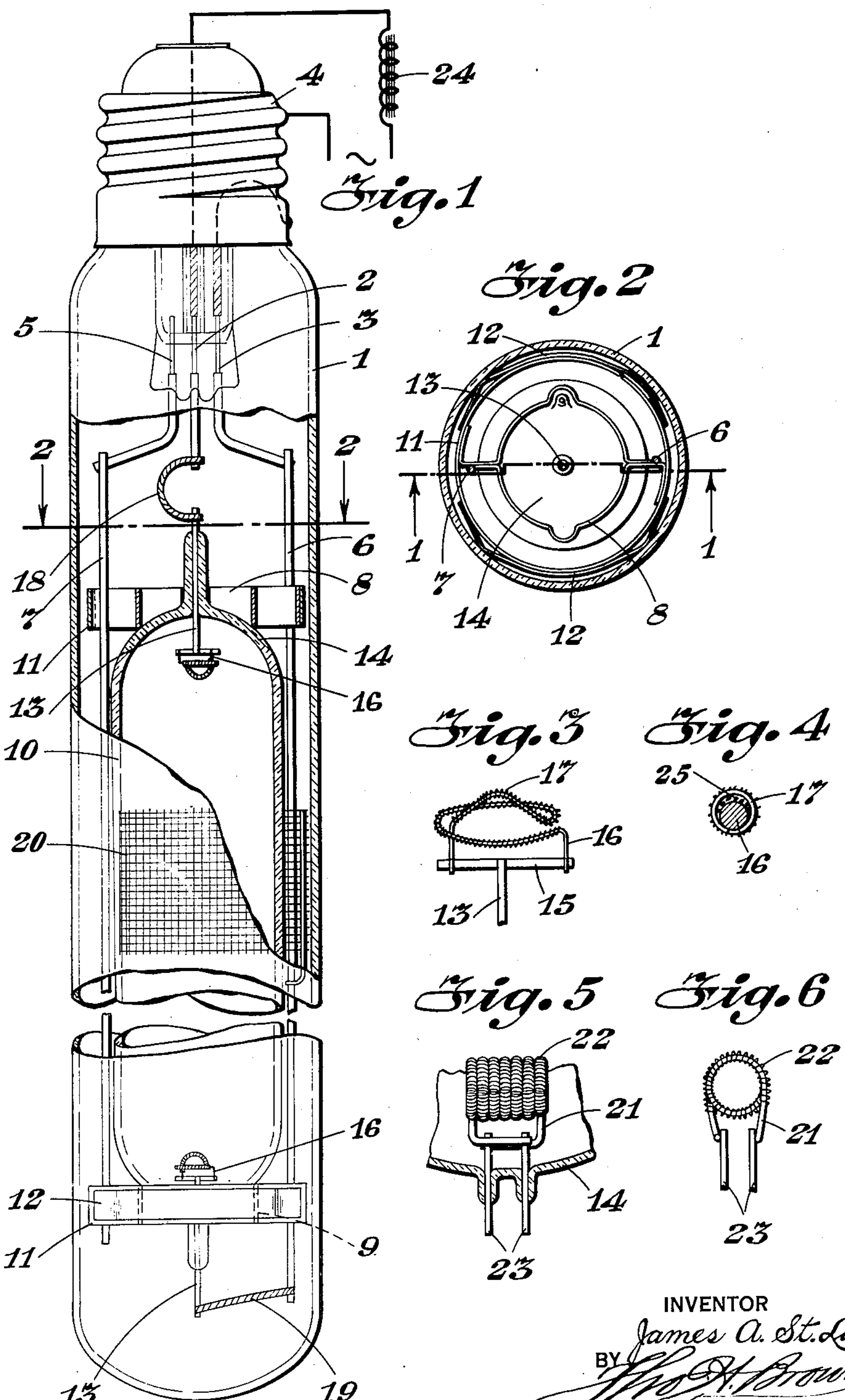
July 23, 1935. J. A. ST. LOUIS 2,009,211

GASEOUS ELECTRIC DISCHARGE DEVICE

Filed May 8, 1934



INVENTOR
James A. St. Louis
BY Thos H. Brown
ATTORNEY

Patented July 23, 1935 2,009,211

UNITED STATES PATENT OFFICE

2,009,211

GASEOUS ELECTRIC DISCHARGE DEVICE

James A. St. Louis, Montclair, N. J., assignor to General Electric Vapor Lamp Company, Hoboken, N. J., a corporation of New Jersey

Application May 8, 1934, Serial No. 724,586

12 Claims. (Cl. 176—122)

The present invention relates to gaseous electric discharge devices in general, and in particular to metallic vapor devices.

A particular object of the invention is to provide a high efficiency light source which will have an exceptionally long useful life. Another object of my invention is to provide an electrode useful in the arts generally which will have a long useful life, particularly in a metal vapor arc lamp operating at a relatively high pressure, of the order of an atmosphere. A further object of my invention is to provide a novel means for reducing the flow of heat from the portions of said lamp which are adjacent to said electrodes. Still another object of my invention is to provide a novel mounting means within my new lamp whereby it may be shipped without danger of breakage. Still other objects and advantages of my invention will appear from the following detailed specification, or from an inspection of the accompanying drawing.

The invention consists in the new and novel structure and combination of elements which is hereinafter set forth and claimed.

In the ever-continuing search for better light sources considerable attention has recently been directed to metal vapor, and particularly to mercury vapor, lamps operating with an unsaturated vapor pressure. I have found by experiment that a very high luminous efficiency, of the order of 35 lumens per watt, can be obtained with such a lamp wherein the operating vapor density corresponds to a pressure which approaches that of the atmosphere. With such a high vapor density, however, the arc discharge is so constricted that it tends not only to destroy any of the usual thermionic electrodes, but also to deposit particles of the electrodes on the walls of the envelope, thus producing an opaque film which rapidly decreases the luminous efficiency of the lamp, so that these lamps have had only a short useful life. I have now discovered, however, that by using a novel uni-potential cathode of my invention this electrode destruction can be so greatly reduced that these lamps can now be satisfactorily operated for thousands of hours, without any excessive depreciation in luminous efficiency. The novel cathode by which this new result is produced consists of a refractory wire, such as tungsten or molybdenum, on which there is wound a helix of tungsten or the like. The turns of this helix are fairly close together, but said helix fits loosely on the supporting wire, leaving many cavities within the helix which are filled with a good thermionic emitting substance such as barium or strontium oxide when said helix and its supporting wire are coated therewith in any usual manner. The oxide thus stored in these cavities creeps out during operation of the lamp and reactivates any part of the helix which may be momentarily deprived of its active coating by the arc, and thus serves to keep all of the helix and its supporting wire in an activated condition throughout a long useful life of thousands of hours.

A further problem encountered in this type of lamp is that of preventing mercury condensation about the leads to the electrodes. I have now solved this problem in a unique manner by using a heat absorbing glass about this seal, and have furthermore made this heat absorbing glass perform the additional function of facilitating the making of the seal. I likewise have discovered that by using a novel supporting structure I can further raise the temperature of the envelope about the seal through the cooperation of this supporting structure. By the addition of spring fingers to this novel supporting structure I have also eliminated the hazard of breakage due to movement of the inner envelope during shipment, thus eliminating what has heretofore been a serious obstacle to the development of this new type of lamp.

For the purpose of illustrating my invention I have shown a preferred embodiment, together with a modification thereof, in the accompanying drawing, in which

Fig. 1 is an elevational view, in part section, of a preferred form of my novel lamp,

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1,

Fig. 3 is a perspective view, somewhat enlarged, of my novel cathode,

Fig. 4 is a sectional view of this cathode, and

Figs. 5 and 6 are respectively side and end views of an alternative form of cathode.

As shown in the drawing, the preferred form of my novel lamp has a sealed tubular envelope 1 of any suitable vitreous material, such as glass. This envelope may be either transparent or translucent, as desired. For a 400 watt lamp this envelope is conveniently made two inches in diameter and eleven inches long. A pair of inleads 2 and 3 extend through a reentrant pinch seal at one end of said envelope, said inleads being connected to the tip and sleeve, respectively, of a conventional mogul base 4. A support wire 5 is likewise fused into said pinch seal symmetrically with the inlead 3. Said inlead 3 and support wire 5 are each bent outwardly and carry at their outer ends the wires 6 and 7, respectively, which are of nickel, tungsten, or any other metal having the necessary rigidity. Said wires 6 and 7 extend parallel to the axis of the envelope 1 to a point near the opposite end thereof. Two spaced metal collars 8 and 9 are welded to the wires 6 and 7, these collars being conveniently formed of two similar halves of sheet nickel or the like which are bent and then welded together to form a short cylinder, as particularly shown in Fig. 2. A sealed tubular envelope 10 of suitable heat resisting vitreous material, such as a hard glass, fused silica or the like, has hemispherical ends which rest in said collars 8 and 9, whereby it is supported in a fixed longitudinal position within the envelope 1. Each of the collars 8 and 9 has a second collar 11 of larger diameter affixed thereto, and to each of the latter there are welded a pair of spring members 12 of molybdenum or the like. Each end of said spring members 12 bears upon the inner surface of the envelope 1, so that a four point resilient support is provided for each end of the envelope 10 to maintain it against lateral displacement.

For a 400 watt lamp the envelope 10 is preferably made about 7 inches long and 1⅜ inches in diameter. The walls of this envelope are preferably of the order of a millimeter thick, so that it has little heat capacity and thus warms up quickly without danger of strains.

At each end of said envelope 10 there is an inlead 13 which is conveniently made of tungsten. Since the thermal coefficient of expansion of tungsten is slightly higher than that of the hard glass which is ordinarily used for the enevelope 10 I find it desirable to form the hemispherical ends 14 of said envelope of a uranium borosilicate glass which is in common use in the lamp trade and which has a coefficient of expansion which is intermediate that of the envelope and that of tungsten. These end sections 14 serve as part of a graded seal and thus prevent strains, and at the same time intercept considerable heat radiation from the electrodes and from the discharge, due to the well-known infra-red absorption characteristic of uranium glass, with the result that this portion of the envelope is maintained at a higher temperature than would be the case if this special glass were not used. This maintenance of a higher temperature is also aided by the supporting collar 9, which not only tends to reduce the cooling flow of gas over the lower end of the envelope 10, but also reflects a considerable amount of heat radiation back to the end 14 of said envelope 10. Moreover, due to the limited area of contact between the collar 9 and the envelope 10 little heat is lost by said envelope through conduction to said collar 9. Hence this novel arrangement serves admirably to both support and to maintain the desired temperature of the envelope 10.

A transverse wire 15 of nickel or other suitable metal is welded to the inner end of each of the inleads 13. Said wire 15 serves to support the electrode which consists of a tungsten wire 16 which rises from a welded union with one end of said wire 15 and then again descends to form a rather flat V in a vertical plane, after which it describes a horizontal circle about said V and terminates in a welded union with the other end of said wire 15, as best shown in Fig. 3. Said wire 16 in practice has a diameter of 16 mils, and on it is a closely wound helix 17 of six mil tungsten wire which has been formed on a 20 mill mandrel, said helix thus loosely fitting the wire 16, as shown in Fig. 4. The wires 16 and 17 are coated with a substance, such as an alkaline earth oxide, which is a good thermionic emitter. Such a coating 25 is conveniently produced, for example, by dipping the electrode assembly in a water suspension of a mixture of barium and strontium carbonates, 15 grams of each of these in 100 c. c. of water having been found to produce good results. Due to the many cavities produced between the wire 16 and the loosely fitting helix 17 considerable quantities of this activating material are retained by the electrode assembly, as illustrated in Fig. 4. When dry these electrodes are sealed into the envelope 10, which is then evacuated and the carbonates then reduced by heating, as by means of a high frequency furnace, to the oxides of barium and strontium. These electrodes are arranged quite close to the hemispherical ends of the envelope 10, in order to radiate as much heat to these ends as possible, and thus to avoid mercury condensation at this point. Since convection currents cause the upper end of the envelope 10 to be somewhat warmer than the lower end thereof, it is usually found desirable, however to mount the upper electrode 16 slightly farther away from the end than the lower electrode, as shown, in order to equalize the temperatures at the ends of the envelope. The seal-off tip of said envelope is also preferably located at the upper end so that mercury condensation therein will be prevented as a result of this heating by convection currents. In a 400 watt lamp these electrodes are about six inches apart. The upper inlead 13 is joined to the lead 2 by a flexible lead 18 which is conveniently formed of stranded soft nickel wire, while the lower inlead 13 is similarly connected by a soft stranded wire 19 to the support wire 6. These stranded conductors 18 and 19 prevent the placing of any strain on the inleads 13, the envelope 10 in my novel construction being resiliently supported entirely independently of said inleads. A strip 20 of rather coarse nickel gauze about an inch in width is closely wrapped around the envelope 10 at a point about a third of the way from the upper electrode 16 toward the lower electrode, this wire being electrically connected to the wire 6, and thus to the lower electrode.

The inner envelope 10 has a filling of a rare gas, argon being preferably used, at a pressure of the order of 5 m. m. of mercury, which constitutes the ionizable medium when the lamp is first started. An accurately measured quantity of the vaporizable metal, such as mercury, sodium, cadmium, or the like, is likewise sealed within this envelope. The amount of this metal is so chosen that it will all be evaporated when the lamp is operated somewhat before a temperature equilibrium is attained. In a mercury vapor lamp it has been found that a vapor density corresponding to a temperature of the order of 360° C. is especially desirable for many purposes, hence the mercury is preferably so limited as to be completely vaporized when the coolest part of the envelope is at this temperature, 200 milligrams being ordinarily used in a lamp of the size described.

If convenient the outer envelope 1 would be evacuated in order to minimize the heat conduction from the inner envelope 10, but in practice it is found to be impracticable to entirely degas the various metal parts therein, with the result that residual gas evolves during operation of the lamp and supports an undesired glow discharge between the leads 2 and 3. Accordingly, I prefer to fill the envelope 1 with a gas, such as nitrogen, at a pressure which is sufficient to prevent the production of a glow discharge between these inleads. Thus in a 220 volt lamp I preferably use nitrogen at a pressure of approximately half an atmosphere.

My novel device, when constructed as described, will start when an alternating current potential of 150 volts is applied thereto, this relatively low breakdown potential being due in part to the effect of the gauze **20**, as set forth in my pending application, Serial No. 699,264, filed November 22, 1933, and in part to the active coating on the electrodes. The geometry of these electrodes is likewise extremely important and enhances this result to a marked degree. As clearly shown in Fig. 3 the turns of the helix **17** separate somewhat on the outside of the curves on the electrode wire **16**, and likewise bear against the inside surface of said wire **16** at each curve. Thus at the top of the V part of the wire **16**, for example, there are a number of turns of relatively fine wire **17** which are not only spaced from each other but which extend outwardly into the gas space toward the other electrode. These separate turns of fine wire serve to concentrate the electrostatic stress during starting in the same fashion as a point, and thus greatly facilitate the necessary ionization of the gas to permit a gaseous discharge between said electrodes, with the result that this discharge can be initiated with my novel electrode at a lower potential than would be possible in the absence of these loose turns.

Due to its refractory nature my novel unipotential cathode withstands to a remarkable degree the destructive action of the highly constricted arc thereon so that the erosion thereof which has heretofore limited the life of these lamps is virtually eliminated. Likewise the luminous efficiency of my novel lamp decreases at an exceptionally low rate, due to the virtual elimination of the opaque film which in prior lamps has been rapidly deposited on the lamp envelope as a result of the destruction of the electrodes. Such a refractory electrode would be of little value in my novel lamp, however, if it were not for the activating coating thereon, since without this novel coating satisfactory operation on 220 volts or less cannot be attained. Under the rigorous conditions existing with the extremely constricted arc in my novel lamp, however, the usual surface coatings of oxide, such as have been used heretofore on tungsten electrodes, are extremely short lived. Hence I have found it necessary to devise the novel electrode of the type hereinbefore described, wherein a relatively loose wrapping of the refractory wire **17** provides many interstices between said wire **17** and the main electrode **16** which retain considerable quantities of the active material. During operation of the device this very large reserve supply of active material creeps out and thus continuously reactivates any parts of the exposed tungsten surface which may have been momentarily deprived of their active coating. This process continues, of course, so long as there is any oxide left within the cavities, which has been found to be of the order of at least a thousand hours. This novel result is moreover obtained in an electrode having not only an extremely low thermal capacity, but also a low thermal conductivity from one point to another thereon. As a result my novel electrode almost instantaneously reaches its operating temperature at whatever point the arc impinges thereon, thus virtually eliminating the destructive effects of the so-called "hot-spotting" when the arc is initiated. The entire electrode operates at the same potential, of course, due to its low electrical resistance.

In some cases the electrode shown in Figs. 5 and 6 is preferred, especially where an even greater storage capacity for the alkaline earth oxide is desired. In this construction the electrode is formed of a helix **21** of tungsten wire on which there is loosely fitted a closely wound helix **22** of smaller tungsten wire, the whole being coated and filled with an activating material in the same manner as the electrode of Figs. 3 and 4. Said helix **21** has its axis arranged transverse to the path of the arc discharge, and the ends thereof are turned back parallel to said axis and then connected to the inleads **23** which extend through the end **14** of the envelope **10**, so that a relatively long connection is provided, as shown, in order to minimize heat transfer to the seal. The two inleads **23** are preferably used in this case, as shown, in order to permit the passage of an electrical current through the helix during manufacture to reduce the alkaline earth carbonates to the oxides. In operation of the lamp these inleads are preferably connected together. It is to be understood, however, that a single inlead can be used, as in Fig. 1, if desired.

With this construction the arc impinges upon the nearest portion of one or another of the turns of the helix **22** until that part of the helix is momentarily deactivated, after which it jumps to an adjoining turn, whereupon a fresh activating film of the oxide creeps up from the lower part of the helix **21** and immediately reactivates the denuded portion, so that it is again ready to support the arc. Due to the very large reserve supply of the active material available with this construction this novel electrode has an exceptionally long useful life, even longer than that of the electrode of Figs. 3 and 4, in addition to all the other advantages pointed out for that electrode.

Like all gaseous discharge devices my novel lamp has a negative volt ampere characteristic. Hence as schematically illustrated in Fig. 1 my novel lamp is ordinarily operated in series with a suitable inductance **24** on 220 volts A. C.

When potential is first applied to this lamp the gas is stressed between the upper electrode **16** and the band of gauze **20**, the separate projecting turns of the wire **17** causing an abnormal distribution of this stress which greatly accelerates the electrons emitted from the active surface of the electrode **16** and thus causes the gas to be ionized. This initial ionization permits a low intensity glow discharge to take place at the existing potential difference between the electrodes **16**. This discharge in turn greatly increases the ion concentration within the envelope **10**, and also heats the electrode **16**, causing an increased electron emission from the active surface thereof, and as a result of this increased ion concentration and increased electron emission the discharge rapidly turns into an arc. The foregoing phenomena all take place, of course, in a very short period, so that the arc appears to be instantaneously established as soon as the potential is applied.

When this arc first starts the argon plays an important part in the discharge, but as the temperature rises the mercury vapor density increases, and the arc becomes virtually a pure low pressure mercury vapor discharge. During this time the arc spreads over the whole cathode surface, but as the temperature rises further, with an accompanying increase in vapor density, the arc becomes more and more constricted and finally concentrates on a single point on the encircling helix 17 or 22 of each electrode 16 or 21, respectively, whichever is used. With the electrode 16 the arc usually takes off from the helix 17 near the apex of the V. After the mercury has all been vaporized there is, of course, no further increase in vapor density. Hence with a further increase in temperature, such as is found desirable to insure constant operating conditions despite slight variations in line voltage, ambient temperature and the like, the vapor is merely superheated and behaves as a fixed gas, with a substantially constant arc drop of 150 volts and a substantially constant current of about 2.9 amperes. This makes my novel lamp especially desirable for street and other outdoor lighting, where the extreme variations in temperature have made it impracticable to operate a merucury vapor arc heretofore. It likewise is of advantage where my novel lamp is combined in a single fixture with incandescent lamps, for the heat radiated by the latter have virtually no effect upon the operation of my novel vapor arc lamp. When operated under the conditions described my novel device has a luminous efficiency of approximately 35 lumens per watt, and this efficiency is maintained without undue depreciation throughout a long useful life of thousands of hours.

While I have described my invention by reference to specific embodiments thereof, it is to be understood that various substitutions, changes or omissions, within the scope of the appended claims, may be made therein without departing from the spirit of my invention.

I claim as my invention:

1. An electric gaseous discharge device comprising a sealed envelope, a gaseous atmosphere therein, and a plurality of electrodes sealed within said envelope, at least one of said electrodes consisting of a body of a refractory metal having a closely wound helix of a refractory metal loosely mounted thereon, and a thermionically active substance on said body and helix and within the interstices therebetween.

2. An electric gaseous discharge device comprising a sealed envelope, a gaseous atmosphere therein, and a plurality of electrodes sealed within said envelope, at least one of said electrodes consisting of a wire of a refractory metal having a closely wound helix of a refractory metal loosely mounted thereon, and a thermionically active substance on said wire and helix and within the interstices therebetween.

3. An electric vapor discharge device comprising a sealed tubular envelope of vitreous material, an inlead sealed into each end thereof, an electrode mounted on each of said inleads close to the adjacent end of said envelope, said electrodes consisting of a tungsten wire of a desired configuration on which there is loosely mounted a closely wound tungsten helix, and a coating of a thermionically active substance on said wires and within the interstices therebetween, and a vaporizable material within said envelope in an amount which is less than that necessary to saturate the space within said envelope at the normal operating temperature of said device, but which is sufficient to support a constricted arc discharge between said electrodes.

4. A cathode for an electric gaseous discharge device comprising a body of refractory metal, a closely wound helix of a refractory metal loosely mounted on said body, and a thermionically active coating on said body and helix and within the interstices therebetween.

5. A uni-potential cathode for an electric gaseous discharge device comprising a wire of tungsten which has a desired configuration, a closely wound helix of tungsten wire loosely mounted on said first mentioned wire, and a thermionically active coating on said wires and within the interstices therebetween.

6. A uni-potential cathode for an electric gaseous discharge device comprising a wire of tungsten whose ends are electrically connected together, a portion of said wire being in the form of a projecting loop, a closely wound helix of tungsten wire loosely mounted on said first mentioned wire, and a thermionically active coating on said wire and within the interstices therebetween.

7. A uni-potential cathode for an electric gaseous discharge device comprising a tungsten wire which is coiled into a helix, a closely wound helix of smaller tungsten wire loosely mounted on said first mentioned helix, and a thermionically active coating on said wires and within the interstices therebetween.

8. An electric vapor discharge device comprising a sealed tubular envelope of vitreous material containing a vaporizable substance, an inlead sealed into each end of said envelope, and a thermionic cathode on each inlead close to the adjacent end of said envelope, the end portions of said envelope consisting of a heat absorbing glass whose coefficient of expansion is intermediate that of said envelope and that of said inleads.

9. An electric vapor discharge device comprising a sealed tubular envelope of vitreous material containing a vaporizable substance, an inlead sealed into each end of said envelope, a thermionic cathode on each inlead close to the adjacent end of said envelope, a sealed enclosing jacket for said envelope, and means to support said envelope in a fixed position within said jacket, said last mentioned means including a pair of metal collars of smaller diameter than that of said envelope abutting against opposite ends of said envelope.

10. An electric vapor discharge device comprising a sealed tubular envelope of vitreous material containing a vaporizable substance, an inlead sealed into each end of said envelope, a thermionic cathode on each inlead close to the adjacent end of said envelope, a sealed enclosing jacket of vitreous material for said envelope, and means independent of said inleads to resiliently support said envelope within said jacket, said means including a collar of smaller diameter than that of said envelope abutting against the end of said envelope and having springs affixed thereto which bear upon the inner surface of said jacket.

11. An electric vapor discharge device comprising a sealed tubular envelope of vitreous material containing a vaporizable substance, a thermionic cathode located at one end of said envelope, a sealed enclosing jacket for said envelope, and means to support said envelope in a fixed position within said jacket and to reduce the heat loss from the aforesaid end of said envelope, said means including a collar of smaller diameter than that of said envelope abutting against said end thereof.

12. An electric vapor discharge device comprising a sealed tubular envelope of vitreous mate-

rial containing a vaporizable substance, a thermionic cathode located at one end of said envelope, a sealed enclosing jacket for said envelope, a gas within said jacket, and means to support said envelope within said jacket and to reduce the heat loss from the aforesaid end of said envelope, said means including a collar of smaller diameter than that of said envelope abutting against said end thereof and cooperating with said envelope to form a pocket which reduces the flow of convection currents across the aforesaid end of said envelope.

JAMES A. ST. LOUIS.