March 16, 1943. H. EKNAYAN 2,314,134

GASEOUS DISCHARGE DEVICE

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Fig. 1.

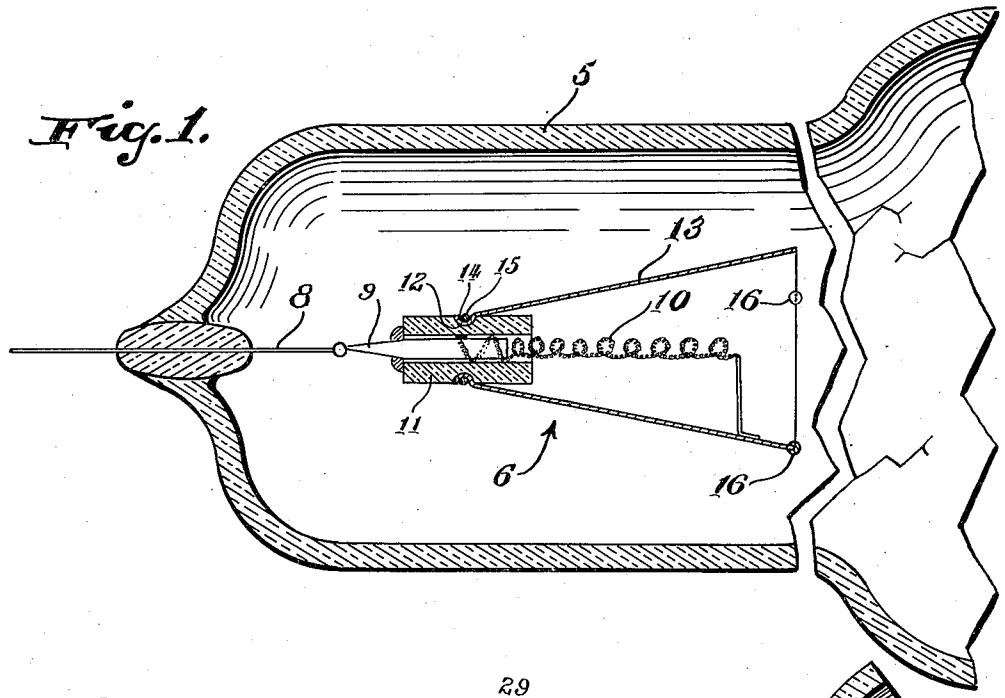
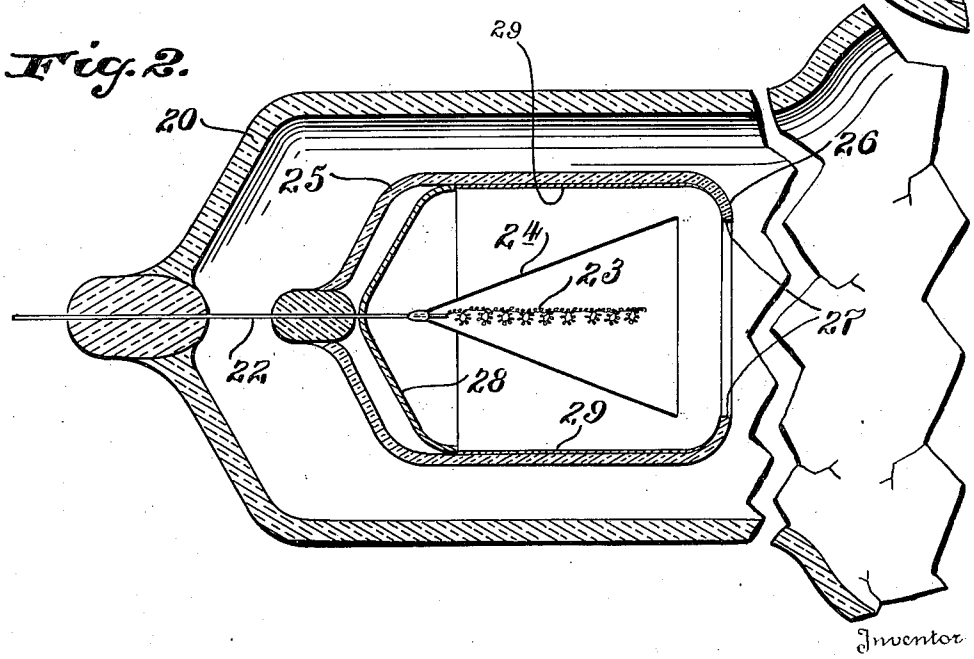


Fig. 2.



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GASEOUS DISCHARGE DEVICE

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23 Claims. (Cl. 176—126)

This invention relates to electric discharge devices, and more particularly to luminous devices of the positive column type.

It has been found that by the use of higher amperages in such devices higher light efficiencies can be obtained when the tubes are loaded with rare gas at lower gas pressures than the pressures commonly used in cold cathode tubes. The use of such higher amperages, however, requires certain significant changes in electrode construction. The present invention, in certain of its aspects, provides electrode construction satisfying these requirements. Pursuant to the present invention, tubes having an efficient light-giving life of more than 1000 hours is made possible.

As the gas pressure is lowered in these tubes, the intensity of light increases for a given tube current, and it happens that the voltage drop of the tube decreases as the pressure is lowered down to a certain value. These two facts make it apparent that the tube is consuming less watts and giving more light as the pressure is lowered from the cold cathode tube pressures. In a mercury discharge tube of the fluorescent type, other technical reasons besides those mentioned, make the low pressure gas loadings more necessary for obtaining an efficient light source of proper color.

Hot cathode tubes have the definite disadvantage that a supplemental heater element and an independent circuit for heating this element are required.

There is another type of tube which has been utilized with mercury vapor discharges. In such tubes filamentary electrodes are used, these being in the form of a U, one end of each of which is connected with an operating circuit and the other end of each of which is connected with a shunt circuit containing a switch. In order to start the arc the switch is closed to pass current through the electrodes. Once a hot spot is formed on the cathode, the switch is opened to strike the arc, and a self-sustaining arc is continued.

These last electrodes have the following disadvantages:

(1) Even though a constant source of heating current is not supplied to the electrodes, two wires must be connected to each end of the tube.

(2) A starting switch of some type must always accompany the tube, and the proper operation of the lamp depends upon the switch which is not as reliable as the tube itself, and the tube does not strike as soon as the voltage is applied.

(3) As the self-sustaining stability of the discharge is obtained only through the bombardment of positive ions of gas or vapor, there will always be a good deal of sputtering. The sputtered materials from the electrodes with the mercury vapor in their path, have full freedom to reach the neighboring inside face of the glass tube causing a black ring which augments continuously. The provision of baffle means between the operating electrode and the tube wall pursuant to the invention has the marked advantage of eliminating the formation of such a dark spot.

(4) These electrodes could not well play the part of an anode when the tube is connected to an alternating current source, and the direction of the current changes to make these electrodes anodes. Some of the quick sputtering is due to this reason.

Any attempt to strike and operate this last tube by applying to the circuit a high enough voltage by any means without using a switch would badly damage the electrode and decrease the tube life enormously.

The use of the cylindrical or cone-shaped electrodes used in conventional types of luminescent tubes operated at relatively low currents is unsatisfactory at relatively high currents. If the voltage is increased enough to strike and operate, for example, at 200 to 600 milliamperes, the electrodes will disintegrate very quickly.

A filamentary electrode formed of a metal such as tungsten which has a high melting point, a high resistivity, and enough rigidity to hold its shape in filamentary form, and coated with an oxide of an alkaline earth metal, provides an excellent electrode during operation of a low-pressure discharge tube but is unsatisfactory for the striking of the arc with relatively high current (e. g. currents of from 200 to 600 milliamperes) without preheating it to red temperature.

With the foregoing and other considerations in mind, the present invention, in certain of its aspects, contemplates the provision of a two-part electrode, one member of which serves to receive the major portion of charged particles during operation and the other member of which serves while cold to receive the major portion of the charged particles during the striking of the arc, and, in certain of its more specific aspects, a proper arrangement and design of this last member facilitates the shifting of the discharge to the former member quickly.

In low pressure tubes it is desirable that there be provided a metallic shell electrode, the thickness of which is very small—e. g. .001 to .003 of an inch compared with .02 to .03 of an inch, which has been the thickness of previously utilized shells. In addition, in positive column mercury

discharge tubes difficulties have arisen due to the tendency of the liquid mercury to come in contact with the electrode. In addition, in the striking of the arc, the mercury evaporation is so swift and intense that the fluorescent coated surfaces in proximity to the electrodes become covered with a fine layer of condensed globules, a large percentage of which remain there resulting in an unilluminated area at that point. In an attempt to overcome this condition, and other, there are cold cathode heavy shells coated with mixtures of barium and strontium compounds which are supposed to break down at low temperatures. This does not give the desired results because if the ceramic powders break down to partially emitive oxides during bombardment or processing at lower temperatures, these partially broken down emitive chemicals become deposited on the heavy metal shells in a loosely piled up state and are not fused in with the metal shell to become an integral part of same. During the said processing, the heavy shells cannot be freed of all gases and vapors occluded in them in great quantities. These gases and vapors coming out of the heavy shells also prevent a good bond between the metal shell and the ceramic emitive oxides.

With the foregoing and other considerations in view the present invention in certain of its aspects contemplates the provision of an electrode comprising a metallic shell and a tungsten filament, and, more specifically, also of an outer shell-like member which is interposed between the metallic shell and the tube. The sputtered material deposited on the outer shell-like member is of such character as to enable the outer shell-like member to be utilized as an additional electrode, and to this end the invention in certain of its specific aspects further contemplates the provision of means to connect this deposit with the lead wire.

The invention accordingly comprises an article of manufacture possessing the features, properties, and the relation of elements which will be exemplified in the article hereinafter described and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 is a longitudinal sectional view of one end of an electric discharge device embodying the invention; and

Fig. 2 is a similar view of another form of an electric discharge device embodying the invention.

The particular embodiment of the invention illustrated in Fig. 1 is an electric discharge device of the luminescent tube type used in luminous signs. This tube is designed to operate at currents of from 200 to 600 milliamperes. It comprises a sealed tube **5** composed of glass or other suitable transparent material, ordinarily of a vitreous nature, the inside surface of which may be coated with fluorescent powders for light generation. The tube may vary in volume, the exemplified tube having a volume of 38 cubic inches. The tube contains a suitable inert (monatomic) gas at a low pressure—in the present instance argon (or, in certain instances, an argon-neon mixture) at a pressure of from 1 to 4 mm. (When millimeters of pressure are specified herein, millimeters of mercury column are intended.) It also contains mercury in such quantity as to provide a mercury vapor pressure of from .01 mm. to .1 mm. depending on the tube cross section, the current, and rare gas loading, and the ambient temperature. For example, with a tube 48 inches in length and having an interior diameter of one inch (except at its ends where the diameter is ¾ of an inch), a current of 300 milliamperes, and a rare gas loading of 3 mm., the mercury vapor pressure should be .02 mm. Only one end of the tube is illustrated. In it is an electrode generally designated as **6**. In the other end is a second electrode. This second electrode may be similar to the electrode **6** in which case the tube may be used with alternating current, each electrode serving alternately as an anode and as a cathode; or it may be of a well known or desired type adapted to serve as an anode, the electrode **6** serving as a cathode. The tube **5** in the present instance has the dimensions above indicated.

The electrode **6** is supported by a current-carrying lead consisting of a portion **8** which is sealed in the glass tube and extends inwardly thereof to a larger diameter portion **9** composed of nickel or iron and welded to the portion **8**. The portion **8** is covered by a protective layer of its own oxide or other insulation. About the end of the portion **9** there is wrapped, and welded thereon, one end of a filamentary electrode member **10**, composed of a high-melting-point, high-resistance metal, and consisting in the present instance of a tungsten wire having a thickness of from .001 to .003 inch, for currents of 200–600 milliamperes. For higher currents it may be up to .01 inch in thickness. Other metallic materials having these characteristics as well as sufficient rigidity in filamentary form, for instance thoriated tungsten, molybdenum, tantalum, platinum, osmium, indium, or alloys thereof may be used in certain instances. A metallic substance which has a resistivity at red heat greater than 30×10^{-6} ohm-cm. and a melting point greater than 2000° C. is desirable. It should also desirably have a substantial rigidity at a dull red temperature. The tungsten filament is desirably, and as exemplified, in the form of a coil as it extends from the lead, and this coil is itself coiled to provide a coiled coil extending inwardly from the lead. Filaments in other form may be employed however. The filament **10** is coated with an emitive material such as the oxides of alkaline earth metals, a mixture of barium and strontium oxides being employed in the present instance. These are in the form of carbonates when the tube is originally manufactured, but become oxides when the tube is processed.

On the outside of the portion **9** there is secured an insulating member **11** which in the present instance is in the form of a tubular quartz portion and which, preferably and as exemplified, extends inwardly of portion **9** so as to surround the outer end portion of the filamentary electrode **10**. The tubular quartz portion **11** is formed at a point in proximity to the inward end of the coiled filament **10**, with an exterior annular recess **12** in which is secured the lower end of a second electrode member **13** which is in the form of a metallic shell. The shape of this shell **13** is preferably frusto-conical with an inwardly expanding interior diameter. The shell in the present instance is uncoated, but, if desired, may be coated interiorly with barium oxide or other emitive material.

An important consideration is that the outer end of the shell should be fairly close to the in-

terior surface of the tube 5. For example 3/8 of an inch is a desirable diameter for the large end of the shell in the present instance, leaving 1/16 of an inch between it and the tube. The external diameter of the portion 11 and the diameter of the outward end of the shell may be between 1/8 of an inch and 3/32 of an inch in the present instance. If the diameter of the tube were only 1/4 of an inch and the diameter of the outward end of the shell were still 1/8 of an inch, for example, a shell with a uniform diameter would operate satisfactorily in certain instances.

The outward end of the shell is pressed in at 14 to fit in the recess 12, and a molybdenum wire 15 acts to secure the shell snugly in the recess. This provides a closure at the outward end of the shell to prevent the escape of charged particles to a point where they might form an arc between the shell and the lead 8. The shell 13 is composed of nickel for example, or of any metal or alloy having the proper qualities for the requirements of metallic shells used as cold cathodes, such for instance as Swedish iron, certain nickel-iron alloys, or certain iron-aluminum alloys.

In accordance with the invention in certain of its more specific aspects, there is deposited at two or three points along the inner edge of the shell 13 a metal, for instance thorium, having comparatively high emission characteristics when cold. Other metals than thorium, e. g., barium, calcium and caesium, may be employed in certain instances. Powdered thorium may be adhesively secured to the shell as indicated at 16, or pieces of thorium may be welded thereon. The filament 10 is coated with an emitive material, for example, barium oxide or other oxide of an alkaline earth metal, and the filament is connected at its inward end by means of a connector wire to the shell 13 at a point which is preferably spaced somewhat from the inward edge of the shell. In the present instance, for example, the length of the shell is 5/8 of an inch and the distance from the inward edge of portion 9 to the point where the filament is attached to the shell is 7/16 of an inch and the distance between the bottom of the shell and the inward end of the portion 9 is between 1/8 to 1/16 of an inch.

It is to be noted that the tubular portion 11 extends inwardly over the outward end of the coil (about 1/8 of an inch in the present instance). By this means the junction point of coil and portion 9 of the lead is protected—an important consideration since the density of ionized molecules is greater in the outward portion of the shell, i. e., the cavity inside the small end of the shell in the exemplified construction.

In operation, as soon as proper voltage is applied to the tube, the arc builds up instantly on the interior of the shell 13, but due to the presence of the insulating member 11, cannot reach the lead except through the filament 10 with the result that tungsten filament heats up sufficiently to serve as the main electrode during continued operation—approximately 95% of the current is then carried by the filament 10 and only about 5% thereof by the shell.

This desirable action and the operating characteristics of a tube equipped with an electrode of the type under consideration are greatly improved when the tube contains mercury vapor. The reason for this may be due to the following:

(a) It is easier for the heavy mercury ions to grab electrons from the emitive filament with the least amount of damage to it, due to their comparatively low velocity.

(b) In the intense mercury ionization in this locality where the coated filament is, ultra-violet rays also caused the coated filament to emit electrons.

(c) This is due to the heat generated by the ionization in the cavity of the electrode.

(d) This very high current density on the small shell, causes an intense field to aid the attraction of electrons from the filamentary cathode.

(e) Before leaving the tube, the initial discharge current on the shell, passing through the cathode coil, increases the temperature of the filamentary cathode for emission.

A construction such as exemplified permits the striking of the arc with a current of from 200 to 600 milliamperes in a tube containing mercury having a rare gas pressure of from one to four millimeters, without damaging the electrode and at the same time giving a commercial life to the tube, whereas in previous tubes when the mercury pressure dropped due to a drop in the outside temperature the bombardment of the cathode increased, and tube voltage drop increased, because instead of the current being carried fully by the highly conductive mercury vapor, at the optimum pressure, the inert gas carried some with a resulting increase in sputtering. In addition, outside temperature changes affected adversely the generative light if the particular mercury tube is of a fluorescent type (that is, with the inside surface of the tube coated with fluorescent powders). This is avoided in the present construction due to the needed increased heat supplied by the metallic shell electrode member.

An important consideration in the construction of electrodes such as those under consideration, is that there be a zone of intense ionization in the outward portion of the shell and to this end the volume is restricted at this point. Excellent results have been obtained when the interior volume of that portion of the shell which lies between the end of the shell toward the lead and a bisector of the axis of the shell (e. g. the outward end portion of the space within the shell—that portion which is disposed about the half of the axis of the shell which is adjacent the lead) is approximately .01 cubic inch, which is a preferred volume. This volume should desirably be from .007 to .018 cubic inch. When such volumes are used there is provided within the limitations of construction and operating considerations, an intense ionization zone which facilitates the shifting of the arc from a shell such as 13 to the filament such as 10, and, in addition, assures, especially effectively, the cooling of certain of the parts of the filament other than the point thereon where the hot spot is formed, because of the small size of the area between the filament and shell.

In Fig. 2 there is exemplified a form of construction embodying the invention and designed for operation at relatively low currents, e. g. currents of less than 200 milliamperes. In this form of construction, there is provided an electrode arrangement including a tungsten filament, a thin metallic shell which, in this instance, must be interiorly coated with emitive material, and an outer shell of substantially non-conductive (ordinarily vitreous) material, in connection with which there is provided a plate connecting the lead wire with the interior of the shell so that this plate together with the material deposited

during the processing on the interior of the shell will form a supplementary electrode. By the provision of an intermediate metallic shell which is very thin it is possible for the shell to reach very much higher temperatures during the bombardment of the finished tube on the exhaust pump. By the provision of an outer shell extra protection is provided for the metal shell during the striking instant due to the thin layer of particles sputtered from the inner shell during the very high heat of processing and deposited on the interior of the outer vitreous shell. In addition, this added layer on the vitreous shell increases the capacity of the tube and facilitates the striking. Without this glass shell the sputtered hot particles will deposit themselves on the inside wall of the tube, or on the fluorescent powders bonded to the inside of said tube. In most cases these hot evaporated sputtered metal particles will crack the walls of the glass tube upon striking same.

The following will explain why it is necessary to reach the high metal boiling temperatures in bombarding.

When, in a vacuum device, a metal is coated with a molecularly balanced mixture of barium and strontium carbonates, and when, during the processing of the tube, these carbonates are broken down to metal oxides of highly emitive characteristics, the metal bed at this point, must have a high enough temperature so that these emitive ceramic oxides will have a chance to fuse with the metal and form a tight bond with it. In this manner all of the carbonates are changed to the desirable barium and strontium emitive oxides which become an integral part of the shell and will be least affected by positive ion bombardment.

In the exemplified construction there is provided a tube **20**. The tube contains a suitable inert (monatomic) gas at a low pressure—in the present instance argon (or in certain instances an argon and neon mixture) at a pressure of 3 to 6 millimeters. It also contains mercury in such quantities as to provide mercury vapor at a pressure of from .01 to .02 mm.–.015 mm. for a tube 6 feet long having an inner diameter of ⅞ inch thruout the major portion of its extent, and a current of 100 milliamperes.

As in the case of the construction exemplified in Fig. 1, only one end of the tube is illustrated, there being provided in the other end of the tube an electrode construction of similar construction to that shown in Fig. 2 or of different construction if the tube is to be used only with direct current rather than with alternating current. Through the illustrated end of the tube **20** there extends a lead **22**. On the inward end of this lead is a tungsten filament **23** which is desirably, and as exemplified, in the form of a coiled coil as in Fig. 1 and which is coated with an emitive material which may be similar to that on the filament exemplified in Fig. 1. On the outside of the filamentary electrode **23** and connected with the lead at the same point as the electrode **23** is a second electrode member **24** consisting of a metallic shell generally conical in shape and having a thickness of about .001 of an inch to .003 of an inch. The shell **24** is coated interiorly with a mixture of barium and strontium oxides. Mounted on the lead **22** is an exterior shell of vitreous or other substantially non-conductive material—in the present instance "Pyrex" glass—and providing an enclosure for the interior electrodes **23** and **24**. The exterior member **25** extends inwardly of the inward ends of the interior electrodes and has its inward edge turned interiorly as indicated at **26**, leaving a central opening **27** for the discharge. As above indicated a conductive metallic deposit is formed on the interior of the shell **25** during the processing of the tube. In order to enable the vitreous shell **25** to serve its additional electrode member there is provided a curved plate **28** welded to the lead at a point inwardly of the point where the member **25** is mounted on the lead and outwardly of the point where the lead joins the electrode members **23** and **24**. This plate **28**, serves together with the material deposited on the interior of the member **25** to form a complete shell-like electrode member.

Instead of the filament **23** being formed of tungsten it may be formed of other suitable metal as suggested as substitutes for the filament in Fig. 1. The shell **24** may be formed of nickel or Swedish iron or a suitable nickel-iron alloy. The lead may be formed of a suitable metal such as suggested for the lead **8** of Fig. 1. The shell **24** may desirably be between $\frac{1}{16}$ of an inch to ½ of an inch in length and may have a diameter of about ⅜ of an inch at its open inward end. The vitreous outer member **25** should be spaced about $\frac{1}{16}$ of an inch from the shell **24** at its closest point. The opening at inward end of the member **25** should correspond in diameter to the inward end of the shell, being about ⅜ of an inch in diameter in the present instance.

The volume within that portion of the shell **24** which is between the point where the shell **24** joins the lead **22** and a point half way along the axis of the shell should be about .0023 cubic inch for the maximum effectiveness of operation. Desirably this volume should be from .001 to .005 cubic inch, thus providing, within the limitations of construction and operating considerations, especially effective conditions for shifting the arc from a shell such as **24** to a filament such as **23**, and an especially effective cooling effect on certain of the parts of the filament other than that where the hot spot is formed.

Not only is the metallic shell **24** very thin, but the thickness of the filament **23** is exceedingly small; being desirable from .0005 inch to .0009 inch. The combination of the thin filament and thin shell provides an electrode unit which performs exceedingly well at low currents such, for example, as 150 milliamperes. The outer "Pyrex" shell **25** serves to collect particles evaporated from the metallic shell **24** at the high temperature employed in the processes of the tube and to prevent these from reaching the walls of the tube **20**. These particles provide an interior layer **29** which during each striking of the arc serves as a supplementary electrode, thus providing the maximum electrode surface during the high voltage low current striking. As the current builds up, the outer shell **25** acts as a charged grid making it easier for the discharge to build up to full value, and to settle on the metallic shell **24**. The discharge is drawn off from the deposited layer **29** by means of the plate **28**, which has the additional function of preventing the summit of the cone **24** from heating up too fast during the processing. The outer shell **25** also has an additional function in preventing liquid mercury in the tube from coming in contact with the metallic shell **24**.

Since certain changes may be made in the above article and different embodiments of the invention could be made without departing from

the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. An electrode device for a gaseous discharge device of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with emissive material, and another a shell surrounding at least a part of said filament but separated therefrom, electrical leading-in means for said electrode member, means to connect said filament with said leading-in means, and means to connect said filament with said shell, said shell being electrically unconnected with said leading-in means except through said filament.

2. An electrode device for a gaseous discharge device of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a coiled tungsten filament coated with emissive material, and another a shell surrounding at least a part of said filament but separated therefrom, electrical leading-in means for said electrode member, means to connect one end of said filament with said leading-in means, and an electric connection running to said shell, from a point on said filament remote from said end, said shell being electrically unconnected with said leading-in means except through said filament.

3. An electrode device for a gaseous discharge device of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with emissive material, and another a shell surrounding at least a part of said filament but separated therefrom, said shell having an interior which tapers toward one end of said filament, electrical leading-in means for said electrode member, means to connect the other end of said filament with said leading-in means, and an electrical connection running to said shell from a point on said filament remote from said other end thereof, said shell being electrically unconnected with said leading-in means except through said filament.

4. An electrode device for a gaseous discharge device of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with emissive material, and another a shell surrounding said filament but separated therefrom, electrical leading-in means for said electrode member, means to connect one end of said filament with said leading-in means, and an electric connection running to said shell from a point on said filament remote from said end, insulating means closing the end of said shell adjacent said leading-in means, said shell being electrically unconnected with said leading-in means except through said filament.

5. An electrode device for a gaseous discharge device of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with emissive material, and another a shell surrounding said filament but separated therefrom, electrical leading-in means for said electrode member, means to connect one end of said filament with said leading-in means, and an electric connection running to said shell from a point on said filament remote from said end, insulating means closing the end of said shell nearest said leading-in means and surrounding the portion of said filament adjacent said leading-in means, said shell being electrically unconnected with said leading-in means except through said filament.

6. An electrode device for a gaseous discharge means, said electrode device comprising a thin high-melting-point and high-resistivity filament coated with an emitive material, conductive means enclosing the filament at its sides and one end to provide a constriction in which an intense field may be built up around the coated filament, a single lead for said device, and means for electrically connecting said filament and said conductive enclosing means with said single lead.

7. An electrode device for a gaseous discharge device of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with emissive material, and another a shell surrounding at least a part of said filament but separated therefrom, electrical leading-in means for said electrode member, means to connect said filament with said leading-in means, means to connect said filament with said shell, said shell being electrically unconnected with said leading-in means except through said filament, and insulating material about a portion of said leading-in means, said shell being mounted on said insulating material.

8. An electrode device for a gaseous discharge device of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with emissive material, and another a shell surrounding at least a part of said filament but separated therefrom, electrical leading-in means for said electrode member, means to connect said filament with said leading-in means, said shell having an open end at a point remote from the point of connection of said filament with said leading-in means, and an electric connection running from a point on said filament remote from the point at which it is connected with said leading-in means to a point on said shell spaced from said open end, said shell being electrically unconnected with said leading-in means except through said filament.

9. An electrode for a gaseous discharge device, said electrode comprising an electrode element having a large area for the reception of charged particles during the starting of the arc, and an electric conducting means to carry current set up by the reception of said particles, a portion of said carrying means consisting of an electrode element which is coated with an emitive material and which will receive the major portion of the discharge during operation after striking the arc.

10. An electrode for a gaseous discharge device comprising an electrode element having a large area on which a discharge can be built up when the electrode is cold, and means to carry off said discharge current, at least a portion of the last mentioned means consisting of an electrode element in the form of a high-resistivity metallic filament disposed interiorly of the first men-

tioned electrode element and coated with an emissive material whereby it is adapted to be heated up as it carries off said discharge current and serves to receive the greater part of the arc during operation.

11. An electrode for a gaseous discharge means, said electrode comprising a metallic shell on the edge of which there is disposed thorium.

12. A gaseous discharge device containing mercury vapor at a pressure of not over one tenth of a millimeter, an electrode therein, said electrode comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coating with emitive material, and another a shell surrounding at least a part of said filament but separated therefrom, a lead running from one end of said filament, and an electric connection running to said shell from a point on said filament remote from said end, said shell being unconnected with said lead except through said filament.

13. An electrode device for a gaseous discharge means, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with an emitive material, and another a shell surrounding at least a part of said filament, said electrode elements being electrically connected, and a lead running to at least one of said electrode elements, the portion of said shell disposed about that half of the axis thereof which is adjacent said lead having an interior volume of from .001 to .018 cubic inch.

14. An electrode device for a gaseous discharge means, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a tungsten filament coated with an emitive material, and another a thin metallic shell surrounding said filament, said electrode elements being electrically connected, and a lead running to at least one of said electrode elements, the portion of said shell disposed about that half of the axis thereof which is adjacent said lead having an interior volume of from .001 to .005 cubic inch.

15. An electrode device for a gaseous discharge means of the positive column type, said electrode device comprising an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with emitive material, and another a shell surrounding at least a part of said filament but separated therefrom, a lead running from one end of said filament, and an electric connection running to said shell from a point on said filament remote from said end, the portion of said shell disposed about that half of the axis thereof which is adjacent said lead having an interior volume of from .007 to .018 cubic inch.

16. In an electrode device for a gaseous discharge device, an electrode member comprising a plurality of electrode elements, one a filament composed of a high-melting-point and high-resistivity metal coated with an emitive material, and another a shell surrounding at least a part of said filament but spaced therefrom thruout at least the greater portion of its extent, said shell being of increasing radius toward an open end thereof, the other end of said shell being closed, and a single lead for said electrode member, said filament and said shell being connected with said lead.

17. In a gaseous discharge device an electrode device comprising a plurality of electrode elements, one a filament composed of a high-melting-point and a high-resistivity metal carrying an emitive material, and another a shell surrounding at least a part of said filament but spaced therefrom thruout at least the greater portion of its extent, and a substantially non-conductive member surrounding the aforesaid elements, said non-conductive member being open at one end and closed at its other end.

18. In a gaseous discharge device an electrode device comprising a plurality of electrode elements, one a filament composed of a high-melting-point and a high-resistivity metal carrying an emitive material, and another a shell surrounding at least a part of said filament but spaced therefrom thruout at least the greater portion of its extent, a substantially non-conductive member surrounding the aforesaid elements, said non-conductive member being open at one end and closed at its other end, and a lead running through said other end to said non-conductive member, said electrode elements being connected to said lead.

19. In a gaseous discharge device an electrode device comprising a plurality of electrode elements, one a filament composed of a high-melting-point and a high-resistivity metal carrying an emitive material, and another a shell surrounding at least a part of said filament but spaced therefrom thruout at least the greater portion of its extent, a substantially non-conductive member surrounding the aforesaid elements, said non-conductive member being open at one end and closed at its other end, a lead running through said other end to said non-conductive member, said electrode elements being connected to said lead at a point near said other end of said non-conductive member, said non-conductive member having an emissive deposit on its inner surface, and means providing an electrical connection within said non-conductive member between the said lead and said deposit.

20. In a gaseous discharge device an electrode device comprising a plurality of electrode elements, one a filament composed of a high-melting-point and a high-resistivity metal carrying an emitive material, and another a shell surrounding at least a part of said filament but spaced therefrom thruout at least the greater portion of its extent, a substantially non-conductive member surrounding the aforesaid elements, said non-conductive member being open at one end and closed at its other end, a lead running through said other end to said non-conductive member, said electrode elements being connected to said lead, and a metallic plate providing a connection to an interior side of said non-conductive member from said lead at a point between said other end of said non-conductive member and the point of juncture of said filament and said shell.

21. An electric discharge device comprising a sealed tube loaded with an argon-containing inert gas and mercury vapor and containing an electrode device comprising a high-resistivity filament coated with emissive material and conductive means enclosing this filament at its sides and one end to provide a constriction in which an intense field may be built up around the coated filament, a single lead for said device, and means for electrically connecting said filament and said conductive enclosing means with said single lead.

22. An electrode for gaseous discharge means

comprising a metallic shell on the edge of which there are disposed particles of thorium.

23. A gaseous discharge device comprising a sealed tube, electrodes in said tube, leads to said electrodes, mercury vapor in said tube, at least one of said electrodes comprising one or more interior electrode elements and an outer electrode element in the form of a shell which encloses said elements, the emissive portion of the outer electrode element having an emissive deposit on the inner surface of the shell, and means to electrically connect said deposit with at least one of the interior electrode elements.

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