July 9, 1935. C. H. BRASELTON 2,007,919

ELECTRICAL DISCHARGE DEVICE

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Fig. 1.

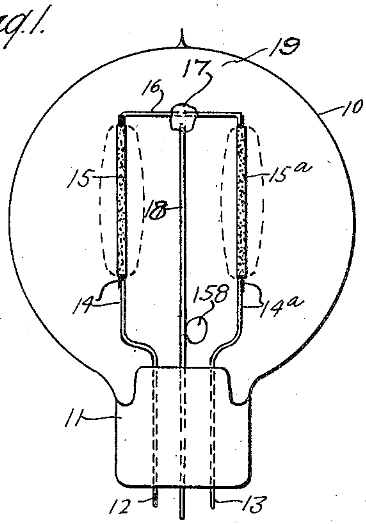

Fig. 2.

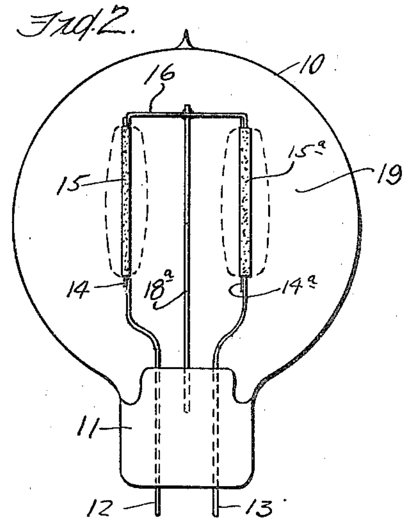

Fig. 3

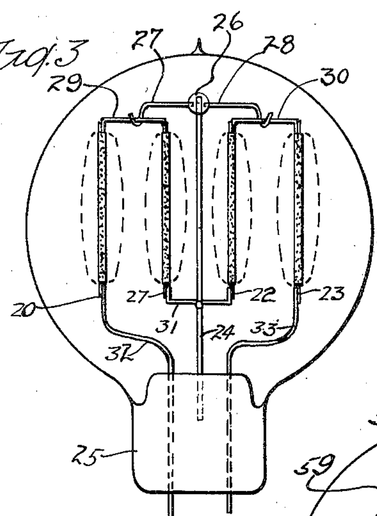

Fig. 4.

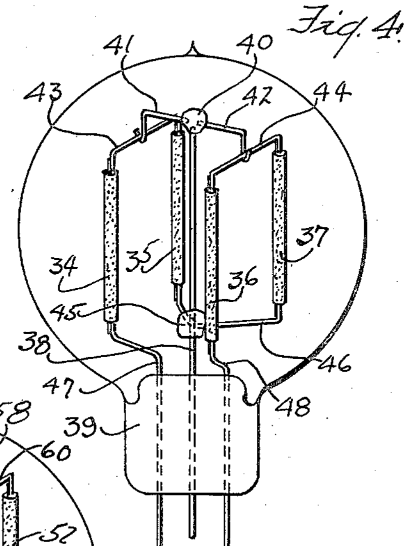

Fig. 5.

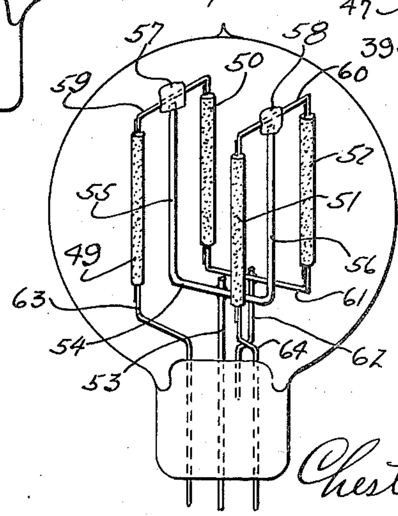

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Fig. 6.

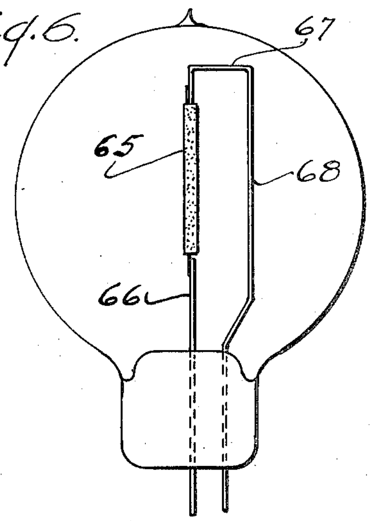


Fig. 7.

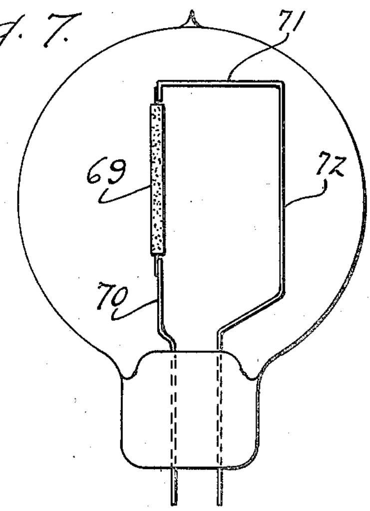


Fig. 8.

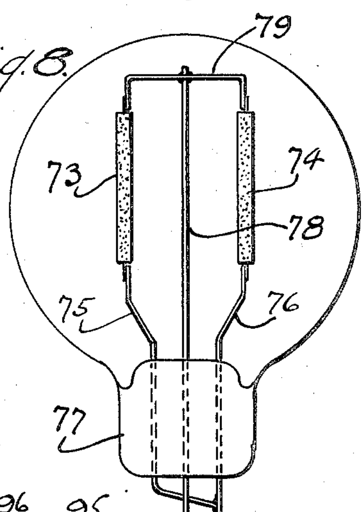
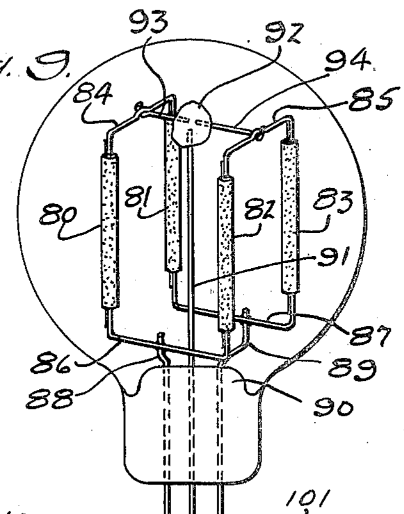


Fig. 9.



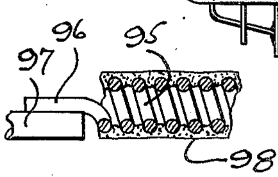


Fig. 10.

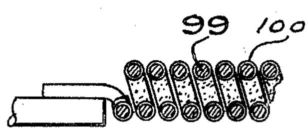


Fig. 11.

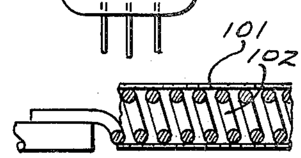


Fig. 12.

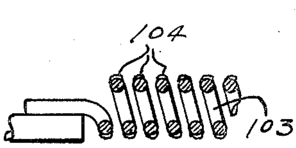


Fig. 13.

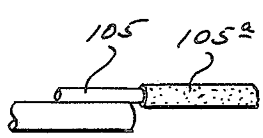


Fig. 14.

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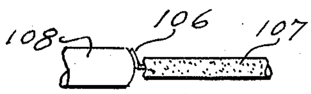

Fig. 15.

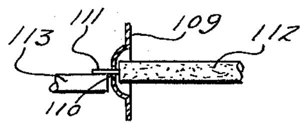

Fig. 16.

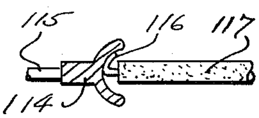

Fig. 17.

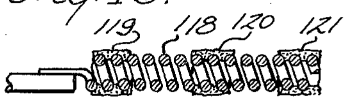

Fig. 18.

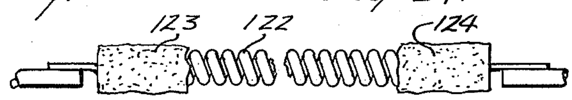

Fig. 19.

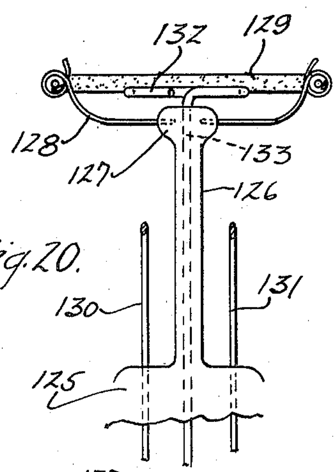

Fig. 20.

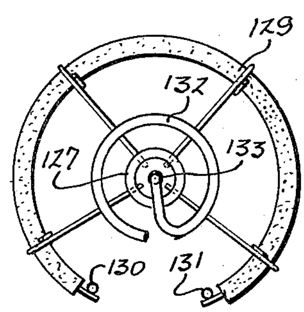

Fig. 21.

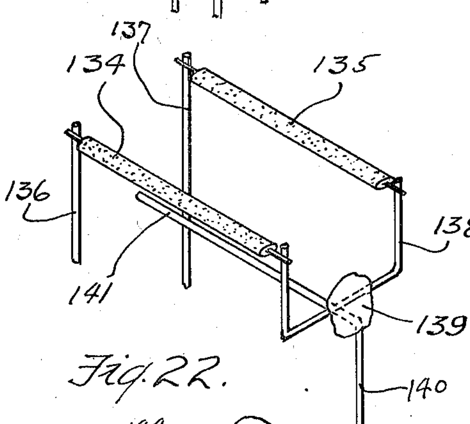

Fig. 22.

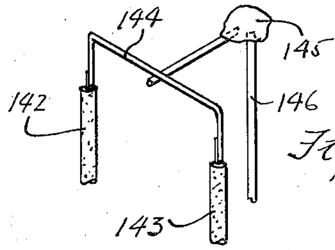

Fig. 23.

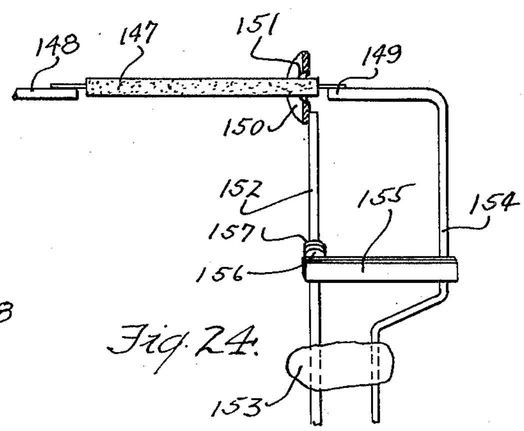

Fig. 24.

INVENTOR

Chester H. Braselton

Patented July 9, 1935

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UNITED STATES PATENT OFFICE

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ELECTRICAL DISCHARGE DEVICE

Chester H. Braselton, New York, N. Y., assignor to Sirian Lamp Company, Newark, N. J., a corporation of Delaware

Application June 3, 1930, Serial No. 459,048

19 Claims. (Cl. 176—1)

This invention relates to a method and apparatus for the production of conducting paths for electric currents adjacent but external to the surface of a dense body, and to the means and the method for controlling the paths for utilization in various arts such as the art of electrical illumination.

One of the objects of the invention is to provide a method and a device for converting electrical energy into radiant energy throughout the entire range of the ether spectrum.

Another object of my invention is to provide an electrical conducting path adjacent a conducting element serving as an auxiliary or shunt path for the current flowing in said element.

Another object of the invention is to provide a means for causing gas or vapor adjacent a conducting element to serve as an auxiliary conductor for the current which would normally flow in said conducting element.

Another object of the invention is to provide a means for causing gas or vapor adjacent an electron emitting element to serve as an auxiliary conductor in the same general direction as the axis of the element.

Still another object of the invention is to maintain an ionic discharge adjacent a heated conductor so that it forms an auxiliary and shunt path for the potential applied to the conductor.

Another object of the invention is to obtain an ionic discharge and maintain and control the potential gradient along the path of the discharge by the voltage drop in a heated conductor adjacent to the discharge.

A further object of the invention is to maintain a diffused or non-localized ionic discharge in contact with a heated conductor by the potential difference between various parts of the conductor.

Still another object of the invention is to maintain a highly conductive gaseous discharge adjacent to an ionizing element by virtue of the electron emission from said element and the potential gradient along said element.

Another object of the invention is to obtain ionic discharge of high energy density distributed over an ionizing surface.

A still further object of the invention is the efficient production of radiant energy obtained simultaneously from an ionized gas discharge, a glow caused by bombardment of a refractory material, and the thermal effects of current flow through a conductor, all caused by the current flowing through said conductor.

Other objects of the invention and objects relating to various uses for the phenomena involved will be apparent as the description of the invention proceeds.

Several embodiments of the invention applying particularly to illuminating devices are illustrated in the accompanying drawings in which:

Fig. 1 is a side elevation of an electric lamp having a double electron emission element;

Fig. 2 is a side elevation of a modified form of the lamp shown in Fig. 1;

Fig. 3 is a side elevation of still another modification of the lamp;

Fig. 4 is an enlarged perspective view of still another modification of the lamp;

Fig. 5 is another perspective view of a modified form of the lamp;

Figs. 6 and 7 are side elevations of a lamp showing a single element;

Fig. 8 is a side elevation of a lamp with the elements connected in parallel;

Fig. 9 is a perspective view of a modified form of the lamp shown in Fig. 8;

Figs. 10, 11, 12, and 13 are enlarged longitudinal sections of one end of different embodiments of electron emitting elements;

Fig. 14 is an enlarged view of another embodiment of an electron emitting element;

Figs. 15, 16, and 17 are enlarged views, the latter two being in section, of several different methods of attaching the electron emitting elements to the supports;

Fig. 18 is a longitudinal sectional view of another embodiment of an electron emitting element;

Fig. 19 is a side elevation of still another embodiment of an electron emitting element;

Fig. 20 is a side elevation partly in section of a portion of another embodiment of the lamp;

Fig. 21 is a plan view of the parts of the lamp shown in Fig. 20;

Fig. 22 is a perspective view of a portion of still another embodiment of the lamp; and

Figs. 23 and 24 are perspective views of the active portions of other embodiments of the lamp.

I have discovered that if an electron emitting surface has a potential applied across it and is heated to an electron emitting temperature that a conductive path will be formed adjacent to the surface but outside of it. One way to make effective use of this conductive path is to provide a gas in contact therewith. The cross-section of the conductive path and its proximity to the emitting surface when a gas is used appears to be dependent upon the gas used and the pressure thereof, as well as the resistance of the conducting base and the potential used across it. Thus a conducting element coated with electron emitting material and heated by the passage of a current at a suitable potential and in the presence of an ionizable gas at a suitable pressure may be made to maintain an ionic discharge adjacent the emitting surface which has the characteristic of being uniformly distributed over the surface and apparently follows the electrical field maintained between oppositely charged parts of the element and differs from the ionic discharges of the prior art by being spread out or diffused over a large area and by being independent of the consumption of an electrode material for its maintenance and of gap-separated electrodes. The gas discharges heretofore used have, in general, been between two or more electrodes maintained at an adequate potential difference, while in making use of the principles discovered by me the discharge may be made to follow the potential gradient produced by the conduction of a current through an electrically resistant and thermally refractive ionizing element. The relation between the potential impressed across the element and the pressure of the gas used is important in preventing the discharge, if desired, from occurring in any other direction except along or parallel to the axis of the ionizing element.

For purposes of illumination any desired spectral characteristics may be imparted to the emitting surface by proper choice of gases or vapors and operating pressures. The material chosen as the ionizing agent should be one that will withstand high temperature operation and preferably have selective radiation characteristics, so that if used for illumination purposes the heat energy imparted to it by conduction, radiation, or ionic bombardment will be effectively translated into visible radiation. When this principle is specifically applied to a lamp for general illumination purposes the ionizing element may consist of a coiled refractory filament of tungsten, for instance, coated with a mixture of calcium and barium oxides or calcium oxide alone, or other oxides may be used depending on the particular characteristics desired. For such a lamp a mixture of argon and neon might be used at a pressure of about two hundred millimeters.

In the construction of a lamp to operate on this principle it is desirable that the emitting oxides be as pure as possible, such as being free from binding elements or inactive materials, and that the gases be as free from impurities as possible. This is accomplished by the proper exhaustion of the container and elements at suitable temperatures to discharge all occluded gases or vapors at low pressure prior to the introduction of the inert gas. For uses where the radiation must extend into the invisible part of the spectrum, as in ultra-violet radiations, metallic vapors such as the vapors of mercury, caesium, or rubidium may be used, especially the first mentioned. In general the most preferable gases are those which are inert and monatomic such as neon, argon, krypton, xenon, and helium, and which may be designated as the gases of the argon group. These gases have low ionization potential and chemical inertness. Where exceptionally low ionization potentials are desired metal vapors such as those of rubidium or caesium may be mixed with the inert gases.

The operation of an illuminating device built upon my discovery may utilize a combination of some or all of effects, such as the formation of a diffused and uniformly distributed ionic discharge maintained by the electron bombardment of a gas from an electron emitting compound intimately contacting with a refractory base, with the drop of potential along the refractory base serving as the electron accelerating potential, the heating of the refractory base by electron bombardment from itself and from the gas, and the heating of the refractory base by the current passing through it. The ionic discharge occurring at the surface of the oxide coated element appears to ionize the gas immediately surrounding it so as to make it an auxiliary conductor and because the discharge extends along the ionizing element and is uniformly distributed as an intense sheath around it, localized effects are avoided with resultant elimination of spot vaporization or decomposition of discharge terminals.

It is preferable to activate the electron emitting compounds if, for example, an oxide of the alkaline earth type is used, in order to obtain efficient thermionic emission.

I have found that in most cases for practical consideration that the drop of potential along the filament or ionizer element should be greater than the breakdown potential of the gas or vapor atmosphere, and that the electron emission temperature necessary for ionization of the gas should be sufficiently low so that increased temperature due to the ionic current discharge will not destroy or materially injure the ionizing material or melt or vaporize or detrimentally injure the base metal.

Referring now more specifically to the drawings a lamp is shown in Fig. 1 having a transparent envelope 10 provided with a press 11 for sealing in the leading-in conductors 12 and 13. The conductor 12 may extend a short distance into the envelope 10 where it may form a support for one end of a coiled filament 14 which is coated with a suitable electron emitting material 15. A second filament 14*a* provided with an electron emitting coating 15*a* may be supported at one end by the leading-in conductor 13 and may extend substantially parallel to the filament 14. A connector 16 may be attached to the other ends of the filaments and may be sealed in a glass bead 17 which may be supported by a central support 18 sealed in the press 11. As will be hereinafter described the filament may be either straight or in the form of a coil which is perhaps preferred in order to get a sufficient resistance into a given length and it may be composed of tungsten, molybdenum, tantalum, nickel, or nichrome or other suitable material. The electron emitting material may be mixtures of calcium and barium oxides or calcium oxide alone or other oxides or any other of the well known electron emitting oxides, such as the alkaline earth oxides, may be used depending on the particular characteristics desired. Thus where exceptionally high visible radiation effects are not specifically required the emitting material may be composed of mixtures operable at lower temperatures, such, for example, as a mixture of the oxides of strontium and barium. However, the emissivity of the electron emitting material should be comparable to that of the alkaline earth metal oxides such as barium oxide, strontium oxide and calcium oxide and in excess of that from such oxides as thorium oxide in order to obtain the effects and results of the invention.

The envelope 10 may be filled with an inert gas 19 such as a mixture of neon and argon at a pressure of about two hundred millimeters. Other gases or mixtures of gases may also be used depending on the effect desired.

In Fig. 2 is shown a construction similar to Fig. 1 except that the supporting rod 18a is welded to the connector 16 at the top and is not brought through the press 11 but is merely sealed therein acting solely as a support for the electron emitting elements and forming during the manufacturing process a convenient electrode for activating the electron emitting surfaces. As in this process it may be found desirable to put an additional potential on the support for activating purposes the construction shown in Fig. 1 may be preferred. In that construction the center support 18 is insulated from the filaments and passes down through the press and in the manufacture of the lamp may be connected to a source of potential, as is the anode of a thermionic amplifying tube during the activating of the cathode.

A lamp such as is shown in Fig. 2 was made in the following manner: A pair of tungsten filaments wound into helices of about 1½ inches long and .012 of an inch in diameter with approximately 230 turns to the inch were coated with a material made by mixing about 40 grains of barium carbonate, 40 grains of calcium carbonate and 8 grains of barium nitrate with a binder of sufficient nitro-cellulose dissolved in amyl acetate to hold the coating on the wire. This coating was about .003 of an inch thick. These filaments, connected in series, had an initial resistance of 150 ohms. After the filaments were mounted on a press and the press sealed in the envelope 10, in a well known manner and with the filaments spaced about 1⅛ inches apart and substantially parallel to each other, the bulb was connected to an exhaust pump, care being taken that all the manifolds were glass so that there was a gas-tight connection between the bulb and the pump and that the oil in the pump was as pure as possible. With the pump operating an oven was placed over the bulb and the bulb thoroughly baked in the usual manner of treating lamp bulbs, to free it from water vapor or other gases. A low voltage was then connected to the filament leads and the temperature of the coated filaments was slowly raised by increasing the voltage until they reached a red heat so as to sinter on the coating and make it adhere as closely as possible to the filament wire. During this time all occluded gases were discharged and a high vacuum condition of about .5 micron was maintained. When the current was applied to the filaments a slight blue haze or glow appeared in the bulb, discharging between the opposite ends of the ionizing filaments or the supporting leads, and this glow gradually disappeared as all the gases or vapors were discharged from the bulb. A slight amount of neon gas was then admitted to the bulb and the bulb was evacuated again to the high vacuum of about .5 microns to make sure that all of the occluded gases were removed. When this point was reached a small amount of neon gas at a pressure of about two millimeters was allowed to enter the bulb and a potential of about 30 volts was applied to the filaments and raised until the entire bulb was filled with a reddish-colored discharge which in major quantities was between the coating on each of the filaments and the center supporting rod 18a, Fig. 2. The intensity of the current applied to the filaments was increased until every portion of the oxide coating on each of the filaments appeared to have a discharge between it and the support rod or other parts of the filaments. In this manner the electron emitting oxide on each of the filaments was activated to allow them to discharge more evenly and at lower temperatures. Care was taken during this step to raise the temperature of the filaments materially higher than their normal operating temperature so as to completely remove occluded gases.

When the oxide coatings on the filaments had been completely uniformly activated the bulb was again exhausted to around .5 microns and thereafter filled with neon gas at about ten millimeters pressure and then argon gas was added to raise the pressure to about two hundred millimeters. When the filaments were raised to an electron emitting temperature by alternating current at this increased pressure the ionic discharge had an intense bluish-white color and appeared to be uniformly distributed or diffused over the electron emitting oxides in the manner illustrated by the dotted lines in Fig. 2. This discharge produced in itself considerable light but the light so produced was augmented by the incandescence of the calcium oxide used on the emitting surface which was apparently caused by ionic bombardment and also because of its inherent selective radiation. The bulb was then sealed off and the lamp completed. When operated on either alternating or direct current at about 60 volts the discharge surrounded the elements as indicated and produced a steady bluish-white light.

In Figs. 1 and 2 two electron emitting elements in series have been shown but it may be desirable to provide additional elements and hence the construction of Fig. 3 wherein four electron emitting elements 20, 21, 22, and 23 are connected in series. A central support rod 24 may be provided sealed in the press 25 and this rod may extend vertically within the bulb and be provided at its upper end with a glass bead 26 into which may be sealed a pair of oppositely extended support wires 27 and 28. The upper ends of the two filaments 20 and 21 may be connected by means of a connector 29 which is supported by the wire 27 while the other two elements 22 and 23 may be connected at their upper ends by a connector 30 which is supported by the wire 28. The lower ends of the center elements 21 and 22 may be connected together by a connector 31 which is welded to the center support rod 24. The lower ends of the outer elements 20 and 23 may be connected respectively to support wires 32 and 33 which are sealed in the press and form the leading-in wires for the lamp. As thus constructed current flows through the leading-in wire 32, the element 20, the connector 29, the element 21, the connector 31, the element 22, the connector 30, the element 23, and the other leading-in wire 33. The center support rod 24 aids in the activating process as does also the elements themselves, as each one may form an activating electrode for one or more of the others.

In Fig. 4 another modification of the lamp is shown with four electron emitting elements 34, 35, 36 and 37 equally spaced from the axis of the lamp. In this construction the center support rod 38 is insulated completely from the filament circuit and extends out at the bottom of the press 39 so that it may be used as an additional electrode during the activating process. A glass bead 40 at the top of the rod 38 may support two oppositely extended wires 41 and 42 for supporting the upper ends of the elements. The elements 34 and 35 are connected at their upper ends by a connector 43 supported upon the hook 41 and the elements 36 and 37 may have their upper ends connected by a connector 44 supported from the wire 42. A glass bead 45 may be provided upon the upright 38 just below the lower ends of the elements and a connector 46, bent at an angle, may have its center sealed in the bead and its ends welded to the lower ends of the elements 35 and 37. When the leading-in wires 47 and 48 are connected to a source of electricity, current will flow through the leading-in wire 47, the element 34, the connector 43, the element 35, the angular connector 46, the element 37, the connector 44, the element 36, and the leading-in wire 48.

Fig. 5 shows a modified form of the construction of Fig. 4. Here four elements 49, 50, 51, and 52 are shown connected in series. A center support 53 extends upward to a point about even with the lower ends of the elements and forms a support for a U-shaped supporting member 54 having uprights 55 and 56 positioned parallel to and between the elements 49 and 50 and 51 and 52. A glass bead 57 may be provided at the upper end of the upright 55 and a similar glass bead 58 may be provided at the top of the upright 56 for supporting respectively without making electrical contact therewith connectors 59 and 60 which connect the upper ends of the elements 49 and 50, and 51 and 52 respectively. A connector 61 may be welded to the lower ends of the elements 50 and 52 and a support rod 62 may be sealed in the press and bent outwardly and upwardly to a point adjacent the connector 61 to which it may be welded. Leading-in wires 63 and 64 may be connected respectively to the lower ends of the elements 49 and 51 and when the lamp is connected in a circuit the current flows through the elements in series similar to the manner described in connection with the two previous constructions.

While two or more elements have been shown in the figures already described it may be desirable to have a single element. Thus in Fig. 6 a single element 65 is shown attached at its lower end to a leading-in wire 66 and at its upper end to a second leading-in wire 67 which extends outwardly from the top of the element and is bent downwardly at right angles, having a portion 68 parallel to the element which forms a convenient electrode for activating purposes. The lower end of the wire 67, of course, passes through the press as shown.

It may be found desirable to activate the element without the use of a cooperating electrode, portions of the element itself acting as the activating electrodes. This may be done with the construction shown in Fig. 7, where the element 69 has its lower end attached to a leading-in wire 70 and its upper end attached to the other leading-in wire 71, the downwardly extending portion 72 of which is spaced far enough from the element so as not to materially affect it during the activation thereof.

Fig. 8 shows a construction in which two elements 73 and 74 are mounted in parallel. Two leading-in wires 75 and 76 are connected to the lower ends respectively of the elements 73 and 74 and may be joined together after passing through the press 77.

A third leading-in wire 78 is sealed in the press and extends upwardly between the elements and supports at its upper end a connector 79 to which it is attached and which is in turn attached to the upper ends of the elements 73 and 74. As in some of the constructions previously described, the center support, which in this case is one of the leading-in wires, aids in the activating process.

In Fig. 9 a modification of the construction of Fig. 8 is shown wherein two sets of parallel elements 80, 81, 82, and 83 are spaced about a central axis similar to the spacing shown in Figs. 4 and 5. The elements 80 and 81 are connected together at their upper ends by a connector 84, while the elements 82 and 83 are connected by means of the connector 85. The lower ends of the elements 80 and 82 may be connected by the connector 86 and the lower ends of the elements 81 and 83 may be connected by the connector 87. The two connectors 86 and 87 may then be welded respectively to two leading-in wires 88 and 89 which are sealed in the press 90 and form the support for the lower ends of all of the elements. A central support wire 91 is sealed in the press and extends upwardly in the center of the lamp, terminating at a point slightly above the elements. A glass bead 92 may be sealed at the upper end of the support 91 and two support wires 93 and 94 may be sealed in the bead 92 for supporting respectively the two connectors 84 and 85 and thus the upper ends of all the elements. Current passing through the leading-in wire 88 divides and passes through both the elements 80 and 82, both the connectors 84 and 85, both the elements 81 and 83, and passes out through the leading-in wire 89. The central support may have a potential connected to it for activating purposes but is intended to be used for supporting purposes only when the lamp is in use.

In Fig. 10 a longitudinal sectional view of an enlarged end of one of the elements is shown. This element consists of a coil of resistance wire 95, the end 96 being bent outwardly along the axis of the element where it may be welded or otherwise attached to the support wire 97. The outside of the coil may be coated with an electron emitting material 98 which may be applied to the wire similarly to the manner in which such material is applied to the cathodes of thermionic amplifying tubes. Preferably the material should not extend too far inside the coil.

In Fig. 11 another embodiment of the element is shown in which the wire 99 is coated with electron emitting material 100 either before or after winding into the coil, each coil of the wire being individually coated.

Fig. 12 shows a construction in which a sleeve 101 of electron emitting material is made with an internal diameter just sufficient to slip a coil 102 inside of it.

Fig. 13 shows a construction in which the coil 103 of resistance wire is coated with electron emitting material on the outermost sides of each turn as at 104.

While the coiled filament is deemed preferable for practical purposes, a single straight filament 105, Fig. 14, with a suitable coating 105a of electron emitting material may be used if desired, but of course a much longer filament is necessary in order to equal the resistance of a coiled filament.

Fig. 15 shows a method of attaching the element to a relatively large support. As illustrated, the end 106 of the element 107 is merely laid against the end of the support 108 and welded thereto. The large support forms a terminal for the end of the discharge and appears to prevent the extra current which flows through the ionized gas from passing through the end of the filament, thereby preventing any tendency for overheating at this point.

Figs. 16 and 17 show two alternative methods for accomplishing this same purpose. A cup-shaped member 109 in Fig. 16 is provided with a hole 110 through which the end 111 of the element 112 passes. Both the member 109 and the end 111 of the element may be welded to the support wire 113. In Fig. 17 a solid cup-shaped member 114 attached directly to the support wire 115 may have the end 116 of the element 117 welded upon the inner central face thereof.

In some instances it may be desired to coat the wire with electron emitting material only in spots, as shown in Fig. 18, where a wire coil 118 is coated at spaced intervals, as at 119, 120, and 121. This construction appears to depend on the ionization of the gas adjacent the coated portions of the element to carry the discharge past the uncoated portions.

Fig. 19 shows a coil of wire 112 which is coated only at each end, as at 123 and 124. With such an element the ionization of gas at each end of the element produced by the electron emitting material must be sufficient to maintain the discharge along it.

In all the figures so far described the elements have been shown as parallel to the axis of the bulb but in many instances it may be desirable or even preferable to mount the elements transverse to the axis of the bulb, in which case a construction similar to that shown in Figs. 20 and 21 may be used. The press 125 in this instance is provided with an upstanding glass support rod or tube 126 with an enlarged portion 127 at the upper end thereof. A plurality of support wires 128 are sealed in the enlarged portion 127 and may extend outwardly and slightly upwardly to support an electron emitting element 129 which may be formed of a coil of wire coated with electron emitting material similar to the elements already described, but in this case bent in the form of a circle, as indicated in Fig. 21. The ends of the element are separated far enough apart to prevent any discharge between the ends and are attached to two leading-in wires 130 and 131 which extend downwardly through the press 125. Adjacent to the element 129 I preferably provide a member suitable to act as an electrode for activating. This member may be in the form of a ring 132 which may be spaced inside of the element 129 and may be made of a wire one end 133 of which may be bent inwardly and downwardly extending through the rod 126 and through the press 125 so that it may be given a potential during the step of activating.

Parallel elements may also be used placed transverse to the axis of the bulb, as indicated in Fig. 22, where the elements 134 and 135 have one end each attached to the leading-in wires 136 and 137. The other ends of the elements may be attached to a connector 138 which may be substantially U-shaped with the center part extending downwardly below the plane of the elements. A glass bead 139 may be sealed onto the center of the connector 138 and a third support rod 140 may be sealed in the bead with its end 141 extending parallel with the elements 134 and 135, to a point about even with the ends of the elements. The elements of this construction light up similarly to those already described and the rod 141 may be used when the electron emitting material is activated.

As heretofore explained, with a suitable pressure and voltage the discharge of the lamp follows the electron emitting elements as shown by the dotted lines in Figs. 1, 2, and 3. If the voltage is increased, however, it begins to bridge the gap between the elements, starting adjacent the connector to which the ends of two of the elements may be attached, and spreading until it appears to cover the entire space between the elements. It may be desired to operate the device in this manner, and if so, it is necessary to make any support which comes between the elements out of heat resisting material to avoid melting or other deterioration. In Fig. 22, however, the rod 141, being below the plane of the elements, is outside of the discharge when such a discharge occurs, and may thus be protected from the intense heat.

Vertical elements such as are used in Figs. 1 and 2 may also be made to operate in this manner with discharge between the elements by supporting them with an offset support, as indicated in Fig. 23. In this figure the elements 142 and 143 have their upper ends supported by a connector 144 which is in turn supported upon a wire sealed in a bead 145 mounted at the end of a support rod 146 which is spaced somewhat in back of the elements as shown.

In some instances it may be desired to stop the normal flow of current in the coiled wire when the discharge has been formed and this may be done by any suitable means, as by the construction shown in Fig. 24. In this figure the element 147 is positioned between two terminals 148 and 149. A flat metal ring 150 is positioned adjacent the end of the element near the terminal 149 with the element protruding through a hole 151 therein. The metal ring is supported upon a rod 152 which may extend down to the press of the bulb and which forms one of the leading-in wires for the lamp. A glass bead 153 may be sealed upon the support rod 152 and forms a support for the lower end of the wire 154 whose upper end forms the terminal 149, the wire being sealed therein. A bimetallic arm 155 is attached to the wire 154 and has a contact 156 which is adapted to normally touch the contact 157 mounted on the support rod 152 but to move away from it when the arm 155 bends under the influence of heat. In this embodiment of the lamp, when the current is turned on it flows up the rod 152, through the contacts 157 and 156, through the bimetallic arm 155, the wire 154, the terminal 149, and element 147 to the terminal 148. The discharge as already described immediately starts around the wire, passing through the ring 150, but as soon as the temperature in the lamp has reached a predetermined point the thermostat arm 155 opens the contacts 156 and 157 and breaks the circuit through the element. The heat generated by the discharge is sufficient to maintain it and the current will thereafter flow between the terminal 148 and portions of the element and the ring 150. If desired, another ring may be provided at the other end of the element and a second thermostat may be used to completely disconnect both ends of the element so that all of the current must flow through the ionized gas alone.

The plurality of elements shown in Figs. 1 and 2 may be necessary when the potential applied exceeds a certain value in order to prevent localization effects such as a discharge between the highest potential ends of the filaments. This limiting of potential is dependent upon the gas pressure, the nature of the gas, and the characteristics of the ionizing element, such as the material used, temperature, and the geometry of the parts.

The pressure of the gas in the bulb is not critical but may be given such a value that it will prevent the ionic discharge from occurring between the filament elements themselves or between the filament elements and a support rod, or, in other words, where the lamp is designed to operate in that manner the pressure should be such as to confine the ionic discharge along the length of the ionizer element.

If increased glow effect is desired in the lamp, materials having highly selective radiation characteristics, such as thorium oxide with one percent of cerium oxide, may be added to the ionizing agent. When it is desired to have the discharge occur at lower potentials, metal vapors such as caesium vapor may be added. Caesium may be introduced into the lamp by providing a small metal container, such as I have shown at 158 in Fig. 1, with magnesium metal and caesium chloride in it. This container is inductively heated till the reactive temperature is reached, at which time the caesium is distilled and condenses on the walls of the bulb. The same method may be used with rubidium or mercury. When the lamp is used the heat from the filament is conducted by the gas to the walls of the bulb and revaporizes the caesium or other vapor condensed thereon. When radiations of other wave lengths are desired, such as ultra-violet radiation, mercury vapor may be used either with or without the gas discharge. When heat is necessary to increase the effect of the metal vapors a low pressure of helium, such as about five millimeters, may be of great advantage because of its high conductivity.

While I have specifically described my discovery in connection with illumination devices this unique form of discharge may be used for other devices wherein the conducting path adjacent the electron emitting element is used as a means of control or as a conductive element in a circuit using either direct or alternating current. The invention is not therefore intended to be limited to what has been specifically shown and described except as such limitations occur in the appended claims.

What I claim is:

1. In an electric lamp a resistance element, a coating of electron emitting material on said resistance element, a terminal for one end of said resistance element, an electrode adjacent the electron emitting material and symmetrically positioned with respect thereto but out of contact therewith, a leading-in wire connected to said electrode and to said terminal, and means to break the circuit between said terminal and said leading-in wire when the temperature of said lamp has been raised to a predetermined degree.

2. An electric lamp comprising a closely wound coil of tungsten wire, a coating of a mixture of the oxides of barium and strontium on the surface of said coil, and an ionizable gas consisting of approximately 10 mm. of neon gas and 190 mm. of argon gas surrounding said coil.

3. An electric lamp comprising a transparent envelope, a pair of tungsten filaments within said envelope each formed of a closely wound helix about one and one-half inches long and .012 of an inch in diameter with approximately 230 turns to the inch and having a coating of a mixture of barium and strontium oxide having a thickness of approximately .003 of an inch, the total resistance of the two filaments in series being about 150 ohms, means to electrically connect said filaments in series and support said filaments spaced about one and one-eighth inches apart and substantially parallel to each other, and a mixture of argon and neon gases at a pressure of substantially 200 mm. of mercury surrounding said filaments.

4. In an electrical discharge device an envelope, a conductor constituting the sole source of the discharge within said envelope, a gaseous fluid within said envelope surrounding said conductor, and means to render said fluid conductive in the immediate vicinity only of said conductor when said conductor is heated and a potential is applied to the ends thereof, said means consisting of a coating of an electron emitting substance having an emissivity in excess of that from thorium oxide.

5. In an electrical discharge device an envelope, a filamentary conductor constituting the sole source of the discharge within said envelope having an electrical connection at each end thereof, an electron emitting coating having an emissivity in excess of that from thorium oxide on said conductor, and an ionizable gas surrounding said conductor, the breakdown potential of said gas per unit length of said conductor being less than the potential drop along said unit length necessary to raise said conductor to electron emitting temperature.

6. In an electron discharge device an envelope, a filamentary conductor constituting the sole source of the discharge within said envelope, an electron emitting coating having an emissivity in excess of that from thorium oxide on said conductor, and an ionizable gas surrounding said conductor, the pressure of said gas being sufficient to restrict the ionized portion of said gas to the vicinity of said electron emitting coating when said coating is raised to electron emitting temperature.

7. In an electric lamp an envelope, a readily ionizable gaseous medium within said envelope, means to lower the normal breakdown potential of said medium along a restricted path of lesser diameter than said envelope, said means consisting in a mass of electron emitting material having an emissivity in excess of that from thorium oxide, and means to energize the emitting material, said emitting and energizing means constituting the sole source of energy discharge in said envelope.

8. In an electric lamp an envelope, a filamentary conductor constituting the sole source of the discharge within said envelope and wound in the form of a helix and having an electrical connection at each end thereof, a coating of electron emitting material having an emissivity in excess of that from thorium oxide on said conductor, and an ionizable gas within said envelope and surrounding said conductor, the breakdown potential of said gas per unit length of said helix being less than the potential along such unit length of helix necessary to raise said conductor to electron emitting temperature.

9. In an electric lamp an envelope, a filamentary conductor constituting the sole source of the discharge in the form of a helix, a coating of electron emitting refractory material having an emissivity in excess of that from thorium oxide on said helix, and a gas comprising a mixture of neon, argon, and a metal vapor within said envelope and having such a pressure that the

ionization of said gas when said conductor is heated will be restricted to the vicinity of said electron emitting material.

10. In an electric lamp an envelope, a closely wound coil of resistance wire in said envelope, a coating of electron emitting material having an emissivity in excess of that from thorium oxide on the surface of said coil, and an ionizable gas consisting of a mixture of neon and argon surrounding said coil and having a pressure of substantially 200 mm. of mercury, said coated coil forming the sole illuminating element of the lamp.

11. In an electrical discharge device the combination of an envelope, a conductor constituting the sole source of the discharge mounted therein, particles of an alkaline earth metal oxide in intimate contact with said conductor, and a gas of the argon group and mercury vapor or mixtures thereof surrounding said conductor.

12. In an electrical discharge device the combination of an envelope, an electron emitting conductor constituting the sole source of the discharge having an electron emissivity in excess of thorium oxide mounted within said envelope, and an inert ionizable gas of the argon group surrounding said conductor.

13. In an electrical discharge device the combination of an envelope, a conductor constituting the sole source of the discharge mounted within the envelope, barium oxide on the surface of said conductor, and a gas of the argon group within said envelope.

14. In an electrical discharge device the combination of an envelope, a conductor constituting the sole source of the discharge mounted within said envelope, a coating of an alkaline earth metal oxide on said conductor, and a gas of the argon group within said envelope.

15. In an electric lamp the combination of an envelope, an inert ionizable gas of the argon group and mercury or mixtures thereof within said envelope, a conductor constituting the sole source of the discharge formed of coiled tungsten metal mounted within the envelope and surrounded by said gas, and an alkaline earth metal oxide coating on said conductor.

16. In an electrical discharge device the combination of an envelope, a coiled refractory metal conductor constituting the sole source of the discharge mounted therein, strontium oxide on the surface of said conductor and an atmosphere of argon and neon gases within said envelope.

17. In an electrical discharge device the combination of an envelope, a coiled refractory metal conductor constituting the sole source of the discharge mounted therein, particles of calcium oxide on the surface of said conductor, and an atmosphere of argon, neon and metal vapor within said envelope.

18. A process for forming and maintaining a luminous gas discharge in the vicinity of a wire coated with electron emitting material and immersed in an inert ionizable gas which comprises passing an electric current through said wire and raising the potential across the wire to the point where the potential per unit length along the wire is in excess of the ionization potential of the ionized gases adjacent the wire.

19. A process for forming and maintaining a luminous gas discharge in the vicnity of a wire coated with electron emitting material which coated wire constitutes the sole source of the discharge and immersed in an inert ionizable gas which comprises passing an electric current through said wire and raising the potential across the wire to the point where the potential per unit length along the wire is in excess of the ionization potential of the ionized gases adjacent the wire.

CHESTER H. BRASELTON.