July 29, 1952 J. L. BOYER ET AL 2,605,439

VAPOR-ELECTRIC DEVICE

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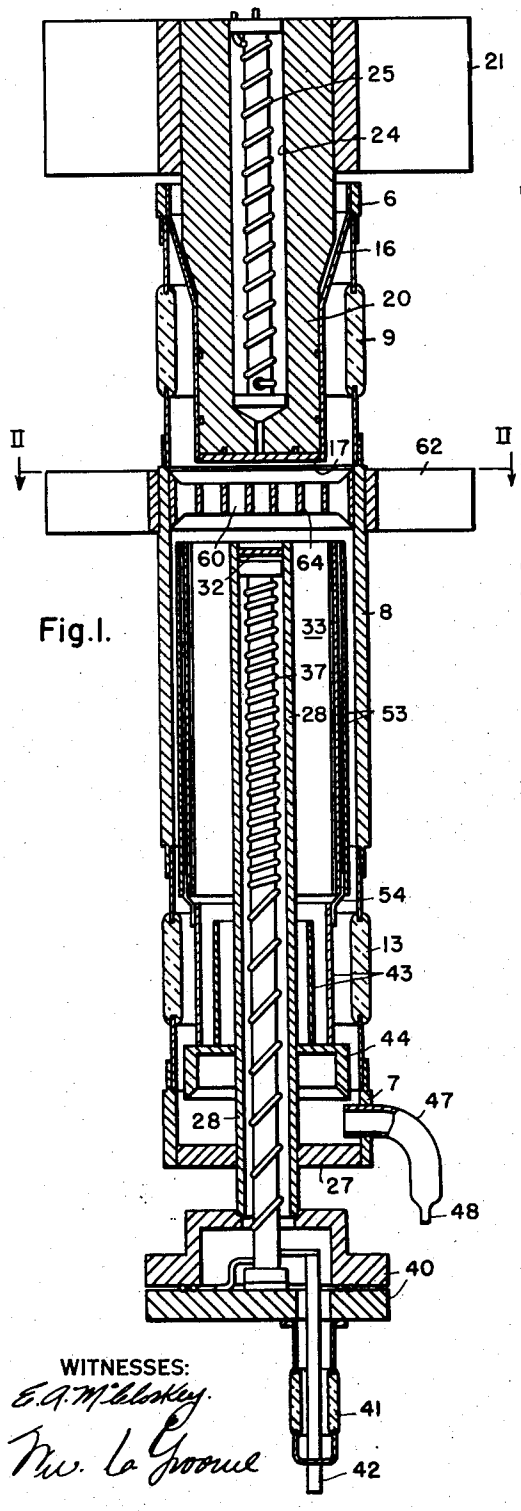


Fig.1.

Fig.2.

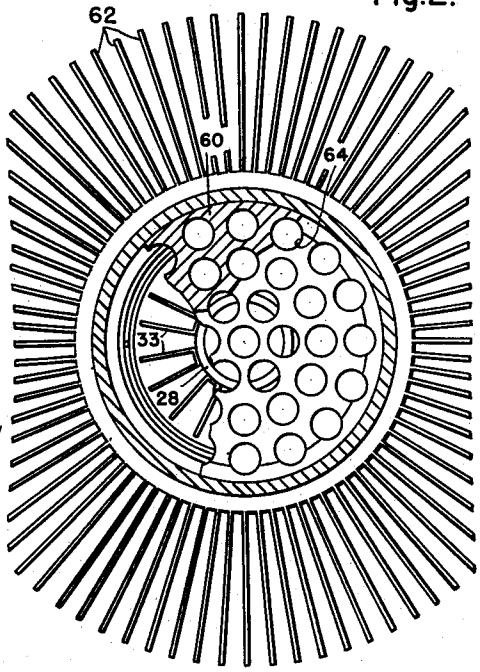


Fig.3.

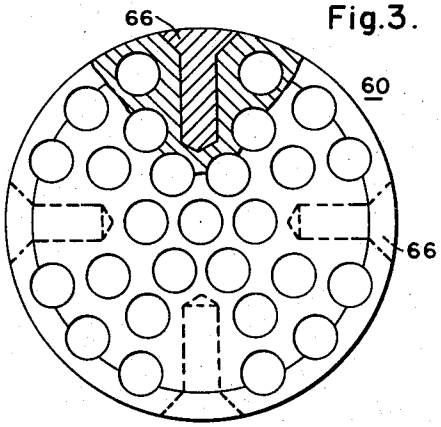
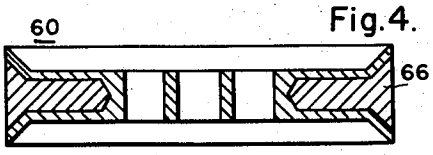


Fig.4.



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VAPOR-ELECTRIC DEVICE

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18 Claims. (Cl. 313—227)

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Our invention relates to vapor-electric devices or tubes, and particularly to low-arc-drop hot-cathode arc-discharge devices using a vaporizable discharge-metal selected from the group consisting of potassium, rubidium and cesium. Our present invention is an improvement over the vapor-electric devices which are described and claimed in an application of John L. Boyer and August P. Colaiaco, Serial No. 144,354, filed February 15, 1950.

Our present improvements relate to a new tube-design in which the grid is disposed transversely of the tube, in good thermal contact with an externally cooled metal wall-part of the tube. Preferably, also, as more particularly described and claimed in a copending application of John L. Boyer, Serial No. 201,783, filed Dec. 20, 1950, now Patent No. 2,600,300, the cesium or other discharge-metal is condensed on the cold end of the cathode, as distinguished from being condensed on the anode, as in previous designs.

This condensation-place of the discharge-metal is determined by making the cold end of the cathode the coolest part of the tube. This has the double advantage of getting the discharge-metal pool at the cathode-potential, in a place where it is protected against positive-ion bombardment under all conditions of operation. The discharge-metal pool, at the cold end of the cathode, is also at a spot at which the temperature is not materially affected by the intensity of the arc, and hence not materially affected by the load-current, as in previous tube-designs in which the discharge-metal pool was at or near a part of the anode.

Our mounting of the grid on an externally cooled metal enclosure-portion of the tube enables us to maintain the grid at a much cooler temperature than has been heretofore possible with any other grid-mounting, with the result that we are now freed of the necessity for choosing, for the grid-surface material, a metal having a low work-function, such as was required in the tube-construction shown in the Boyer-Colaiaco application.

As explained in the Boyer-Colaiaco application, the three preferred discharge-metals, potassium, rubidium and cesium, form a more or less distinctive class by themselves, which may be described as the alkali metals having four, five and six shells in their atomic structure, or the stable alkali metals having more than three shells. The entire group of alkali metals consists of six elements, of which the first two and the last are readily distinguishable from the other three, with which our invention is particularly concerned.

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The two lightest alkali metals, lithium (Li) and sodium (Na) are separated, in some periodic tables, from the heavier light metals of the alkali-metal group (IA), as being distinctive because of their electron-grouping. The physical and chemical characteristics of these two lightest alkali-metals are also distinctively different from the group comprising potassium, rubidium and cesium. Sodium has a minimum breakdown-voltage which comes at too low a pressure-distance product *pd* for our purposes, as will be understood from explanations given later on; and it is also too active, chemically. Lithium has a vapor-pressure which is much too low for our purposes, as this low vapor-pressure requires too high a temperature to obtain a practically usable vapor-pressure which is high enough to give a sufficiently high current-density to be practical for our purposes.

The sixth or heaviest alkali metal, No. 87 in the periodic table, was formerly called virginium, but has now been proved to be an element which is called francium (Fa), an unstable atomic-pile product which is very radio-active, and which has an extremely short half-life of only a few minutes, so that it is unsuitable for our purposes.

Our present invention consists in the structures, combinations, systems, parts, and methods of design and operation, hereinafter described and claimed, and illustrated in the accompanying drawing, wherein

Figure 1 is a vertical sectional view of a preferred illustrated form of embodiment of our invention,

Fig. 2 is a horizontal sectional view, on a somewhat larger scale, on the section-plane indicated by the line II—II in Fig. 1, with parts broken away,

Fig. 3 is a plan view of an alternative form of construction of the grid-element on a still larger scale, with parts broken away, and

Fig. 4 is a vertical sectional view of the grid shown in Fig. 3.

In the exemplary form of embodiment of our invention, as shown in Fig. 1, the vapor-electric device comprises a vertical-axis enclosure-means including top and bottom metal end-portions 6 and 7, and a central metal portion 8, all three of which are illustrated as being tubular. Between the bottom of the top metal end-portion 6 and the top of the center metal portion 8, there is disposed a tubular insulator-portion 9,

which may be glass, and which is connected to the metal portions by suitable glass-to-metal seals. Between the bottom of the central metal portion 8 and the top of the bottom metal end-portion 7, there is another tubular insulator-portion 13, which may also be of glass, and which is provided with suitable glass-to-metal seals to the respective metal portions.

The top metal end-portion 6 is closed at its upper end, either by an integral end-part, or a brazed or welded connection to a separate metal piece 16, which is preferably a reentrant portion which extends down below the top tubular insulator-portion 9, and which terminates, at its lower end, in an arc-terminating metal anode-portion 17.

The three metal enclosure-portions 6, 7 and 8, and the metal anode-portions 16 and 17 are all preferably made, either altogether of a metal chosen from the group consisting of iron and nickel, with perhaps a slight preference for iron or steel, or at least their surfaces which are exposed to the vapors within the device are of one of these two metals, iron or nickel. The anode 16—17 is illustrated as being a mere shell, which encloses a massive copper core-part 20, which carries, at its upper end, a plurality of copper fins 21, with good thermally conducting contacts between the copper core 20 and the fins 21, and between the copper core 20 and the iron anode surface-parts 16 and 17. The copper core-parts and the copper fins serve as excellent heat withdrawing materials, of good heat-conductivity, for withdrawing heat from the arc-terminal anode-portion 17, which gets quite hot by reason of the playing of the arc thereon, during the operation of the tube. Frequently, it is desirable to provide the copper anode-core 20 with a central hole 24 in which an anode-heater 25 may be placed for occasional use in controlling the anode-temperature, as may be required.

The lower metal end-portion 7 of the enclosure is provided with a bottom closure-means 27, which is perforated to receive an upstanding reëntrant cathode-tube 28. The cathode-tube 28 is preferably made of nickel, or at least its surfaces which are exposed to the vapors within the device are preferably made of nickel, as explained, in the Boyer-Colaiaco application, and as is known in the art of alkali-metal-tube-design. It will be understood, of course, that the bottom-member 27 is either integral with, or tightly welded or brazed to, the bottom metal end-portion 7 of the enclosure, and that the cathode-tube 28 is either integral with, or tightly welded or brazed to, the bottom end-closure 27. This bottom end-closure 27 may be either iron (including steel) or nickel.

The top end of the reëntrant cathode-tube 28 is closed, as indicated at 32. About half of the total length of the cathode-tube 28, at the top end thereof, is provided with radial fins 33, of the same material (nickel) as the cathode-tube 28, as explained in the Boyer-Colaiaco application.

In common with other known types of hot-cathode alkali-metal discharge-devices or valves, the active cathode-portion, which is the finned portion of our cathode, has to be heated to a suitable thermionic-emission temperature. To this end, we insert, within the reëntrant cathode-tube 28, a cathode-heater 37, almost all of which is concentrated at the finned end of the cathode-tube 28, so as to heat the active-emitting-portion.

The bottom metal enclosure-part 7, which carries the cathode, is exposed to the ambient atmosphere, which usually provides sufficient cooling to make the lower end of the cathode-tube 28 the coolest part of the tube. The portion of the cathode-tube 28, below the finned upper end thereof, is made sufficiently long, and, if necessary, sufficiently thin in cross-section, so as to reduce the rate of heat-conduction from the hot upper end of the cathode-tube 28 to the cool lower end thereof, thus assisting in maintaining the cool temperature-conditions at said lower end.

The open lower end of the reëntrant cathode-tube 28, which extends down below the base-portion 27 of the enclosure-means of our tube, is provided with any suitable closure-member 40, which includes a suitable insulating-seal 41 for introducing the heater-terminal 42 for the cathode-heater 37.

It is usually desirable to protect the lower tubular insulator-portion 13 of the enclosure-means from the temperature of the cathode-tube 28, which is done, in the illustrated embodiment of our invention, by means of a plurality of concentric metal baffles 43, which are carried by an inverted cup-shaped metal member 44 which encircles the cool lower end of the cathode-tube 28, so as to be supported thereby. The open end of this cup-shaped member 44 faces downwardly toward the cathode-end of our tube, that is, toward the bottom end-closure member 27.

It is a feature of our invention that we use this inverted cup-shaped member 44, and the space between it and the bottom end 27 of the tube, as a place for locating our evacuating-tube 47, the inner end of which we extend into the tube to a point between said lower end 27 of the device and the open bottom end of said cup-shaped member 44. This evacuating-tube 47 is used for evacuating the internal space within our tube, and when this evacuation-process is completed, the outer end of the evacuating-tube 47 is commonly sealed off, as indicated at 48.

However, before sealing off the evacuating-tube 47, it is customary to use this tube for introducing the small amount of alkali metal which is needed for the operation of the tube, this alkali metal being commonly introduced by in some way breaking an ampule containing it, in the evacuating system, usually in such a way that the wreakage of the ampule itself will be maintained in the evacuating system and will not be introduced into the container of the discharge-tube. For this purpose, it is convenient to turn the tube temporarily upside down, while the alkali metal is being introduced, so that the introduced material will be caught within the cup-shaped member 44. In this way, the initial charge of the alkali metal will be entrapped in the space defined between the inverted cup 44 and the bottom end-closure 27 of the tube, and since this is the coolest part of the tube, in operation, the condensed alkali metal will always be collected in this portion of the discharge-device or tube.

Since this cooling or condensing-place for the alkali-metal "pool" (which may be only a few drops) is at the cold end of the cathode, this alkali-metal pool is at the cathode-potential, and it is also fairly well shielded (by the inverted cup-member 44) from the arc which plays from the finned cathode-portion upwardly onto the lower end of the anode 17. Since the alkali-metal pool is thus at the cathode-potential, it

cannot have any positive-ion bombardment which, if it were present, would initiate electron-emission and produce faults. As previously mentioned, the collection of the alkali-metal pool at the cold end of the cathode is further advantageous over previous constructions in which this pool has been collected at or near the lower end of the anode of the device, because the lower end of the cathode is inherently much the better place, since its temperature is not affected by the intensity of the arc, and hence it is not affected by the load-current of the device.

As explained at the outset of our description, the alkali-metal which we use for our discharge-metal is selected from the group consisting of potassium, rubidium and cesium. At present we prefer cesium, for most types of tubes with which our experience has been mainly directed, although potassium and rubidium are both possible alternatives, particularly for certain tube-characteristics. When cesium is the discharge-metal, the cold lower end of the cathode-tube **28** is kept between the temperatures of 130° and 180° C. during the operation of the tube, while the upper hot end is kept betwen 650° and 850° C. When rubidium is the discharge-metal, the cold end of the cathode-tube **28** is kept between 180° and 225° C., and the hot end between 700° and 900° C. When potassium is the discharge-metal, the cold end of the cathode-tube **28** is kept between 260° and 310° C., and the hot end between 800° and 900° C. These are the temperature ranges which at present seem preferable, in the operation of our device.

In common with other finned-cathode alkali-metal tubes, it is desirable to place a suitable thermal guard around the finned portion **33** of the cathode. In our illustrated construction, the lower end of our finned cathode-portion **33** is thermally guarded, or heat-insulated from the bottom end **27** of the enclosure, by means of the inverted cup-member **44** and the concentric cylindrical meal heat-shields **43**. It is necessary, also, to thermally guard the lateral sides or peripheries of the fins **33**, which we have done by the provision of two closely-spaced, but separated, concentric metal tubes or cylinders **53**, which are disposed between the fins **33** and the adjacent side-walls of the enclosure-means for the tube, being spaced from both, and being supported by a plurality of stiff wires **54** from one of the cylindrical guards **43**. In our device, the arc plays upwardly from the finned portion **33**, so that it is possible for the laterally disposed thermal guards or heat-shielding means **53** to be imperforate cylindrical or tubular members.

Most tubes of the type to which our invention relates are grid-controlled tubes, and our present invention is primarily adapted for such tubes. Our new tube-construction and arrangement enables us to use a massive metal grid **60**, which is disposed transversely of the tube, between the top of the cathode-fins **33**, which constitute one arc-terminal, and the bottom anode-plate **17**, which constitutes the other arc-terminal. In accordance with our invention, the periphery of the grid **60** is secured in the best possible thermal contact to the inner bore of the tubular central metal enclosure-portion **8**, thus giving our grid a heat-conducting or radiating means which is directly cooled by the ambient atmosphere, (or by other externally applied cooling-means). Usually, if atmospheric cooling is relied upon, it will be desirable to use cooling-fins **62**, which are carried by the casing-portion **8** at the position of the grid **60**, so as to improve the heat-radiation from the grid.

In a grid-controlled vapor-electric discharge-tube, the grid is subject to the greatest heating, of all the parts of the tube, because it is necessarily enveloped in the hot arc. In previous tube-designs, the grid has been thermally isolated from all external connections, and it has run at very high temperatures, notwithstanding all that could be done in the way of shielding it from the necesarily high temperature of the cathode, and increasing the heat-radiation from the grid to the anode, which has always been externally cooled. This high operating-temperature of previous grids has necessitated a resort to low-work-function metals for the grid-material, as explained in the Boyer-Colaiaco application.

In our present invention, we are able to operate the grid **60** at a much cooler temperature than has heretofore ever been possible. In a cesium tube, it is necessary to operate the grid-cooling envelope-portion **8** at a temperature which is at least as high as about 200° C., in order to prevent condensation of cesium thereon, and in our invention we make our design so that this envelope-part **8** will run at somewhere around that temperature. There will necessarily be some temperature-drop between the hottest point of the grid **60** and the envelope-portion **8**, and the rating of the tube depends in large measure upon the temperature to which the grid can be held. In a cesium tube, 315° C. is about the temperature at which emission starts to be heavy enough to hurt, on the grid **60**. It is to be understood, of course, that these temperature-figures are illustrative only, and that slightly different temperature-limits will be encountered when the discharge-metal is either potassium or rubidium.

As to the grid-material, we are no longer limited to low-work-function metals, and we may prefer not to use such metals. Copper would be an ideal material for the grid **60**, except for the necessity for degassing the tube, during the process of evacuating it, at which time temperatures of the order of 900° C., or more, are used for a brief time, but this will evaporate enough copper, from any exposed copper surface, to cause a very damaging copper-condensation or deposit on the other internal parts of the tube. At least the surface-portions of the grid **60**, which are exposed to the vapors of the tube, that is, which are exposed to the interior of the tube, should be made, therefore, of a material which is able to resist vaporization at the degassing temperature, even though this material is not as good a heat-conductor as copper, as in geenral it will not be. A suitable material for the grid, or for the grid-surface, is a low-carbon steel, or nickel. In actual operation, some nickel will be deposited on the surface of the grid **60**, as a result of evaporation from the cathode, so that we have to consider that the grid is nickel-plated anyway, and we have to design our tube accordingly.

In the design which is shown in Fig. 1, the grid **60** is preferably made of iron or steel, and its periphery is thickened so as to present a broad contact-surface, which is brazed to the enclosure-portion **8**, preferably by using a small amount of copper. It is possible, however, to make the grid of copper, with a protective plating, coating or surface-covering of iron, as indicated at **64** in the broken-away portion of the grid **60** in Fig. 1.

Alternatively, as shown in Figs. 3 and 4, the

grid 60 might be made of iron or steel, with a number of copper inserts 66, which enter into radial holes in the iron material of the grid, from the periphery of the grid, and thus aid in carrying heat radially outwardly from the center of the grid to the casing-wall 8.

In our improved tube-design, it will be noted that the axial arc-gap separation or spacing is extremely small, thus contributing to a low arc-drop. This arc-gap spacing is only enough to provide for the thickness of the grid, and a suitable spacing between the top and bottom grid-surfaces and the anode and cathode, respectively.

It will be noted that, (in our preferred design at least), no shielding of any kind is needed, between the grid, on the one hand, and the anode or the cathode, respectively, on the other hand.

Our direct cooling of the grid 60, by reason of its thermal connection to an external wall of the tube, makes it possible for us to maintain our grid 60 at the extremely low operating-temperatures which have been above described.

While we have illustrated our invention in a single illustrative form of embodiment, with some suggestions regarding alternative forms of the grid, we wish it to be understood that the forms shown are merely intended to be illustrative, and we desire that our appended claims shall be accorded the broadest construction consistent with their language.

We claim as our invention:

1. A vapor-electric device comprising an enclosure-means including two metal end-portions, a tubular central metal portion, a tubular insulator-portion between each end of the central metal portion and the end of the corresponding end-portion, and insulator-to-metal seals between each end of each tubular insulator-portion and the end of the adjacent metal portion; an arc-terminating metal anode-portion carried by one of said metal end-portions of the enclosure; an arc-terminating finned metal cathode-portion carried by the other metal end-portion, said cathode-portion including a reëntrant metal tube-portion having a closed inner end carrying the cathode-fins; a quantity of a discharge-metal within said device, said discharge-metal being selected from the group consisting of potassium, rubidium and cesium; a cathode-heater within said reëntrant metal tube-portion; means for externally cooling a substantial part of the external portions of said enclosure-means, including said tubular central metal portion; and a metal grid-member carried by said tubular central metal portion in good thermal contact therewith, said grid-member being disposed transversely across the vapor-electric device, between the arc-terminating anode-portion and the arc-terminating finned cathode-portion.

2. The invention as defined in claim 1, characterized by the surfaces of the metal enclosure-portions which are exposed to the vapors within the device being of a material chosen from the group consisting of iron and nickel.

3. The invention as defined in claim 1, characterized by the surfaces of the grid which are exposed to the vapors within the device being of a material chosen from the group consisting of iron and nickel.

4. The invention as defined in claim 1, characterized by the surfaces of the grid and the metal enclosure-portions which are exposed to the vapors within the device being of a material chosen from the group consisting of iron and nickel.

5. The invention as defined in claim 1, characterized by the surfaces of the grid and the metal enclosure-portions which are exposed to the vapors within the device being of a material chosen from the group consisting of iron and nickel, and further characterized by the surfaces of the cathode-tube and cathode-fins which are exposed to the vapors within the device being of nickel.

6. The invention as defined in claim 1, characterized by the cathode-heater being concentrated at the finned end of the cathode-tube, and said cathode-tube being long enough so that its other end, which is adjacent to the cathode-end of the vapor-electric device, is the coolest part of the device, whereby the discharge-metal condenses thereon.

7. The invention as defined in claim 1, characterized by the cathode-heater being concentrated at the finned end of the cathode-tube, and said cathode-tube being long enough so that its other end, which is adjacent to the cathode-end of the vapor-electric device, is the coolest part of the device, whereby the discharge-metal condenses thereon, and further characterized by said device having a plurality of spaced concentric tubular metal heat-shields supported between the cathode-fins and the surrounding wall-portions of the enclosure-means.

8. The invention as defined in claim 1, characterized by the cathode-heater being concentrated at the finned end of the cathode-tube, and said cathode-tube being long enough so that its other end, which is adjacent to the cathode-end of the vapor-electric device, is the coolest part of the device, whereby the discharge-metal condenses thereon, and further characterized by said device having means providing a cup-shaped member surrounding the cold end of the cathode-tube within the device, the open end of said cup-shaped member facing that end of the device, and an evacuating tube extending into the device to a point between that end of the device and the open end of said cup-shaped member.

9. A vapor-electric device comprising an enclosure-means, an anode, a cathode, and a quantity of a discharge-metal within said device, said discharge-metal being selected from the group consisting of potassium, rubidium and cesium; said cathode including a reëntrant metal tube-portion extending into said enclosure-means, said cathode-tube having a closed inner end, metal fins carried by said cathode-tube near said closed inner end, a cathode-heater disposed within said cathode tube, said cathode-heater being concentrated at the finned end of the cathode-tube, means for externally cooling the enclosure-entering end of the cathode-tube, said cathode-tube being long enough so that its enclosure-entering end is the coolest part of the device, whereby the discharge-metal condenses thereon, and means providing a cup-shaped member surrounding the cold end of the cathode-tube within the device, the open end of said cup-shaped member facing that end of the device, and an evacuating tube extending into the device to a point between that end of the device and the open end of said cup-shaped member.

10. A vapor-electric device comprising an enclosure-means, an anode, a cathode, and a quantity of a discharge-metal within said device, said discharge-metal being selected from the group consisting of potassium, rubidium and cesium; said device having means providing a cup-shaped member, the open end of said cup-shaped mem-

ber facing an enclosure-wall so as to provide a partially enclosed pocket within said device, and an evacuating tube extending into said pocket.

11. A vapor-electric valve comprising a substantially tubular envelope, a cathode at one end of said envelope, an anode at the opposite end of said envelope, said envelope having an intermediate metal section insulated from said anode and said cathode, a metal grid disposed transversely across the valve, between said anode and said cathode, in good thermal contact with said intermediate metal section, and external cooling-means for said intermediate metal section.

12. A vapor-electric valve comprising a substantially tubular envelope, a cathode at one end of said envelope, an anode at the opposite end of said envelope, said envelope having an intermediate metal section insulated from said anode and said cathode, a metal grid disposed transversely across the valve, between said anode and said cathode, in good thermal contact with said intermediate section, and an externally projecting radiator disposed in good thermal contact with said intermediate metal section in opposed relation to said grid.

13. An electric valve comprising a container having a substantially tubular wall-portion, a cathode extending axially into said container, a heater disposed within the extreme inner end of said cathode, a thermal shield interposed between said inner end of said cathode and the sides of said cointainer, means disposed behind said inner end of said cathode for providing a cup-shaped member, the open end of said cup-shaped member facing that end of the container, an evacuating tube extending through a portion of said container at cathode-potential and extending into proximity to the open end of said cup-shaped member, an anode disposed at the opposite end of said container in opposed relation to said cathode, and a quantity of a discharge-metal within said container, said discharge-metal being selected from the group consisting of potassium, rubidium and cesium.

14. An electric valve comprising a container having a substantially tubular metal wall-portion, a cathode extending axially into said container, an insulating seal between said cathode and said tubular metal wall-portion, a heater disposed within the extreme inner end of said cathode, a thermal shield interposed between said inner end of said cathode and the sides of said container, means disposed benind said inner end of said cathode for providing a cup-shaped member, the open end of said cup-shaped member facing that end of the container, an evacuating tube extending through a portion of said container at cathode-potential and extending into proximity to the open end of said cup-shaped member, an anode disposed at the opposite end of said container in opposed relation to said cathode, an insulating seal between said anode and said tubular metal wall-portion, a quantity of a discharge-metal within said container, said discharge-metal being selected from the group consisting of potassium, rubidium and cesium, and a metal grid interposed between said anode and cathode, said grid extending transversely across said valve in good thermal conducting relation to said tubular metal wall-portion.

15. The invention as defined in claim 14 characterized by said grid having an inner portion composed of a metal having good thermal conductivity, and surface-portions composed of a metal having less thermal conductivity but having a lower vapor-pressure at a temperature of the order of 1000° C.

16. A metal-vapor electric discharge-device comprising a closed envelope, a heated cathode extending into one end of said envelope, an anode at the opposite end of said envelope, said envelope having an intermediate metal section insulated from said anode and said cathode, and a metal grid disposed transversely across the device, between said anode and said cathode, in good thermal conducting relation to said intermediate metal section of the envelope, the discharge-metal of said device being selected from the group consisting of potassium, rubidium and cesium.

17. A metal-vapor electric discharge-valve comprising a cathode structure, means for heating said cathode, a heat-shield substantially enclosing the sides and back of said cathode, the back portion of said shield constituting a rearwardly extending cup-shaped portion, a tubular member extending through a portion of the device at cathode potential, said tubular portion member extending into the area defined by said cup-shaped portion, an anode spaced from the exposed front portion of the cathode, an intermediate metal enclosure-portion extending between said anode and cathode, said intermediate metal enclosure-portion being sealed in insulating relation to said anode and said cathode to provide a closed container, and a grid interposed between said anode and cathode, said grid being in good thermal contact with said intermediate metal enclosure-portion, the discharge-metal of said valve being selected from the group consisting of potassium, rubidium and cesium.

18. A vapor-electric device comprising an enclosure-means, an anode, a cathode, and a quantity of a discharge-metal within said device, said discharge-metal being selected from the group consisting of potassium, rubidium and cesium; said cathode including a metal tube-portion extending interiorly into said enclosure-means, a portion of said cathode-tube carrying metal fins at a region within the interior of the enclosure-means, means for heating the inside of the cathode-tube at the finned portion thereof, means for externally cooling the cathode-tube in a region where it enters the enclosure-means, said cathode-tube being long enough so that said cooled enclosure-entering region is the coolest part of the device, whereby the discharge-metal condenses thereon, and means providing a cup-shaped member surrounding said cooled region of the cathode-tube within the device, the open end of said cup-shaped member facing that end of the device, and an evacuating tube extending into the device to a point between that end of the device and the open end of said cup-shaped member.

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