E. WEINTRAUB.

VAPOR ELECTRIC DEVICE.

APPLICATION FILED MAR. 13, 1913.

1,138,162. Patented May 4, 1915.

Fig.1.

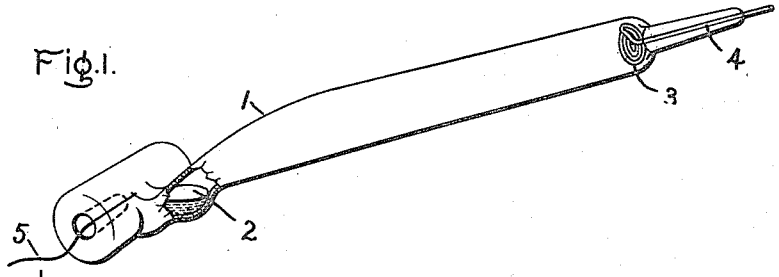


Fig.2.

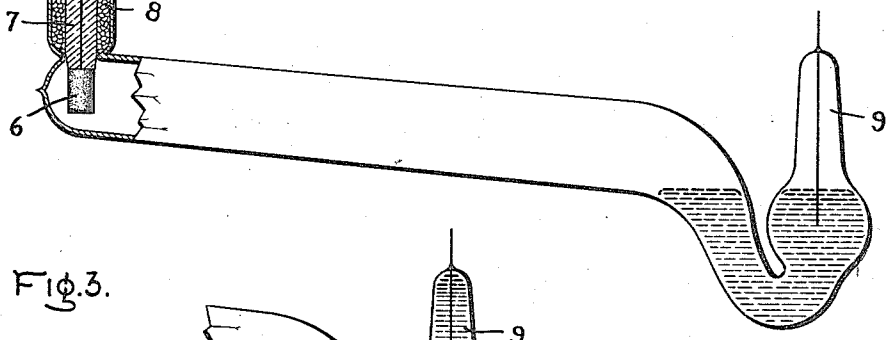


Fig.3.

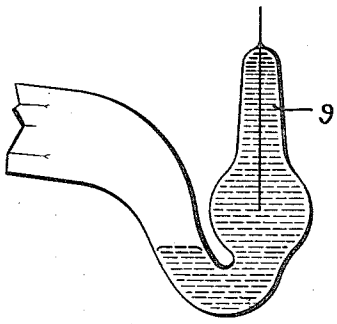


Fig.4.

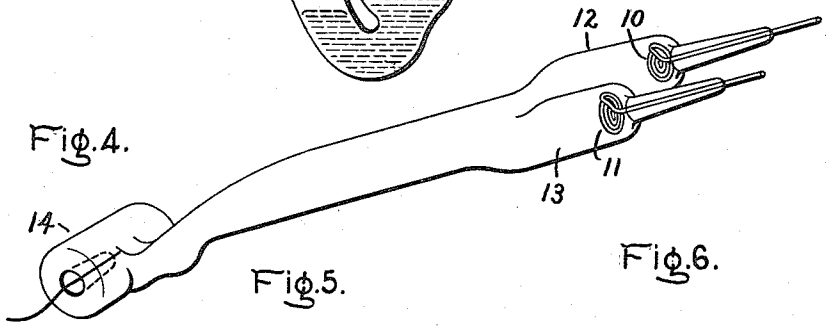


Fig.5.

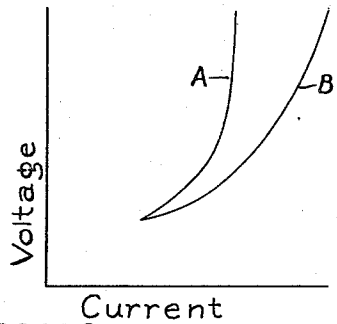
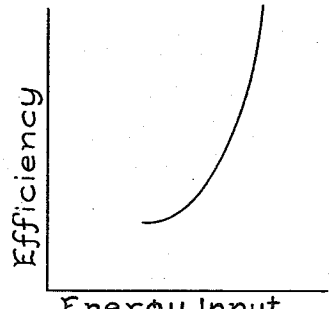


Fig.6.



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VAPOR ELECTRIC DEVICE.

1,138,162. Specification of Letters Patent. Patented May 4, 1915.

Continuation in part of application Serial No. 698,741, filed May 21, 1912. This application filed March 13, 1913. Serial No. 753,946.

To all whom it may concern:

Be it known that I, EZECHIEL WEINTRAUB, a citizen of the United States, residing at Lynn, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Vapor Electric Devices, of which the following is a specification.

The present application is in part a continuation of my former application, Serial No. 698,741, filed May 21, 1912.

My invention relates to vapor electric devices, particularly to what is known as the high pressure arc lamp which consists essentially of a light-transmitting refractory envelop, such as a fused quartz tube in which a mercury, or other vapor arc, is operated at a relatively high temperature.

One of the best distinctions that may be drawn between the well-known low pressure mercury arc lamp and the high pressure lamp is the following: A low pressure lamp takes about the same voltage and energy at starting as it does at normal operation, while a high pressure lamp starts at a much lower voltage and at starting takes less energy than under normal operating conditions when the lamp has come to a final equilibrium. On multiple circuits the starting current is high and is reduced as the lamp assumes equilibrium. The high pressure lamp as now commonly constructed and proportioned operates with an energy consumption of more than 25 watts per inch in a tube about one-half inch in diameter. In fact, the energy consumption commonly is about 80 to 100 watts per inch in a tube of this size. The conditions in a lamp of this character differ materially from those of the long, low pressure glass-inclosed mercury arc lamp. A number of conductive materials may be used for the anode in the low pressure lamp. Mercury, iron, platinum, and graphite may be interchanged for one another without a marked change in the arc. In a high pressure lamp conditions are quite different. All the single walled high pressure mercury arc lamps that have appeared on the market have been provided with ground plug seals for the introduction of current and this construction practically precludes the use of a solid anode on account of the high temperature developed at the anode which would endanger the seal. The use of mercury as anode material not only limits the lamp to a narrow range of service, as will be more fully explained, but what is equally important, a mercury anode needlessly increases the vapor pressure in the lamp by its rapid volatilization. The increased vapor pressure results in an increased electrical resistance, and with a given impressed voltage correspondingly decreased energy input. As the efficiency of the lamp decreases at a greater rate than the energy consumption, the economy of a high pressure lamp on commercial 110 volt circuits has been low and this fact has practically limited the high pressure mercury lamp to large units operated at higher voltages. In the so-called German type of quartz lamp cooling fins are used at the electrodes for the purpose of reducing this vapor pressure, and in the French type a large anode condensing chamber is used for the same purpose but these devices themselves waste energy and lower the efficiency. At 110 volts the efficiency of either lamp is only about 1.3 to 1.6 watts per candle power when losses in a series resistance, etc., are included.

By the use of the so-called graded seal comprising a tungsten wire sealed into a sodium-magnesium boro-silicate glass which blends or merges with the quartz wall to form a continuous structure, a high pressure mercury lamp may be built having a solid anode. In experimenting with different solid conductive materials for the anode, I have discovered that most of them rapidly disintegrate and blacken the tube so that their successful commercial use is practically excluded on account of the inefficiency of the lamp due to the effect mentioned. This rapid disintegration is observed even in the leading-in conductor joined to the anode. In my opinion it is not solely due to the temperature of the anode as a material like graphite, which is highly refractory and does not easily vaporize, disintegrates very rapidly under the peculiar conditions existing in a lamp of this kind although its temperature is not much higher than 1100 to 1200 degrees. A graphite filament will operate almost indefinitely in an incandescent lamp at this temperature. Another difficulty encountered with anode materials even as refractory as platinum is the melting of the anode by the high starting current of the lamp.

My invention as will be pointed out with

greater particularity in the claims comprises a high pressure vapor lamp having a solid anode, in particular, a tungsten anode, situated remote from both condensing space, or other cooling means and liquefied mercury in the tube. Other novel features will be pointed out with particularity in the claims.

In the attached drawings, Figure 1 is a perspective view of a single-walled vapor lamp illustrating my invention; Fig. 2 illustrates a modification; Fig. 3 is a detail view showing the cathode under operating conditions; Fig. 4 shows a lamp adapted for use in alternating current circuits; Fig. 5 shows volt-ampere curves contrasting my improved lamp with the prior form; and Fig. 6 shows the relation between energy input and efficiency in my improved lamp.

When a solid anode preferably of pure tungsten, in a ductile state is used in the lamp, the resistance of the arc is lowered enabling it to be utilized with high efficiency on low voltage circuits. The blackening of the tube is entirely avoided or is reduced to such a small amount as to be of little harm. When carefully prepared pure ductile tungsten is used and the sealing-in process carried out so as to avoid all oxidation; the blackening of the tube is in fact entirely absent. Other refractory materials such as molybdenum and tantalum may also be used. I have found also that under these conditions, the relation between energy input and efficiency when plotted respectively as abscissa and ordinate are represented by a constantly rising curve without minimum point. A lamp thus constructed having a length of say $3\frac{5}{8}''$ and a diameter of about $\frac{1}{2}''$ may be operated on a 110 volt circuit in series with a resistance of about 6–8 ohms, with an efficiency of 0.45 to 0.5 watts per mean spherical candle power across the arc or even higher. The efficiency of the unit with all accessories is about 0.7 watts per mean spherical candle power. This includes all losses, such as loss in the series resistance, absorption of light in a clear globe, and the like. The voltage drop in a lamp operating at this efficiency is about 22 volts per inch of length. The voltage drop depends to a large extent upon the shape of the tube near the cathode and the size of the cathode mercury surface. The change from mercury to a solid anode material, together with the structural changes made possible thereby, so modifies the volt-ampere curve of the high pressure lamp that a new field is opened up for it, namely, its operation on series, or constant current, variable voltage, lighting circuits. Up to the present the high pressure vapor lamp has not been available for economical operation on series circuits for reasons more fully explained hereinafter, and this fact has greatly limited the use of the lamp in this country. On series circuits, the efficiency of my improved lamp is even higher than on multiple circuits because of the absence of a steadying resistance. In a unit of 600–700 watts the very excellent efficiency of 0.35 watts per mean spherical candle power is obtained. Another very important advantage resulting from the use of a solid refractory anode is to be found in the simplicity and high efficiency of the high pressure alternating current mercury lamp. It has been attempted heretofore to use mercury anodes in this type of lamp but their use necessitates a complicated lamp structure to avoid arcing between anodes. In a lamp provided with solid anodes, and properly proportioned, arcing is absent.

Referring to Fig. 1, the envelop 1 of fused quartz is provided with a cathode 2 of mercury or other easily vaporizable material and a coöperating tungsten anode 3. The tungsten anode is preferably in the form of a coiled wire, the outer turn of the spiral being continued as the leading-in wire 4 so that a unitary structure results. As the point of greatest heat is at the center this method is conducive to keeping the seal cooler than when the wire joins the center of the anode. The anode leading-in wire 4 and also cathode lead wire 5 consist of tungsten and are both sealed by fusion into a sodium-magnesium boro-silicate glass, or equivalent low expansion glass, which is integrally joined to the silica wall by gradually merging therewith in composition. In other words, the basic constituents of the glassy material decreases until the material blends with the pure quartz. The space above the anode is contracted as much as possible so that practically no idle condensing space exists near the same. The flat shape of the anode favors the attainment of this result. The lamp is started by tilting so that the cathode material comes in contact with the anode and thereby strikes the arc. Tilting mechanism of this kind is well known in the art, so will not be described herein.

In the modified form of lamp shown in Fig. 2, the idle condensing space back of the anode 6 is filled up by refractory material such as quartz block 7 embedded in granules of quartz silica 8 in order to completely fill out the space. This construction prevents any small globules of condensed mercury from dropping through the arc. I find that this disturbs the equilibrium of the arc and in some cases may even put it out entirely. It is one of the important features of my invention to avoid the presence of either condensing space or mercury near the anode.

The cathode construction shown in Figs. 2 and 3 provides space for a free develop-

ment of the arc in a direction perpendicular to the cathode. If the mercury were permitted to remain at the level at which the body of mercury line assumes in Fig. 1 the quartz near the bend of the arc would be heated to redness and in some cases soften and blacken. By providing a space back of the cathode the pressure developed within the tube lowers the mercury level by pushing the mercury upward into the chamber 9 as shown in Fig. 3. The arc is thus removed from proximity with the silica envelop.

The advantage of a solid anode in a series lamp has already been referred to but its effect may be more fully understood by reference to Fig. 5 in which the volt ampere relations in the lamp having a mercury anode and a lamp having a solid anode are plotted as ordinate and abscissa as indicated. As will be noted, by reference to curve A, the volt ampere curve for a lamp with a mercury anode rises very sharply at the current value between two and three amperes. At this value of current the lamp is unstable as its voltage constantly increases. In a constant current variable voltage circuit the voltage soon becomes great enough to destroy the lamp. If it were desired to operate such a lamp on a constant current circuit it would have to be run at a very uneconomical low current value. When a solid anode is used the volt-ampere curve while maintaining its general shape does not begin to rise sharply until the current value has become considerably larger, as shown very clearly by curve B. This change in the volt-ampere characteristic makes it possible to run the arc at a higher current value without instability and this difference in operating current improves the efficiency by 50–100%. As a series resistance which consumes about 25% of the total energy of a unit is not required in a series circuit a correspondingly higher efficiency may be achieved with the quartz lamp in this new field.

The structure of the alternating form of lamp shown in Fig. 4 is very simple; the anodes 10 and 11 are placed quite close together in the branched ends 12 and 13 of the envelop. The two half wave arcs running to the cathode 14 from the two anodes may be superimposed in the same tube thereby getting higher efficiency. The construction is so chosen that no mercury can condense and drop on the anodes as this might cause arcing as already described.

As already stated and as shown in Fig. 6, the curve obtained when plotting energy input against efficiency rises sharply. An increase in energy consumption thus results in considerably more than a proportionate increase in efficiency.

In order that the high pressure vapor arc may be clearly distinguished from the low pressure arc the following characteristics already indicated above are enumerated for the purpose of explaining the language of the appended claims: 1. The high pressure arc requires a starting current substantially higher than the operating current. 2. After the envelop becomes heated and the arc is operating normally the high pressure arc contracts to a comparatively narrow zone instead of filling the entire space within the envelop as does the low pressure lamp. 3. As indicated in Fig. 5, the high pressure arc operates when the voltage exceeds a certain value with a substantially constant current.

In my copending application Serial No. 753,947, filed concurrently with the present application, I have described and claimed a method of operating the type of lamp embodying the present invention. According to this method the cooling capacity of the cathode or of the lamp in the immediate vicinity of the cathode is so adjusted that the arc may be run at higher current input before approaching the critical value of current at which the voltage increases so abruptly with increases of current as to make the operation of the arc unstable on series circuits.

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

1. A vapor electric device comprising a quartz envelop, a mercury cathode at one end of said envelop, an anode consisting of a metal more refractory than platinum at the opposite end of said envelop, and current-conveying conductors for said electrodes the part of the anode conductor adjacent the anode proper also consisting of a metal more refractory than platinum, and the envelop section surrounding the anode and the anode conductor being proportioned to assume a temperature at which substantially no mercury will condense when said device is operating with an energy input sufficient to produce a high pressure arc.

2. A vapor electric lamp comprising a mercury cathode, a tungsten anode, current-conveying conductors for said electrodes sealed into said envelop, the part of the anode conductor adjacent the anode also consisting of tungsten, and an inclosing quartz envelop which is contracted upon the anode conductor to proportion the space back of the anode so that mercury will not condense therein when said device is operating with an energy input sufficient to produce a high pressure arc.

3. A vapor electric lamp comprising a mercury cathode, an anode of material more refractory than platinum, an inclosing silica envelop and current supply wires for said electrodes, the part of the anode wire adjoining the anode consisting of a metal more refractory than platinum, and the parts of said envelop surrounding the anode being ar-

ranged and proportioned to assume a temperature at which no globules of mercury will form large enough to drop through the arc path when said lamp is operated with an energy input sufficient to produce a high pressure arc.

4. A lamp comprising a tubular envelop consisting largely of silica, a cathode of mercury at one end of said envelop, an anode of metal more refractory than platinum at the opposite end of said envelop, current conveying conductors for said electrodes, the anode conductor consisting of metal more refractory than platinum, and a seal of zones of vitreous material merging from quartz to a glass having the same coefficient of expansion as said conductor surrounding said conductor, the envelop wall being contracted upon the anode conductor so that but a negligible condensing space remains back of the anode.

In witness whereof, I have hereunto set my hand this 28th day of February, 1913.

EZECHIEL WEINTRAUB.

Witnesses:
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FRANK G. HATTIE.