties caused by hydrogen encountered in the commercial lamps with tubular jackets used in the United States are avoided since no part of the globular jacket is heated to a temperature at which hydrogen appears in the lamp. The temperature distribution over the walls of a globular glass jacket is much more uniform than the temperature distribution over the walls of a tubular glass jacket and the effective radiating area of a globular jacket is more the equivalent of a sphere about the quartz arc tube rather than of a cylinder capped by hemispheres at each end and surrounding the discharge gap in such tube. The specific wall loading on the main radiating area of the globular jackets used abroad is less than one-half watt per square centimeter. I prefer a specific wall loading of not less than about one watt per square centimeter on the tubular jacket of my lamps so that the lamps are of convenient size.

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

1. A high pressure mercury vapor electric discharge lamp deleteriously affected by hydrogen in its discharge space and comprising in combination, a sealed tubular quartz envelope, pervious to hydrogen at elevated temperatures, defining a discharge space and containing mercury, a starting gas and electrodes mounted at its ends, a sealed tubular glass outer envelope completely enclosing said quartz envelope and containing an inert gas, the glass of said outer envelope being a hard glass characterized by the presence of hydrogen in said glass envelope at elevated temperatures, means supporting said quartz envelope within said glass envelope, and an energizing circuit for said lamp connected to said electrodes, said circuit including means for supplying the lamp with a predetermined power input, said quartz inner envelope and said glass outer envelope being so dimensioned with respect to said predetermined power input that the specific wall loading on the said glass envelope is within the range of not less than about 1 and not more than 1.5 watts per square centimeter and the specific wall loading on said quartz envelope is between about 8 and 13.2 watts per square centimeter to minimize the occurrence of hydrogen in the lamp.

2. A high pressure mercury vapor discharge lamp as defined in claim 1 characterized by the fact that the glass envelope is made of glass of the following composition:

	Per cent
SiO_2	72
Na_2O	4
B_2O_3	15
Al_2O_3	1.5
PbO	6
K_2O	1.5

3. A high pressure mercury vapor discharge lamp as defined in claim 1 characterized by the fact that the glass envelope is made of glass of the following composition:

	Per cent
SiO_2	74.3
Al_2O_3	3.1
K_2O	1.5
Na_2O	3.7
B_2O_3	13.5
BaO	3.7

4. A high pressure mercury vapor discharge lamp as defined in claim 1 characterized by the fact that the glass envelope is made of glass of the following composition:

	Per cent
SiO_2	56.4
Al_2O_3	20.8
Na_2O	1.6
B_2O_3	4.4
CaO	4.9
MgO	11.9

5. A high pressure mercury vapor discharge lamp as defined in claim 1 characterized by the fact that the electrodes are spaced apart approximately 60 millimeters and the part of said quartz envelope surrounding the space between said electrodes has an inner diameter of approximately 15 millimeters so that the area of the inner surface of said quartz envelope part is approximately 28.3 square centimeters, the fact that the outer surface of the corresponding part of the glass envelope is approximately 57 millimeters in diameter and approximately 211 square centimeters in area and the fact that the energizing circuit means supplies a power input of 250 watts so that the specific wall loading on the quartz envelope is approximately 8.8 watts per square centimeter and the specific wall loading on the glass envelope is approximately 1.18 watts per square centimeter.

6. A high pressure mercury vapor discharge lamp as defined in claim 1 characterized by the fact that the electrodes are spaced apart approximately 70 millimeters and the part of said quartz envelope surrounding the space between said electrodes has an inner diameter of approximately 18 to 20 millimeters so that the area of the inner surface of said quartz envelope part is approximately 39.4 to 44 square centimeters, the fact that the outer surface of the corresponding part of the glass envelope is approximately 63.5 millimeters in diameter and approximately 267 square centimeters in area and the fact that the energizing circuit means supplies a power input of 400 watts so that the specific wall loading on the quartz envelope is approximately 10.2 to 9.1 watts per square centimeter and the specific wall loading on the glass envelope is approximately 1.5 watts per square centimeter.

7. A high pressure mercury vapor discharge lamp as defined in claim 1 characterized by the fact that the electrodes are spaced apart approximately 150 millimeters and the part of said quartz envelope surrounding the space between said electrodes has an inner diameter of approximately 25 millimeters so that the area of the inner surface of said quartz envelope part is approximately 118 square centimeters, the fact that the outer surface of the corresponding part of the glass envelope is approximately 88.9 millimeters in diameter and approximately 668 square centimeters in area and the fact that the energizing circuit means supplies a power input of 1000 watts so that the specific wall loading on the quartz envelope is approximately 8.5 watts per square centimeter and the specific wall loading on the glass envelope is approximately 1.5 watts per square centimeter.

8. A high pressure mercury vapor discharge lamp as defined in claim 1 characterized by the fact that the electrodes are spaced apart approximately 30 millimeters and the part of said quartz envelope surrounding the space between said electrodes has an inner diameter of approximately 7¾ millimeters so that the area of the inner surface of said quartz envelope part is approximately 7.32 square centimeters, the fact that the outer surface of the corresponding part of the glass envelope is approximately 31.8 millimeters in diameter and approximately 66 square centimeters in area and the fact that the energizing circuit means supplies a power input of 100 watts so that the specific wall loading on the quartz envelope is approximately 13.2 watts per square centimeter and the specific wall loading on the glass envelope is approximately 1.5 watts per square centimeter.

EDWARD B. NOEL.

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